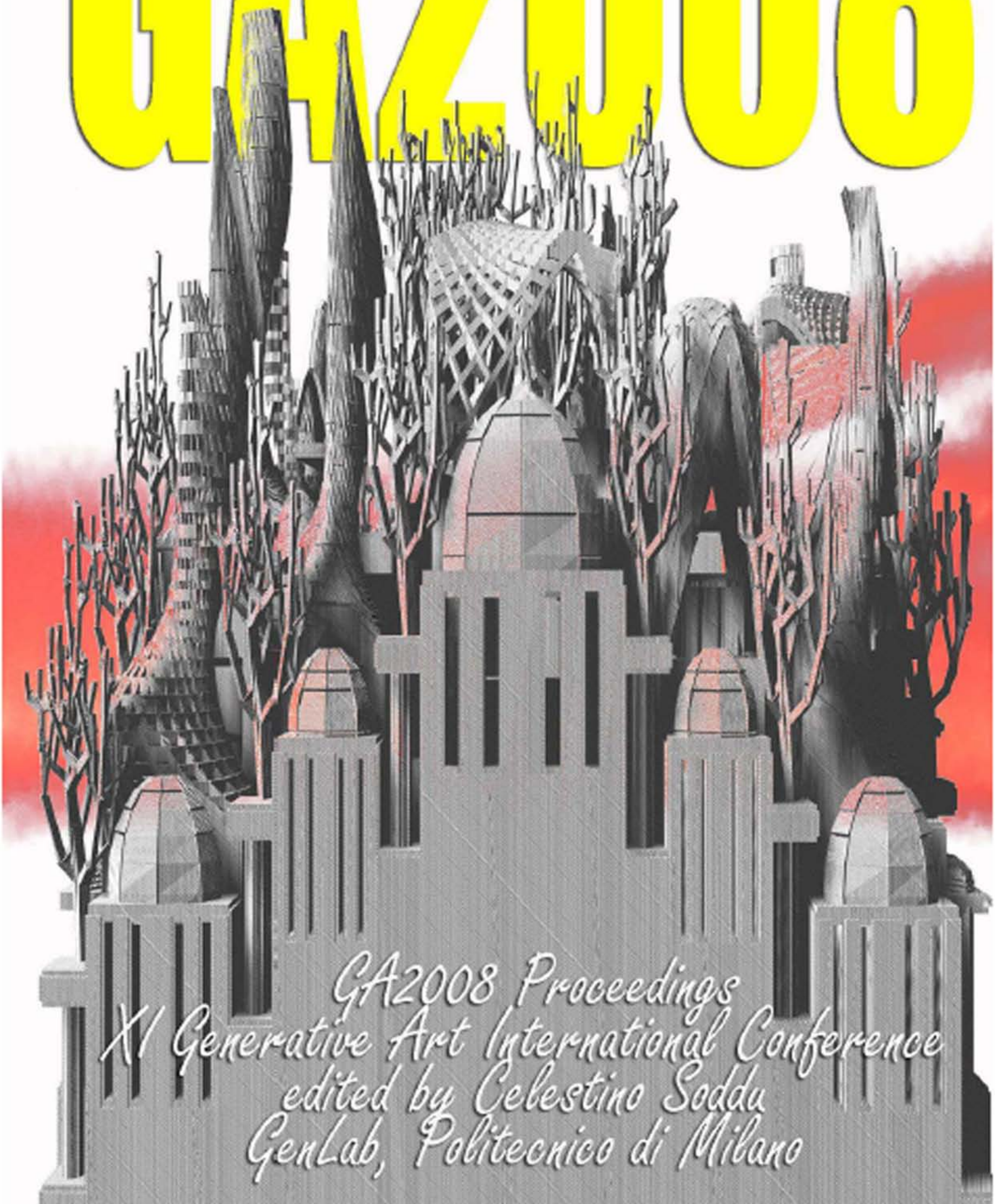
GA2008



GA2008 Proceedings
XI Generative Art International Conference
edited by Celestino Soddu
GenLab, Politecnico di Milano

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GENERATIVE ART 2008

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Part 2, Papers

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In the cover of this book a visionary variation of Italian Garden by Celestino Soddu.

In the 2nd cover a drawing of Leonardo da Vinci about the allegory of shipping in the river.

In the DVD external cover "ad continuum" following G.B.Piranesi, generative variations of Babel Tower in 50 numbered variations, each one for each participants to GA2008 conference. Celestino Soddu 2008.

In the DVD face an anamorphic representation of "caravanserraglio", a generated architecture.

All artworks are generated using the software Argenia created by Soddu, www.soddu.it

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Index Papers

Dear Generative Art friends,

When, in 1998, eleven years ago, in the same Aula Magna at Politecnico di Milano we meet for the first for the 1st GA conference, Generative Art was just born. With Enrica Colabella I founded in 1996 the Generative Design Lab and we decided to name this conference "Generative Art" , choosing the word Art, in the ancient significance of Art sinonimous of Science, and also because our aim was to enlarge the generative approach by facing it to other disciplines and to other similar approaches as Evolutionary Systems, Genetic Algorithms, Software Art, Emergent Design, Interactive Installations and Fractal Art. Starting from this first event, Generative Art increased its importance, identity and recognizability opening to other fields and disciplines the use of Generative attribute that, until that moment, was only used for Grammar language.
Now, as you know very well, Generative Art is worldwide identified and, year by year, increased its creative role by involving artists and researchers, naming university courses, founding new labs, research groups and research centers.
Now, at our XI Generative Art conference we can clarify better potentialities and boundaries of our Art.
We cannot talk only of techniques, also if techniques are important for identifying each generative approach.
Generative Artist uses techniques and dedicated software, for running the generative process. But this is not enough for identifying GA.
Generative Art is not a tool only, as Evolutionary Systems or Genetic Algorithms are, because as Art, needs to be pursued following a possible vision.
Generative Art is the "Art of creative processes". These processes can be created, developed and used by designing peculiar tools. Creating own subjective tools, quoting Henry Focillon, is the way used by Visionary People. People that look at future through their creative processes.
Always in our history each artist have created processes and subjective techniques for carrying out his artworks. Generative Art focuses in the creation of processes the main creative field. Processes are the generative artworks.
Many generative artists, architects, designers, musicians and mathematicians present and discuss here their creative processes and how they performed them with a generative approach. Art and science is the common field of interest and we find in these discussions a lot of suggestions for going ahead. Each subjective generative approach to Art is not against the others but, all together, they succeed in creating the field named Generative Art. Each subjective process is used for creating by referring to each own cultural references.It clarifies itself bygenerating future visionary scenarios. All are different but all belong to the same generative approach.
When a vision is represented as operative process and the process can be automatically repeated , we have Generative Art.
Generative Art is a philosophy of creative processes which aim is to generate Variations, like in Nature. The process identifies the Species, that are recognizable by Variations, the contingent identifies the individuals inside the Species.
This is a bridge that connects tradition to future.
In these eleven years we had here at Generative Art conference enthusiastic discussions about this approach, finding out fields of interest like Identity, Recognizability, Clarity, Complexity, Random, Transformations, and trying to

exchange among different disciplines, from Mathematics to Visual Art, from Music to Architecture, from Robotics to Design, from Literature to Geometry, how this philosophy can help human creative acts in defining better future and quality of life.
Some contributions were about particular tools and particular technical approaches but the main stream of Generative Philosophy was the common field of discussion. And, in this way, each participant found the possibility to go ahead in his subjective creative path.
I am sure that this year we will go ahead in this way. We have participants from different disciplines and from different cultural heritages.
If Generative Art is defining processes able to be applied to our own Past for creating future scenarios, the multiple cultural references and the multiple technical knowledge of the participants to Generative Art conference are the main treasure of our meeting.
Thank you so much to be here,

Celestino Soddu
Chair of Generative Art International Conferences

Milan, 16 December 2008

On-line Development of Man-Machine Relationships: Motivation-driven Musical Interaction

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Abstract

This paper documents an interactive musical generative system built from minimal explicit design specifications. Given the fact that conventional, responsive rule-based systems cannot cope with large swings in context, a method of on-line development is suggested. The machine develops a dynamic motivation as to whether integrate with a musical context suggested by a human interactor, or in contrast, express a native musical character. Motivations are configured as networks of relationships that provide continuous interpretation of changes in human behaviour. A combination of a simple form of reinforcement learning and genetic evolution continuously optimise motivations in order to accommodate input from an unpredictable human performer. Experimental evidence shows that man and machine may indeed develop common objectives such as mutual agreement during interaction.

1. Introduction

Generative works of art are often thought of as conceptual machines that – once they are activated - realise themselves. Given enough critical mass, such works correspond to micro-universes obeying some invented physics of arbitrary complexity. Conventional rule-based systems have been used successfully to implement style specific programs; they rely on the complexity entailed from the combinatorial explosion of the implied rule-base [8, 4]. In contrast, much artificial life oriented work follows the premise that both interesting morphology and behaviour may follows from the local interaction of simple rules [12]. Both approaches prove to be effective instruments for managing visual complexity. However, they are both characterised by a *one-way specification* of expertise; the artist implements rules while observing their implicit results. Most significant, the artist often specifies further rules from the observation of the current behaviour of the program; therefore programming generative systems is a form of artistic introspection. In reality, one-way specification takes place in a creative procedure of circular thinking. The main point here is that the art production system (whether visual, musical or hybrid) is thought of a as a closed container – complexity of form and behaviour is conditioned by some local rule-base in isolation – the system is not grounded into the real world and, in this respect, it is not interactive.

In contrast, this paper addresses the issue of open systems, systems that feature a physical connection with the external universe in which we live. Such systems offer internal generative potential while remaining open to influence from outside. In addition, open systems may develop *autonomous* behaviour rather than reflect the automatic behaviour from the activation of a rule-base in isolation. Autonomous systems are intrinsically *interactive*; they develop their own rules as a side effect of interaction itself. The resulting spatiotemporal patterns observed in biological workspaces speak to the imagination [1], therefore we attempt to identify the essential features of living systems as they may guide us to the synthesis of artificial ones.

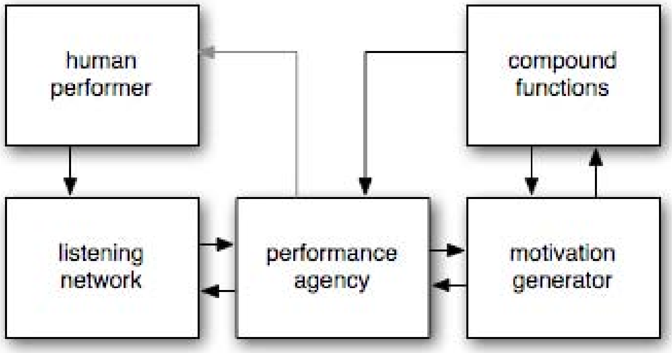

Figure 1: Global systems outline comprising functionality for listening, performance and on-line synthesis of machine motivations

In short, a living system contains some form of self-representation stretched out in its DNA, a living system exchanges information and energy with a dynamic environment, they rely on the integrity and relationships between their constituent components, they evolve over many generations while learning in-between points of evolutionary breeding. Finally, living systems develop motivations on-line, what to do next does not follow programmed instructions but emerges spontaneously from a set of competing drives.

We suggest these features to serve as first principles towards the development of an interactive musical entity, a system that will express its own native character while remaining open to pressure from a single human improviser. Behaviour in such a system follows from the competition between two conflicting forces: either *expression* (create output irrespective of current context) or *integration* (create output that is complementary to the prevailing context and keen to contribute to its further existence). We developed a real-time architecture (figure 1) to support rewarding man-machine interaction, it consists of three main networks; an evolved sensor-activator network for the purpose of machine listening [2] a distributed player agency equipped with evolved musical processing functions [3] and finally, networks serving the representation and management of internal machine motivations. The latter is the core subject of the present paper.

We take inspiration from the biologically rooted behaviourist theory of motivation [11] as it avoids all explanation of actions in terms of internal events such as desires and emotions. In contrast, behaviourist thinking explains complex behaviour in terms of external impact from the environment. One may consider the theory of *autopoiesis* [9] as a generalisation of this idea; the theory of structural coupling suggested here explains interaction not so much in terms of the complexity or content of a signal but in terms of the kind of structural changes it causes in the receiver. In this light, the model presented here is based on the articulation of activation and inhibition forces in a networked architecture; perpetual renewal of its structure is achievable while, however, its structural integrity (ontogenesis) is guaranteed.

2. Rationale of motivation-based interaction

Provided that our system aspires autonomous behaviour, we cannot accept its identity to be designed exclusively by external, human design specifications. We hope for a musical personality that maximises diversity, a system spawning many musical traits of great variety. System behaviour should be totally unpredictable while still displaying a coherent personality. Articulate musical patterns should develop from initial randomness. In other words, interaction is seen as navigation in a vastly multidimensional space featuring patterns of great diversity; from relative periodicity to unrestricted chaos. Such dynamic patterns reflect the variable degrees of man-machine understanding within the process of interaction.
A dynamic mechanism is needed that can make up criteria to interpret external agitation in terms of positive (agreement) or negative (conflict) impact. It must be robust and create an opinion by itself according to demands generated by its own internal dynamics. The *drive object* aims to provide such

a structure.

A drive is a computational object that specifies a simple psychological orientation. It can be considered an abstract suggestive *machine speculation*. It has two options: either integration or expression. *Integration* means that the machine aims to produce music that assimilates well with the last sequence played by the human player. In contrast, *expression* implies that the drive prefers to move away from the musical style suggested by the human improviser. The options are not mutually exclusive, they are viewed as two competing alternatives represented by two fluctuating quantities on a scale of 0 to 100.

The drive object implements a first principle: the appreciation and accommodation of change. Activation of the system happens in terms of changes, that is, *signed intervals* reflecting changes of features of given melodic material[1]. A first order quantity in our system is the current melodic distance between the last sequences produced by man and machine. We simply track if musical similarity (i.e. the inverse of musical distance) between the output of man and machine actually increases, decreases or remains the same over time.

At the very moment the machine just finished playing (detected by an adaptive segmentation algorithm) its most recent response, the effect on the situation can be computed. If the new distance is higher than the previous distance, we interpret this action as a wish to increase musical contrast between man and machine. If the new distance is lower, we know that both parties are musically getting closer together. Intuitively, we may track consecutive differences (delta-similarities) in time. If many such consecutive delta-similarities have the same sign, we infer that man and machine are either engaged in an escalating process of incremental contrast (negative sign) or apparent mutual understanding (positive sign).

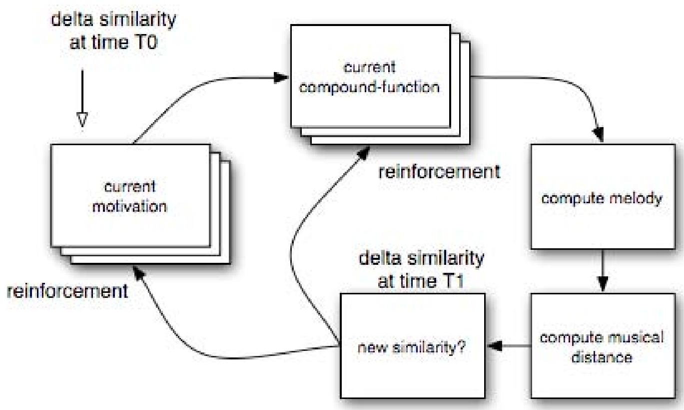

Figure 2: Circular model featuring reinforcement of motivation levels driven by changes in the environment.

Now, the idea is to learn which behavioural motivation (integration or expression) should dominate given a specific perception of behavioural changes in the human performer. From this knowledge, an appropriate musical processing function can be selected to fulfil that specific orientation.

The notion of a *relationship* was developed to specify a qualitative link between observed external changes and internal quantities representing the strength of an internal motivation. Internal motivations and external pressures are thus operationally connected as a complex dynamical system.

3. Relationships

[1] In practice, a feature vector is computed documenting changes of a large number of higher level features in a four dimensional representation of a string of musical events (pitch, loudness, duration and entry-delay), these include: changes in diversity, regularity, tempo, harmonic tension and entropy.

The idea of a *relationship* is inspired on the two-axis theory of personality suggested by Eysenck [5] and the relationships inside model ecosystems developed by Steels [13]. Eysenck's model suggests a four-quadrant system with the horizontal axis denoting a degree of stability (stable to unstable) and the vertical axis denoting introverted vs. extraverted behaviour. The way the human performer behaves is imagined as being reflected in the two-axis model. Behavioural changes are suggested by specific trajectories in two-dimensional space. Steels' model involves the acquisition of couplings between processes in the environment and internal processes. It studies couplings in order to evolve favourable relationships between a mobile robot, its resources and an unpredictable environment. Four complementary types of couplings are suggested which we view as functionally equivalent to the four quadrants described by Eysenck.

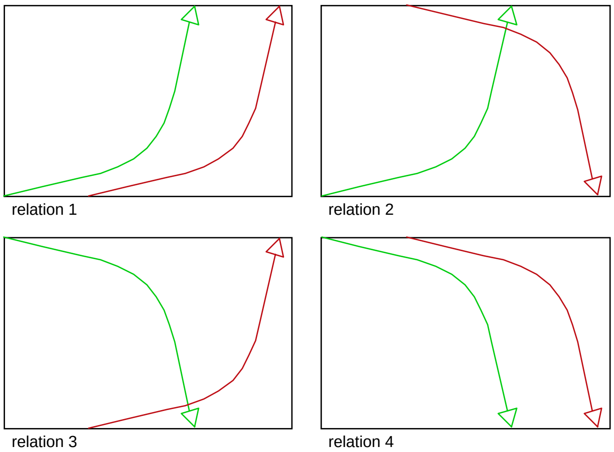

Figure 3: Four types of basic relations between changes in an input quantity (green arrows) and the effect in an output quantity (red arrows).

A basic set of four relations exist, we consider them in their most basic form, as linking two quantities by way of a multiplication factor f. A more qualitative interpretation follows in the next paragraph. For now we consider the 4 different couplings between changes in a source quantity ΔQ-source(t) at time t, and the value of a destination quantity Q-dest(i+1) at time (t+1).

The 4 relations are defined as follows:

If ΔQ-source(t) > 0 then Q-dest(t+1) = Q-dest(t) + ΔQ-source(t)*f1
If ΔQ-source(t) > 0 then Q-dest(t+1) = Q-dest(t) - ΔQ-source(t)*f2
If ΔQ-source(t) < 0 then Q-dest(t+1) = Q-dest(t) + ABS(ΔQ-source(t))*f3
If ΔQ-source(t) < 0 then Q-dest(t+1) = Q-dest(t) – ABS(ΔQ-source(t))*f4

The four types of relations are visualised in figure 3. Note that every relation { r1 … r4 } features a private multiplicative weighting factor { f1 … f4 }. Relation type 1 implies that a positive change in a source quantity will introduce a positive change in a destination quantity, the amount of change being proportional to the change at the source modulated by the private weighing factor of relation 1. In relation type 2, positive input changes produce negative output changes: output is inverse proportional to input. Relation type 3 connects negative input changes to positive output changes. Finally, relation type 4 implies that negative input changes produce negative output changes, again scaled by the weighting factor of the given relation. It was decided to keep the weighting factors local to every relation, rather than have individual weights in every relationship in order to limit the state space and create a better chance to monitor the impact of the individual relations.

4. Implementation of motivations

A motivation is implemented as a drive object that is sensitive to three kinds of changes: (1) the first derivatives of the similarity between the most recent melody produced by man and machine and (2) the first derivatives of the quality and (3) quantity of the contents of the most recent man produced melody. All input changes are computed and normalized in a range -100 to +100.

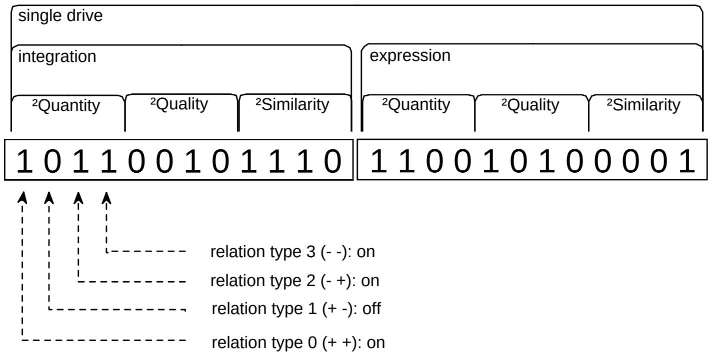

Figure 4: Topology of a single drive object showing three groups of four bits per motivation

Relationships are specified as two 12-bit vectors. Since there are three types of input sensors each feeding four types of relationships, we must accommodate 12 potential effects of external change – 3 blocks of 4 bits. For instance, bits 0~3 account for delta-similarities, bits 4~7 account for delta-quality and bits 8~11 account for delta-quantity. We must include both primitive motivations: integration and expression resulting in a total of 24 bits. If a bit equals 1, it means that its relationship is active, if the bit equals zero, its relationship is not accounted for. Note that many relationships can be active (bit on) in a single block. The output will reflect the contributions of all active relationships. When simultaneous relationships contribute opposite pressure, they may partially neutralise their mutual effect. This phenomenon contributes to non-linearity in the network.

drive-ID : 0
nr-runs : 7
current-orientation : EXPRESSION
relationships Exp : 1 0 1 0 1 1 0 1 0 0 1 0
relationships Int : 1 0 1 1 1 0 0 0 1 0 0 0
expression-level : 80.86634
integration-level : 31.14185
efficiency-value : 2.24824
understanding-level : 45.21349

Figure 5: Prototype snapshot, list of principal instance-variables inside a drive.

Intuitively, we understand that the density of ‘on’ bits in the vector will condition the global responsiveness of the drive. Too many ‘on’ bits may potentially produce over-stimulation leading to erratic output. In contrast, too few ‘on’ bits lead to under-stimulation, in this case, significant changes in input may get lost. We turn to a learning algorithm that learns to create appropriate couplings between input changes and internal motivations.

The behavioural motivation of a drive – its current orientation – depends on the strength of the two competing levels (0~100) for integration and expression. We expect a minimum contrast between both values; we introduce a threshold of 10%. If the difference between the levels for integration and expression is higher than 10%, then the higher value decides on the orientation else the current orientation remains ambiguous.

Notice the current orientation in figure 4 is *expression*. This has a double impact on further computations. First, the expression-vector becomes the source of temporary relationships and second, the output value affected by these relationships is the expression-level. The purpose of the *understanding-level* instance variable is addressed in section 5.2. Now, as an example, consider the first block of 4 bits of the Integration relationships: (1 0 1 1). Since the first bit is ‘on’, relationship type 1 (+ +) takes effect. Thus when the input level increases the output level follows. Relationships type 2 (+ -) is not considered since the second bit equals zero. The third bit is ‘on’ meaning that the contribution of a relationship type 3 (- +) is added to the previous. In other words, when delta-similarity is either positive or negative, the output level will increase. In addition, the relationship type 4 (- -)

says that if input level decreases the output level will follow in the same direction.

5. Learning in the drive object

5.1 Learning to be efficient

It is important to know how *efficient* a given drive actually is. When the external changes are processed by the relationships, they receive a qualitative interpretation because of non-linear couplings take place between the dynamics of external higher level quantities (similarity, quality and quantity) and competing internal behavioural motivations (integration and expression). Given the current orientation, we analyse if man and machine are coming together or drifting apart – according to their melodic similarity. For example, in pseudo-code;

```
if ( current-orientation == integration )
        if (currDist – prevDist) > 0 )
        then ( efficiency = (efficiency * inhibition-weight))
        else
        if (currDist – prevDist) < 0 )
        then ( efficiency = (min 100 (max 1 (efficiency * activation-weight))))

1.11 < activation-weight < 1.50
0.50 < inhibition-weight < 0.99
```

The learning method suggested here is similar to reinforcement leaning (RL) [14]. RL is a form of unsupervised learning; the learning agent receives feedback about how appropriate its actions are in order to achieve a given goal. However, the goal itself is not communicated, the agent aims to approach optima essentially by trial-and-error and learns from positive (rewards) or negative (punishment) feedback – corresponding to the fluctuations in drive efficiency according conditional scaling by activation and inhibition weights. As the efficiency of a given drive increases, so will its probability to be selected in succeeding trials. Eventually, the drives-pool will progress towards values that will maximise reinforcement. RL is typically applied in real-world problems characterised by a huge state space. All of this seems to fit the essence of interactive composing: man and machine must learn to behave successfully without any a priori information about their mutual personalities.

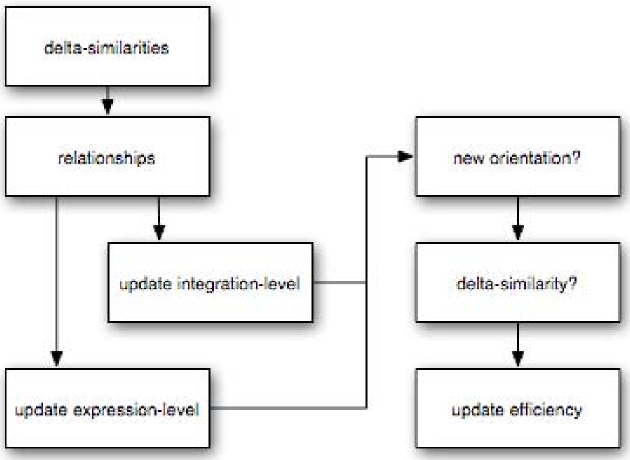

Figure 6: Simplified representation of two-stage learning algorithm: evaluation of the drive's relationships and consequently adjusting the drive's efficiency level.

A two-stage learning algorithm is depicted in figure 6. Stage one updates the levels of integration and expression from the evaluation of the current relationships. Stage two updates the efficiency according to the current orientation. Let us tackle stage one in detail. For every delta value, the respective slot of the relationships-vector is evaluated.

Stage one encloses two nested loops; the arguments are the current gradients (delta-values) in man-machine melodic similarity and the changes in quality and quantity of the contents of working memory. All 24 bits of the relationships-vector are addressed (figure 4). The levels are scaled up (activation) or down (inhibition) according to the type of relationship and the delta value. In the end, the integration and expression levels will reflect the accumulated impact of the combination of vector on-bits and the sign of the respective delta-values.

Stage two evaluates the resulting (potentially changed) drive-orientation, decided on by taking the highest value of the two competing levels as the winning current orientation. Take note that we exploit only the delta-similarity at stage two. This delta value and its sign provide information as to whether the current relationships were helpful to steer the drive towards the optimal orientation. The intended optimal orientation (integration or expression) is the one that is consistent with the last change in man-machine similarity. For example, when the man-machine melodic distance decreases and the orientation is integration, we conclude that the drive is indeed resourceful towards the fulfilment of this drive's orientation – therefore, its efficiency-level is scaled up using the activation-factor. In similar vein, in case the melodic distance increases and the orientation is expression, the efficiency level is also scaled up. Efficiency-level is inhibited when the changes in distance are in conflict with the orientation i.e. either a combination of integration and increasing distance or expression with decreasing distance.

Any given orientation is considered a machine *suggestion* to temporarily approach musical interaction from a given perspective i.e. either a wish for man and machine drifting apart (expression) or narrowing the man-machine melodic distance (integration). The rationale is that a suggestion is first generated at random and subsequently adjusted according to the evaluation of the data gathered during actual interaction – the argument for having a learning component in the first place.

Finally, the obvious question arises of how to compute the similarity of two melodies (the last segment input by the human performer and the current machine response), possibly of unequal length. Different methods were implemented and evaluated, including; the use of 4 transition matrixes tracking the quantised values of consecutive intervals in a sequence of MIDI events in the dimensions of pitch, velocity, duration and inter-onset-time – similarity is viewed as being proportional to the degree of overlap between the respective matrixes. The current implementation calculates similarity indirectly; by comparing the feature-vectors[2] of two given melodies. Further discussion is, however, beyond the scope of the present paper.

5.2 Learning to optimise man-machine agreement

A second higher-level form of learning is introduced. Remember, the implicit goal of our system is to maximise man-machine agreement i.e. having man and machine demonstrating the same *global* orientation. To this purpose, one additional quantity is introduced, the *understanding-level*, acting as an instance variable in the drive object (figure 5). This variable is updated proportional to the degree of conflict or agreement between the current global orientations of man and machine.

The listening module continuously adjusts two quantities: *integration-pressure* and *expression-pressure*, scalars between 0~100. The update is proportional to the current delta-similarity – the amount and direction of change in similarity between the most recent and the previous musical sequence played by the human performer in relation to a given machine output. For instance, when the musical distance decreases (similarity increases), we infer that the human performer wishes to integrate, so *integration-pressure* is scaled up and *expression-pressure* is slightly scaled down. The activation factor is proportional to the absolute value of the similarity interval, formally:

activation-weight = 1 + abs(delta-similarity) / 5
inhibition-weight = 0.98

[2] We analyse the respective lists for global direction (incremental, decremental or stationary), angularity (smooth or angular), regularity and diversity (low or high), and the relationship between the first and last value (interval is positive, negative or zero). This yields two 48 element binary feature-vectors; melodic similarly is considered proportional to the amount of coinciding values in both vectors.

```
if ( delta-similarity > 0 )
        integration-pressure =
                (min 100, integration-pressure * activation-weight)
        expression-pressure =
                expression-pressure * inhibition-weight

        else
        if ( delta-similarity < 0 )
                expression-pressure =
                        (min 100, expression-pressure * activation-weight)
                integration-pressure =
                        integration-pressure * inhibition-weight
        then
then
```

The level of *human-global-orientation* is obtained as follows:

```
sum = integration-level + expression-level

if (integration-level > expression-level)
        orientation = ( integration-level / sum ) * 100
        else
        orientation = ( -1 * (expression-level / sum )) * 100
then
```

The resulting global orientation yields a signed value between -100 and +100, negative values denoting expression, positive integration. The complementary level of *machine-global-orientation* is computed using a similar algorithm; the contrast between levels of integration and expression in the current drive returns a likewise signed numeric result between -100 and +100.

It is now straightforward to compare the formatted orientations of man and machine in order to infer an estimate of *common-understanding* i.e. the nature and strength of mutual orientation between both. In pseudo code:

```
if (machine-global-orientation.signum == human-global-orientation.signum
        common-understanding = Agreement
        common-understanding-level =
                (human-global-orientation.abs + machine-global-orientation.abs) / 2
        else
        common-understanding = Conflict
        common-understanding-level =
                (human-global-orientation.abs - machine-global-orientation.abs) / 2
```

The procedure above returns a signed value reflecting the strength and type of man-machine orientation, *agreement* occurs when both pursue the same orientation i.e. either integration or expression. The interaction is characterized as in *conflict* when both interactors produce levels of divergent sign. Then, the understanding-level of the current drive is further adjusted as follows:

```
if common-understanding-level > 0
        ;; activation
        factor = remap(common-understanding-level 0  100 1.0 3.0 )
        else
        ;; inhibition
        factor = remap(common-understanding-level 0 -100 1.0 0.3 )

understanding-level = min( 100, understanding-level * factor )
```

The reinforcement factor is proportional to the common-understanding-level and its sign; levels of 0 ~ 100 and -100 ~ 0 are remapped to respectively 1.0 ~ 3.0 and 0.3 ~ 1.0). The understanding-level is a second indication of how appropriate a given drive performs given a specific interaction context – it may thus guide the selection of specific drives in forthcoming interactions.

Finally, we might wish to get an impression of the *global* behaviour of the complex dynamical system comprising a single man and a single machine; the dynamics of the interaction as articulated by the fluctuating orientations of both parties. The *system-global-orientation* (-100 to 100) is computed as:

system-global-orientation = (human-global-orientation + drive-global-orientation)/2

This average continuously documents global systems behaviour at the highest level of abstraction; in essence, it provides an indication of the social processes emerging from the interaction process itself.

6. Managing simultaneous, competing motivations

A critical mass is needed *and* a procedure to maximise diversity and guarantee the potential development of many different types of interactions. We turn to a genetic algorithm [6] to breed fresh populations of drives by considering the fittest drives (the most efficient drives) as parents to breed the next set of offsprings (section 7). However, let us first examine how acquired competence may actually be put to good use within the process of interaction.

In the current implementation, the drives-pool contains between 8 and 30 drives. The initial relationships are random with a density of 50 percent, while both orientation levels receive a random value between 40~60. The rationale is to provide initial momentum for change in either positive or negative directions. A random selection scheme is used, the chance for a drive to be selected being inverse proportional to the number of times it ran in the past. Thus, all drives get a chance to perform but not in any specific order.

At the beginning of the learning period, any drive can be selected because none has developed an efficient behavioural orientation. *Exploration* takes place: the pool of drives is sampled at random and the orientation levels are pushed up or down. When a clear contrast gradually emerges, we may decide to actually exploit the knowledge that was acquired online. So first we give many options a chance to develop while later on, the promising ones are applied. We use a probabilistic ranking scheme that proportionally conditions efficient drives to be selected. Once the learning period is finished, the genetic operators are applied. The drive's efficiency-level is viewed as equivalent to fitness. A newly bred generation will thus reflect the knowledge gathered during the learning period.
This situation described above is known as the dilemma of opting for *exploration* or *exploitation*. A global parameter is introduced: the *exploration-exploitation-ratio* (probabilistic selector, 0 = only exploration, 100 = only exploitation, 50 = equal chances) – the hypothesis is that its value should be congruent with *changes* in responsiveness of the human performer.

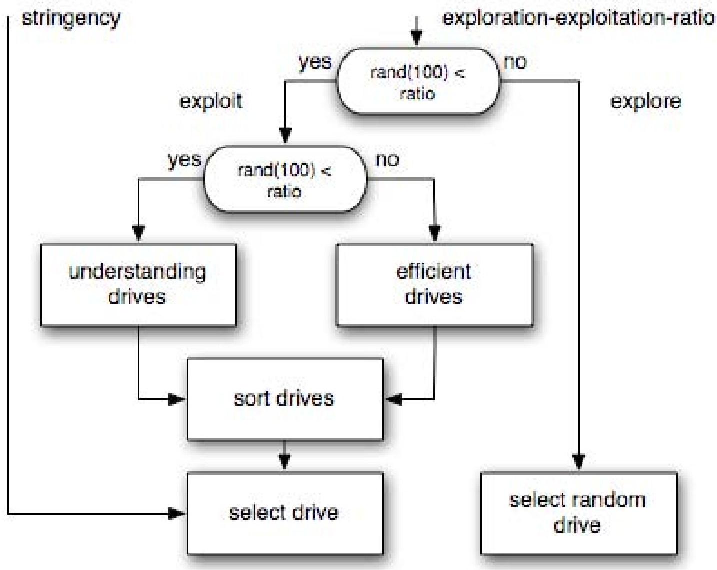

Figure 7: The exploration-exploitation-ratio acts as a probabilistic threshold for selecting the next drive.

The level of *human-responsiveness* is another systems variable computed from the normalised sum of 3 items: quality and quantity of the current contents of working-memory (a FIFO structure holding the last 32 MIDI events input by the human performer) and the *current-no-input-gap* (the time since the last event was input). We keep track of the previous and current levels of human-responsiveness. Now, it is imagined that increased responsiveness signifies a readiness to connect with the current context from the part of the human performer; consequently opportunistic *exploitation* of what happens to be available should be favoured over the uncertainty associated with adventurous exploration.
Otherwise, when the interval of current minus previous human-responsiveness is negative, we reason that the human performer is temporarily loosing attention; therefore, we should increment chances for exploration to potentially induce renewed interest in the human performer. In short, the exploration-exploitation-ratio continuously tracks changes in human-responsiveness as to yield a probabilistic threshold between 0 and 100.

Yet one additional concern will guide the selection of a particular drive: its *understanding-level*. The understanding-level of a prospective drive is addressed as this level reflects the short-term efficiency in terms of social conformity during interaction as explained in the previous section. Figure 7 illustrates the twofold application of the exploration-exploitation-ratio in picking the most advantageous drive. The higher the ratio, the more chance for exploitation *and* the more chance for selection of understanding drives. Lower ratios shift towards selection of drives based on efficiency while very low ratios promote exploration i.e. random selection. Before selection, sorting according to respectively positive understanding-level or positive efficiency collects fit drives. The *stringency* parameter (0~100) further constraints the selection process. Given a stringency value of zero, any fit drive is subject to selection irrespective of its fitness level. Given a stringency value of 100, only the fittest drive is a candidate. Values in between exercise variable pressure on the selection process.

7. Genetic optimisation of motivations

Nowadays, genetic methods are a hot item in computer music research [10]. For our purpose, in terms of evolution, the fitness of a drive is equivalent to its efficiency. Genetic optimisation aims to modify the relationships inside the drives to make them better adapted to the variable external pressures i.e. the *changes* in human-machine similarity and the changes in quality and quantity of the material provided by the human performer.

Breeding the next population is organised as follows:

- The current drives population is sorted according to fitness.
- The two fittest drives are considered parents.
- A new population is created: the relationship-vectors of both parents are considered genotype and new vectors are computed using a single point crossover operator.
- A small amount of mutation is applied to all drives in the new population, mutation level is lower than 5% in most experiments.
- All instance variables of every new drive are reset and the integration- and expression levels are set to a random centre value between 40 and 60.

In the current implementation, the moments of genetic activity are timed explicitly. Genetic operators should take action when all drives had a chance to build up enough experience during interaction, all drives must be applied at least a few times and gather expertise from the learning process as described above. The breeding-cycle, therefore, is taken as a multiple of the number of drives in the drives-pool. Given a population of 16 drives in the drives-pool, a typical breeding-cycle is 16 * 5 or 80 process cycles. This implies that, on the average, every drive has a chance to be applied 5 times.

8. Experimental results

We conducted a substantial number of experiments to investigate the potential of motivation-driven interaction. Each experiment monitors a considerable number of systems parameters (exactly 50) and saves their momentary values to disk. This yields a large data file documenting an interactive session; the data is further subject to various types of off-line analysis and visualisation. However, only a few aspects directly relating to motivations and global behaviour are included here. Two experiments offer a chance to compare behavioural development in two independent experiments: e24 and e25. The population size is 8 drives, the breeding-cycle is only 16 and the total number of process-cycles is 320 – therefore, these experiment contain exactly 20 epochs of genetic evolution. The experiments respectively take 38’24” and 44’23”.

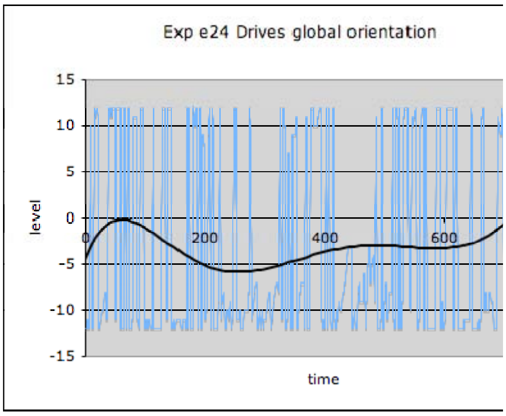

Figure 8: Evolution of the drives-pool global orientation, integration (positive values), expression (negative values) in experiment e24.

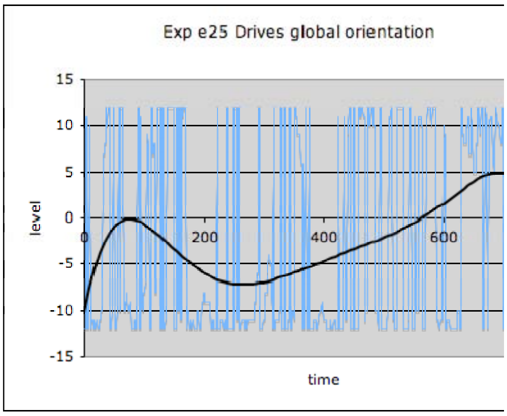

Figure 9: Evolution of the drives-pool global orientation, integration (positive values), expression (negative values) in experiment e25.

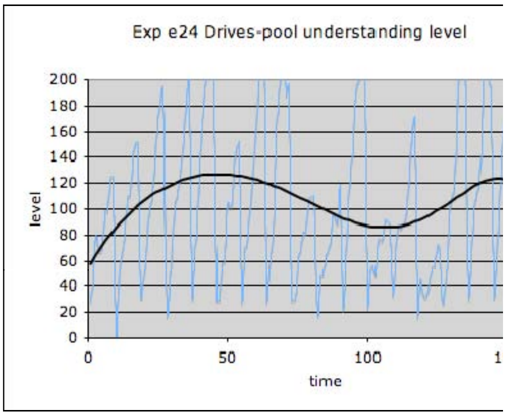

Figure 10: Evolution of the drives-pool understanding-level in experiment e24.

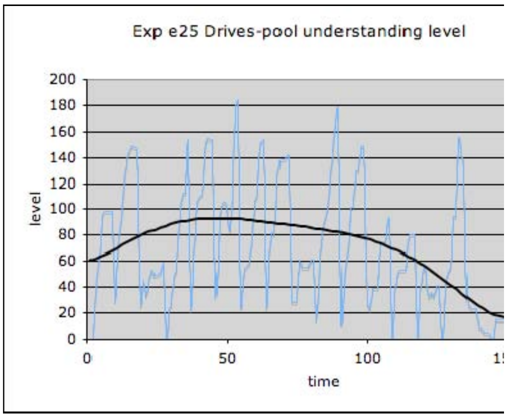

Figure 11: Evolution of the drives-pool understanding-level in experiment e25.

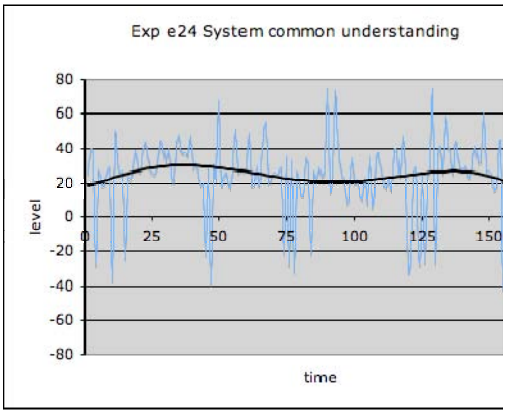

Figure12: Evolution of the level of system common understanding in experiment e24. Agreement (positive values), conflict (negative values).

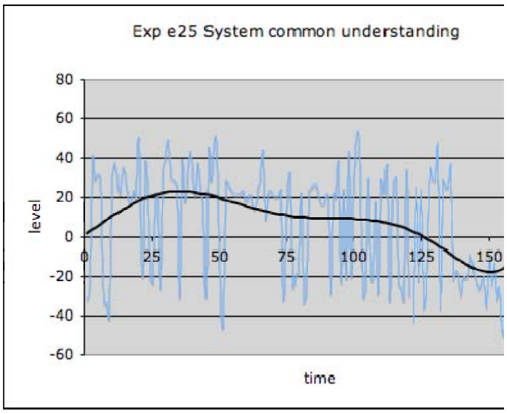

Figure 13: Evolution of the level of system common understanding in experiment e25. Agreement (positive values), conflict (negative values).

Figures 9 and 10 document drives global-orientation i.e. the overall result of the competing forces of

integration and expression. Both show an incremental data profile, the machine develops momentum to favour integration.
Figures 10 and 11 show the evolution of the drives-pool understanding-level. The polynomial reveals wave-like behaviour; the understanding-level is subject to slow oscillation.
Figures 12 and 13 document system behaviour at the highest level of generalization. System common understanding shows areas of relative stability and areas of oscillations constrained between specific upper and lower levels. Both experiments maintain a significant interaction climate characterized by man-machine *agreement*. A strong correlation exists between the incremental nature of the drives-pool understanding level (figures 10 and 11) and a similar profile in system common understanding level.

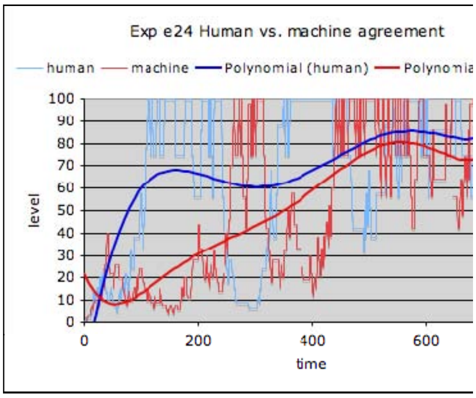

Figure 14: Evolution of the levels of human vs. machine agreement in experiment e24.

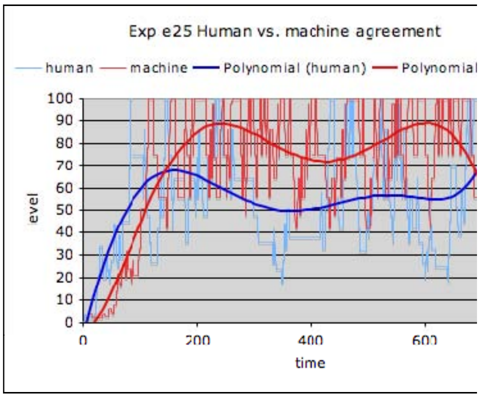

Figure 15: Evolution of the levels of human vs. machine agreement in experiment e25.

All experiments keep track of two additional systems variables: human-agreement and machine-agreement (figures 14 and 15). *Human-agreement* is updated each time the segmentation algorithm considers the human performer 'just finished playing'. *Machine-agreement* is updated every time the machine just finished playing its most recent response. The rationale is to have quantities that respond immediately (in contrast to accumulated changes inferred at the end of a learning period) to changes in the musical distance between man and machine. The levels of agreement are scaled up or down according to the interval in similarity. For instance, human-agreement goes up when the most recent human input sequence manages to be more similar to the current machine output than the previous human input sequence. In contrast, given an increase musical distance, human agreement it is scaled down. Exactly the same principle articulates machine-agreement.

Remarkably, figure 14 and figure 15 (somewhat less so) demonstrate a steady increase in agreement for both man and machine. When both values are highly similar *and* of a high value there is evidence that both parties managed to develop musical functionality to perform in a common effort with shared objectives. In other words, man and machine expose adaptive behaviour. As a result, these observations reveal emergent goal directedness as a side effect of leaning in the drives.

9. Conclusion

In conclusion, a drive implements machine motivations – a facility to generate temporal machine suggestions. The drive object advocates a method to avoid explicit design that typically characterizes conventional mapping procedures in interactive systems design. In contrast, a drive is a flexible data structure that adapts its integration and expression levels according to its relationships and the accommodation of external changes during the process of interaction itself. In addition, a drive features learning components: long-term efficiency and short-term understanding.
The fluctuations in system common understanding -- representing the top-most impression of the global systems behaviour – reveal the dynamic qualities of the interactive process. The systems' implicit intention is to develop networks and musical processing functions that are optimised towards generating agreement between man and machine as musical partners. *Agreement* implies that both man and machine show competence to develop functionality that contributes to sustaining the current

system-global-orientation, irrespective of whether it is integration or expression. The experiments reported here show strong evidence that the current systems architecture manages to support such functionality successfully.
A short note on implementation: a first version was written in Macintosh Common Lisp using MIDI functionality provided by Common Music [15]. The most recent version is written in SuperCollider 3.2 [7]. Both versions feature a style of object-oriented programming and message passing, perfectly in harmony with the idea of musical interaction by way of networked relationships.

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A Generative Nervous System for the Planet

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Abstract

Generative systems are now being proposed for addressing major ecological problems. The Complex Urban Systems Project (CUSP) founded in 2008 at the Queensland University of Technology, emphasises the ecological significance of the generative global networking of urban environments. It argues that the natural planetary systems for balancing global ecology are no longer able to respond sufficiently rapidly to the ecological damage caused by humankind and by dense urban conurbations in particular as evidenced by impacts such as climate change. The proposal of this research project is to provide a high speed generative nervous system for the planet by connecting major cities globally to interact directly with natural ecosystems to engender rapid ecological response. This would be achieved by active interactions of the global urban network with the natural ecosystem in the ecological principle of entropy. The key goal is to achieve ecologically positive cities by activating self-organising cities capable of full integration into natural eco-systems and to network the cities globally to provide the planet with a nervous system.

Introduction

The prevalent industrial pattern of design and development in the urban environment which is expanded and driven by fossil fuels has significant impacts on the global environment. Broadly speaking, the depletion of natural resources, the reduction of biological diversity, and the degradation of carrying capacity of the earth, global climate change and global warming are remarkable indications. In statistics [3], cities consume three quarters of global energy, responsible for at least three quarters of global pollution; approximately 64 per cent of the world's economic production, consumption and pollution are associated with cities. It has been summarised [27] that cities have become parasites in the landscape, immense organisms that drain the world in search of food and energy, relentless consumers and relentless polluters. The explosive urban growth in the use of energy and materials characterise in the twentieth century is warned with the global limits to space and resources [14]. Specifically, ecological footprint is defined to account for resources consumption and environmental degradation, and calculations show that only 1.5 hectares of ecologically productive land and about 0.5 hectares of productive ocean are available for every person on earth [26]. On other hand, it is expected by United

Nations Human Settlements Programme that in 1950 only 30 per cent of the world's population was urban; by 2008 more than 50 per cent are living in urban areas, and by 2030 60 per cent will live in cities.

With the challenges of degenerated natural resources, degraded natural environment and increasing global population, conventional industrial development which has been practiced for nearly two centuries is recognised inherently unsustainable [4]. A growing recognition is that long term economic and social vitality depend upon more efficient use of natural resources, coupled with improved human and environmental health [32]. This integrated concern from economic, social, and environmental perspectives campaigns for sustainable development globally. Further, the concept of sustainability is identified as a systematic composition of social, ecological, economic, cultural and technological dimensions [9]. In other words, design for environmental sustainability should be an integral participation of man, nature and technology.

A New Sustainable Strategy for Complex Urban System

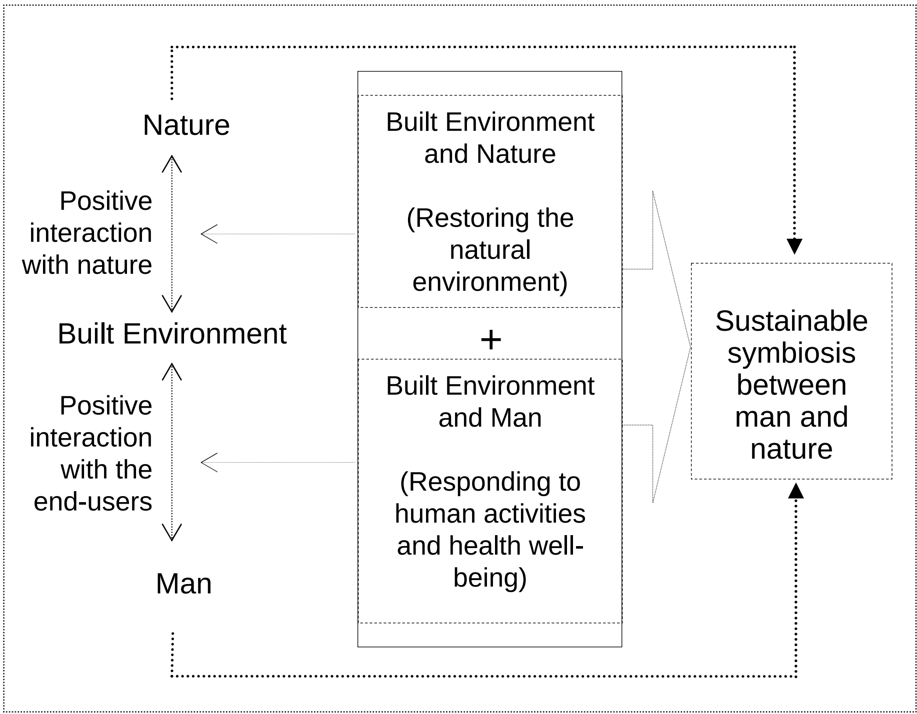
The integration of sustainability implies that sustainable design should aim to technologically implement the interactions of all the factors for an optimised environmental performance of the built environmental system, in order to achieve sustainable symbiosis of man and nature. Specifically, the factors of system sustainability in the environment can be identified as parameters of the end-users' aspirations such as climatic demand to satisfy human activates contained within spatial design, and the physical environmental context, including energy and material resource used in the built environment. All of these parameters interact with one another in complex non-linear patterns, which contribute a dynamic characteristic of system sustainability of the built environment [22]. In brief, sustainable development must naturally change in response to shifts in any part of this dynamic interrelation.

Currently, most design strategies and technologies for sustainable design in the built environment focus on improving the environmental performance of energy and resource use and reducing the environmental impact of that use [7] [8] [13] [33] [37]. These approaches are interpreted as a respect for the local contexts, the concerns for the end-users of the built environment and the conservation of energy and resource. However, the hybrid of fragmented techniques towards the vision of environmental sustainability is employed without predicable and controllable tools to indicate ongoing environmental performance of the holistic system, particularly ecological interactions with the natural ecosystem which is the host environment in essence.

In this context, a radical concept of sustainable architecture is advocated [33], pushing the generally acceptable identification of sustainable design to interactive and even ingeniously adaptive to the natural ecosystem. This advanced strategy aims to design environmental sustainability climatically and culturally effective over time, responding to regional microclimates and materials and even to global scale. In general, sustainable design urban environment is re-identified to imaging the interrelations between human beings and living ecosystems in an ecologically positive manner.

A significant component of this positive design is restorative design [1] [16]. It is argued to design urban environment to nourishing and restoring living ecosystems in an analogy with the positive interrelation of sun with a tree. By this restoration, cities are designed as ecologically productive systems with positive contributions to the environment, to restore the environment without sacrificing natural resources and to increase the carrying capacity of the natural ecosystem. This proposition for positive interrelations of urban environment and nature is consistent with the concept of environmental fitness [17]. From the basis of ecology and biology, it is argued every organism or any system modifies the environment, and the environments adapt and evolve to accomplish the fittest of the organisms and the natural environment. This ecological interdependence provides a positive model for sustainable symbiosis of man-made space and the natural environment.

Fig. 1: Positive Design for System Sustainability in Urban Environment



In sum, a holistic composition of positive design aims to bridge the gap of man and nature which are identified as two main components of system sustainability in urban environment. Positive design is proposed not only to satisfy human activities and aspirations including climatic demands and health well-being, but also to produce ecological contribute to the natural ecosystem. Through positive design, an ecological symbiosis of man and nature in urban environment will be established. With the identification of composition of system sustainability in urban environment, a new design program for sustainable design is thus expected which needs the assistance of relevant innovative technologies. It is hypothesized as an integrated response to the full spectrum of sustainability, the parameters of which evolve in a non-linear pattern towards an optimized environmental performance of the system.

A Design Framework of Entropy for Complex Urban System

It is argued that one of the great misconceptions on sustainable design is that the environmental consciousness is not dictated by sound science [34]; furthermore, science is argued [19] bound to play an increasingly important role to meet the challenge of understanding and reshaping the environment to achieve constructive modification of the environment with a less destructive coexistence with nature. By applying the laws of science and taking nature as a constructive model [2] [16] [21] [28] [33] [34] [39], the ecological principles of entropy, for example, it is possible to design a sustainable urban environment which is embedded by the demands of society.

In general terms of thermodynamic science, the built environment is considered as entropy result at high order. It is a highly ordered material environment constructed with a highly ordered power through energy use with energetic order, including refining, processing and purifying energy itself, provided from the low-ordered natural environment [10] [35]. Another generally acceptable thermodynamic interpretation argues that the consequence of energy and matter use in the environment is entropy, the inescapable negative environmental impact, including energy inefficiency and pollution emission [11] [18]. In particular, climate change is considered as entropic consequence, chaos in the built environment, mainly caused by fossil fuel use for greenhouse gas emission. In contrast to this collective sense of guilt accelerated by human technology to the point of endangering the survival of the species on the earth, on the other hand, entropy is interpreted as the nature's technique for balance [2]. This positive recognition regards entropy as spontaneous chemistry and physics thermodynamic change between man-made environment and nature due to the temperature and pressure differentiates, and other thermodynamic gradients.

Most strikingly, the latest interpretation of the Second Law of Thermodynamics states that entropy of an open system is the origin of order [19] [23] [24] [25] [29]. Through evolutionary thermodynamics, an open system evolves towards positive outcome, a highly ordered state with complex organisation, when order is generated from chaos. During the evolution, entropy functions as an informational indicator, representing the phase changes of microscopic configuration of the open system, such as thermodynamic distribution of energy and matter in the system. In short, this interpretation of entropy in an open thermodynamic system provides a microscopic configuration and formulation for positive design in the environment.

Open system in thermodynamics science refers to a system open to energy, matter and information, in which the interactions of energy and matters as the thermodynamic parameters are non-linear. The status quo of an open system is far-from-equilibrium when various self-organising processes such as the distribution of energy and matter occur in the system. With complicated feedback loops, the open system is highly sensitive and adaptive to external influences. It means any small change in the system triggers fluctuations, for example, remarkable space-time re-organisations and re-distributions of energy and matter in the system.

In the evolution of an open system, entropy is both physical and chemical potential in the spontaneous change of the system, due to the differences or gradients of temperature, pressure, concentration of the system, and between the system and the surrounding. In the dissipation of material and energetic fluxes as thermal changes between the open system and its host environment, entropy is produced by heat and mass fluxes across the system boundary and the open system itself.

In specific, an open thermodynamic system evolves through three phases: an initial positive entropy state with negative environmental impact, an entropy balance state with neutral environmental impact, and a negative entropy state with positive environmental impact. The evolutionary pattern of entropy in an open thermodynamic system can be specified as follows.

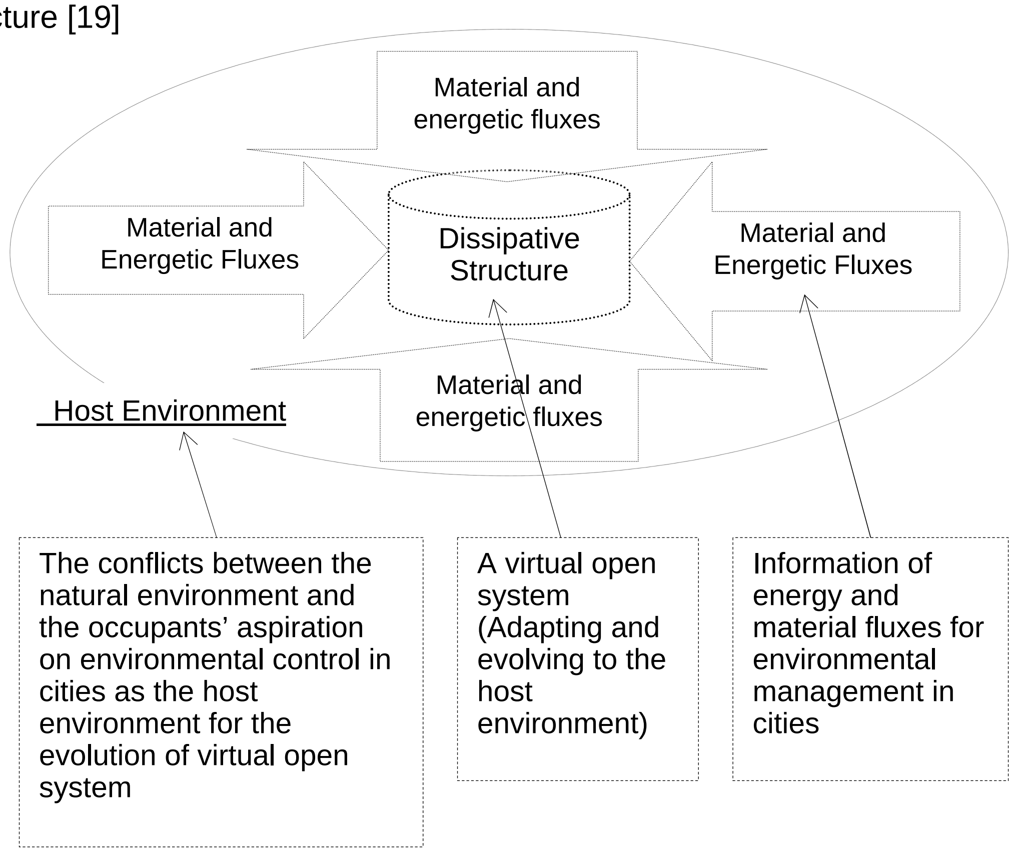
> Phase I: when the system is at a far-from-equilibrium state, entropy in the system is incorporated by the internal production within the system and external entropy flow from the surrounding; the rate of entropy in total is positive. This stage represents increasing entropy of the open thermodynamics system, and results in negative environmental impact. In other words, entropy production of the open system is compatible with the constraints imposed upon the boundary of the system.
>
> Phase II: when the system is at a non-equilibrium state, the rate of internal generation of entropy within the system is compensated by the net rate of entropy flow due to the energy, heat, and materials fluxes into and out of the system. In consequence, the system finishes the thermodynamics change, and arrives at a highly-ordered organisation of energy and matter in the system. This state is when order emerges from the system through the spontaneous and self-organising evolution of energy and matter fluxes.
>
> Phase III: when the system is at a highly order state after the evolution of the system. In this case, order increases in the course of the evolution. This can be observed in biological evolution, where an irreversible evolution process of an open system such as an organism is associated with increasing complexity.

It is thus argued that [12] [19] the nature of an open system such as living systems and biological organisms are open thermodynamically dissipative structure, which evolve towards organised complexity. This dissipative structure, with the work of physico-chemical processes of developmental mechanisms, evolves from far from thermodynamic equilibrium in order to survive; it is thermodynamically self-adaptive, open to both energy and matter; it exchanges with the host environment by continuous fluxes of neg-entropy from the universe, to which they return an even larger amount of positive entropy. In consequence, open systems evolve to higher and higher forms of order while isolated systems evolve to disorder.

In sum, by self-organizing and self-spontaneous thermodynamic change to fully take use of energy and matter fluxes across the system, an open system evolves through the steady growth of structure, organization and complexity to constitute new organizations of the system [23] [24] [25] [30]. This evolutionary paradigm of entropy has been used to interpret the creation of the universe as an entropy production [19], the regenerative process in nature from chaos to order [20] [24], the evolution of an organic life [5] [6] [24] [30] [38], the model of origin-of-life [36] and the formation of matter's structure [19].

With the clarification of the concept of entropy, the implication of entropy in a complex open system to the built environment is a conceptual model for sustainable urban development. It is specified as a complex model of open system design for the evolution of system sustainability. The hypothesis is cities as open complex systems exchanging both energy and matter with the natural environment and evolving towards positive environmental impact in entropy evolution; thus cities work as ecological productive ecosystems to produce ecological contribution to the natural ecosystem. More specifically, by designing a city as an open system, it is possible to facilitate the non-linear interactions of all the parameters of system sustainability in the self-organising pattern. In an entropy paradigm, the complex open system of a city or cities network, is self-adaptive and self-spontaneous to the constraints in the host environment, and evolves with positive feedback towards a highly ordered organisation, such as an optimised environmental performance.

Fig.2: An Open System Model of Complex Urban System adapted from Dissipative Structure [19]



In general, it is argued [14] that the fundamental biophysical bases for an urban system like a city to survive indefinitely rely on its consistency with physical limits imposed by thermodynamics and the preservation of ecological surroundings and, consequently, of ecosystem services. In this paper, an open system of a city or cities network refers to a virtual environmental system immersed with dynamic information which represents the non-linear interactions of all the parameters of system sustainability. These include the local climate context such as climate, soils, and topography, the end-users' demands and satisfactions of past performance and future prediction on the microclimate in urban environment, the available energy and material resources, the distribution and consumption of energy and material resources, the environmental impact of that use, such as energy waste and emission, or self-generated energy, and the available building technologies. These parameters can be translated and converted as elementary parameters of an open system in entropy paradigm, including the system, the boundary, the surrounding, the constraints, and the drivers.

Controller of open systems: the information of the end-users' aspirations such as micro-climate control;

Host environment of open systems: the constraints such as the conflicts between the local physical context and the end-users' demands and satisfactions;

Open system: a city or a city network;

Dynamic fluxes of open systems: the information of the fluxes of energy and material resources across the boundary of the system;

Internal entropy production: the irreversible environmental impact such as emission and waste, and positive contributions such as self-generated and self-contained energy and etc.

These parameters follow the rule of the entropy evolution, adapting and evolving towards the positive outcome of a highly-ordered organisation of energy and material resources as sustainable environmental performance. A formula of parametric design for open system in buildings will be developed, which refers that the complication of energy and material resource distribution in a system or subsystem of buildings, will be controlled by and responded to the conflicts of end-users and the environmental condition as the constraints of the evolution of the open system of buildings or the subsystem.

Virtually, a city or its subsystem can be designed in a self-sufficient and self-organizing mechanics to organize energy capture, distribution and consumption. The interactions of all the parameters, including the active involvement of the end-users and the sensitive response to the local environmental context are thus identified as the constraints for the adaptive evolution of urban complex systems. In this process, entropy is a sensitive indicator of the evolution of the adaptive system, indicating the state quo of the system. Once entropy is balanced neutrally, it means the positive outcome of non-equilibrium of the system arrives, and the constraints or conflicts of the system are resolved.

This model composed with parameters and the rule will converge to control modelling for system sustainable design of complex urban systems, by which the environmental performance of the system is manipulable and responsive to the accessible constraints with positive outcome. In this context, control modelling represents a wide range of information on the physical characteristics of the system, to simulate and analyse alternative scenarios such as the critical constraint of local climate, a variety of demands from the end-users and dynamic fluxes of energy and material, which can then be convert into a final design solution for sustainability. A differential equation of parametric design for open system of urban network will be developed, in which the rate of change of each variable is written down in terms of the present values of all the variables which influence the variable in question.

$$dS/dt = \text{Function}\ (x, y, z)/dt + \text{Controller}\ (\lambda)/dt \qquad (1\text{-}1)$$

- dS/dt: entropy change rate;

- Fucntion (X, Y, Z)/dt: entropy produced by the embodied energy in material flows, entropy produced by the operational energy, entropy produced by energy waste and emission in the open system,
- Controllers (λ)/dt: controller rate of energy and material fluxes controlled by the end-users and the environmental context.

In this composition of complex model, the relative information of the internal energy and material distributions in the system, which are used to create an optimised environmental performance in urban environment, is connected to the information of the system's constraints of the conflicts between the end-users' demand and the local environmental context. Within each individual system, conflicting constraints will yield a fitness design solution responding to individual environmental context and the human demands.

A Model of Generative Nervous System for Complex Urban Systems

Through manipulable information organisation of ecologically environmental performances of complex urban system, the urban system will not only reserve energy and resource use, but also produce positive ecological contribution to the surrounding environment restoring the natural ecosystem. In terms of the framework for entropy analysis of open thermodynamic system, the active thermodynamic fluxes of energy and resources will accelerate the ecological interactions of urban system with the natural ecosystems. By these positive interactions, the harmonious interrelation of urban environment to their surroundings is ecologically positive. Therefore, cities can be identified as part of productive ecosystem in nature, restoring the natural environment for sustainable symbiosis of man and nature. The constitution of control modelling of complex urban system will provide sufficient informative feedback of ongoing environmental performance to facilitate the adaptation and optimisation of environmental management of urban system for an efficient organisation [31]. By changing the constraints of the system and identifying the order of the system, through the analysis of informational feedback, a variety of design solutions for sustainability can be generated, which will be used to design forms and structures for the stabilities of complex urban systems.

This Complex Urban Systems Project (CUSP) founded in 2008 at the Queensland University of Technology aims to provide a high speed generative nervous system for the planet by connecting major cities globally to interact directly with natural ecosystems to engender rapid ecological response. By following the paradigm of open system in entropy evolution, cities will positively interact with the natural ecosystem by both internal ecosystem and external ecological interactions with the natural environment in the form of dynamic fluxes of energy and resources, which can be engaged by human active participations assisted with control modelling techniques. Therefore, urban environment is activated with capabilities of self-organising and adaptation for a full integration into natural eco-systems and to network the cities globally to provide the planet with a nervous system to achieve ecologically positive cities.

CUSP aims to establish the beginnings of a digital sustainability network which will research and develop a new approach of Generative Urban Systems. We posit that this project will contribute to the development of environmentally sustainable cities by expanding ecological and urban assessment capabilities and harnessing real–time sensing technologies. It will also contribute to an expanded awareness of innovative approaches to reducing the environmental impact of urbanisation. The end product will further demonstrate methods of retooling cities in alternative approaches to designing for a zero carbon emission strategy. This differs from restorative or regenerative design, which is about producing a clean energy, water and air, and is essentially remedial and focussed on resource autonomy – and is not net positive.

Conclusion

This paper proposes a generative model of complex open system for sustainable urban design within the framework of entropy evolution. This model is converged to control modelling of ecologically environmental performance of complex urban system, with an interactive involvement of the end-users and a responsive engagement to the natural environment. By employing control modelling technique to identify the constraints of the system adaptive and responsive to the local context, and to design a desired order of the systems, the paper argues it is possible to attain an ideal sustainable environmental performance of complex urban system, a highly-organised energy and material use. Hence, the harmonious relationship of man and nature can be established for the imperative of environmental sustainability.

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Design by Computation

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Abstract

In our paper we put Generative Design in a historical context. We will define Generative Design and briefly discuss the most important mathematical methods that have been developed, that are relevant with regard to shape generation. Often these methods don't have any relation to architecture, but are nevertheless very valuable when applying Generative Design.
In the second part of our paper will show Generative Design can be used in architectural training. A link is necessary between the traditional way of visual modeling and the mathematical formulae. To establish this link we use CAD scripting languages. The problem however is twofold: (1) scripting languages are meant to extend the system functionality and not to easily generate shapes and (2) most architectural students have no programming skills at all. We will show some the results of our "Generative Design" design atelier and most importantly explain the underlying mathematical approach that was encoded in the script.
Finally, we will summarize our experience with this studio and provide the guidelines for successful application of Generative Design in architectural design.

1. Introduction

The microprocessor, which was developed in the early eighties, is the root of the desktop computer. Because of the broad acceptance and low cost of desktop computers, the demand for software grew rapidly. For the architectural designing process this resulted in the development of graphical software, first mainly 2D but nowadays 3D.
At the end of the eighties research started to create new shape/forms which only could be drawn by computers, so called NURBS, non-uniform rational B-spline, (see figure 1.1) These 3D-shapes are the graphical representation of complex mathematical formulas. Today, a growing number of architects use these techniques, with well-known representatives such as Kas Oosterhuis, NOX and UN-studio.

Recently there is a renewed interest in the use of computer software during the form finding phase in the architectural design process, named “generative designing”.

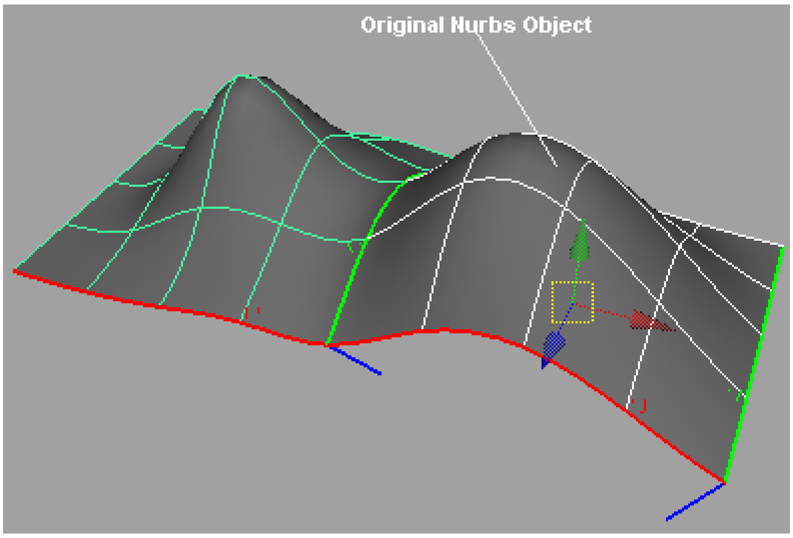


Figure 1.1 a simple NURBS surface

Terzidis (2008) refers to this renewed interest as the shift from computerization to computation. According to Terzidis computerization is the act of “entities or processes that are already conceptualized in the designer’s mind are entered, manipulated, or stored on a computer system.” In contrast, computation or computing, shapes aren’t manipulated by the designer but generated by the computer. Mouse-based operations on objects, as done in well-known CAD applications, such as AutoCAD, ArchiCAD etc, aren’t computations but belong to the ?act? of computerization. By using the embedded scripting languages of CAD-applications like VBA or AutoLisp in AutoCAD, the designers go beyond the limitations of the built-in functions. In a discussion with several leading scientist in the “CAD-field” (Kolarevic, 2005, pp 296) from the audience Ulrich Flemming formulated it as follows: “I would like to challenge the notion that you program only as a last resort in case software vendors don’t provide you with the right tools…. I wish architect would abandon this passive stance in which they simply accept what the software vendors offer them. They don’t even make suggestions as to how to improve the software; they don’t understand the software at the level at which you need to understand it if you want to make intelligent suggestions.”
So in the development of CAD-software the first range of meaning of this new technology was expressed not from “technical rationality” but from the past practices of users (A. Rahim in Kolarevic, 2005, pp 201). The current generation architect students never learned designing with pencil and ruler, so their expressing will be different to the former generation’s architects. The act of “computerization” will stay important in design practice, but there will be more and more demand for “computation”, as the new generation designers will go beyond the limitations given by standard CAD-software.
Because of this shift from computerization towards computation the following questions come to mind:

What does computation mean in design or what is generative design;
Are there ‘standard’ mathematical models which can be used?

How can one use generative designing in architectural design? Or is designing not becoming a mere running of a piece of software.

In the next paragraphs we will address these questions.

2. Research

2.1 What is generative design?

Generative designing isn't a design process in the traditional way, but it is the use of a combination of different arithmetic methods in order to generate a set of different alternative solutions for the design problem at hand. In this way it becomes possible to find solutions to complex problems which in a traditional way of problem solving can't be found.

Galanter defined generative art as follows:

> *"Generative art refers to any practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art."* (Galanter, 2003)

This definition is also applicable for architecture, in most cases it is a computer program (script) which is used instead of a set of natural language rules. These computer programs have the same underlying design pattern:

1) Describe the initial state;
2) This state will be modified according to a well describe set of rules;
3) Evaluation of constraints; these constraints test if alternatives fulfill the design goals;
4) This new state, derived in step 2, will become the initial state for the next iteration.

This step-by-step plan can be fully automated, in which case the designer decides when to stop the process. However, one or more steps can be accomplished by the designer self, in which case the designer becomes part of the iteration process.

The basic parts of the procedure mentioned above, are "state" and "rule-set". The state describes the architectural design; the rule set describes the transformations and denotes the constraints which the design has to fulfill in order to be an acceptable solution. This initial state will be, depending of its degree of freedom, transformed into alternatives of the initial design.

This formal approach resembles, not by coincidence, a big similarity with theoretical design methods as well practical design methods. These, most often complex, problems can't be solved by human's designers in a reasonable amount of time, if at all. However, generative designing makes use of the number crunching power and calculation speed of computers, to solve the design problems at hand.

2.2 Categories

Generative designing is based on a number of arithmetic models, as explained in the previous paragraph. These arithmetic models or better these algorithms can be grouped in a few categories. These categories are only indicative, because most of these algorithms aren't use separately but mixed, which blur the classification boundaries. For simplicity we use the following categories:

Parametric design (see 2.2.1)
Cellular automata (see 2.2.2)
Flocking of birds (see 2.2.3)
Genetic algorithms (see 2.2.4)
Shape grammar (see 2.2.5)

In the following sub-paragraphs we will discuss shortly the above mentioned categories and their underlying algorithms.

2.2.1 Parametric designing

In parametric designing, a geometric form (like a building component or building layout) is denoted as a set of depended variables or relations. By changing one or more of these variables or parameters, alternative forms are generated. Each of these generated forms can be checked upon functionality, usability etc. If a solution doesn't prove to fulfill all constrains, a new alternative solution can easily be generated and checked, by changing one or more parameters. This process continues till a satisfactory solution is found. The designer is in complete control of the process. The CA(A)D applications ArchiCad and Revit are parametric design tools. The designer can create different solutions to a design problem by manipulation different parameters in a relative easy way.

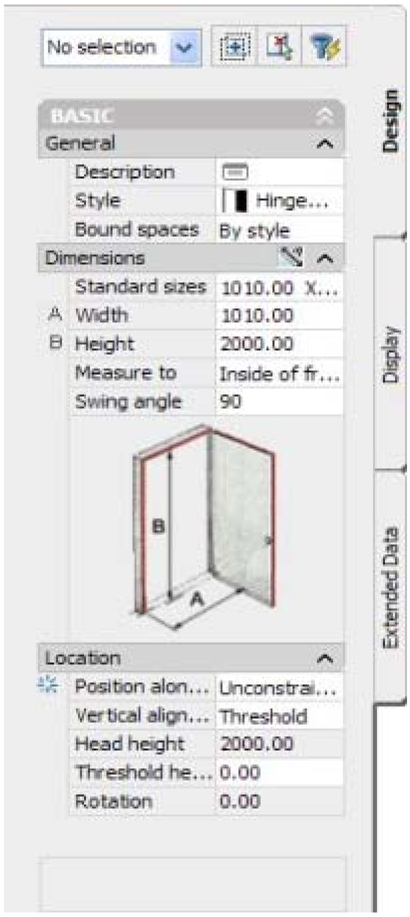


Figure 2.1 Parametric component

2.2.2 Cellular automata

Wolfram was for his age a genius; he proved that complexity can be derived from a set of simple rules and structures. Wolfram developed an application consisting of a grid in which every cell is ‘on’ or ‘off’ (dead or alive, 0 or 1). The application starts with an initial configuration, the state of the next row of cells is derived from the previous row of cells. There are 8 possible combinations for Row A defines the next state of row B in 000, 001, 010, 011, 100, 101, 110 and 111. The end result depends which rules are chosen, in this case there are 256 possible rule sets.

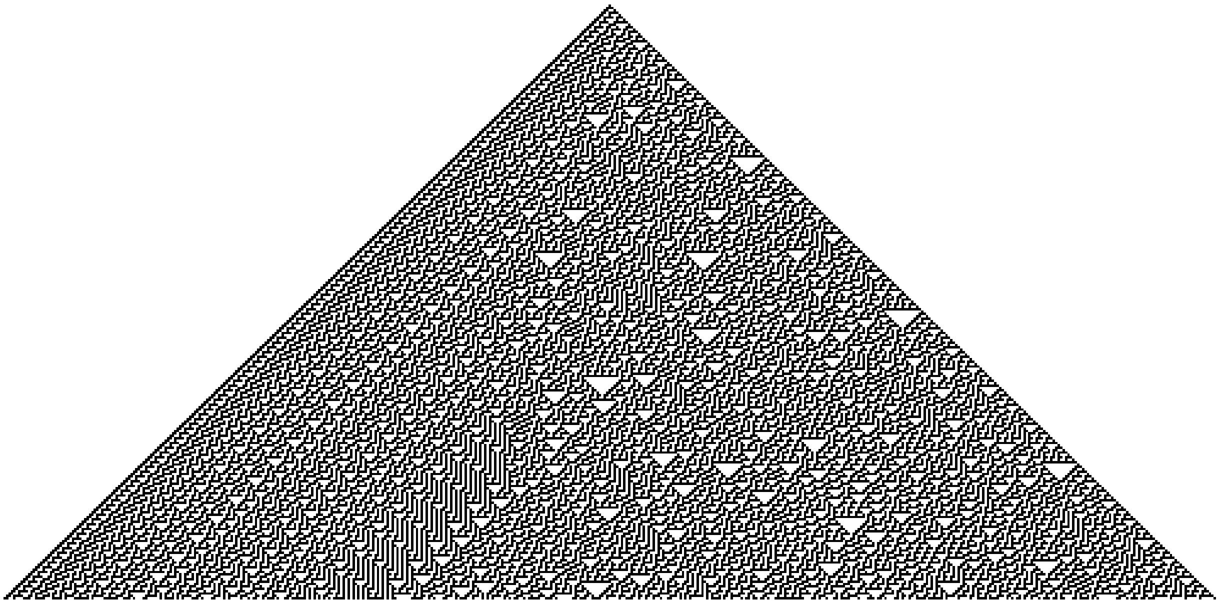


Figure 2.2 Cellular automata

A derived algorithm of the cellular automata algorithm is the so called ‘Conway’s game of life’. This algorithm is a classical application of an artificial life application (= A-life). Conway’s game of life consists of a set of simple rules, implied on a grid of cells. A cell can’t be alive if there are more then 3 or less then 2 adjective cells. A new cell will come to life when an empty cell is surrounded by 3 living cells. This simple rule set results in a complex behavior. The system will converge to a stable state, by dying of all cells or by reaching a steady state.

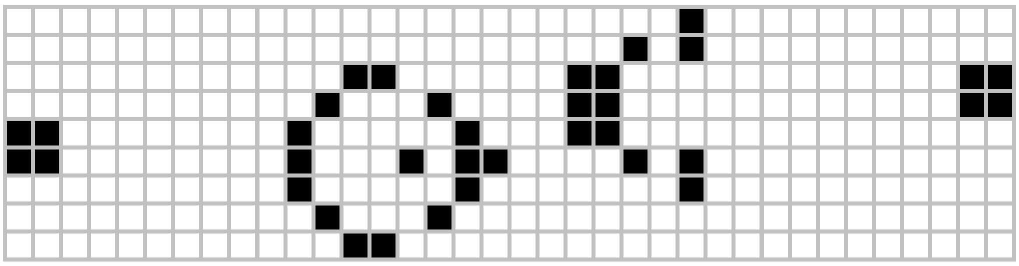


Figure 2.3 Game of Life

2.2.3 Flocking

A different area in which the A-life community is active is that of animal behavior, and the formulation of mathematical formulas which resemblance this behavior. A well know study is that of Graig Reynolds, named ‘Boids’ - an application that the flocking behavior of birds mimics in a realistic way. The algorithm is based on 3 very simple rules and results in an incredible realistic behavior. These 3 rules are:

Separation: Steer to avoid crowding local flock mates.
Alignment: Steer towards the average heading of local flock mates.

Cohesion: Steer to move towards average position of local flock mates.

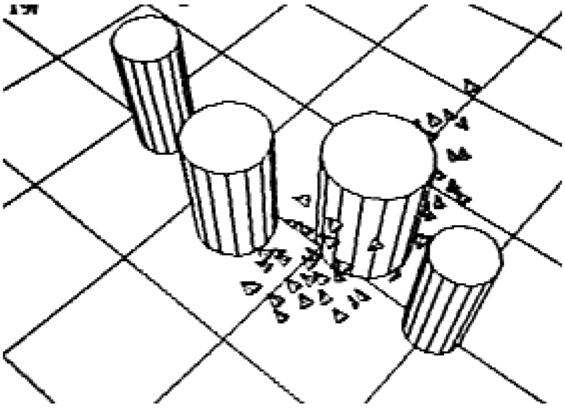
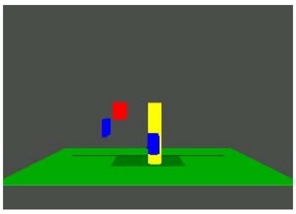


Figure 2.4 Flocking

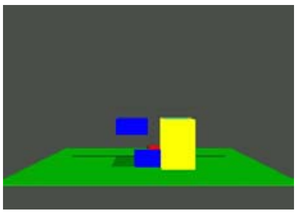
With use of these three rules the behavior of one bird is mimicked. If applied to a number of birds, the behavior of a flock of birds is simulated.

2.2.4 Genetic algorithm

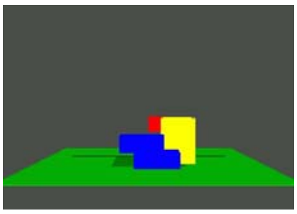
In the sixties Holland (Holland, 1992) describes an algorithm based on genetic reproduction. A problem is parameterized, and these parameters are ‘collected’ in a string of numbers. By filling this string of numbers (= genotype), with randomly chosen numbers, one gets an indiscriminate solution (= phenotype) to the problem.
Because of the process of iteration the string with numbers will improve and subsequently a better solution to the problem at hand will be found. The algorithm is capable of finding solutions for optimizations problems, especially for problems with different, sometimes conflicting constrains. For research on this topic see van der Zee en de Vries (2004)



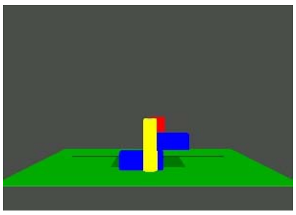
Fitness 0.02635



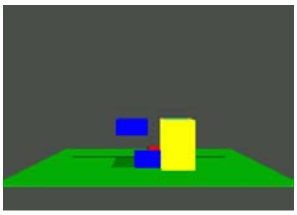
Fitness 0.900165



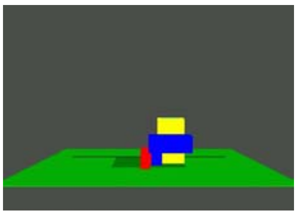
Fitness 0.912840



Fitness 0.95595



Fitness 0.961112



Fitness 0.961695

Figure 2.5 Genetic algorithm

2.2.5 Shape grammars

A ‘shape grammar’ consists of a number of shape rules and one ‘generation engine’ which selects and processes the shape rules. A shape rule defines in which way an existing shape (or part of a shape) will be transformed. A shape rule is built up from two parts, separated by a right pointing arrow. The left side of the arrow is called ‘Left-Hand Side’ (=LHS). On the LHS are the conditions in terms of ‘shape’ and ‘marker’. The right hand side is called ‘Right-Hand Side’ (=RHS). On this side of the arrow is the transformation of the LHS written down, and where the new marker is positioned. The marker is use to localize and orientated the new form.

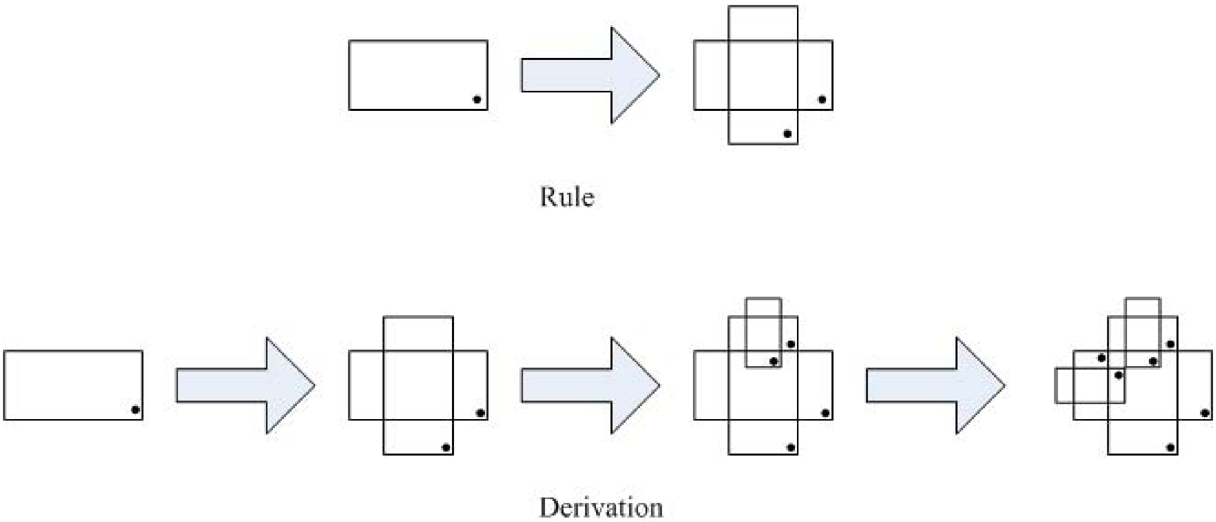


Figure 2.6 Shape Grammars

A shape grammar is build of at least 3 shape rules: a start rule, at least one transformation rule and a termination rule. The start rule is used to start the process of shape generation; the termination is used to stop this process. The simplest termination rule is a rule in which the marker is deleted.
Shape grammars are frequently used in historical architectural research on Palladian Villa’s and Victorian windows, as well in the design of new designs like the Malagueira Dwellings project by Alavaro Siza (Duarte, 2000). The shape grammar for a Palladian villa consists of 69 rules (Mitchell, 1990).

2.3 Implementation

As seen in the previous paragraphs all the methods start with an abstraction of the problem, this abstraction is the starting point of the process to come to a useable algorithm.
De building engineer who uses one of these models must have good understanding of the theory behind these models, in order to make a good abstraction. Specifically the representations of rooms as rectangular volumes, walls as lines, etc are not evident. Evaluation is only possible with these data in order to calculate distances

between rooms, outside area, volume of a room etc. Following this abstraction process, the algorithm can be implemented in CAD software by translating the model into ‘a script’ using an embedded script language. After a run of the script, alternative solutions will be visible on the screen. If the designer approved the generated solution, the process stops, otherwise the cycle is rerun. Finally the abstract solution must be refined into more detail for practical usage. So the outcome of the ‘software’ isn’t the outcome of the process, it is mere a starting point. The software helps the designer in finding a starting point of his/her own design process.

3. Education

Since the start of the academic year 2006 there we conduct, at the Eindhoven University of Technology, a design atelier ‘Generative Design’. This atelier is held in 3rd year of the bachelors. During this atelier the students do research on the feasibility of generative design.
In the next paragraph we will explore shortly the organization of the design studio. Then we continue with some examples of student work.

3.1 Design atelier organization

The design studio lasts 12 weeks, with a general meeting every week, at the first meeting there is an explanation about generative design and what it stands for. The first two weeks the students perform a literature research on the topic, to trace their on field of interest. During this period the students phrase their own design problem, which has to be solved with use of scripting. Together with the supervisors, CA(A)D software and the initial algorithm are chosen. Because of the familiarity of most students with AutoCad, this application is mostly use together with the VBA scripting language which is implemented in AutoCad, but also Generative Components or Rhinoceros are used.
The design problem is reviewed, because it has to be a problem in which ?generative designing? can be fully explored. Students are introduced to scripting with help of simple exercises. These exercises are also a start of the design problem they want to script. For simplicity the initial exercise is chosen in 2D. During the course, the results and progress are weekly monitored, and students get support with their scripting tasks. At the end of the design studio, the digital model will be used to create a physical prototype, with help of a laser cutter, milling machine or a 3D printer.

3.2 Student work

To clarify the meaning of generative design, we discuss the projects of a few students. As mentioned in previous paragraphs, the outcome of the design process is generated by a script made in AutoCAD. We don’t discuss the script itself, but describe the theoretical principles behind the script and the design. The text is taken from the student’s works.

3.2.1 Dom. Van der Laan (M. Burgman)

“If you get a design assignment, most of the times the function is the main focus point of the design- process. What to do if one is given the opportunity to choose the function of the building itself, and the only criteria is that the design has to be scripted, in order to be generated by the computer.”

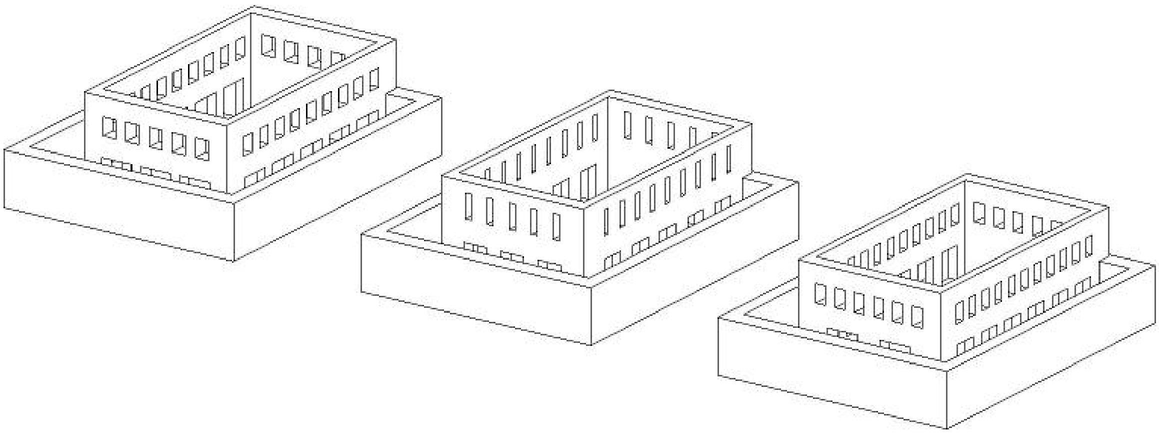


Figure 3.1 Alternative solutions

Brugman took up the challenge to focus entirely on the form, quality and perception of space. These issues are normally a mater of feeling, instead of mathematical output. Brugman looked for a design theory which made it possible to calculate the ideal form of space. This study let him to the design theory of Dom van der Laan. The design theory of Dom van der Laan is based on the so called ‘ideal’ measurements. Dom van der Laan reduced these to mathematical expressions. These expressions are the basis of the dimensions of his buildings. Brugman adapted these expressions and coded these in a script, in order to make ‘infinite’ alternatives, and to study these alternatives, figure 3.4. He used for his study the Monastery of Vaals, this is one of van der Laan’s building designed according to these expressions.

Figure 3.2 Rendering of the generated interior

One of the generated alternatives is rendered, figure 3.5, to have a more realistic view of the design. With use of a laser cutter the 3D model is transformed to a physical model. This project made clear what the strength is of parametric designing, in design studies.

3.2.1 Madolis (H.J. Bijlsma)

Differentiation and unification in interaction with each other, these are the underlying principles of the Silodam project in Amsterdam, designed by MVDRV. “The final design left many question unanswered, as if it was the easy way out of this fascinating concept. What would be the effect if we use modern computers to generate complex but attractive alternatives, with use of a set of newly developed constrains.”

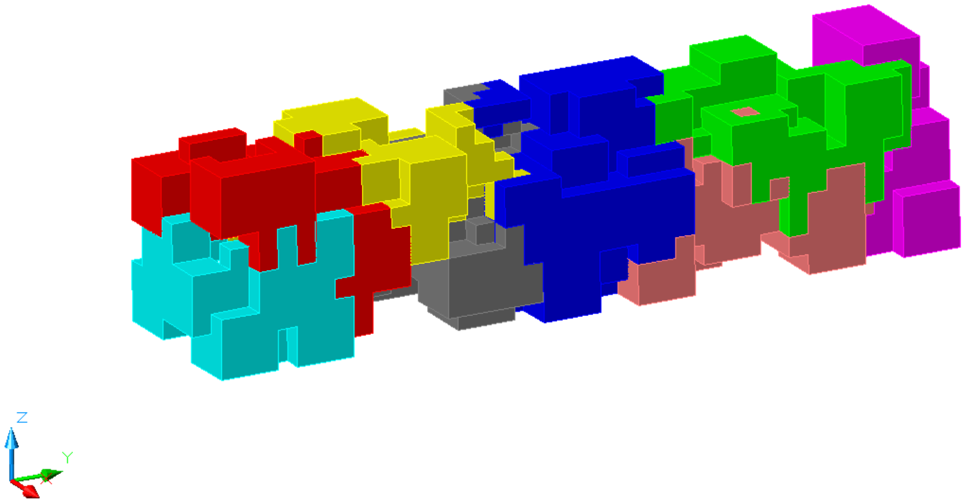


Figure 3.3 Basic Madolis

Madolis is an alternative solution to the Silodam project. The underlying concept is left intact, but the design is generated by the computer, figure 3.3. On the building site a pre-set number of buildings blocks is the starting point. A building block occupies a total floor area within certain limits. These building blocks will increase, with the smaller ones having a higher priority. Fulfilling the constraint area, the entree of each building block is created, to ensure that it is connected to the pier, figure 3.4.

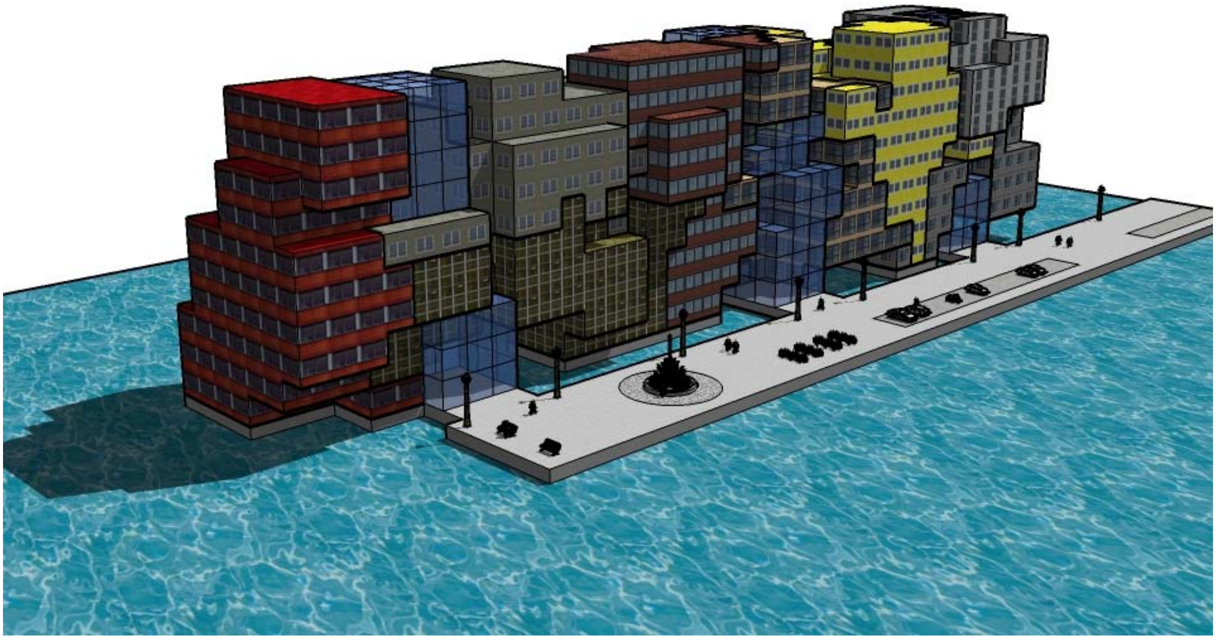


Figure 3.4 Rendered Madolis

The generated design is a complex but easily to comprehend building. The script, developed by Bijlsma, is based on cellular automata and shows that with use of simple rules complex buildings can be designed which has a resemblance with traditional designed buildings, figure 3.5.

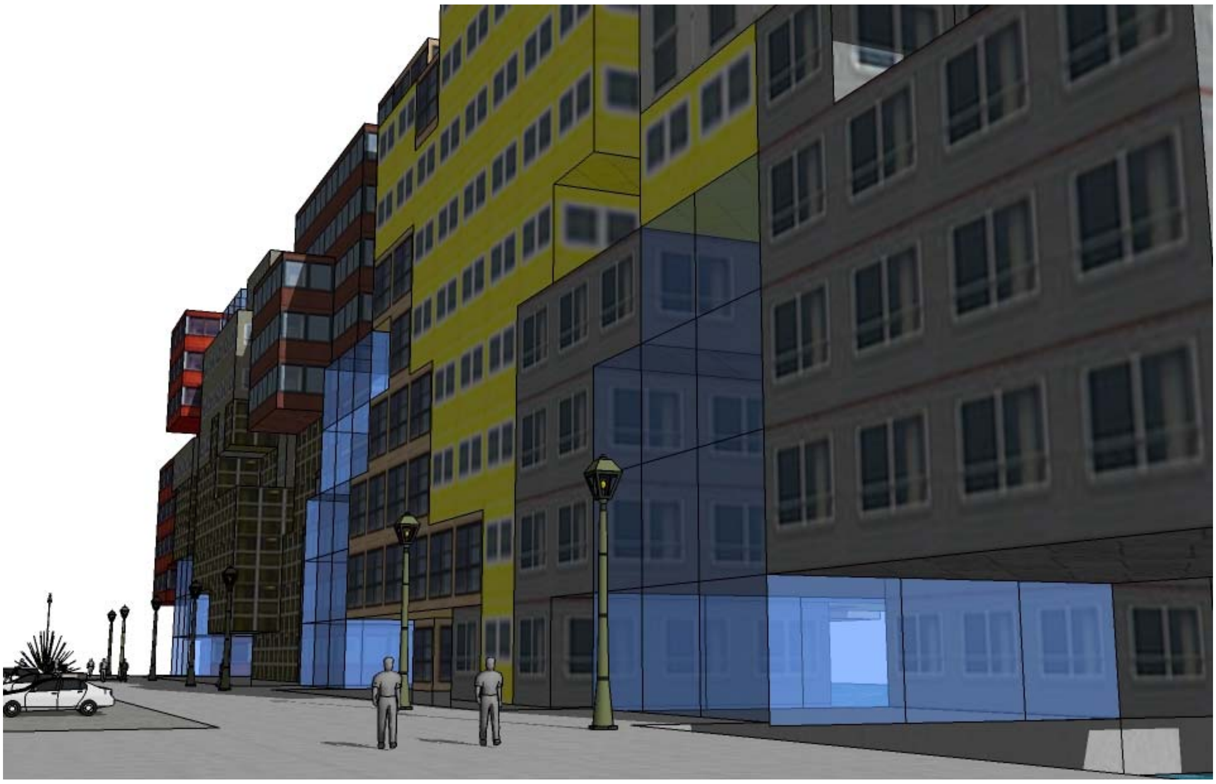


Figure 3.5 Walkthrough of Madolis

3.2.1 Tetris XX (B. Kramer)

Goal of this project was to develop a dynamic building which changed accordingly to the age of its habitants. Each habitant has to answer a number of questions about its age, minimal floor area, maximal width and length. The apartment will be ordered accordingly to age.

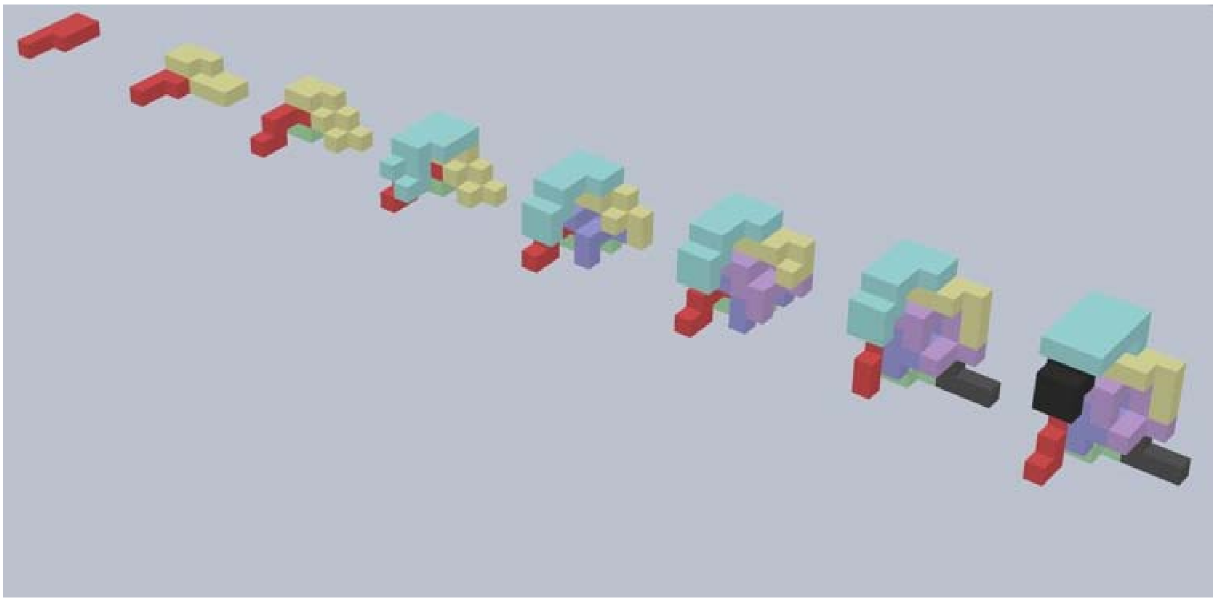


Figure 3.6 Time steps

This ordering will take place each time a new habitant moves into the building, see figure 3.6. The youngest inhabitant will find its apartment on the highest floors and the eldest on the lower floors. The younger are still vital and need their freedom. Families are living in the middle section; they are the separation between the younger and the elderly. They can keep an eye on the younger and lend a helping hand to the elderly. In course of time, families will be split up in elderly and younger. The elderly will be living close by the street, so they don't feel lonely or separated from the neighborhood. When entering the building the younger inhabitants are walking by the elderly.

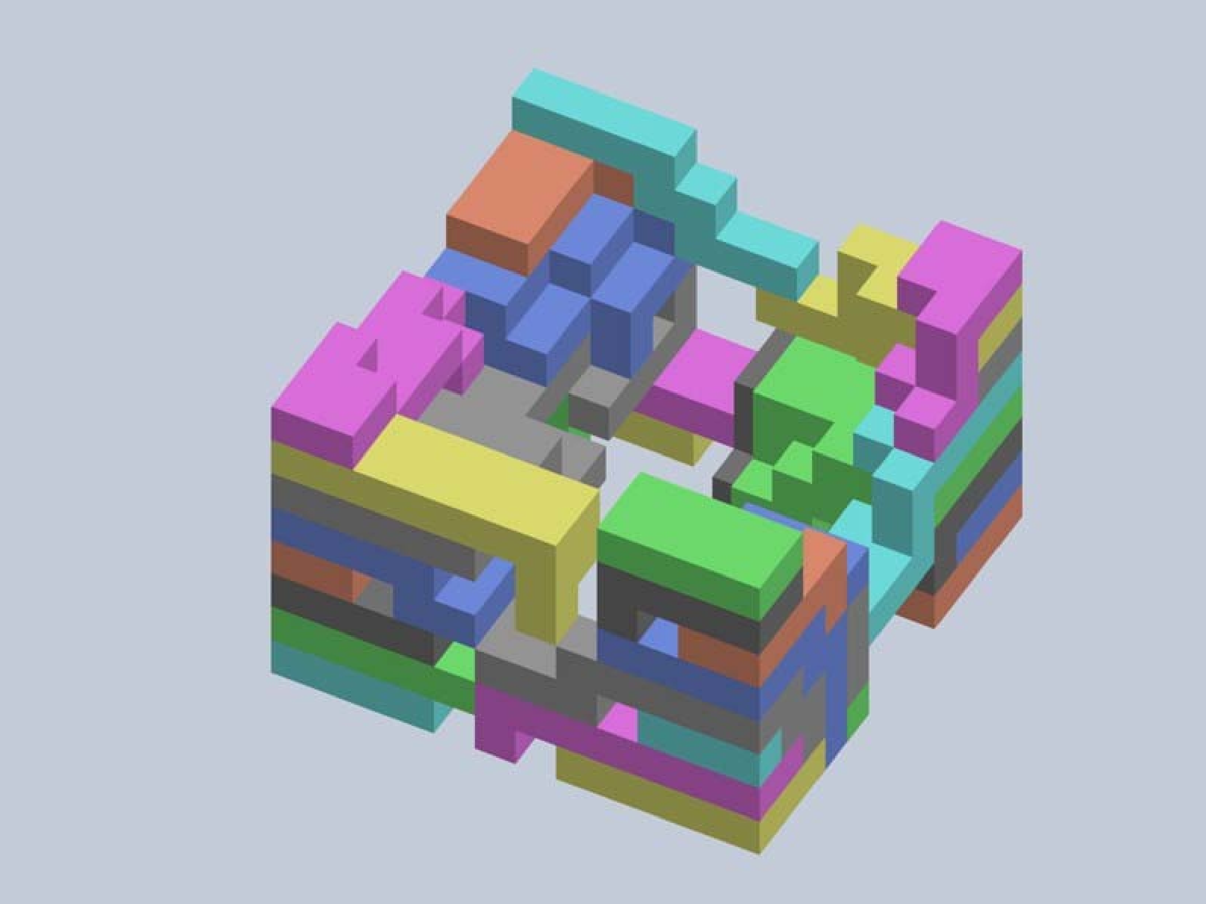


Figure 3.7 Apartment building

The script is based on cellular automata but with not so 'traditional' rules. If an inhabitant is older then 50 years their apartment will be on one floor, on the other hand if an inhabitant is younger then 50 their apartment the apartment will be occupy maximal 3 floors. Before the 'blocks' are moving one level downwards, there will be one block-unit left open, see figure 3.7. This space is an open-air terrace of the adjacent apartment.

3.2.1 Greedy Otto (G.J. Rohaan)

While generative designing isn't designing in the traditional way, it is necessary to find the parameters which determine the shape of the design. References are found in the surrounding nature. Variables as wind direction, sunlight, and minimal surface determine the final shape of for instance a tree. Goal of generative design isn't to imitate natural life forms, but to find the underlying ruling patterns. A general pattern is optimization and minimization. A so called minimal surface is a good example of this principle; every span has a shape in which the use of material is minimal. Extensive research in this domain has been done by Frei Otto, with use of soap bubbles. With use of this knowledge Frei Otto developed a way to create meshes which has a minimal distance between the vertices and in which the paths are minimized. The complex forms Frei Otto designed looks at first glance rather arbitrary, but are the result of the ruling pattern and prescribed parameters. Goal of this project is to develop a structure which at first glace is rather arbitrary but has ruling pattern ‘optimization’. This project was a way to investigate how to convert the parameters into a script. The script has to create a structure in which the distance between the vertices is minimized as well the total length of the paths. Each path between the vertices has a weight factor; the result is that vertices can get more weight then others. Rohaan used the ‘force density’ method to calculate which vertices would be connected. The generated structure will react to changes in these weight factors by pushing away or attracting added vertices. The script generates a structure based on entered points. The resulting structure has no scale, and can be used for town planning problems as well for wall design. To illustrate this multi usability, the script is used to generate to solution on a different scale:

Hallways: the script is used to generate an alternative layout for the hallway between the buildings on the campus, see figure 3.8.

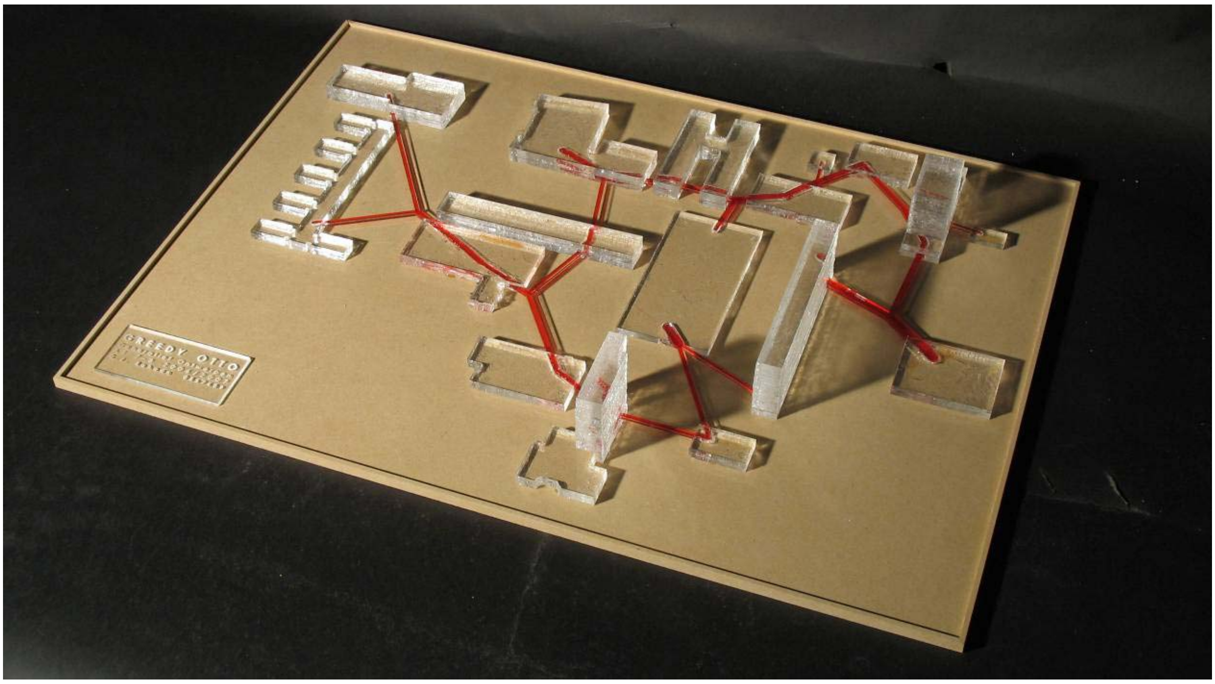


Figure 3.8 Hallways

Façade: The façade is build made of 4 elements, each with a 6 by 6 dimension. Each element is made of 8 points, chosen in such way that the elements have a good connectivity. Within this framework lie 5 arbitrary points, so each element will have a different structure. The façade is the result of joining 4 sides together. Each side consists of a group of 6 elements which will be mirrored on both axes, see figure 3.9.

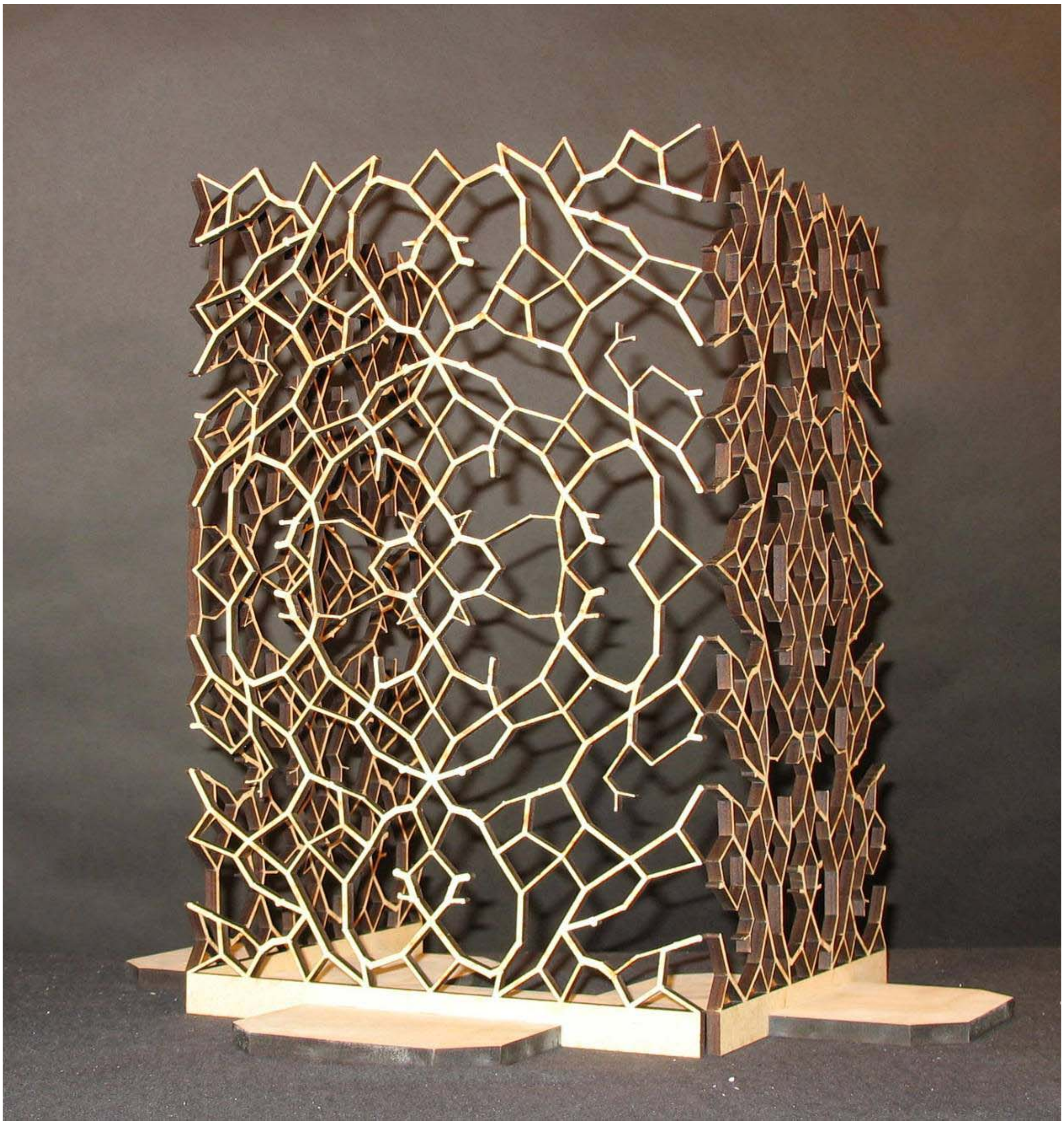


Figure 3.9 Façade

3.3 Conclusions

Students who participate in the design studio learn a new way of designing. They also learn that there is a hidden relation between many aspects of the design and they learn to think and look in a more abstract way.
By phrasing their own problem in the first week of the design studio the students are shaken up. For the first time in there study they don't have a ready made problem. The students are thrown back to their self. The second confrontation is learning to master a script language. After a slow start, the students learn quickly to program a script, and the end result is always astonishing.

By translating an, developed by their own, algorithm, with use of an embedded script language, into 'a script', the CAD-software can perform the task. According to Terzidis (2008, pp 65) "an algorithm is a computational procedure for addressing a problem in a finite number of steps. It involves deduction, induction, abstraction, generalization, and structured logic." He continues with "Algorithmic strategies utilize the search for repetitive patterns, universal principles, interchangeable modules, and inductive links." Every one of the former mentioned 'actions' is part of a general problem solving strategy. So learning to develop an algorithm from scratch as well learn how to program, serves a few purposes, namely:

Learn to solve a problem in general way;
Learn to master CAD software in a more fundamental way;
Learn to surpass the limitation of the 'out of the box' CAD ?software;
Looking at a problem in a different way.

After this scripting period the proto typing phase is a felt as a 'back on home ground'. With the experience of two design studios we conclude that students adapt quickly to this new way of designing. Some students see the advantage of this way of thinking and the possibilities to generated new alternatives. But some students think it is a nice experience, but will probably not design like this again.

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Exploring Evolutionary Possibilities for Digital Doilies

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Abstract

Textiles, as an industry, a field of research, and a creative discipline is at the forefront of exploring the potentiality of new technologies and digital media. However, at the grassroots level of textiles, domestic hobbyists primarily use new media technologies to set up websites, blogs and community groups for the discussion of designs, exchange of patterns, for distribution of images of craft objects produced.

While some handicraft techniques were industrialised during the industrial revolution, for example, knitting, embroidery and some forms of lace making were mechanised, other techniques remained relatively unchanged and the industrial revolution had minimal impact on many forms of domestic handicrafts. So, like the industrial revolution will the information age also have little impact on many domestic handicraft hobbyists?

New media technologies present opportunities for hobbyists to engage with their handicrafts at the source of their interest, which for many engaged in activities such as lace making, is the process and the pattern. This paper shows how domestic hobbyist handicraft activities have inherent properties that enable them to be used to explore complex issues such as evolutionary development of pattern forms and emergent possibilities, by using new media and digital technologies. The project discussed translated crochet lace pattern forms – doilies - into the digital environment. The crochet lace pattern forms were digitally reconstructed (two dimensionally in the first instance) in the digital environment by writing computer software scripts to create onscreen images, emulating the process of construction of a crochet lace patterns. Once the rules for the construction of a pattern form had been translated into computer code, the data is available for manipulation. The data relating to the crochet lace pattern forms were purposefully manipulated the introduction of 'noise' into the system was encouraged, in an attempt to evolve the crochet lace pattern forms or promote emergence.

Introduction

Crochet lace is a familiar pattern form in many societies. However, in their 200-year history, crochet lace patterns have not changed significantly. [1] An experimental research project, conducted through a generative art practice, explored pattern as process focussing on crochet lace patterns and investigating the potential for these patterns to evolve and become emergent. The research explored the developmental potential of these human-designed physical patterns by translating them into and working in the digital environment.

Systems and processes used in the construction of generative artworks may be simplistic or highly complex and may use one, or a combination of systems. This experimental art project used multiple systems. It employed, in the first instance, systems that were established and used extensively before the advent of digital media - the set of rules applied to create craft-based, physical, crochet lace patterns, and the written instructions for crochet lace pattern-making. The crochet lace system was translated into the digital environment by utilising a set of programming scripts. The research project then combined the crochet lace pattern systems with those inherent in digital media and the digital environment. As a result the simulacra produced at the culmination of the project were a hybrid of crochet lace pattern forms (the systems of crochet lace), digital media (pixels and vectors), and the digital environment (computer languages and operating systems). The computer programming language and the operating systems of the digital environment intervene and interact with the systems of the crochet lace patterns. It is at the convergence of these systems that the artwork, the crochet lace simulacra is located.

Understanding of the pattern-making history, techniques and materials used in crochet lace shows that these pattern forms are an excellent source material with which to explore the development of pattern and its evolutionary potential. This paper explains the properties of lace that make it worthy of investigation. It shows that the patterns' development has undergone a stasis. However, the research project identifies that properties are present within crochet lace patterns that make it available for change.

In addition, this paper suggests that the instructional language used to pass information relating to the construction of lace patterns between lace-makers is a code which, while pre-existing the programming scripts that operate in contemporary software, has similarities to it. All of these elements make this pattern form open to development and the digital environment is a ripe arena for experimentation.

Lace

There is a long and varied history of pattern-making in constructed textiles. Patterns that use craft techniques to manipulate threads can be found in many cultures and throughout recorded history. [2] The range of techniques employed is broad and includes weaving, knitting, crochet and macramé. In addition, a wide variety of materials can be used including silk, wool, metal and plant fibres. [3] In spite of the mechanisation of knitted and woven textiles following the industrial revolution, many textile patterns are still created by hand using low technology tools. [4] The fabrics created are used for a variety of purposes including for clothing or other utilitarian and functional purposes; as decoration; as a means of displaying wealth; to communicate beliefs and traditions; or specifically to explore how a technique influences a pattern form. [5]

The techniques employed in constructed textiles and the materials used have a direct impact on the structure of the fabric created. For example, a woven fabric differs both visually and physically from a knitted fabric. The structure of the fabric, in turn, influences how a pattern forms.

Lace is one form of constructed textiles where the relationship between the technique, the structure and the pattern is pronounced. The making technique impacts profoundly upon the pattern form. The thread is manipulated to form not only the structure of the fabric, but also the pattern. (See Figure1)

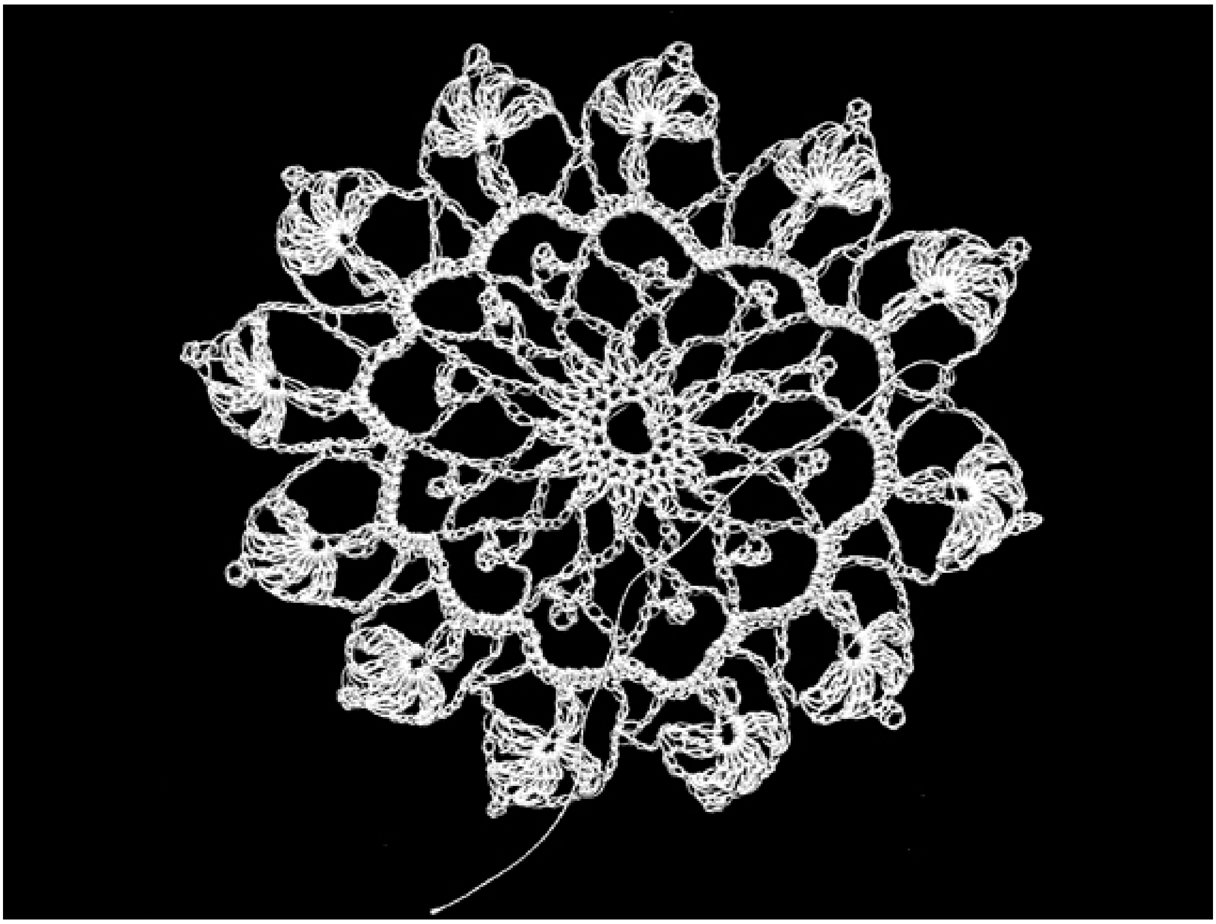

Figure 1 - *Physical Lace pattern*

Lace is constituted by a double structure conjoining the material (the thread) and the immaterial (the space between the thread). Spaces form around and between the threads and are an integral part of the pattern. Without these spaces, the fabric is not lace. Pat Earnshaw suggests that lace is “a lot of holes surrounded by thread.” [6] But the spaces, or ‘holes’ as he calls them, are neither an absence nor a result of removing elements of the fabric. They are defined areas purposely constructed as part of the pattern. [7] So, with lace, the structure of the fabric not only *influences* the pattern, it *is* the pattern. The structure and pattern cannot be divorced. [8]

Unlike many forms of constructed textiles, lace does not have a significant utilitarian function. It is primarily used to adorn and decorate. This freedom from utilitarian purpose should enable attention to be focussed on the exploration of the pattern form, whether in its formal qualities or aesthetic value. However, rather than exploring new and/or innovative lace designs, lace-makers have primarily recycled lace patterns and, as a result, lace has not changed to any great extent in more than 500 years. [9] Churchill-Bath observes:

> Lace-making potentially offers artists as much freedom of personal expression as do painting and drawing, but traditional lace patterns were almost always copied from another lace or from someone else’s pattern. [10]

This immediately raises a question as to why a stasis has occurred in the development of lace patterns. Is it because there is a finite number of patterns available? Or is there some characteristic of the pattern-making process that has limited its scope and, if so, can that characteristic be changed so that new patterns can emerge?

Crochet Lace Pattern Making

Crochet is a thread-work technique that can be used to make fabric suitable for functional items and garments and is also one of the many techniques that can be employed to create lace. The technique involves the manipulation of a single continuous thread with a single metal, wooden or bone hooked tool. [11] While the history of the technique is disputed, it is believed to have evolved from techniques such as needle-point and tambouring and Crochet as we recognise it today is believed to be no more than 200 years old. [12]

Using this technique, not only could new patterns be created, but patterns that had been made using time-consuming techniques such as bobbin lace, Venetian point and needle-point could be reproduced significantly more quickly. [13] However, some criticism has been levelled suggesting that crochet lace is not ‘real’ lace. [14] This is due to the technique being employed primarily to copy other techniques rather then forging new pattern forms and also because, when new crochet lace patterns are made, they often lack the openness and transparency of other techniques as they incorporate less space in their design. [15]

A major use of lace was to adorn garments, and so demand for lace waxed and waned under the influence of fashion. [16] However, the crochet technique developed into a popular hobbyist activity and became commonly used to create individual lace-pattern motifs referred to as doilies. [17] Doilies were used in homes in a variety of ways such as protecting furniture from staining by cups and plates, a partly functional use, although their primary purpose remained decorative.

The extent to which pattern instructions have been documented and shared has contributed to the popularity of crochet lace, including present day interest. The importance of documenting patterns grew with the establishment of lace as a cottage industry. [18] Lace dealers relied on maintaining a series of pattern models that could guarantee sales, and so it became important to not only document successful crochet lace patterns, but also to pass on the instructions for their manufacture. The instructions often took the form of images, as many lace-makers were not literate, but increasingly the patterns were documented as text. The earliest forms of written instructions for crochet-lace patterns were verbose and difficult to follow for all but the most experienced crochet lace-makers. They gave detailed information relating to the thickness of threads to be used, the stitch formation, the stitch series for individual motifs, and how the motifs were to be joined.

Crochet ‘code’

In the last quarter of the nineteenth century women’s magazines became a vehicle for the widespread distribution of crochet lace patterns. Published pattern instructions in magazines proved to be successful and soon thread companies began to produce and distribute instructional pattern booklets to help expand their sales. These booklets contained simplified pattern forms to appeal to beginners and the verbose patterns instructions developed into a ‘shorthand’ or form of code. As they became less verbose they became more systematic, akin to the syntax used within pattern books today. For example “make two single crochet stitches into the space created by the five chain stitches in the previous row” became “2 Sc in 5Ch Sp”. Terms such as “repeat until end [of round]”, “Repeat 3 times then …”, “Repeat from * to *” began to appear. These instructions were compact, taking up less space on a printed page, and concise and were easily interpreted by lace enthusiasts. [19]

While the instructions preceded the programming scripts of contemporary software applications, a similarity can clearly be observed with syntax currently used in software programming. This suggests that we might take seriously the proposition that the digital environment is an ideal environment in which to explore the development of crochet lace patterns. Furthermore, the relationship between textiles and ‘code’ is not new, as textiles have been instrumental in the development of machinery that can interpret operating instructions or code. [20] Throughout the industrial revolution, textile processes were at the forefront of mechanisation. Development of the Jacquard loom advanced machine-production. It was based on a draw loom but in addition used a punch card system which allowed the warp to be manipulated without human intervention. This was a significant achievement and was a working example of how instructions (i.e. the weaver’s design) could be translated into a form of code (the punch cards) that could be interpreted by machinery (the loom).

Situated within a craft context, innovation and originality were neither valued nor a requirement of lace-making, being secondary to the quality of craftsmanship. [21] As a result, there existed a general apathy and active discouragement in the creation of new innovative patterns. Moreover, many hobbyist lace-makers were solely interested in engaging with the meditative process as relaxation with little desire to be innovative. [22] Thus, throughout its history, crochet lace pattern making referenced, resembled, or recreated existing patterns and the development of this form of pattern-making stagnated.

However, there have been lace-makers who argue that lace and lace-making are more than a craft or hobbyist activity and advocate that they are artists introducing innovation and originality into lace and lace-making. [23] But, experimentation with lace and lace-making has primarily focussed on the use of novel materials, techniques and/or the scale of the work. Traditional silk, wool and fibre threads were replaced with metal, plastic or plexi-glass, and work was made on a monumental scale claiming to intensify the integration of space and thread. [24] Although worthwhile developments, these efforts did not, to any significant extent, explore how pattern encompasses the relationship between structure and space. And there was little attempt to examine the developmental potential for lace through pattern. [25]

Placing lace within the broader context of developments in art during this period further illuminates the under-development of this activity. Lace makers had continued to focus on the production of physical objects, paying little attention to the *process*, at a period in time when a shift of focus from object to process was occurring in the art world. Furthermore, in an age increasingly cognisant of the interrelatedness between pattern, process and information, pattern in lace had become secondary to material concerns.

So, to summarise, because of their complexities and cultural context, crochet lace patterns were impacted only minimally by the industrial revolution. The patterns produced in crochet lace today differ very little from the pattern motifs produced over the past few centuries. [26]. However, while the industrial era impacted little on the development of crochet-lace patterns, the relationship between pattern instructions and computer programming code suggests that digital media could affect this pattern form significantly.

The formal pattern properties of crochet lace are key to the development of the pattern form and thus it is the exploration of these properties that may yield signs of evolutionary development and emergent possibilities, Furthermore, it is by translating lace patterns into a digital environment that these possibilities can be more fully explored.

Crochet lace pattern properties

Crochet lace-making has always been a process. The individual patterns form and develop as a result of the physical manipulation – the inter-looping of threads. [27] Crochet lace can exist as physical instantiations and as three-dimensional forms, these patterns exist both in space and incorporate space into them. Furthermore, crochet lace patterns continue to exist as spatial patterns and arrangements even when translated into the digital environment where they occur as both arrangements of pixels on the screen and computer code simultaneously.

In addition to spatial properties, crochet lace patterns also embrace a modular structure. Threads are manipulated to create stitches which can be grouped together in arrangements to form modules. These groups of stitches, acting as modules, can be repeated to form rows and to eventually create motifs (See Figure 2) which can then be combined to create an overall pattern. This modular structure not only exists in the Euclidean spatial arrangements of a physical crochet lace pattern, but also exists in the written instructions detailing the construction of the pattern form. For example, the details relating to the construction of a singular stitch may be referred to in the construction of a module. The module information may form repetitive elements within the design and these elements combine to create instructions for self contained motifs which eventually create an overall pattern. However, instructions for each type of stitch, pattern element or motif need only be written once and then can be referred to on many occasions within the construction of the overall pattern.

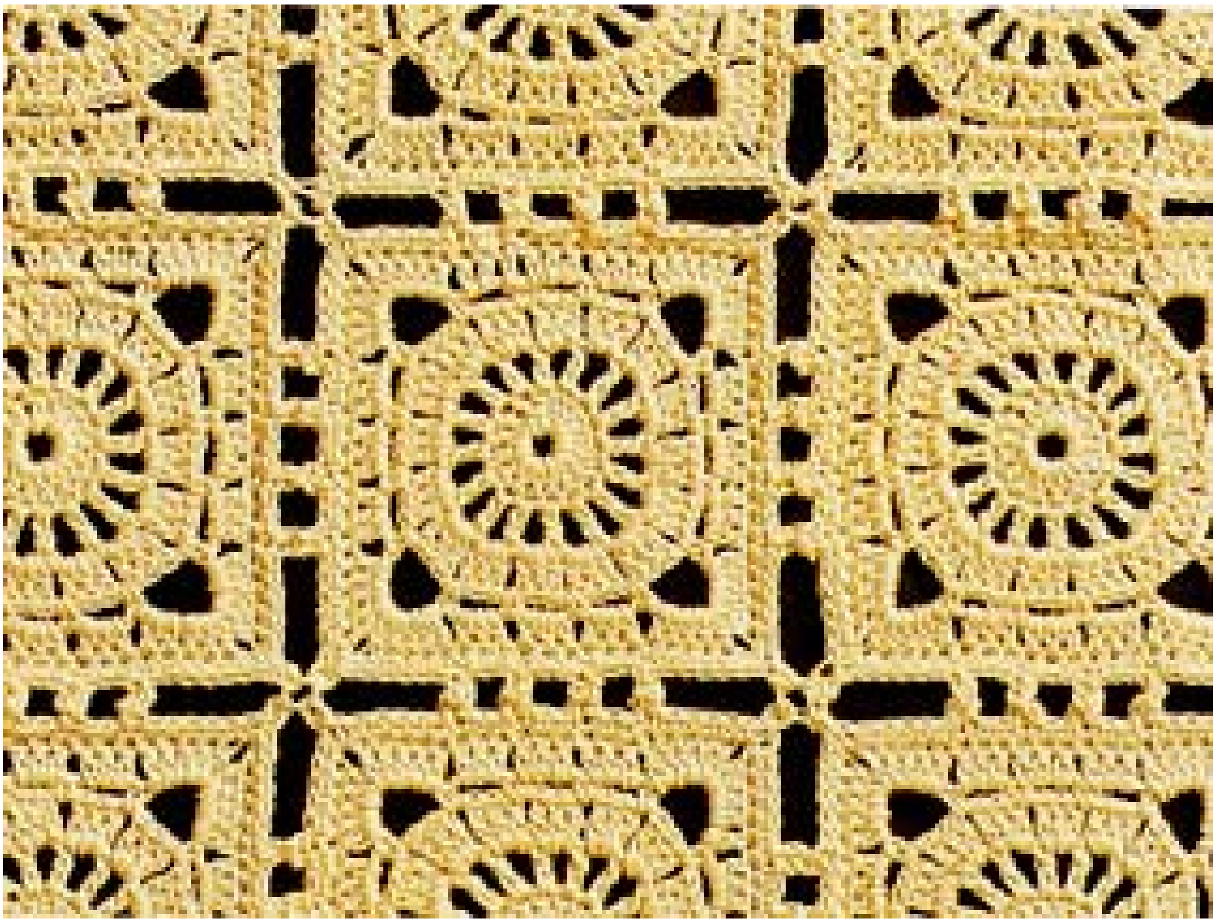

Figure 2 – Modular arrangement of crochet lace patterns

As crochet lace patterns are translated into the digital environment, this modular structure of both the spatial arrangements and the written instructions are retained and, furthermore, the programming code creating the simulated digital pattern is also constructed modularly.

Crochet pattern forms are constructed from a series of actions, rules or instructions which underwrite the creation of the lace patterns. Therefore to translate these patterns into the digital environment involves translating the rules pertaining to the physical process into an algorithm that can simulate the pattern process.

This leads to the final property of crochet lace patterns which suggest their suitability for translation into the digital environment, that is, how these patterns exist not only as physical forms but, simultaneously as code. The once verbose lace-making instructions became abbreviated and a syntax was developed which included feedback loops and modules. This syntax parallels developments in software programmes. For example, ‘if…then’ and ‘Repeat X times’ The pattern instructions operate as a code to be interpreted by the lace-maker. However, it can become a parseable language – that is, a layer of computer code can be added to the pattern instructions enabling them to be read and interpreted by computer software applications. As the syntax of the pattern instructions merge with the programming language, the code of the pattern instructions becomes part of the flow of information.

The digital environment offers this form of pattern-making several opportunities. First, it can remove the focus from the physical object and re-focus attention on the formal pattern process. Second, the pattern’s development can become a hybrid of human and technological influences. The pattern can be impacted upon not only by the subjective decisions of the lace-maker but, in addition, can be exposed to external technological input (that is, mouse, keyboard, etc), and/or be impacted by the information flow of programming scripts and operating systems within the environment in which the pattern is immersed. The digital environment also enables the pattern process (that is, the way the pattern *forms*) to be viewed as a whole rather than focus being placed on how the pattern is *constructed*. Finally, the digital environment can allow a greater number of algorithmic and iterative processes to be carried out more quickly and effectively.

A potential disadvantage of the digital environment is its perceived lack of physicality. However, the digital environment can be viewed as an arena free from many of the constraints of tradition, history and the predispositions of the maker. It is an environment in which alternative materialities can be explored and where pattern can be examined as a concept (the relationship between the code and the pattern); as series of electronic pulses (pixels); or as code (the pattern structure of the programming script).

One final area for consideration in relation to the development of crochet lace patterns within the digital environment is the extent to which patterns can be recognised when they are translated and transformed. It may not be easy to recognise emergent patterns because of our lack of experience with the evolved pattern form. Thus, such explorations require an open mind when assessing the forms created.

Translating and extending crochet lace patterns

While crochet lace patterns are created from a simple set of rules relating to the selection of stitch types and their arrangement, there are many variables, such as stitch size, angle, position etc., handled intuitively by the lace maker that add complexity to the recreation of the patterns digitally. Therefore, the experimental art project simplified the options as much as possible and constructed algorithms to create a series of animations to emulate the visual formation of the crochet lace patterns.

In the experimental research project writing the programming scripts focussed on trying to create a ‘Whirlpool’ pattern (See Figure 5). In this pattern, the number of stitches per round grows incrementally after completion of each round. Also, the pattern module (that is, the sequence of stitches making up a pattern within each round of the overall pattern) is incremental. Each stitch element of the pattern was positioned on screen by allocating it a set of Cartesian coordinates in relation to a fixed point on screen. The result was a range of ‘samplers’ that explored pattern variations. [28] As the animations became more sophisticated the stitches were positioned using polar coordinates in relation to the centre of the stage.

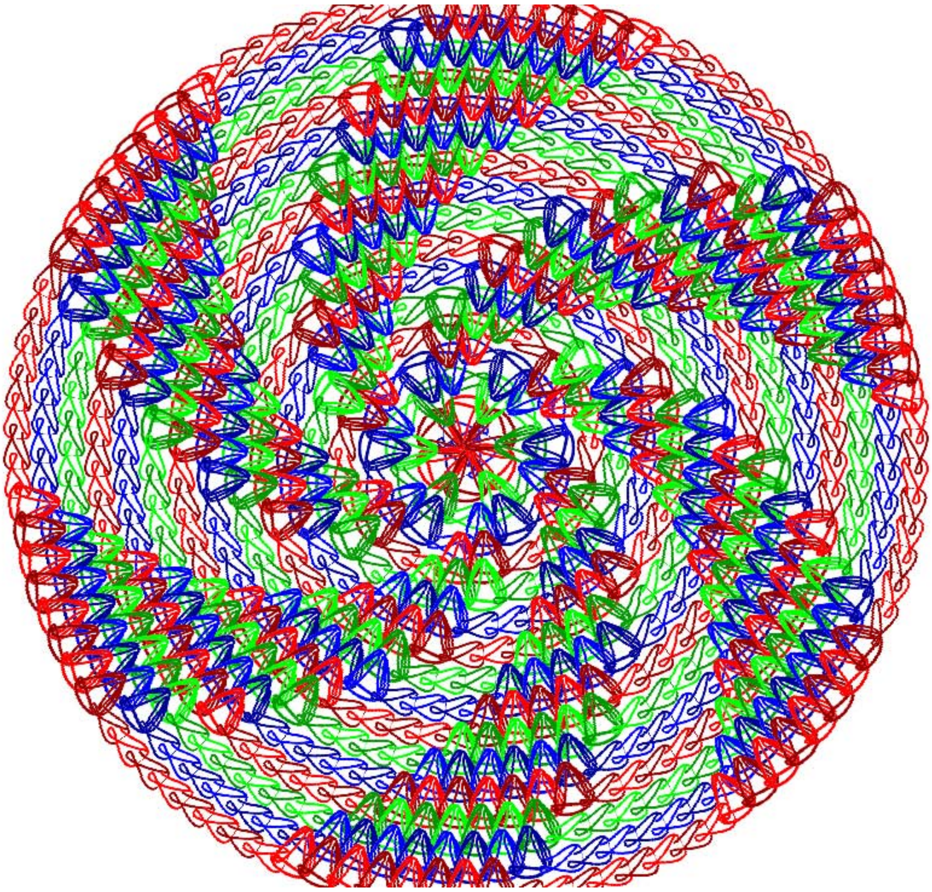

Figure 5 – whirlpool design

The programmed animations enabled patterns to deviate from their planned path as a result of manipulating variables, and/or adapting elements of the code, and/or because of inaccuracies in mathematical logic or formulae, and/or because of data formatting issues. In spite of these variations, the algorithm created to translate the crochet lace system of rules into the digital environment retained a high level of control over the pattern forms.

The next phase of the work attempted to adjust the algorithm to reflect flexibility offered by the physical pattern making process, relinquish some of the control retained by me as programmer, and relinquish the control that the algorithm had had over the pattern form. So rather than creating patterns in relation to a registration point onscreen, the pattern was recreated by programming the scripts to 'find' stitches positioned in close proximity and position new stitches in relation to them. This resulted in greater inaccuracies in the pattern and gave it a 'hand-made' appearance. (See Figure 6)

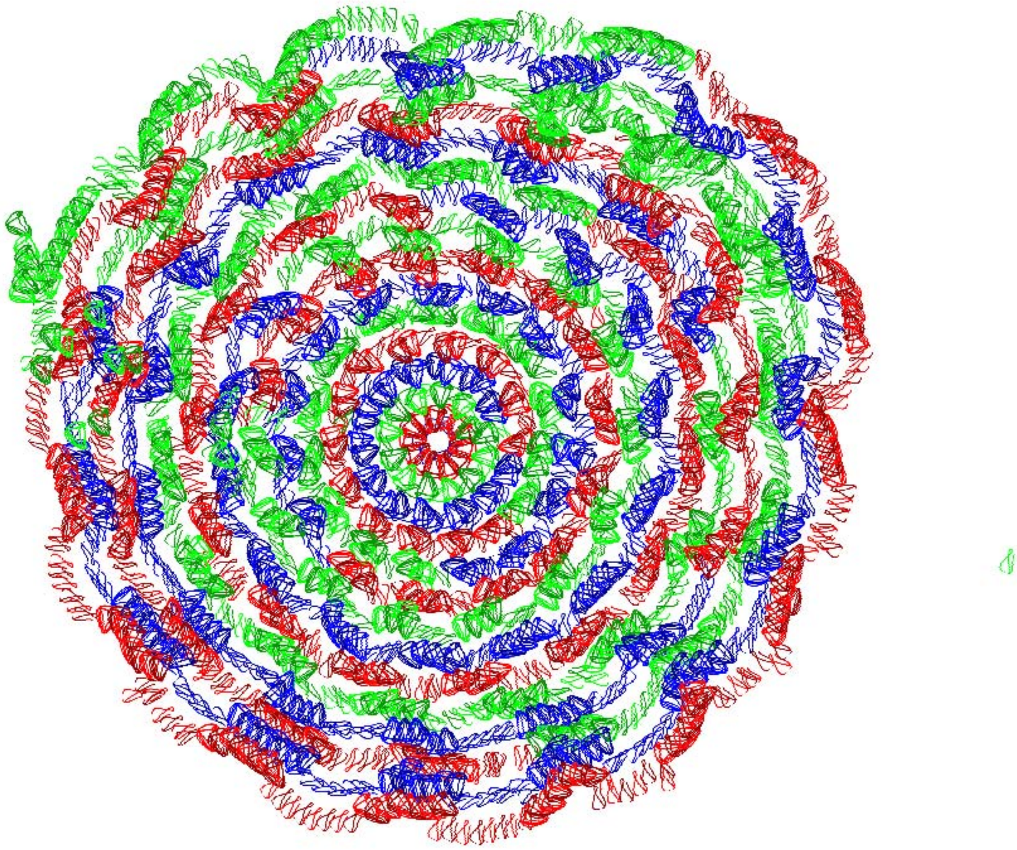

Figure 6 – Whirlpool pattern created by 'finding' stitches in close proximity

Glitch [29]

The programming scripts were checked on a step-by-step basis for accuracy. On occasions a script was uneventful when executed on a step-by-step basis, but when run in its entirety pattern variations would unexpectedly occur. The flow of script could be interrupted by unplanned events such as system halts or inadequate memory resources, or as a result of formulaic or syntax errors and/or illogical programming statements. Such events would cause the programming scripts to halt, jump or collapse into continuous inescapable loops. While the disruption in the flow of the script caused what initially appeared to be random positioning of the stitches, as the programming script continued, elements of repetition could be observed in the sequence and/or placement of the stitches and alternative patterns appeared. Files containing the programming scripts for these 'renegade' patterns could be saved and the script replayed. This enabled the scripts to be re-examined and for the aberration to be investigated. In the normal course of software programming such aberrations would be treated as bugs but, these were welcomed in the experimental project to see the extent to which these glitches impacted on the pattern forms.

On occasions, a pattern would stall because the programming script would be unable to move to the next programmed function and would simply halt. Similarly, sometimes the programming script would become trapped within an inescapable feedback loop and the same pattern would simply be repeated over and over again.

In some instances when the programming script fell into inescapable feedback loops, slight variations would occur in the calculation of the stitch positions and what at first appeared to be a repeat of the existing pattern was not. Stitches seemed to form on top of each other and the patterns appeared to grow three-dimensionally creating tunnel patterns. Other interesting patterns arose because of errors in formulae and miscalculations. This caused patterns to implode – that is, the stitches were repeatedly positioned over the top of existing stitches. The pattern growth path was drawn back towards the centre of the pattern and the patterns appeared to build in layers upon themselves.

Other elements that suggest there is scope for these pattern forms to be developed further, and to possibly become emergent, were the disconnected nature of some patterns and the manner in which multiple motifs were generated. As patterns were generated, some stitches did not connect to other stitches. In these instances, pattern modules or individual stitches operated as discrete elements. [30] The ‘stray’ elements could remain isolated and still be part of the overall pattern, or could become connected later (i.e. reconnected) via other stray pattern elements or stitches. These patterns generated on screen lacked the regularity, repetition and order, of the physical crochet lace pattern forms. They lacked a perceived order as they radiated dramatically from the centre point. [31] (See Figure 7)

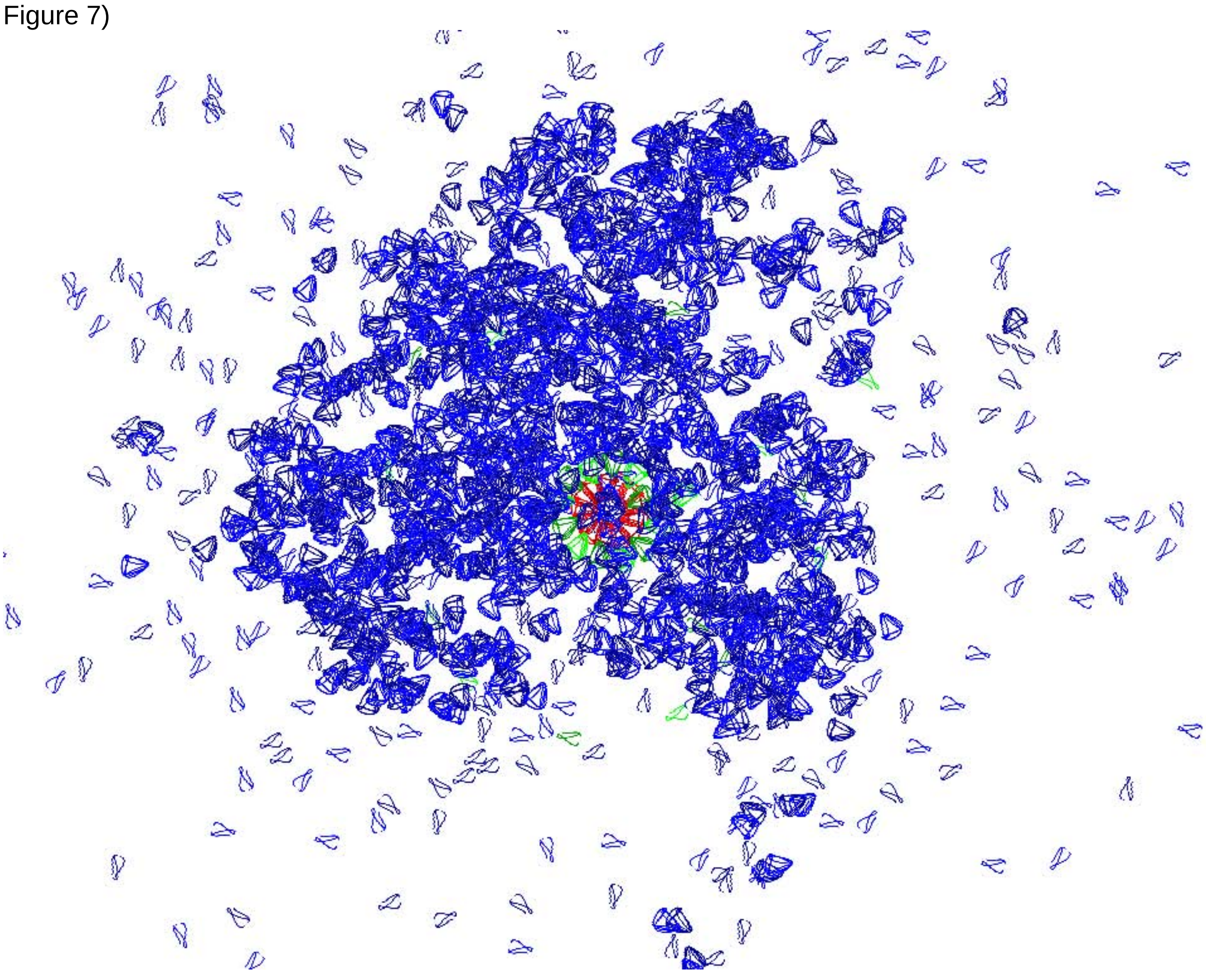

Figure 7 – Patterns elements could be disconnected

Not all of the patterns generated adhered to these classifications. Furthermore, it was not possible to assess whether all patterns generated could be reconstructed physically. However, the physical construction of the generated patterns will occur in the next phase of the project. There are precedents in physical crochet lace pattern making that suggest that many digital patterns *can* be created physically. These precedents include firstly, layering and pronounced three-dimensionality in some forms of Irish crochet lace, secondly, instances where multiple crochet lace makers make individual pattern motifs that are joined late in the process, and thirdly, sets of doilies that are positioned next to each but are not physically joined. Each of these suggest that the ‘layered’ patterns, multiple motifs and patterns with disconnected elements are prime to be reconstituted in the physical environment.

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[11] It should be noted that while patterns use a single continuous thread patterns may consist of multiple motifs that are created separately and are joined together to complete the piece, or on occasions are not joined but form sets of doilies that are positioned in the same vicinity on a piece of furniture.

[12] Although Mary Konior suggests that there were written reference to crochet hooks between AD50 and 137 and that the activity continued in the Middle East this is speculation as there has been no fragmentary evidence found. See Mary Konior, *Heritage Crochet: An Analysis* (London: Dryad Press Ltd. 1987), 10 A more reliable, less speculative history is offered by Lis Paludan. See Lis Paludan, *Crochet: History and Technique* (Colorado: Interweave Press. USA 1995), 76

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[14] http://www.fairfaxcounty.gov/library/information/arts/crocheting.htm accessed and Paludan, Op.Cit.

[15] It is interesting that this criticism is directed at crochet lace for copying patterns as it has been a widespread activity in lace-making generally.

[16] Paludan, Op. Cit., 65 and Patricia Wardle, 'Victorian Lace' in *Irish Crochet Lace: 150 years of a Tradition* Exhibition Catalogue http://lacismuseum.org/exhibit/Irish%20Crochet%20Lace.pdf accessed 12/08/2007

[17] The name comes from a nineteenth century shopkeeper in London who sold fabrics; Mr D'Oyley. See Konior, Op. Cit.

[18] Judith, L Gwynne, *The Illustrated Dictionary of Lace* (London. B.T. Batsford Ltd 1997), 10

[19] Churchill Bath, Op., Cit.

[20] Lev Manovich, *The Language of New Media* (Cambridge, Mass.: MIT Press 2001), 22

[21] Waldrep, Op. Cit.

[22] Rosemary Shepherd. 'Structures of Necessity' Artists Statement in Exhibition Catalogue www.lacedaisypress.com.au/philosophy.html last accessed 10/11/2006

[23] Charlotte Delwich, *Tenth Lace Biennial* Catalogue for the exhibition*.* (Brussels: Musee De Costume et de la Dentelle 2002), 56

[24] Earnshaw. *Threads of Lace: from Source to Sink,* 97

[25] Delwich,. in the introduction to the third lace Biennial 1985 and Earnshaw, *Threads of Lace: from Source to Sink,* 97 and Delwich, *Tenth Lace Biennial* and Rosemary Shepherd, 'The Contemporary Lace Exhibition 2001'

[26] Konior, Op. Cit., 14

[27] Shepherd, 'Structures of Necessity'

[28] Samplers pre-empt the construction of many textile forms across a range of techniques (i.e. knitting, crochet, embroidery etc). They serve as a means to practice the technique, explore the material and to test the accuracy of the tension applied, and to test pattern arrangements.

[29] I am deliberately adopting the term Glitch often associated with a 1990's music genre, in particularly the work of Kim Cascone and using the term to suggest how the patterns are created from bugs, crashes, system errors etc which impact upon the pattern process visually

[30] It is noteworthy that the physical crochet lace patterns usually require all elements of a pattern to be joined for them to be part of the overall pattern. However, a precedent has been set for this way of working with physical crochet lace pattern making where motifs can be constructed as discrete elements of the overall pattern and then joined by another motif or series of linking patterns or simply placed alongside each other.

[31] While this radiating pattern is familiar in physical crochet lace pattern making, the intensity with which these patterns grew, and the relationship between the size of the individual stitches and the size of the overall pattern, have not been explored in physical pattern forms.

The "accusing glance": change in eye movements during the observation of a Van Gogh's painting before and after artistic information on the work of art.

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Abstract:

What is the influence of artistic information on our glance? The variation of ocular movements in 15 voluntaries wealthy subjects was studied, before and after they had received detailed information about the last painting of Vincent Van Gogh, a work finished just before he died, called "Wheat field with crows". Since Yarbus' primary works in 1967 (1) we know that the eye moves 230,000 times a day, it is one of the most frequent movements of the body. Through multiple fixations and saccades (2), the eye collects information that are transmitted to the brain. Subjects observed, during 30 seconds, the painting on the screen of an eye tracker (Metrovision). Before, but also after information, we see that scan paths describe a circle movement between the four opsiemes (the smallest discrete unit that can be isolated in the visual chain): the sky, the wheat, the birds and the paths. The main difference between the pre and the post information's seeing is the fact that the eye tips over in the right crows' zone, and we scrutinize the birds' flight. The glance changes after general knowledge information. Here, the visitor's eye seems lost because Van Gogh's mind is lost at that time. The construction is wrong, with a vanish point reversed. With an unusual construction, result of the psychological disease, the study of the visual strategy informs us of the helpfulness narration before the sighting.

Aim of the study:

What is the influence of artistic information on our glance? The variation of ocular movements in 15 voluntaries wealthy subjects was studied, before and after they had received detailed information about the last painting of Vincent Van Gogh, a work finished just before he died, called "Wheat field with crows" ***(fig. 1)****.* Two days later, the painter decided to come back at the same place to "shoot the crows", but shot a bullet in his chest instead.

Introduction:

The retina is made of specifics cells called cones and rods. The cones account for human's accurate vision. Within the retina a small surface, called fovea, contains only cones. At the periphery of this area the retina contains both rods and cones providing blurry images. This aspect of the eye explains why moving the ocular globe is required to observe an object or a specific detail.

This sequence, fixation and saccades (very rapid movement from one to another point) [1] may be recorded by an eye tracker. Such a method allows for the understanding of the information collected by the eye ("visual tool") and transmitted to the brain. Since Yarbus' primary works in 1967 [2], this technique has been applied to several fields ranging from neurosciences to driving exercises.

Materials and Methods:

15 left handed subjects (44±11 years, 2 men – 13 women) observed, during 30 seconds, the painting on the screen of an eye tracker which measures the glance's direction from the eye's image collected in a near infra red.The number and the mean duration of the fixations, the number, the mean amplitude, the frequency and the direction of the saccades for the all painting were recorded by the device. Areas of interest were selected: 2 horizontals zones (1H: sky, 2H: ground) (**fig. 2**), 2 verticals zones (2V: on the right, 1V: on the left of the central path) (**fig. 3**), 6 zones (zone 1: crows on the left, zone 2: center, zone 3: central path, zone 4: left path, zone 5: right path, zone 6: crows on the right) (**fig. 4**). The access time to these six zones was also carefully monitored.These areas of interests allowed us to evaluate the role of the artistic stimulus on the ocular movement (3). A questionnaire was submitted after the two observations (knowledge of the painting, of the painter, glance's attraction before and after information).The student's test was used for statistical purposes (mean comparison on dependants groups).

Fig. 1: Wheatfield with crows

Fig. 2 : 2 horizontal zones

Fig. 3 : 2 vertical zones

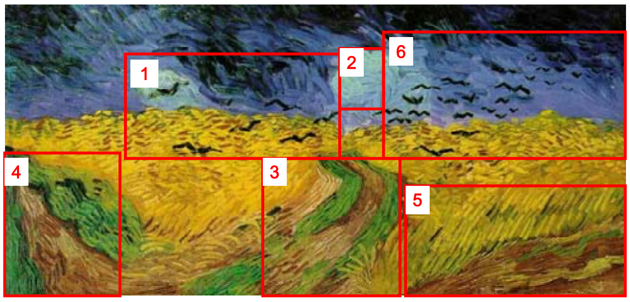


Fig. 4: 6 zones

Results:

<u>A/ Two horizontal zones</u>:
We did not observed, for the zones 1H (sky) and 2H (wheat and paths) before and after information, changes in the number of fixations, mean duration of the fixations, total duration of the fixations, saccades' total number, left and right saccades' number, saccades' mean amplitude in the 2H zone, mean amplitude of the left saccades, right saccades' mean amplitude in the 2H zone.
After information, in zone 1H, a decrease in the average saccades' amplitude in zone 1H (7.12 ° vs 6.56° p = 0.06), and a diminution of the right saccades' amplitude (7.13 ° vs 6.46 ° p = 0.079) was noticeable, but these differences are not significant.

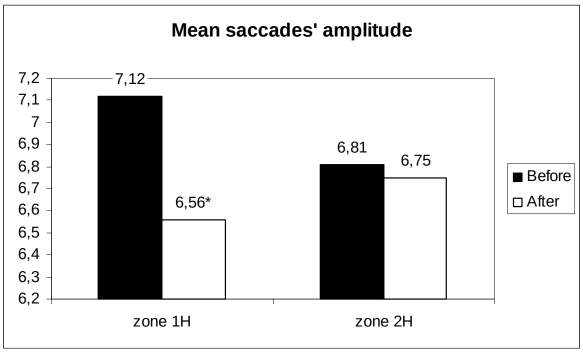


Fig. 5:
*zone 1H *p = 0.06, t=1.65 dof 14 unil*

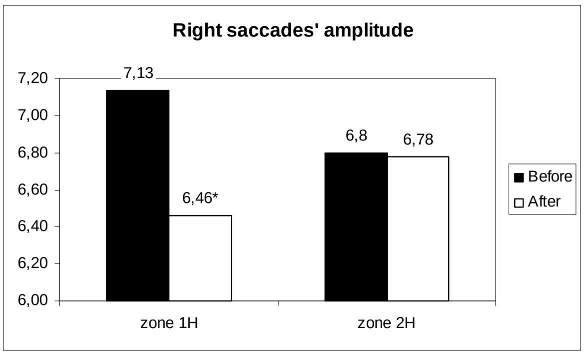
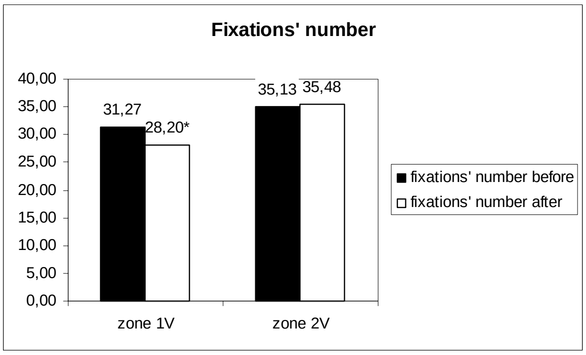


Fig. 6:.
*zone 1H *p= 0.079, t=1.49 dof 14 unil.*

<u>B/ Two verticals zones</u>:
We did not observe, in the zone 1V and 2V (respectively on the left and the right of the central path) before and after information, differences in the fixations' number in zone 2V, fixations' mean duration, fixations' total duration, saccades' total number in zone 2V, fixations' mean duration, fixations' total duration, saccades' total number in zone 2V, number of left and right saccades, mean amplitude saccades, mean

amplitude of the left saccades, mean amplitude of the right saccades in zone 2V. After information, in zone 1V, we notice a decrease in the fixations' number (31 vs 28 p = 0.08), in the amount of the saccades (30 vs 27 p = 0.09), and in the number of the right saccades (8.70° vs 7.87° p = 0.12) but these differences are not significant.



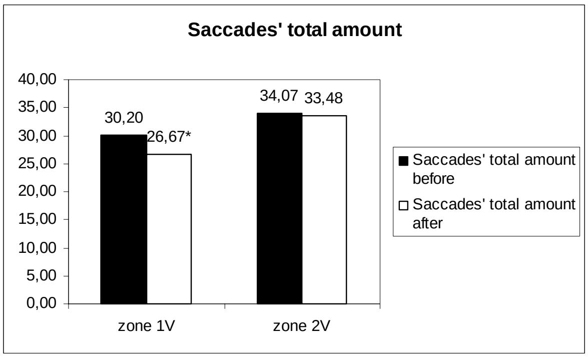


Fig. 7:
*zone 1V, *p = 0.08, t=1.43 dof 14 unil.*

Fig. 8:
*zone 1V, * p= 0.09, t=1.37 dof 14 unil.*

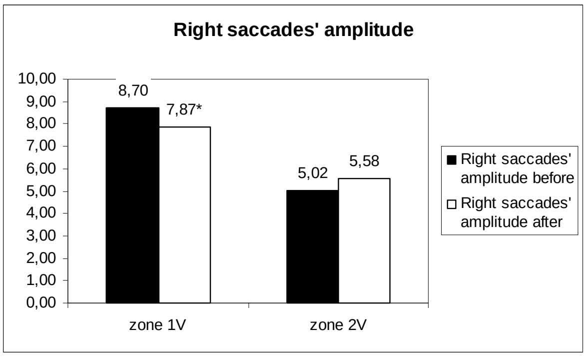


*Fig. 9: zone 1V, *p= 0.12, t=1.27 dof 14 unilateral*

<u>C/ Six zones</u>:
<u>C1/ Fixations' number:</u> We observed after information a switch in the repartition of the fixations' concentration. Before information, the zones more often observed, regarding the amount of fixations are the zone 1 (16.60), then the zone 6 (12.80). After information, we found the opposite and the zone 6 became the most visited (16.53) in front of the zone 1 (12.87).The decrease in fixations' number is significant for the zone 1 (p =0.008) and for the zone 2 (6.13 vs 3.93 p = 0.016). The increase in the fixations' number in zone 6 after information is significant (p = 0.047).

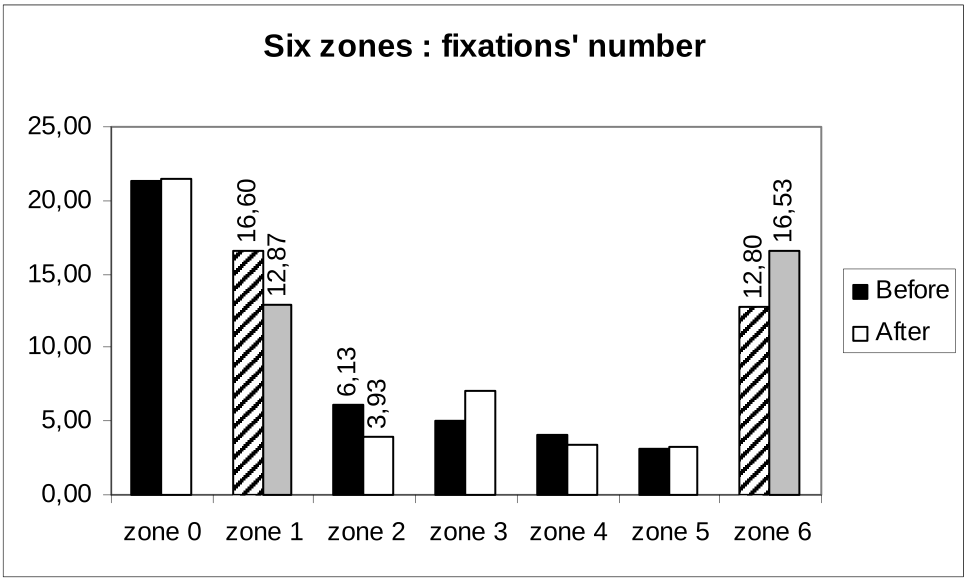


Fig. 10: fixations' number. Cutting out in 6 zones.

*Zone 1 : ** p= 0.008, t= 2.68 - Zone 2 : ** p= 0.016, t = 2.36 - Zone 6 : ** p= 0.047, t = 1.79*

dof 14 unilater Zone 1 and 6 before ne 1 and 6 after

	Before	After
zone 0	21,27	21,47
zone 1**	16,60	12,87
zone 2**	6,13	3,93
zone 3	5,07	7,07
zone 4	4,07	3,40
zone 5	3,07	3,27
zone 6**	12,80	16,53

*Table 1: fixations' number before and after in the cutting out in 6 zones ** p < 0.05*

C2/ Fixation mean duration: There is no significant difference between the six zones concerning the fixation mean duration.

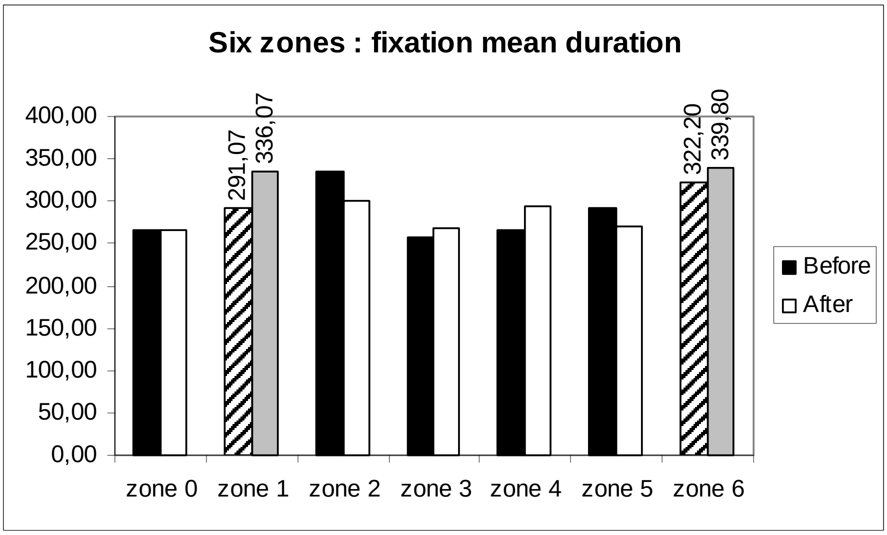


Fig. 11: Fixations mean duration cutting out in 6 zones.

Zone 1 and 6 before *Zone 1 and 6 after*

<u>C3/ Access time:</u> We studied the access time for each of the six zones. Before and after information, the zone 1 is always discovered first, but with a significant delay (413 ms vs 1527 ms p = 0.0007). The access time for the zone 2 is delayed a lot after information (3060 ms vs 6073 ms p = 0.046) (**fig. 12**). The sequence from one zone to another is altered by the information: before 1, 2, 6, 3, 4, and 5 (**Z** aspect), after 1, 3, 6, 2, 4 and 5 (e aspect) (**fig. 13**). Zone 6, after information, is always reached in third position: or after the zones 1 and 2 or after the zones 1 and 3.

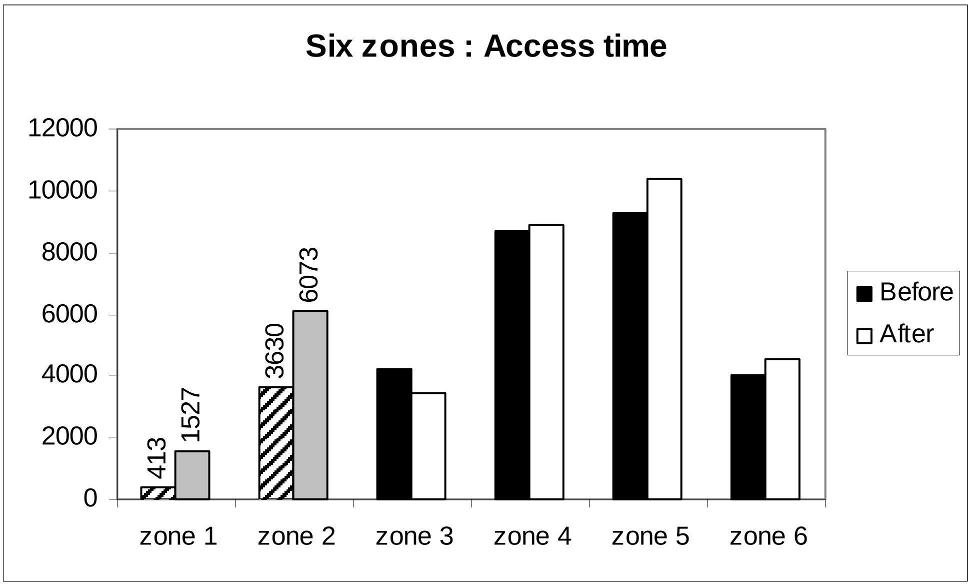


Fig. 12: Access time cutting out in 6 zones.

*Zone 1 : ** p=0.0007 t = 3.92 - Zone 2 : ** p=0.046 t = 1,8*

Before *After*

Fig. 13: Access time: order in discovery

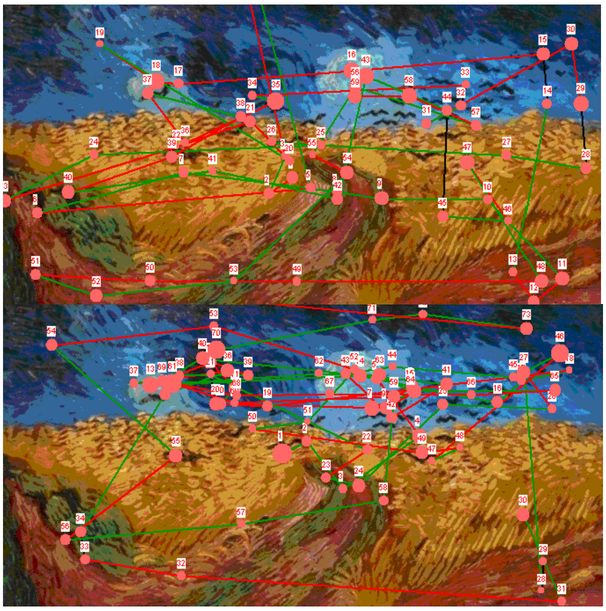
In summary, visual information for the last Van Gogh's painting leads the following modifications. (**significant statistic results):

<u>Two horizontals zones</u>: Saccade's amplitude decrease in the sky zone, right saccades' decreased in the sky, the eye "moves" less in the zone "sky".

Two verticals zones: Fixations' number decreased in the left half, saccades' number decreased in the left half, right saccades' decreased on the left, the eye scrutinize less the left zone of the painting.

Six zones: Fixations' number decreased for the right crows**, fixations' number increased for the left crows**, left crows access time delayed but first of the six zones**, delayed access for the central zone**, access to the right crows equivalent**.

The eye tips over in the right crows' zone (**fig. 14**).



Before *After*

Fig. 14: Fixations and saccades' repartition, subject 10

Discussion:

The results of this study show that the glance changes after general knowledge information about this work of art. Information has the ability to modify our visual strategy. We scrutinize in a precise manner the birds' flight. Did they play a trigger role in the painter's death? The eye seems, after information, to be inspecting the right zone of the painting, area which spontaneously can attract the glance, since it is a contrasted region [2], but also because there is an oblique, cutting the painting from left to right. (**Fig. 15**).

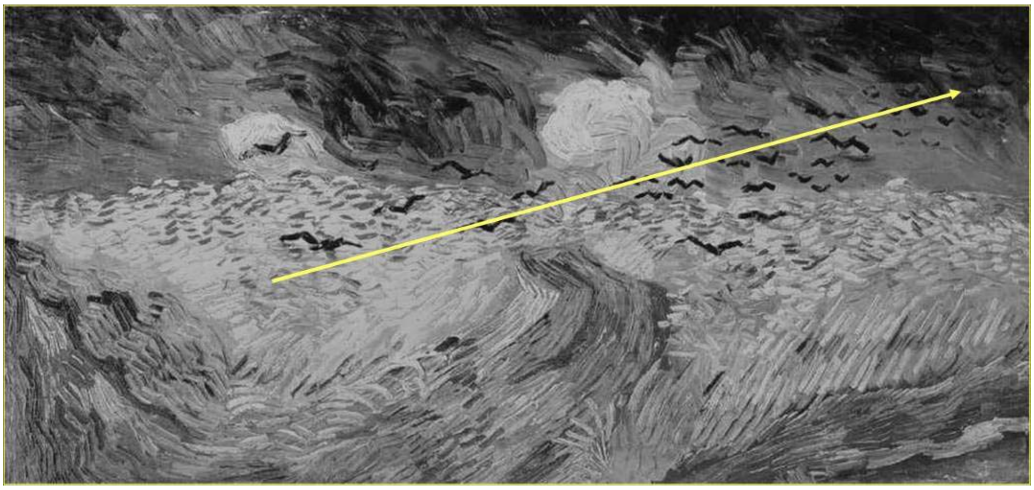


Fig. 15

As previous works' demonstrate [3, 4] the eye is attracted by complex areas, where saccades have lower amplitude and the fixations' number increase to collect as many information as possible.

The boundary zone between the sky and the wheat is intriguing for the eye, or the brain; it seems that the crows leave from the ripe wheat's crest. If we analyze closely the artistic work of Van Gogh, we notice that the birds are succinctly represented with two, three or four black brush strokes. It is the same graphic representation used for the top of the wheat, but this time using the ocher yellow instead of the black. It is this zone that the eye loves to look closely after information (**fig. 16**).

Fig. 16

Post-observation questionnaire confirms this notion since 9 out of 15 subjects recognize the fact that they are attracted to the crows after information (**Table 2**).

	Before	After
subject 1	Path	Crows
subject 2	Birds	Wheat
subject 3	Wheat	Crows
subject 4	Center	Crows, Arm
subject 5	Bright Colors	Wheat
subject 6	Whirlwinds	Crows

subject 7	Sky	Sky
subject 8	Colors	Crows
subject 9	Blue, center	Crows
subject 10	The blue color	Black, blue
subject 11	Wheat	Wheat
subject 12	The bottom, the path	Sky
subject 13	Yellow, field, path	Crows
subject 14	Sky, champ, colors	Crows
subject 15	Sky	Crows

Table 2: What attracted your glance?

Maybe the glance is attracted by the crows because these are the ones explicitly mention during the narration? This can be understood in a complex masterpiece, but the “wheat field with crows”, is a “simple” work of art, with 4 zones of interest: the sky, the wheat, the crows and the paths. It takes us 10 seconds to go around the painting as shown by the access times. After these 10 seconds, the eye “wanders around” the painting searching for an anchor point. We see that scan paths describe a circle movement between the four opsiemes (the smallest discrete unit that can be isolated in the visual chain): the sky, the wheat, the birds and the paths. However, no points will allow the spectator to settle down. Maybe we can, by the visual strategy’s study in this painting, discover in which state of mind was Vincent Van Gogh during this month of July 1890. Indeed we notice that this painting’s construction is unusual. Vincent Van Gogh knows very well perspective, that he described in one of his letters to his brother Theo, drawing the tool which helps him in the field to draw, placing his lines and others escape points (**fig. 17**).

Fig. 17

He will use this technique in many paintings such as “Van Gogh’s room in Arles” (**fig. 18**), or the « Terrace at night », or in his fields’ views « Flowers’ fields in Holland », « Poppies field at Saint-Remy », and also in another similar canvas to the one of our study.

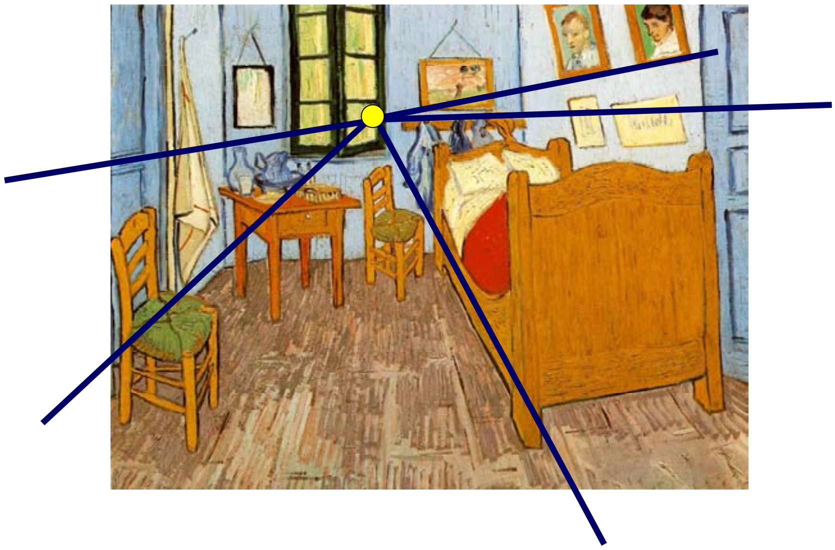


Fig. 18: Van Gogh’s room in Arles (1889)

In our painting the perspective is shockingly inversed! The escape point is not behind but in front of the field, exactly where the painter sets his easel. This inversed perspective certainly explain the nomad glance in the canvas between the field with the crest highly placed as a wave ready to run aground on us, the whirlwind’s sky and these three paths going nowhere, converging to the left bottom (**fig. 19**).

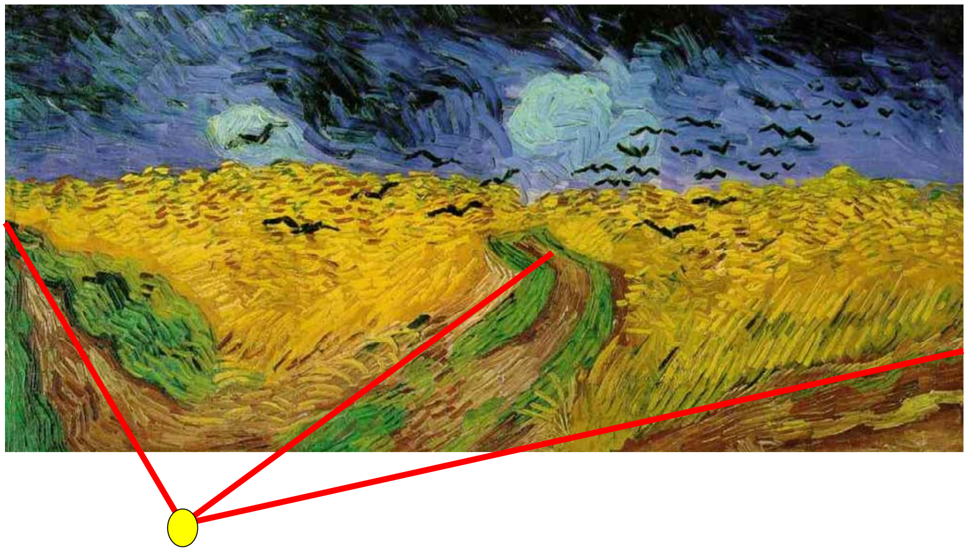


Fig. 19

So, it is two days before his suicidal act that Vincent Van Gogh paints in an abnormal way, “without perspective”.

Van Gogh became an artist painter at the age of 27 (1880), and after renouncing to a carrier in the religious order. Vincent Van Gogh’s all work is done during ten small years! He realizes during this period 900 paintings, 1100 diagrams and sketches. His art is not a merchant act, but more a sort of “breathing”. His recurring comportment’s troubles in Provence motivate his brother Theo to bring him back near Paris, in Auvers-sur-Oise where he will be under the attentive surveillance of Doctor Gachet. It is here on July 25th 1890 that he realizes this odd painting. The analysis of the overall circumstances during this month, may explain this curious arrangement. Vincent Van Gogh is psychologically weak, he fears a new “attack”, and he insists in his letters for Theo to come visit him in Auvers (5). But this one is in conflict with his spouse Jo, young mother since the month of January 1890 and his relations with his employer are fragile, making him anxious about his future. Vincent certainly feels, at this specific moment, more abandoned than any other time in his life. Him, the second family child, who came, at least for the first name (Vincent Willem), to replace his older brother who died at age of six weeks. Indeed, one year later, on the same day (the 30 of March 1852 and the 30 of March 1853), Vincent Willem Van Gogh was born. Child, he used to cross on Sunday morning with his father, going to the church through the cemetery, the little grave with his name…and off by one digit, his birth date. During the beginning of the year 1890, on January 31st, Theo and Johanna had a boy. They decided to name him... Vincent Willem Van Gogh! Thus, between two Vincent Willem, the artist feels lonely and in front of this wheat too tall, in front of this tumultuous sky and in front of these three paths with no way out, the arrival of the crows is a bad sign and they surely announce bad news to the fragile mind of Vincent Van Gogh. His vision of the nature is troubled and the construction of his painting is disturbed. Thus the spectator in front of the canvas feels this discomfort, and his visual path will be nomad. It is at this juncture that the artistic information can guide the observer’s glance with emotion.

Conclusion:

In a simple artistic composition (wheat field, paths, sky and crows), informative narration don’t radically change intrinsic characteristics of the ocular movements, but it steers the glance. In this particular painting, the visitor’s eye will be lost because Van Gogh’s mind is lost at that time. With an unusual construction, result of the psychological disease, the study of the visual strategy informs us of the helpfulness narration before the sighting. Maybe the spectator eye becomes condemning toward those bad sign’s birds.

(1) RAYNER K., POLLATSEK A., «Eye Movements and Scene Perception», Canadian Journal of Psychology, 46, p. 342-376, 1992.

(2) YARBUS A.L., Eye Movement and Vision, Plenum Press, New-York, 1967.

(3) ZEKI, S. 1999. Inner Vision: An Exploration of Art and the Brain. Oxford University Press.

(4) LIVINGSTON M. The biology of seeing (p78). Harry N. Abrams, inc., publishers.

(5) Letter 649 Auvers 10 July 1890. Vincent Van Gogh, Correspondance générale Tome 3, p. 729. Gallimard.

Interactive Evolutionary Computation paradigm for urban planning and architecture design: the URBAG project

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Abstract

The increasing complexity of our surrounding artificial ecosystems is conveniently balanced by the growing power of rising digital technologies, in terms of representation and intelligibility. Today, in architecture design, co-operative partners often collaborate - through digital networks and convergent technologies - to achieve the conceptual intention and its actual realization. Therefore, we believe that former creative exploration could be computer-assisted by specific tools and methods, able to enhance designer's conceptual capabilities and thus, to free its imagination.

Premise

We must quote Donald Shön's opinion, who remarks that research should concentrate on computer environments able to enhance user's ability to comprehend, store, manipulate, organize and speculate over project's matter. Many research projects explored this concept, introducing new operating methodologies able to schematize introductory projectual investigations, long before any possible geometric formalization."Most of CAD software act like over-equipped hand-drafting assistants, assuming the maturity of the designer as much as the maturity of the project itself."

Since many years, the research team MAP aria - within the architecture school of Lyon - works on generative digital processes able to assist initial design intentions, acting like "imagination enhancers".

Recently, we initiated a partnership with a major town-planning design agency in Lyon, "Interland", experimenting a bio-mimetic digital mechanism to improve spatial allocation constraints within a dense urban context: sunlight, orientation and/or sub-spaces connections are modelled, then a cluster of plausible solutions is recursively generated through pseudo-genetic or IEC process.

This very first step produced interesting results, and we aim to improve our generative methods either by building a more efficient interface, dealing with high-complexity programmatic schemes, either increasing the genericity of the built-in "inference engine", extending its adaptability to architecture or product design.

Random strategy & fuzzy logic versus urban standardization

Urban-organisation recurs following infinite parameters, and a single urban ecosystem seems to have its proper "self-organization methods", so much that cities are considered by cybernetics as models of artificial intelligence (Naizot).

But in many cases, the regular contemporary urban fabric appears as the result of purely economic circumstances & factors (Davis). Building lobbies enforce their criteria to select materials & structural designs, in order to build more, faster & cheaper. Among them the building compacity, the strict pattern dedicated to prefabricated materials & prefabricated structures, the uniqueness of the program (one building = one program is the common equation for most suburban establishments…).

Methods are so repetitive that a urban project can be considered as the result of an automatic act of reasoning, of a way of thinking based on deduction – and not to confuse with the art of synthesis, which supposes the ability of letting go together some natural alchemy between both contextual & fundamental elements of planning.

So much that maintaining an ecological balance & a functional diversity demands conceptual efforts to urban planners & political decision-makers.

Most of the common architectural productions thus escape the domain of architects, compelling the urban planners to define detailed shackles (instead of carrying the project global meaning), in order to prevent the industrial logic of property developers, the ones who eventually know where aesthetic & sensitivity can be authorised, in tight relation with the expected commercial mark-up.

These new kind of regulation forms the matrix for the production of today's standard cities, and on this regulated matrix will probably depend the conditions of development for the future forms of urban organizations.

The process of generation is not designed to represent existing cities (as a model of one current city), or to create urban environments (virtual cities), but it aims to understand better which parameters regulate mostly the urban fabrics.

Can we – architects & urban planners – anticipate these major rules, and get to the bottom of their possibilities in order to better qualify the inevitable compromise, and then balance it in a more sensitive way?

So which are these generative rules? What kind of new interesting rules can we test? For instance, about the thermal performance, what kind of new combinations can be envisaged? And how much "more or less different", or "similar enough"?

What is produced by the introduction of a subversive rule within a set of balanced standard rules, still looking after the final margin? ***Can benefit be innovative?***

In fine, which valuable urban and (meta-)architectural forms can be created starting from a multi-criteria random generation? ***Could landscape be enhanced if urban possibilities were better explored?***

Context of the research task:

The **URBAG** project (**U**rban **R**ules-**B**ased **A**rchitectural **G**eneration) was suggested (and tested) by a real case located in a new town between Grenoble & Lyon (France), during an operational advisory mission conducted by the INterland agency (architecture & town planning) in 2007/2008, then with the objective to assess the feasibility of one program for a blank area to urbanize, and to offer the client a range "better than usual[1]" of valid and relevant solutions (town planning scenarios).

The URBAG project was then developed in collaboration between:

• A Research&Development team from INterland, consisting in 1 planner-architect computer-architect & 1 systemic engineer

• Renato Saleri, architect, designer, teacher & researcher within the MAP-ARIA research team of the architecture School of Lyon (France).

The URBAG project is carried by two complementary & converging research directions:

• An explorative approach: for a bio-mimetic generative methods developed within the MAP aria research team. They are able to quickly produce architectural and urban geometric simulations.

• An operative approach: for a selective & systemic generator (INterland), working at the plot and considering buildings as conceptual/undefined forms (stacked parallepipeds) that house possible urban programs, in order to assess them (feasibility about net gross floor areas, uses, movements, connections, ...).

The URBAG project is related to emerging present scientific works (see bibliography below) but mainly to:

• Internal sources :

- Alter EVO : an interactive evolutionary computation tool for instant architecture processing. [Saleri 2007]
- Conception architecturale évolutionnaire – recherche formelle. [Janda 2007]
- Random-generated rule-based 3D objects. [Saleri 2006]

• External sources :

- Evolving urban structures using computer optimisation technics. [GA 2006]
- The FunctionMixer. [MVRDV]

As it emerges today, the final purpose of these combined efforts would be to design an interactive genetic generator (IEC) able to fully articulate both scales (here architectural & urban), and then to integrate the "inter-systems relations" (or "systemic interactions"), in order to embrace the upper-related scale of a specific sub-system (a district, a complete city, a part of a territory, ...).

This article summarizes the progress of both approaches (exploration & operation), and intends to make explicit the process of systemic generation by focusing on a real case history, cornerstone of the URBAG research project.

[1] *I.e. a range of solutions that might be, depending on context, either « larger », « richer », « more divers », or more « innovative » than usual "hand made" solutions.*

<u>Part one:</u> The dimensional paradox

Recalling 1986 exhibition "Il progetto domestico" within the XVIIth triennale di Milano, Italy, I remember an interesting project by Mario Bellini, "la scatola dell'anima" - (the soul box) where a hundred of student projects were exhibited as a standalone collection. 25 years ago, the perspective of loosing the materiality of the representation was somehow disturbing and Mario Bellini just mentioned the frightening eventuality of the final wrapping-up of our consciousness. The ordered and almost obsessional presentation of several different housing project variants - studied and assembled by Remo Buti's students - looks like a final tectonic expression of the project expression. It is rare that historical anticipation is lenient with events to come: pessimistic dystopies are often depicted, and the announced convergence of cultural referents occurs with the inescapable perspective of a general cultural flattening. We are facing a massive complexification of the surrounding artificial ecosystem; however - and it is a paradox - its complexity increases in order to grant its sustainability.

In architecture and town planning, the control of a huge amount of preliminary data is necessary to respond to programmatic - and sustainable - needs. We must consider new present solutions for spatial allocation, functional and environmental constraints, mass transportation, data and goods storage that may become an important conceptual overweight. Traditional Computer Aided Design solutions are unable to help designers properly, they tend to "act like over-equipped hand-drafting assistants, assuming the maturity of the designer as much as the maturity of the project itself." [Chupin - Lequay 2000]: the legitimacy of our scientific approach depends on this observation. Considering our need to (re)order the exponential increasing complexity of surrounding artificial ecosystem, we think that the use of existing natural selection processes could be pertinent. Even if very present evolution theories tend to amend some early Darwinian conjectures, we still believe that evolutionary mechanisms were able to generate well-balanced sustainable biotopes, specifically suitable to a wide variety of species. These mechanisms are quite well known today and widely implemented in present civilian and military applications. Furthermore, the conceptual specificity of architecture makes possible the use of similar bio-mimetic approaches for spatial arrangement purposes, in terms of programmatic arrangement for environmental optimisation: such an experiment has been introduced within GA2007 conference, considering Interactive Evolutionary Computation as an efficient tool for urban and architectural 3D fast processing.

There is a famous Borges's tale relating about some peculiar points in space able to represent simultaneously any possible state of all existing or upcoming objects or beings within the universe. These "Aleph's" - so they're called - are very rare spatial happenings in which every single possible image or representation of anything from the past, the present or the future could eventually appear. Within this pan-optical perspective, if we consider a system able to represent - let's say over a square 128 pixels black&white framework - any possible representable combination, the collection of "intelligible" representations are "a drop in the bucket" within the set of all possible combinatory events.

Such a system is able to represent sequentially a huge quantity of different boolean schemes (2^16384) and we are sure that at a certain moment of its "life" it will certainly display any possible bi-dimensional bitmap configuration and though have an answer for any possible query, however the functional efficiency of such a system is equal to 0, at least for three reasons:

• there is absolutely no reactive feedback - something you could state as a "functional response".

• its temporality widely extends human or even astronomical durations.

• the genericity of its significant basic information (the single pixel) which extends the ergodicity of the system but tremendously increases its feedback response.

On the other hand, a human operator, an architect or a designer can develop with experience functional schemes that may limit somehow the conceptual process, a "schematic response", as they tend to respond in a similar manner to analogous given problems.

The question is: would it be possible to mix somehow the ergodicity of a random parser with human foreshortening ability?

An early Interactive Evolutionary Computation tool - presented within the GA2007 conference - introduced this very concept with the implementation of an Interactive Genetic Algorithm able to explore and improve functional spatial connections within a given programmatic scheme. With such a piece of software, user can (after 2:30 minutes and 10 interactive mouse clicks) virtually explore, by selecting at each generation step one on top of 144 given combinations, a cluster of 3 833 759 992 447 480 000 000 possibilities. The resulting solution raises as an optimal combinatory occurrence, both driven by user preferences on one hand and the underlying system ergodicity on the other.

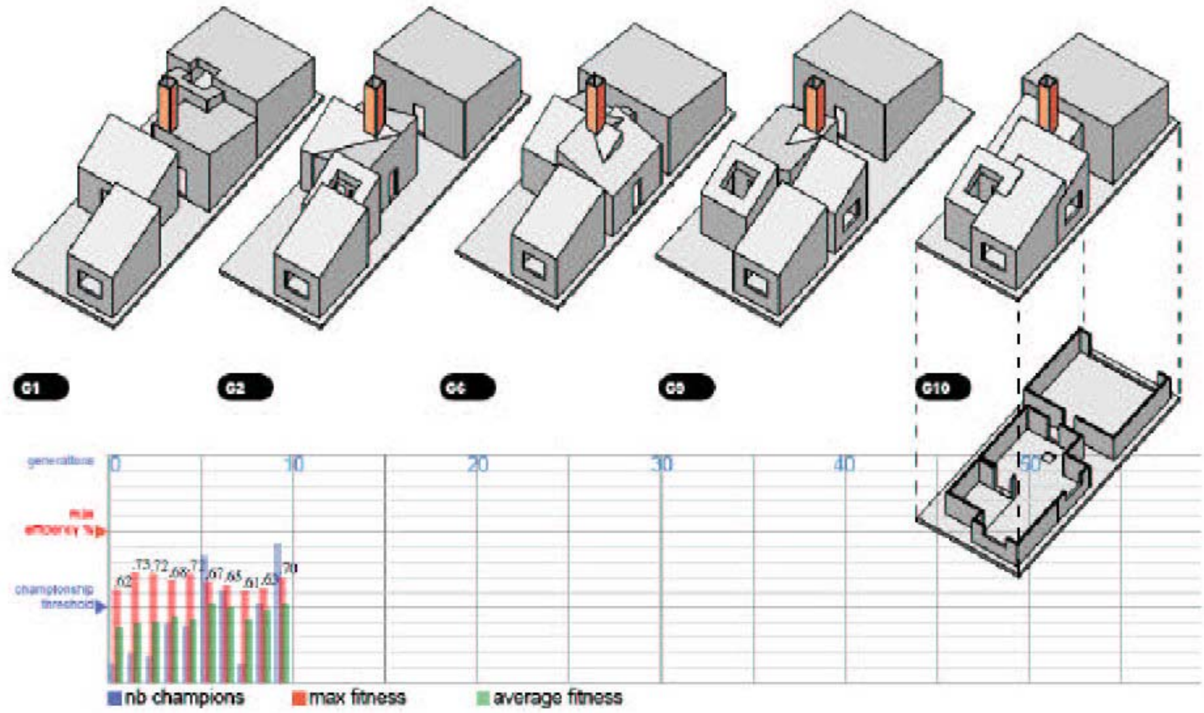
Considering initial drawbacks, as stated above:

• the user-based reactive feedback drives the entire process.

• response-delay is hugely reduced, considering that it would take as long as 7 294 063 912 600 000 years to sequentially evaluate all of the 3 833 759 992 447 480 000 000 possible combinations (one single second each).

• initial significant basic information is "high-level specific" , thus increasing the efficiency of generational process.

And as the functional response is always driven by a random based mechanism we are able to weaken the "schematic response" described above.



Interactive Evolutionary Tools to enhance functional performances

In this example, user drove the generation process searching at each step his preferred solution described as "a moderate East-West outstreched object" with floor areas given as an input. Using IGA, the will of user emerges naturally from the cluster of responses; the integrity of architectural pertinence (non overlapping, spreadout compacity...) is managed by an inner evaluation function.

Part two: Selective systemic generator

Objectives:

At the « pre-design[2]» step of a urban project, the goal is to elaborate a systemic tool that generates spatial sets (volumes organization) & programmatic sets (uses organization) within a limited & regulated area (called "urban plot").

Starting from certain "**systemic**" settings considered as determining & possibly conflicting factors, this generator is designed to suggest several solutions ("individuals"), which resulting properties are quoted, and so classified, in order to help making decisions. These parameters are related to the expected program and to the local context (net gross floor areas, maximal height, rate of public spaces, front aspects, front rows, parking locations, …).

The generator is said "**selective**" due to integration of statistic rules conceived to select "a relevant part" of the possible individuals (= resulting urban plots), with a triple purpose:

1/ Individuals are plausible, i.e. "one could indeed build the returned urban plots", though the architectural forms & building trends are not precisely defined that soon

2/ Individuals are viable, i.e. "the returned urban plots could indeed work in a urban context"

3/ Individuals are satisfying, i.e. "the returned urban plots do indeed respect the local & specific applicable regulations[3]".

In other words, it is possible to monitor the degree of compliance of the returned solutions regarding to the initial settings (which strictly translates the project development initial specifications), and therefore to get a set of solutions "rather complying", while allowing some "more or less important" variations between individuals[4].

Computer environment:

[2] *The « pre-design step » consists in a preliminary phase while the urban designers try several pieces/ starts of possible types of solutions, before deciding the few ones that deserve a further work in order to be fully characterized & presented as possible scenario (proper "design step").At the "pre-design step", the aid of data processing must be fairly gauged, in order to accelerate & diversify the testing process, and not to close or radicalize the results. For cost reasons in operations, data processing aids can't be conducted by a heavy computer engineering, because it would mobilize expert resources (computer scientists, mathematicians, statisticians, research departments in structure, mobility, energy, etc., …) with two major arguments: the cost of these expert resources & the haziness of the emerging data these experts would be supposed to work with.*

***Hence the idea of this small software for decision-helpers, which intends to be simple, efficient & flexible.** Let's precise again that this practical tool is not a technical evaluation tool (measuring kWh etc.), but a parented-solutions generator – a kind of "solutor".*

[3] *These regulations can concern the building sun aspect, the front rows, the road network, the localisation of public spaces, some/all the global dimensions, the potential sun power, the degree of transparence & the degree of traffic inside the plot, etc., …*

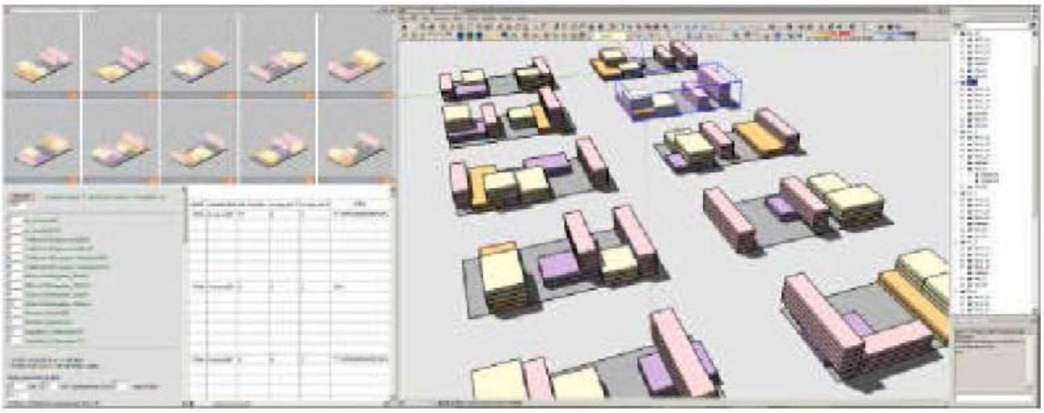
[4] *Thus, users can pilot the generator in order to make, for instance, the building fronts be « globally aligned » on every returned urban plot, with some plots probably consisting of « perfectly aligned » fronts and other plots including « more or less aligned fronts ».*

What we wanted was an internal tool, simple, open to anyone, and quickly functional; that's why we decided to choose a conceptual language based on the allocation of characteristics to objects: {systemic object: characteristics}, and after to reason and then process on the base of a 2D-model (the building height is there not considered as a special 3rd dimension, but only as one secondary characteristic among others).

At the urban scale[5], the systemic terminology would be :
{urban plot : parameters} → {urban plot : global properties} + {urban volumes[6], elementary properties}.

		Interface	System	Under-systems	Elements	
Architecture design	_1	Several related Volumes	Inner volume	Objects	Parts	
	_2	Several related Building	Building	Inner volumes	Objects	
Town planning	**_1**	**Several related Urban plots**	**Urban plot**	**Buildings**	**Blocks (= layers)**	**→ URBAG project**
	_2	Several related Districts	District	Urban plots	Buildings	
Land development	_1	Several related Cities	City	Districts	Urban plots	
	_2	Several related Territories	Territory	Cities	Districts	
CONCEPTS:		POPULATION	INDIVIDUAL	ORGANS	CELLS	

For reasons of simplicity about programming, using & implementing, the URBAG software has been written in Java Script / Ruby, and provides results viewable on a html interface (like a web browser), with an integrated command to launch the automatic modelling of any individuals (among those selected) by Google Sketch-up (where all volumetric characteristics as well as the resulting properties can be accessed, modified, memorized & exploited without limit).



Generation principle:

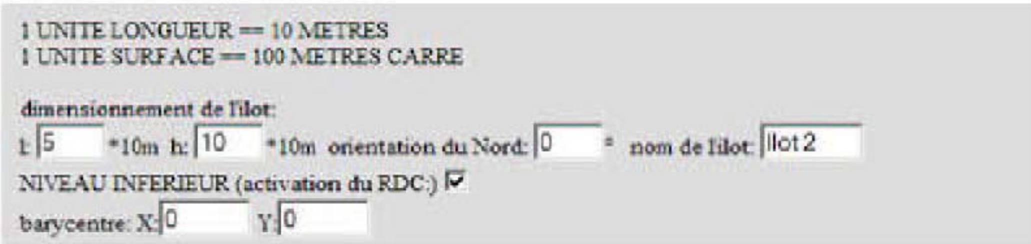
[5] *Object-based languages allow to understand every scale and therefore to work on every conceptual object that can be properly described ; so the studied object could later be re-interpreted, though still remaining on the field of volumetric occupation of spaces (conceptual base of our algorithm), and knowing that the generation rules & the interactions complexity would then have to be reviewed. If the systemic terminology is maintained, our algorithm can describe very different things : furniture, life room, housings, buildings, exhibition places, public spaces, urban plots, districts, infrastructures, cities, agglomerated towns, territories, nations, planets*

[6] *« Urban volume » is the generic word we choose for any designed volume settled in a plot, whether the volume is full (building) or empty (public space, street, hall, …).*

On a digitized pattern (today 5u * 10u, with u=10m, because it corresponds to the inputs of the field project), we run a first generation and optionally (by un-ticking the "RDC activation" button) we run a second generation process, with fresh individuals that are stacked above the first settlement, depending on the free available spaces and dealing with solid interactions[7]. This stack option is designed to allow composite programs (in our prototype: 1 program per layer, and up to 2 vertical programs per building) and to allow transparent volumes at the bottom (non-built covered spaces, as corridors & halls).

Urban plots can be oriented degree by degree regarding to the North, in order to properly realize the analytical evaluation as well as to prepare easy exports to real ortho-photo maps.

Also, a peculiar point (called "barycentre") can be located by users (entering Cartesian coordinates) anywhere inside & outside the urban plot), in order to create a dynamic interaction with the buildings settled in the plot (dynamic interaction being either attraction or repulsion from the peculiar point). For instance, it's very practical if you want to move all the housings away from the side of the plot where there is a high traffic road, or on the opposite if you want to move the shops closer to the part of the plot where is the central park, or even make a public equipment be close to the public place in every returned solution.



Starting from the user' settings (i.e. the urban plot parameters), constraints are calculated in a "2D-layers" mode, since the buildings' height is actually calculated from the net gross floor area (input fixed value) that is to "spatialize".

Thus, generation can be run with two progressive options:

<u>1/ Simple generation:</u> random draw of 10 solution-individuals, used to prefigure the global situation & approximate the spatial configuration of the programmatic input parameters.

<u>2/ Selective generation:</u> selection of the fittest 10 solution-individuals, among n random drawns (n < 1000 on a usual PC computer).

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[7] *This "stacking method" may seem simplistic about construction, but it remains consistent with the town planner purpose, and does not prevent the architects from working in the volumetric & programmatic framework previously given by the urban planner.*

Here the parametric description of the desired systemic urban plot, with the resulting parametric properties of the returned solutions, allows two different characterizations:

a/ Volumetric characterization:

Starting from the output data chart, our URBAG tool realizes a tridimensional virtualization, using a 3D-mesh, and leads to a couple of actions:

• The volumetric evaluation of the resulting properties (calculus of the buildings' outer surfaces, of the isolated volumes, of the quadratic distances, of the solar potential energy, ...)

• The volumetric representation (pseudo-3D) of the selected individuals on a graphic interface (web browser)

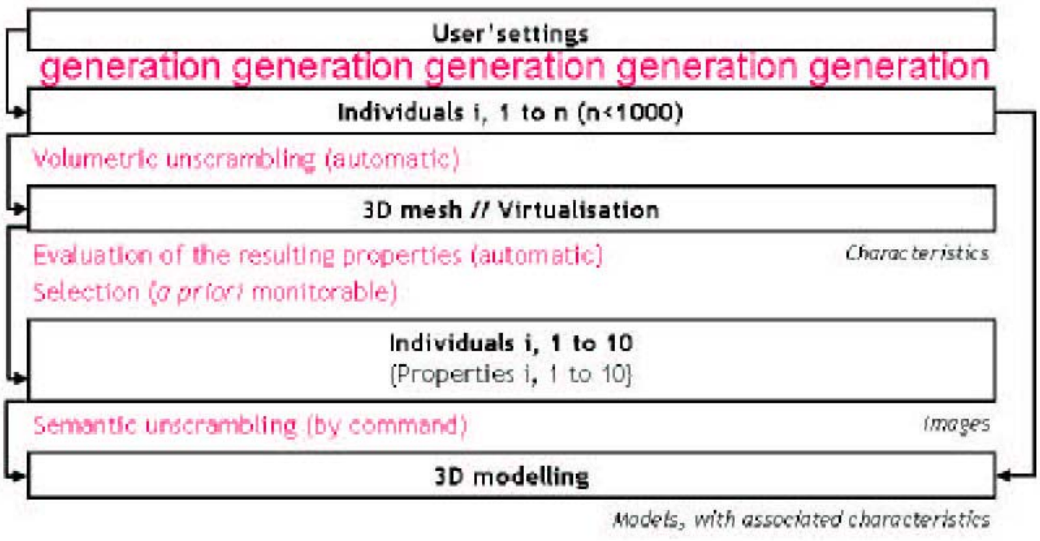
b/ Semantic characterization:

Parallel to the volumetric characterization, individuals' geometry can be interpreted (decoded) with a semantic language in a vectorial software able to model characterized objects (Google Sketch-up).

The semantic characterization makes the objects analysis more accurate, and gives flexible & infinite leads to various solutions.

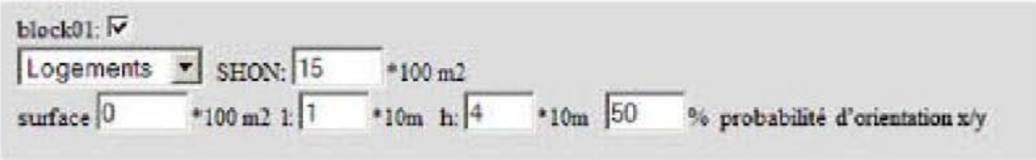
This modelling is available at the user's command for any selected individual (already represented in the html interface).

This generation principle has been set for it's theoretically the faster combination in terms of processing delays. Actually, the real 3D-modelling is not systematically launched for each individual, but commanded in real-time by users.



Setting the programmatic units *(generation parameters):*

In the current URBAG tool, urban programs are characterized a minima (cf. figure below), and this is the expert-user's monitoring which will statistically & progressively move away the non-suitable individuals, by identifying the determining factors (in a given context) and balance them in a multi-criteria dichotomous research of combinations.



In the example (cf. above), the net gross floor area ("SHON") and the XY dimensions are freezed, while ground hold ("surface") and height are calculated.

The "orientation probability" is a plugging added to monitor the statistic distribution with a simple rule: a 0% order means that the volume (here called "block01") will always see its length be oriented along [Ox). In this case, the order for orientation probability is 50%, meaning that the volumes called "block01" shall be equally distributed in the resulting urban plots.

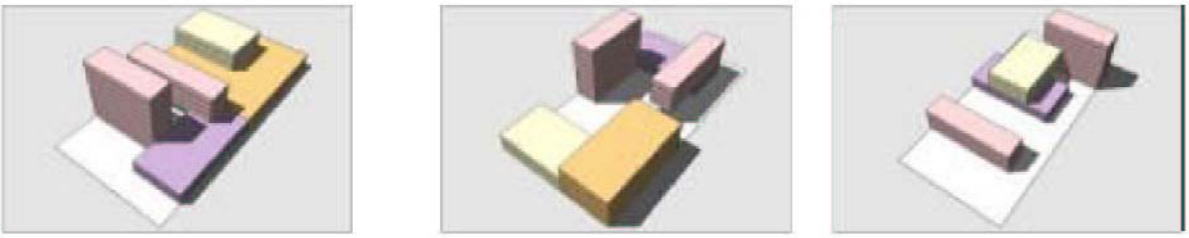
Several types of programs can be entered (stores, offices, public equipments, public spaces, dwellings, ...), without any limit but the processing power & difficulty for the computer to find solutions in a reasonable delay when constraints get stricter (for instance when the built hold tends to be as important as the plot surface.

In accordance to the generation principle (see the previous chapter), settings affects a first layer ("inferior levels": cf. left chart), and a second layer that stacks on it ("superior levels": cf. right chart).

There are some special programmatic units that are treated differently:

• Public spaces & subordinated spaces: considered as normal volumes ("blocks"), and regulated just as the built volumes, though the user reminds that the empty volumes have no matter nor face (transparence)

• Parking spaces: automatically evaluated from modifiable ratios (associated to each type of program – for instance one 8-m²-carpark per dwelling). The user chooses to determine or not determine the parking volume height, in order to adjust the distribution of the two basic types (surface areas, flat buildings or silo building).



The parking building (orange) is calculated from the other building gross floor areas.

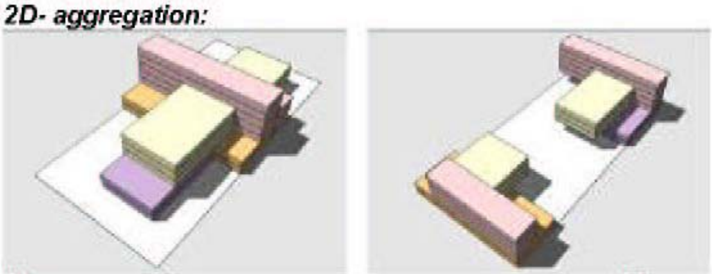
***Analytical evaluation** (classifying criteria):*

Several ratings (ground hold, volumetric occupation rate of the programs into the plot, 2D- & 3D-quadratic distances (from the peculiar interactive point, cf. above), global thermal loss, solar potential energy) make possible to evaluate the returned individuals, and to classify them following one, or another, or a combination of the resulting properties.

For instance, evaluating the quadratic distances from a pre-defined point makes possible to attract/repulse, more ore less, volumes to/from this point, what we can consider as a beginning of programmatic interaction monitoring. It makes possible to monitor locations without necessarily determining unique solutions, and to locate some public equipment close to a public place, some stores close to a central park, housings away from a noisy infrastructure, etc.,

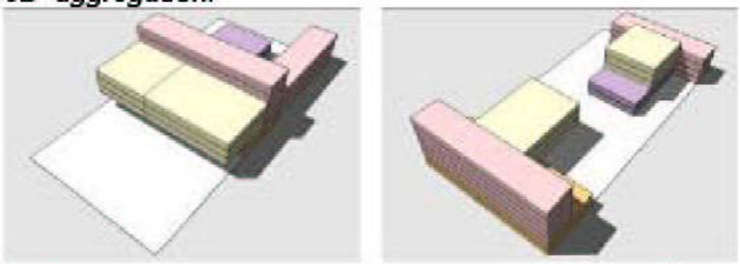
The following figures clarify the resulting properties, by representing the fittest individuals with one property as the classifying criteria.

2D- aggregation:



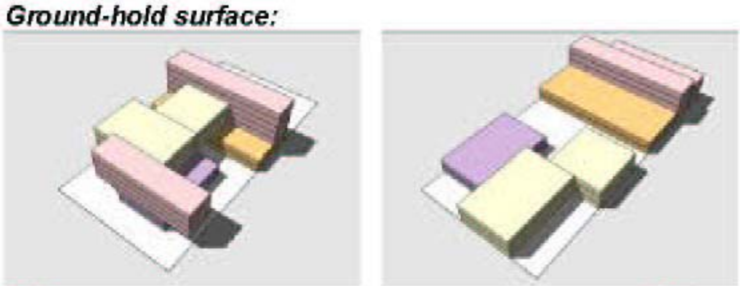
Min *Max*

3D- aggregation:



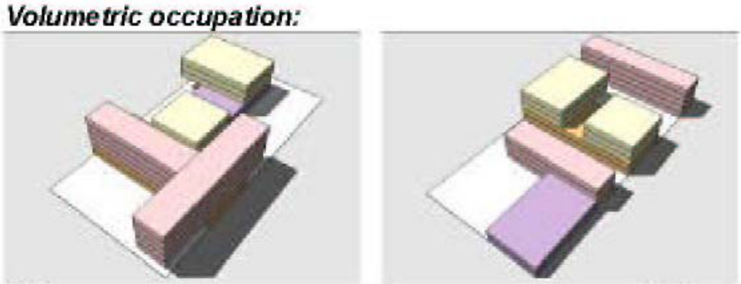
Min *Max*

Ground-hold surface:



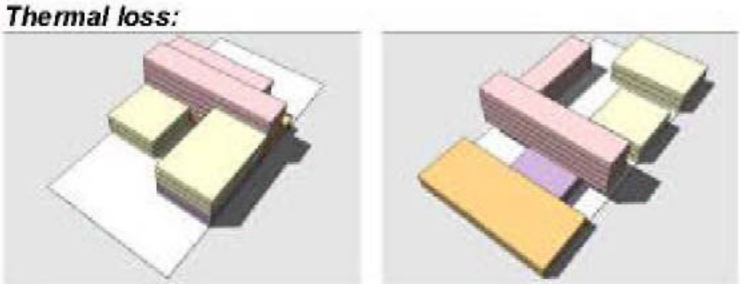
Min *Max*

Volumetric occupation:



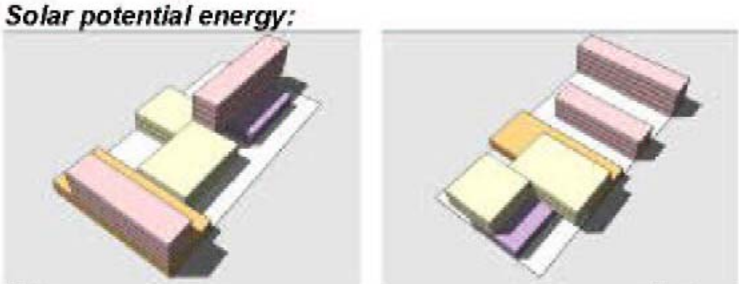
Min *Max*

Thermal loss:



Min *Max*

Solar potential energy:



Min *Max*

***Balanced selection of drawn individuals** (regulation parameters):*

Last step, coefficients can be input, in order to balance the individuals resulting properties, and therefore to modify their global classifying fitness.

Thus, the user can monitor the selection of 10 individuals (among n), by strengthening the weight of one, another, or the combination of the resulting properties (see chart below).

In this example, the input coefficients let think that the next 10 generated individuals will have the following global characteristics:

- ***GI_Smax** = **1** : means the returned plots will be selected for their "best possible" solar potential energy (integrating buildings' aspects & mask effect from the surrounding buildings)*
- ***INDAGG_3Dmax** = **0,5** : means that the returned plots will be "rather close" to the pre-defined peculiar point (here located in the center of the plot)*
- ***D_THmin** = **0,5** : means that the returned plots will have their buildings "rather places side by side", because of the outer surface to minimize.*

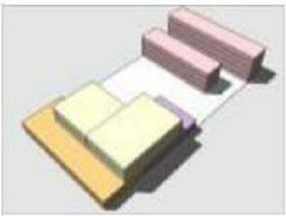
The following figures explicit the effect of the coefficients, by representing the fittest individual following 3 different balances.

In these next examples, only the economical determining factors are used:

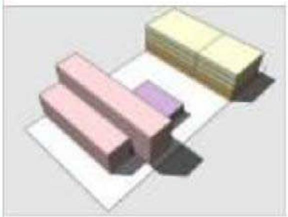
• Solar potential energy → related to heat & lighting annual bills

• Volumetric aggregation → related to urban density, land occupation, networks

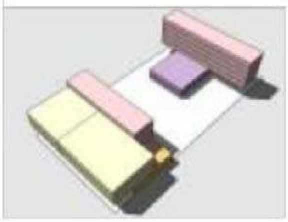
• Thermal loss (outer surfaces) → related to the necessary quantity of materials, as well as the heat annual bill.



Solar energy max:	1,0
Volumetric aggregation:	0,5
Thermal loss:	0,5



Solar energy max:	1,0
Volumetric aggregation:	0,5
Thermal loss:	1,0



Solar energy max:	1,0
Volumetric aggregation:	1,0
Thermal loss:	1,0

Benefits:

The object description is simple, but sufficient at the urban scale ; it's adapted to the operational order that originated the URBAG project (dense urban context including wide public spaces).

This algorithm effectively allows to generate families of solutions (called "populations"), which individuals are all plausible, viable & satisfying.

Limits:

The urban volumes being located randomly ("blind search"), numerous constraints (number & ground hold of the building to settle) leads to a smaller range of solutions, and a longer statistical delay to process before getting the possible solution.

At this point, no kind of artificial intelligence is there to accelerate the generating process (no genetic algorithm).

Aftermath :

• Apply the URBAG tool to specific objects

• Apply the URBAG tool at the lower scale (architecture), by implementing new interaction rules (proximity, clumping rate, smooth stacks, ...) in order to generate plausible & relevant populations

• Apply the URBAG tool to the upper scale (district), by monitoring the essential interface rules, in order to generate viable, consistent & parented urban pieces.

• Improve the ergonomics of the balance coefficients (sliders, cursors, ...)

• Determine fixed positions for some urban volumes (current buildings & spaces), while other can move within the plot area (building to project), leading to the urban renewal field

• Fully separate the volumes and the programs (free, or partly-monitored, distribution of the programs into volumes). This would decrease the constraints, increase the possible solutions, but also increase the non suitable individuals (for instance, buildings can be like moth-eaten by a myriad of small & different programmatic units; this can be regulated by limiting the programs to a maximum of 2 per level, with distribution classes: 30-70% / 50-50% / 70-30% and a tolerance margin).

• Combine the selective systemic generator with the bio-mimetic formal generator

• Use polar coordinates (more flexible)

• Integrate a cellular automate, & manage the inherent side effects

• Integrate a germ, able to instigate a cultural/historical contextual "soul" to the generated populations

• Integrate assessment agents, able to scan the work volume, in order to detect new & unexpected resulting properties (about use, perspectives, drops, landscapes, urban cores, ...)

• Integrate a magnetic device, able to make the initial parameters and/or the resulting raw properties "vibrate", "swing" around the ordered values

• Is it relevant to look for a better algorithm, better and heavier, in the framework of urban projects?

• And isn't it better if our simple tool still demands the expert's eye to monitor the generation?

Practical work:

The subject is to plan district urbanization near 3 new health-&-care public & private establishments, in a new town between Grenoble & Lyon.

Starting from the general urban concept, the town planners had to define for the developers the specifications about heights, neighbours prospects, front rows, permeability...

For the town planners, difficulty was to provide a large number of feasibility studies in a short delay, each time the program evolved. At the end of the 1st. pre-operational phase, the number of feasibility studies was already about 35, with no other purpose but convincing the decision-makers that a mixed & dense district was possible to imagine.

These traditional feasibility studies are long & systematic:

1/ Assess & locate the programmatic units into urban volumes + Evaluate the parking surfaces

2/ Check that all programs work, on their own & together (access, aspect, dimensions, ...)

3/ Check that the volumes comply with the urbanism accepted regulations (local & specific rules and the economical expectations

4/ Illustrate each kind of plot in 3 dimensions

Ideally, this scenarized representation shall demonstrate that a large range of solutions is possible in one given context, and that urban rules open doors to the architectural expressions.

The next figure is what was accepted in the field urban project, basically consisting in a dense district and superstructure parking buildings.

The plot was accepted, for its economical realism and for the relevant configuration of offices & dwellings.

This plot was generated with the following balance coefficients:

- ✓ 2D-aggregation : min (big ground holds go away from the middle)
- ✓ 3D-aggregation : max (big net gross floor areas get close to the middle)
- ✓ Ground hold : max (to cover the largest available ground surface with programs)

Rose: dwellings // Yellow: offices // Purple: stores // Orange: car parks
Green: non impermeable ground // Beige: Impermeable ground

early stages of full-size urban settlement starting with described techniques.

Conclusion:

Interest in modelling cities is high. Many research tasks work with l-systems, Voronoi or cellular automata to simulate architectural and/or urban growth phenomena, some of them can even reliably predict with accuracy low-level upcoming events, considering both topographic and inner socio-economic interactions. We introduced in this paper an integrated device able to assist former functional investigations in the domain of architecture and urban planning; we strongly believe that such environments will soon be part of designer's technical apparatus, easing its work and enhancing its sight, considering the increasing complexity of needs network, data interactions and the necessity to preserve the integrity of a dramatically threatened environment.

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"REBAR": *making the ordinary-extraordinary*

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Professor Anthony Viscardi, Department Chair

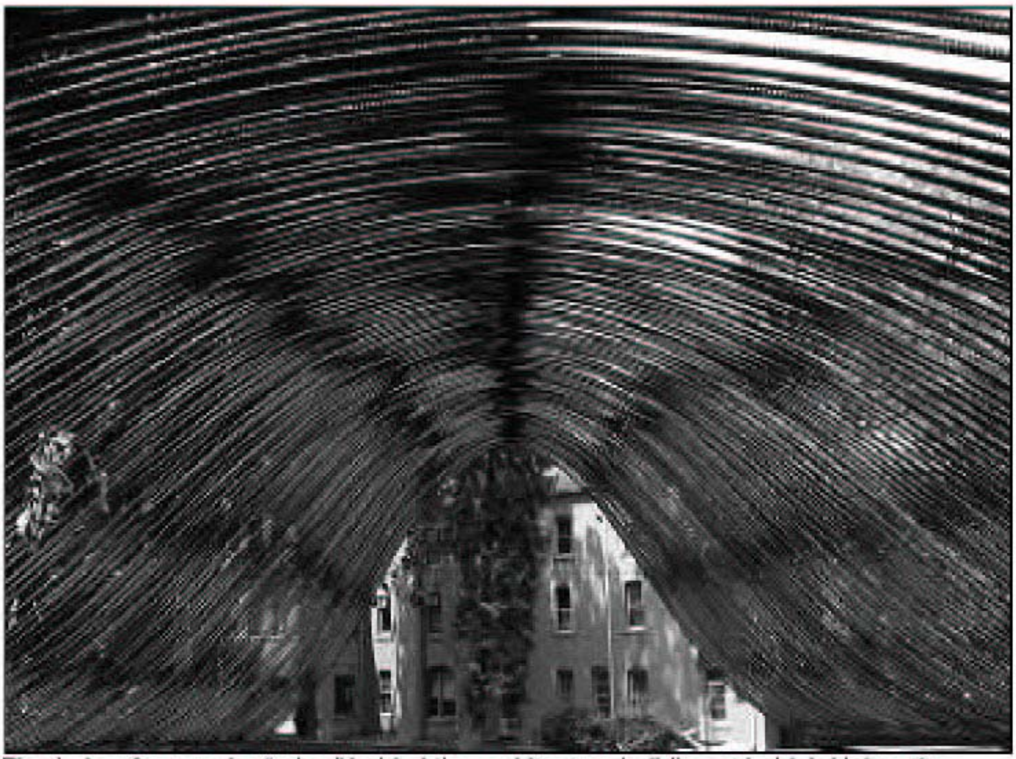

Fig. 1 view from under "rebar" behind the architecture building at Lehigh University

Creative Collaboration

This collaborative project engaged students in the exploration of rebar, a commonly used construction material, in ways that blurred boundaries between the disciplines of art, architecture, and engineering. The artist/architect, Frank Fantauzzi, was chosen as the first visiting faculty for what is intended to be a series of design/build projects in our department of art and architecture because of his critically acclaimed work focusing on site-specific urban interventions that aim to disclose the parallels between social and tectonic structures. As well, important consideration was given to his evident ability to engender a sense of group ownership through creative collaboration with students and professionals. As an architectural faculty at the University of Buffalo, Frank is familiar with abandoned industrial landscapes and appreciates the inherent beauty within their material nature. Lehigh University overlooks the renowned Bethlehem steel plant. Many of the greatest pieces of architectural construction, including the Empire State Building, the Chrysler Building, the Golden Gate and Verrazano Bridges, were realized by steel produced here. With the influx of competitively produced foreign steel and smaller companies not burdened by expensive union workers and top-heavy management structure, the Bethlehem mills closed in 1997, leaving behind a piece of American history and a vast industrial landscape slated for major transformation, a bountiful source of

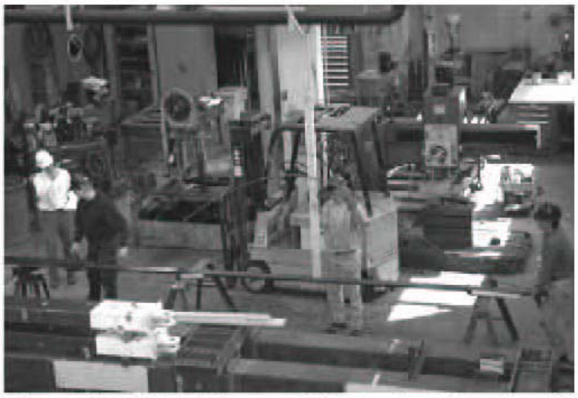

Figure 2 ATLSS Research Center testing strands of rebar for bending

Figure 3 Testing height and deformation during installation of structure on site

inspiration for our first design/build visiting artist/architect.

I initially proposed a project inspired by a visually intriguing image of an abandoned room at the Bethlehem Steel site, "The Welfare Room." In it, steel baskets once used to hold personal items of the employees are suspended in mid-air at staggered heights just as they were left when the mills closed in 1997. The now empty chalices evoke the soul of each worker. We posed the question to our students; "How does one memorialize this haunting room in an architectural design translation?" Each student began investigating possible means of transferring this ready-made installation to a place designed to amplify its potency.

During the early stages of this project we engaged in many conversations about the history of steel production and how Lehigh University played a significant role in

Figure 1 Model of proposed structure by Frank Fantauzzi and icebergprojects.com

Figure 2 Presentation to Richard Sause by Frank Fantauzzi, James Cathcart & Anthony Dong

expanding the exploration and testing of these new processes. To further explore methods and materials, we toured our Center for Advanced Technology for Large Structural Systems (ATLSS) and became fascinated by the capabilities of the Structural Testing Lab and the possibility of engaging their expertise. What began as a collaborative effort between art and architecture grew to include engineering. The "rebar" project, exploring conceptual and material transformation, emerged.

This was a rare opportunity for thirteen students, primarily from art and architecture, to work alongside world-class engineering experts. We began by investigating an ordinary material, steel rebar, commonly used to reinforce concrete, by conducting a series of studies exploring the inherent properties of rebar, including its flexibility and strength. Frank Fantuzzi, as our Artist-in-Residence, and the Lehigh students sought to test certain assumptions in order to more fully understand the latitude of this structural material. The studies, carried out by Dave Altemus, JoeCheszar, John Hoffner, Roger Moyer, and Richard Sause of the ATLSS Center at Lehigh University, performed at 2/3-scale,estimatedthe forces and deformations required to produce sculptural form sketched by Frank that would use 30 ft lengths of ¾ inch diameter rebar.

After exploring the deformation of a standard piece of rebar in the lab, we bundled several pieces together. By compressing each end of the bundle toward the center, similar to when a folded belt is pushed together to snap on the rebound, we discovered natural contours the rebar took under compressive forces. By elevating the importance of the material imagination in the creative design process, we transformed the ordinary into an extraordinary poetic architectural construct.

Once we received the results of the ATLSS Center tests Frank returned to Buffalo to engage in a series of design investigations with his collaborative design partners, James Cathcart and Anthony Dong, (icebergprojects.com). Several weeks later, they returned to Lehigh, bringing with them a large and rather unwieldy model strung with heavy gage wires stretched between two pieces of wood. The students reconvened to watch in anticipation as Frank activated the model by twisting a small piece of wood, tourniquet fashion, thereby pulling the two parallel pieces of wood together at one end to transform the rectangle into a trapezoid. The construct seemed to inhale

Figure 4 Lehigh students preparing for placement of footings

Figure 3 Lehigh students preparing rebar for welding during installation

as it formed into a graceful compound curve.

The "backbone of a whale," one student whispered. "It seems alive," another commented. In wonder about what we had just witnessed we immediately began to consider, "how are we going to build this?"

At this point in the design process it was very important to engage the engineers from ATLSS in this excitement in order to have their invaluable assistance in the fabrication and installation of "rebar". We arranged a meeting with Richard Sause, director of ATLSS, and presented our model for his review. It was as if we were once again young children in a giant playground; our shared spirit of wonder and level of exhilaration rose as the model was activated once again. The simple form of multiple parallel pieces moved in unison to form a complex and most natural hyperbolic contour. WOW!! We were now all ready to make it happen.

Site selection was the next task. We looked at several spaces on campus, each presenting a particular challenge. In the end we chose a gently sloping site, situated between the architecture and the engineering buildings, that also served to create a symbolic bridge between our two disciplines. Numerous students traverse this space frequently on their way between classes, providing the exposure and daily interaction that we desired.

After receiving approval from the university we began to survey the lot. We calculated the proper foundations necessary to transfer the loads of the 30' x 30' structure and starting digging the footings. It was very important to me that our students be involved with every aspect of this project from discussions about load calculations to the physical loading of wheelbarrows with dirt removed to prepare for the footings to be poured. No matter how difficult the task, there was never a problem in getting students to work; their enthusiasm about the project was unbounded. Frank returned to the Lehigh campus approximately every two weeks while in the interim, I coordinated the project with the engineers and arranged for our students to complete a set of scheduled tasks for Frank to review upon his return.

Figure 8 Help from friends and students from Buffalo to thread rebar into the perimeter steal beams

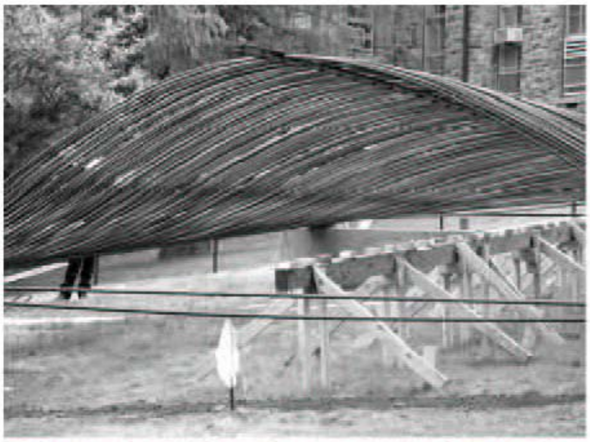

Figure 9 "rebar" takes life as post tensioning rods pull the two perimeter beams together

The framing for the footings were prepared in the shop and installed at their proper placements on the site. We consulted with our engineers and relied on our architecture and engineering majors to verify that construction specifications were followed.

The rebar was appropriately installed at specified locations within the frames. It was interesting for everyone to observe and acknowledge that the traditional use of rebar, as a strengthening device within our concrete footings, would soon support the non-traditional use of the material as an aesthetic conceptual transformation. The innovative application and transformation of this common element elevated our excitement; "rebar" would soon have in its day in the light.

While the footings were being poured the steel beams were being fabricated at the ATLSS Center. Once they were delivered to the site they were fixed temporarily to steel plates bolted to the footing projections. Now began the complicated game of threading the rebar rods into the intricate pattern Frank had devised after many experimental trials in model and drawing. The perimeter beams were numbered and the students began the process of interweaving rebar. Frank invited several of his students and friends from Buffalo to help with this process. After an arduous three-day weekend, the scene was set for the "big squeeze."

"The Big Squeeze"

Now that the 30 by 40-foot wide interwoven grid of rebar was constructed on a flat plane with the ends of the rebar threaded and welded into two perimeter steel I-beams, we all prepared for this next event. Lehigh students, faculty, and other onlookers watched with a look of puzzlement and consternation; Frank and "our gang," poised with their cameras and great expectation. The engineers brought out the big guns as they prepared the stage for the "big squeeze." The post-tensioning

Figure 5 Post-tensioning rods applied to front opening of the grid and slowly cranked.

Figure 11 Engineering consultant welding the beam into place.

rods, added to the front opening of the grid, were slowly cranked by enormous pressure, monitored meticulously by the engineers, causing the once rectangular grid to form into a trapezoid.

Figure 12 View of design/built structure called "rebar" on Lehigh University campus with architecture building in the background

As the post-tensioning rods slowly drew the front face of the rectangle together, the rebar ribcage seemed to inhale slowly, over a period of 12 hours, to arch 12 feet above the ground at its highest point. As the rebar assumed its final form, intersections of rebar were welded together to increase strength and integrity of the structure. Video cameras broadcast the event on a closed cable channel throughout the campus and on several outside web casts. This seemingly organic structure assumed its presence upon a once placid field of grass. This phenomenal space, transformed by light and shadow, and seasonal change that alternately highlights the thin rebar ribs with snow and ice or the green of the grass contrasting the rust of the rebar now activates the site.

It stands as a symbol of wonder for passersby and acts as a formal architectural shell for student gatherings and official occasions. The common material 'rebar,' was transformed from ordinary into extra-ordinary, assuming a lasting presence on the Lehigh campus, paying homage to steel and the art of collaboration in the form of an extraordinary poetic architectural construct.

End Note: All photos by author except *fig.2* by Anthony Dong and *fig. 5 by* Peter Byran.

Swarm Based Computer Music - Towards a Repertory of Strategies

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Abstract

Algorithms, simulations and data collections from the sciences constitute an important source of inspiration and manipulation for generative art. One of the main challenges in adapting such material for artistic purposes consists in the creation of aesthetically meaningful correspondences between the underlying data and the appearance and behavior of the artwork. This paper focuses on the application of swarm simulations for the creation and control of computer music. The authors propose different categories of relationships that can be established between a swarm's behavior and musical processes. These categories include: parameter mapping, proximity based events, procedural patching, physical representation. We hope that the identification and evaluation of these different categories will contribute to the establishment of a repertoire of strategies that help musicians to assess and harness the aesthetic potential of swarm based music.

1. Introduction

Generative and Algorithmic Art emphasize the employment of processes for the automated creation of artworks [1]. Very often, these processes result from algorithms, simulations and data collections that have originally been created with non-artistic goals in mind. Accordingly, artistic realization involves the challenging task of establishing meaningful correspondences between these underlying principles and the appearance and behavior of the artwork. These correspondences should take into account the perceptual peculiarities of the selected feedback modalities and need to balance innate algorithmic properties with stylistic constraints and embellishments in the creation of an aesthetic result. It is rare that a direct relationship between an algorithm and the artwork's behavior and appearance leads to satisfactory results. For example an algorithm's dynamics may be too varied and complex to perceive recurring patterns. The range and density of its output may not be adequate for the selected output modality. The algorithm's long term behavior may fail to create a dramaturgy and aesthetic tension that maintains a visitor's interest. This paper discusses several categories of relationships between algorithmic processes and aesthetic feedback. These categories have been identified based on a set of experiments that employ swarm simulations as prototypical examples of autonomous, self-organized and emergent processes and that explore methods of transforming their behaviors into acoustic feedback.

2. Swarm Music

Swarm simulations possess a variety of properties that render them particularly promising for musical and artistic applications. Swarms can exist within spaces of arbitrary dimension and topology that can be matched to the artworks feedback mechanism. Agents within a swarm tend to move in clusters. This fact can be exploited to create correlations and coherence between parameters. Agent behaviors can be easily customized to meet desired levels of complexity and autonomy for an artwork. Finally, swarm simulations support natural and intuitive forms of interaction. The application of swarm simulations for the creation of music has been explored by several artists such as [2-9].

The research that led to this publication employs software tools that have been developed as part of a project entitled Interactive Swarm Orchestra (ISO) [10]. The activities within this project are twofold. They include research that addresses theoretical and practical aspects of swarm based computer music [11]. In addition, they deal with the development and distribution of generic software and hardware tools and their documentation in order to facilitate the realization of swarm based computer music [12-13].

3. Relationship Categories

This publication describes a series of experiments that served to identify and evaluate different categories of relationships between swarm simulations and musical creation. These experiments have been realized by creating software applications that combine several ISO related software libraries such as ISO Flock (a library for swarm simulation) and ISO Synth (a library for sound synthesis, signal processing and sound spatialization). The applications have been tested on a mobile installation (ISOkaeder) that consists of 20 speakers positioned within the corners of a Dodecahedron structure. Within the interior of this structure, the audience perceives spatially distributed sounds via three-dimensional ambisonic sound projection. All examples employ swarm simulations both for the creation and positioning of sounds. The individual examples differ with regard to the method of sound creation, and the relationship between swarm behavior and acoustic result. All examples are identical with respect to the mapping of agent positions to sound positions. The position of sound sources is directly derived by normalizing the position of individual agents. The only exception to this rule applies when sound sources are placed very close to the origin of the coordinate system that defines the installation's speaker positions. In this case, the position of the sound sources is offset to the surface of a sphere whose center lies at the position of the origin and whose radius corresponds to a predefined proximity threshold between the sound sources and the origin (see figure 1).

The examples that are described throughout the following sections have been categorized based on the relationship between swarm behavior and acoustic result. These categories include: parameter mapping, proximity based events, procedural patching, physical representation.

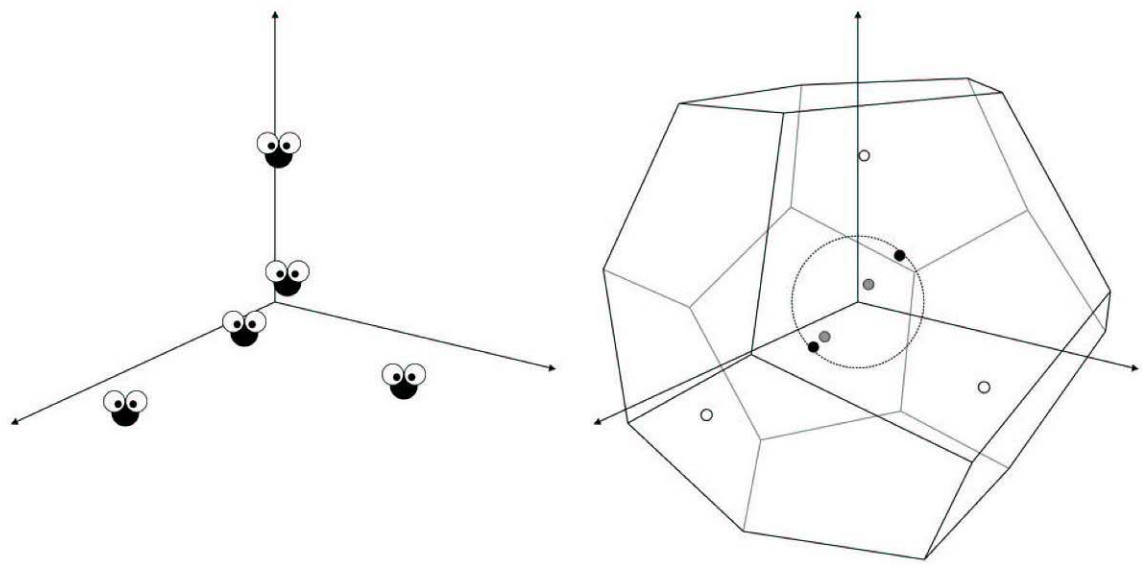

Figure 1: *Swarm Based Sound Spatialization. Left side: swarm of agents. Right side: sound sources placed within a dodecahedron structure. Filled gray circles represent sound sources whose proximity to the origin is below a predefined threshold (depicted as central circle). Filled black circles represent sound sources that have been moved onto the surface of the threshold circle. Empty circles represent sound sources whose position has not been altered.*

3.1 Parameter Mapping

The simplest and most commonly applied correspondence between swarm behavior and musical result employs a fairly direct mapping from agent properties to musical parameters. To match the number of musical parameters that should be controlled by a swarm, the dimensionality of individual agent properties is adapted or several agent properties are combined. Subsequently, the values of these agent properties are scaled and possibly discretized to limit the range and diversity of values that the musical control parameters can assume. Regardless of the specifics of the mapping, this type of correspondence renders the characteristics of swarm behavior clearly perceptible in the musical result. The music is usually made up from a collection of acoustic elements whose number matches the number of agents and whose properties cluster more or less strongly depending on the strength of attractive and repulsive behaviors among agents. In addition, the musical dynamics exhibits correlated acoustic movements whose velocity and diversity matches those of the underlying swarm.

3.1.1 Additive Synthesis

In this example, several sine oscillators, whose number equals the number of swarm agents, sum their output to create the final acoustic feedback (see figure 2). Each agent controls its respective sine oscillator by mapping the y component of its position to the oscillator's frequency and the z component to the oscillator's amplitude. Depending on the spatial distribution of the agents, the acoustic contributions of the individual oscillators are clearly discernible or their output fuses into a single tone. The oscillators' frequencies and amplitudes sweep according to the agents movements. The velocity of these sweeps depends both on the movement velocity of the agents and the update interval of the swarm simulation. This update interval is much slower than audio rate and leads to temporal discretization. This discretization becomes audible at a simulation update rate lower than about a 1/20th of a second.

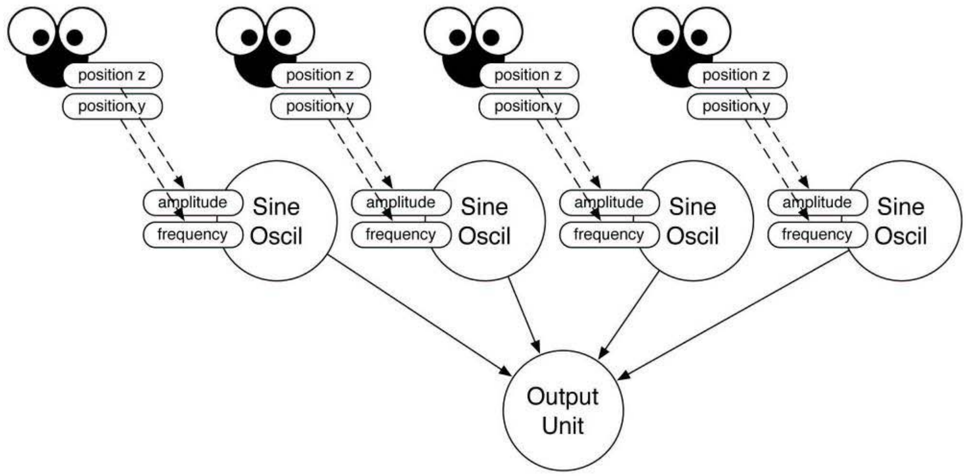

Figure 2: *Swarm Controlled Additive Synthesis. Labelled circles represent audio units. Rounded text boxes represent agent properties and audio control ports, respectively. Solid arrows correspond to signal paths between audio units. Dashed arrows represent mappings from agent properties to audio unit control ports.*

3.1.2 Granular Synthesis

This example also employs parameter mapping but assumes a slightly more sophisticated approach. First of all, it maps those agent properties that reflect the behavior of the entire swarm particularly sensitive well. In addition, musical parameters at updated more frequently than the simulation rate. This effect is achieved my mapping the properties of several agents at slightly different times to a single musical parameter. More technically, the agent parameters are written into control buffers at positions that are specific for each agent (see figure 3). The synthesis engine reads these buffers and applies their content at audio rate to control the corresponding musical parameter. The write position within these control buffers is determined by discretizing the x-component on an agent's position. The resulting index represents the temporal position when the agent's properties take musical effect. The more agents a swarm contains and the further they spread apart, the more frequent the acoustic feedback changes.

This example employs granular synthesis to generate sound. Grains are created by extracting short stretches of audio samples from a ring buffer into which the content of an audio files is continuously fed. When the grains are played back, the samples they contain are multiplied by a bell shaped amplitude envelope. The output of all grains that play simultaneously is summed. Each agent triggers a single grain and controls the characteristics of this grain during one update interval of the sound synthesis engine. The x component of an agent's position controls the trigger time of the sound grain. The amplitude of an agent's velocity determines the playback rate of the grain's content. The direction of the agent's velocity determines the position within the ring buffer from which the grain's content is created. The average distance between an agent and its neighbors determines the duration of the grain. The shorter this distance, the longer the duration of the grain. Finally, the more neighbors an agent possesses, the larger is the amplitude of the corresponding grain.

This parameter mapping creates a musical result whose perceived similarity to the original audio material is strongly dependent on the properties of the swarm. Coherent agent movement is represented by little variation in the agents' relative positions and velocities. Accordingly, grains are chosen and played in the same sequence as the audio was stored in the audio file. In addition, compact swarms result in the formation of clearly audible and continuous audio output whereas agents that are scattered far apart lead to the creation of faint and short audio fragments that fail to merge into a continuous audio stream.

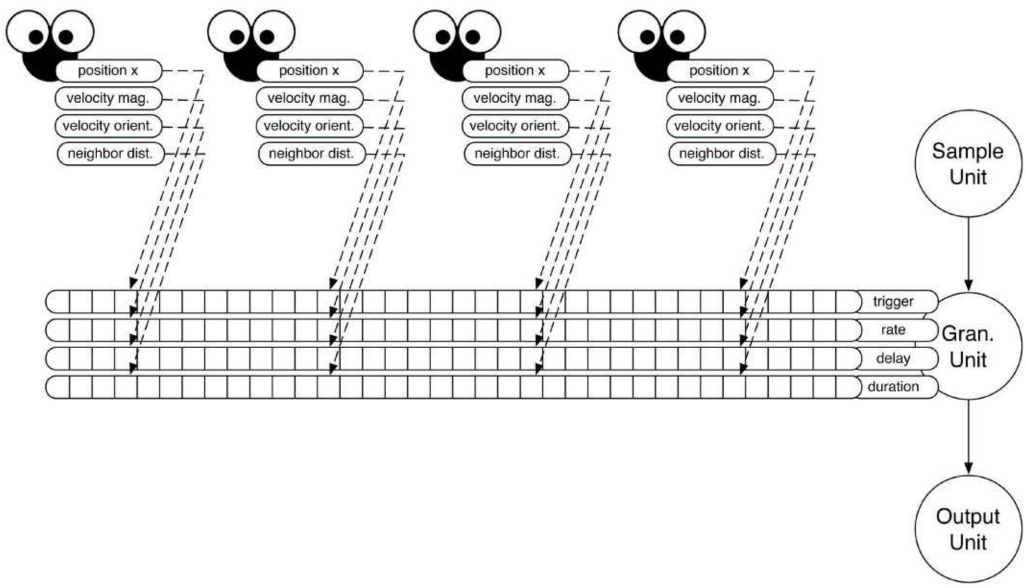

Figure 3: *Swarm Controlled Granular Synthesis. The one dimensional grid patterns represent audio unit control port buffers. Dashed arrows represent mappings from agent properties to particular positions within these buffers.*

3.2 Proximity Based Events

The distinct spatial properties of swarms can be exploited by establishing proximity relationships between agent properties and musical control parameters. Both the agents' properties and musical control parameters are projected as points into a shared space. The euclidian distance between these points may then be employed to change musical properties of trigger musical events. This approach is attractive because it takes into account the inherently spatial nature of swarms. The properties of the shared spaces can be adapted to deal with different musical topologies. Since the number of agent properties does not need to match the number of control parameters, this approach offers good flexibility when the number of agents or musical control parameters changes throughout the course of a musical piece. On the other hand, this approach may introduce some computational overhead due to the possibly many distance calculations that need to be performed. This problem can be addressed by employing appropriate space partitioning techniques. The ISO Space programming library offers a small variety of such techniques such as fixed spatial grids or hierarchical region trees that are applicable for any dimensionality.

3.2.1 Sample Triggering

This example represents a very simple application of the previously described technique. The example employs an audio patch that consists of several sample playback units and whose output is combined to create audio feedback (see figure 4). Each of these units has a three-dimensional position associated to it which is mapped into a three-dimensional euclidian space. The agents' position parameters are also mapped into this space and updated continuously as the simulation progresses. Whenever the sound synthesis engine updates, it evaluates the distance between the positions of the agents and the sample playback units. If this distance falls below a certain threshold, the corresponding audio sample is triggered. A sample keeps playing as long as the distance remains below the specified threshold. The amplitude of sample playback is inversely proportional to this distance and causes samples to fade in and out when agents move close by. Despite its simplicity, this approach illustrates some of the possibilities of a spatial approach to swarm music. For example, the probability that similar audio files play concurrently can be increased by assigning close-by positions to the sample playback units. These positions may also be placed at regular intervals to facilitate the creation of rhythmic patterns. Both the audio files characteristics and the units' distribution patterns may vary across the entire space. An entire composition may then unfold as the agents move slowly through this space.

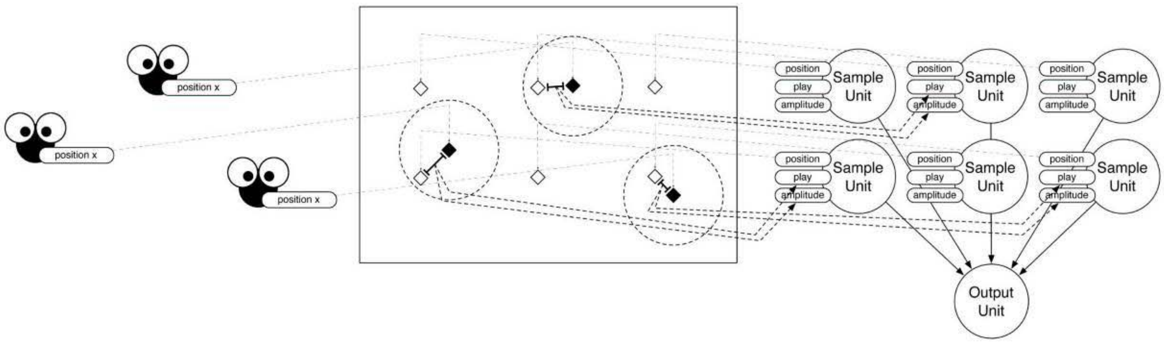

Figure 4: *Proximity Based Sample Triggering. Both agents (depicted on the left) and sample playback units (depicted on the right) possess positions within a shared Euclidian space (filled black diamond shapes designate agent positions, empty diamond shapes designate audio unit positions). Dashed circles represent proximity thresholds among agent and audio unit positions. Black bars stand for neighborhood relationships among these positions.*

3.3 Procedural Patching

In all the categories that have been presented so far, the role of a swarm was limited in that it could only modulate pre-specified control parameters of a pre-existing musical patch. Procedural patching concedes an entirely different and much less constrained role to a swarm. Here, a patch is constructed on the fly according to rules whose execution depends on the behavior and properties of the swarm. As the swarm simulation progresses, the musical patch will continue to evolve as the rules are applied over and over again. This approach offers by far the greatest flexibility but also poses mayor challenges for finding satisfying technical and aesthetic solutions. The technical challenges include the following aspects: the sound synthesis engine needs to support life patching functionality (at the time of this writing, this functionality is only partially implemented in ISO Synth), the resulting patches produce output signals whose dynamic range is within the allowed boundaries for audio data (i.e. in between -1.0 and 1.0), the computational demands of the resulting patches stays below the processing power of the computer. The aesthetic challenges stem from the fact that the introduction of patch construction rules adds an additional levels of design decisions and complexity to swarm based computer music. The swarm in itself represents a generative system that is difficult to exploit musically. A rule based patch construction system represents a second generative layer. Accordingly, it is very hard to make aesthetically informed design decisions for such a two layer system. In addition, it is difficult to preserve the acoustic recognizability of a swarm's behavior across the level of patch construction rules. Despite these challenges, procedural patching is likely to become one of the aesthetically most rewarding forms of swarm based computer music.

3.3.1 Modulation Synthesis

In this example, a swarm simulation controls the topology of a musical patch that consists solely of sine oscillators (see figure 5). The patch exists in two versions, a silent version that is in the process of being created by the swarm and an active version that produces audio output. Whenever, the silent patch is finished, the two patches switch their roles and all the connections between oscillators in the formerly active patch are severed. Every agent possesses two oscillators (one in each patch version) that remain assigned to it as long as the agent exists. The connections among the oscillators are established based on the neighborhood relationships among agents. The first agent that is selected from a group of neighboring agents as well as all agents that possess no neighbors connect the output of their oscillators to the final audio output of the sound synthesis system. The frequency and amplitude of this oscillator is directly controlled by the agent's position. Agents that appear as neighbors of these first agents connect their oscillators to one of the control ports of these output oscillators. The modulation amount and modulation frequency are controlled by the neighbor's distance. In the sequence of increasing distance, the first neighbor attaches its oscillator to the amplitude control port, the second one to the frequency control port and the third one to the phase control port. Additional neighbors are treated as first agents and connect their oscillators to the output unit. Agents that are neighbors of neighboring agents connect their oscillators to the control ports of oscillators that are already connected to other control ports. By this way, a modulation tree emerges that represents the neighborhood relationship among the agents. If agents are scattered far apart, all the agent oscillators produce a directly audible output and an audio feedback that possesses a constant spectrum results. At the other extreme, if all agents form part of the same closely packed swarm, only a single oscillator produces an audio signal but this signal is heavily modulated by a very large modulation three. Therefore, as a swarm's density varies, the method of sound synthesis will gradually shift in between additive and modulation synthesis.

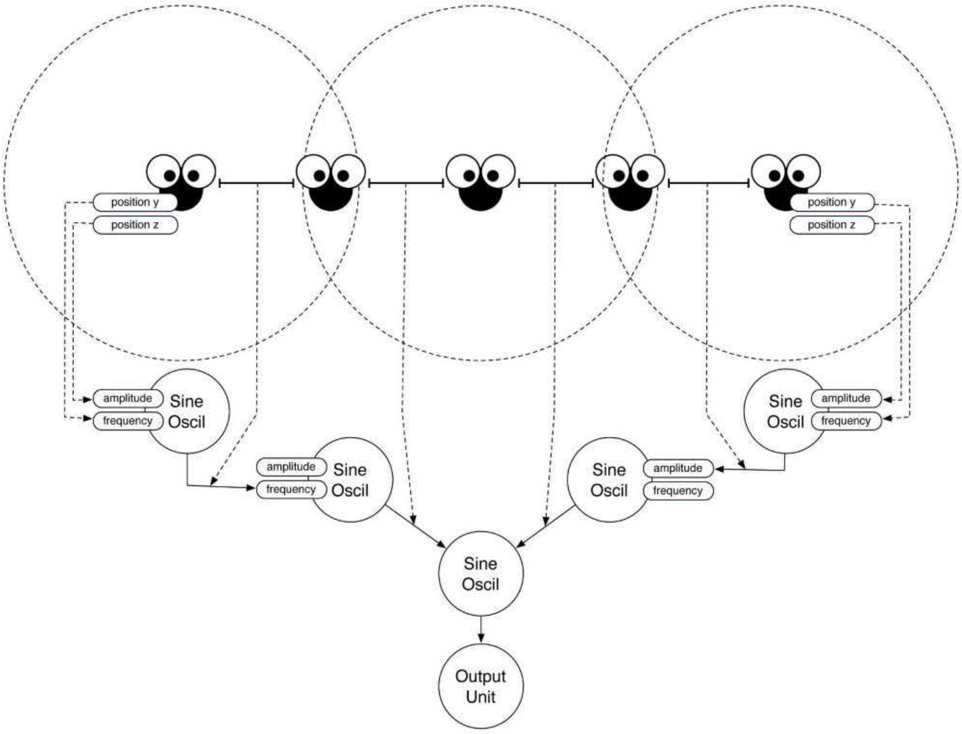

Figure 5: *Agent Neighborhood Based Audio Patch Creation.*

3.4 Physical Representation

Most swarm simulations bear similarity with particle based physical simulations. Agents act as point masses that are subject to proximity dependent attraction and repulsion forces. Physical modeling plays an important role in sound synthesis. It therefore seems attractive to merge swarm simulations with those physical modeling techniques that simulate forces acting among particles in order to reproduce natural acoustic phenomena. This approach is promising since it combines the benefits of realistic sound models with a swarm's capabilities for self-organization and emergence. Accordingly, the emphasis of this approach lies on the creation of an acoustic output that is characterized by naturalness and familiarity in its sound texture and temporal dynamics. The design of this type of swarm based computer music is less prone to problems of arbitrariness and contrivance than those described previously. Here, design decisions involve the selection of swarm models and physical models that share similar characteristics as well as the weighting of their respective behaviors.

3.4.1 Mass-Spring Networks

In this example, swarm agents assume the role of mass points in a mass-spring network (see figure 6). Springs are created and destroyed based on the neighborhood relationships among the agents. The oscillations of these springs generates the acoustic output. The damped springs are continuously excited via white noise. Springs are excited most strongly when they are created or severed. The swarm controls the amount of coupling between the springs. Uncoupled springs oscillate at unrelated frequencies. The resulting sine waves are perceived as individual sound sources. Coupled springs influence each other's oscillations. The larger the number of coupled springs and the more linear the arrangement of their connections the closer the mass-spring network approximates the behavior of a string. In this arrangement, the springs produce sine waves whose output merges and is perceived as a single sound that possess a harmonic spectrum.

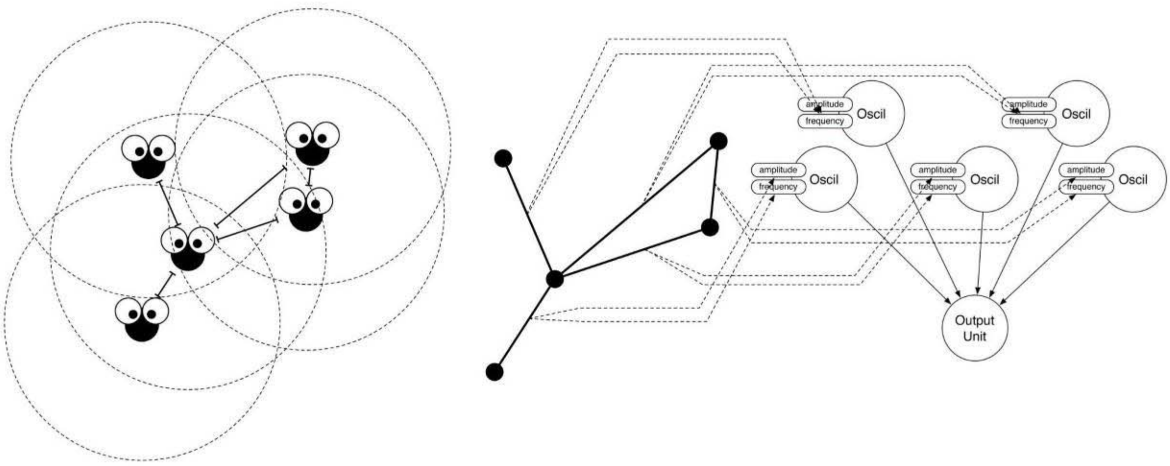

Figure 6: *Agent Neighborhood Based Mass Spring Network. Filled black circles represent mass points, strong black lines represent damped springs.*

4. Results and Conclusions

The evaluation and establishment of design strategies for the creation of swarm based computer music forms an essential part of our research within the context of the ISO project. The identification of several categories of swarm music relationships represents an important step towards our goal to help musicians to assess and harness the aesthetic potential of swarm based music. We hope that this publication convinces the reader that swarm based computer music still possesses largely untapped potential and that its greatest promise is likely to lie beyond parameter mapping based approaches. We believe, that some of these results are of relevance outside the realm of swarm based computer music and therefore may inspire other research within the field of generative art.

Obviously, additional research and artistic experimentation is required to further advance swarm based computer music. So far, in all our acoustic experiments, sound spatialization has been restricted to a direct mapping from agent position to sound position. It is clear that future experiments need to explore more diversified approaches to swarm based audio spatialization and study their effects on immersion and spatial perception. Furthermore, in all our experiments, swarms have existed in spaces of Euclidian topology. In our future research, we would like to substantiate our statement that a swarm simulation's spatial topology can be suitably adapted to match an artwork's specific feedback.

The relationship between swarm behavior and performer activities constitutes another important aspect of swarm based computer music. In a previous publication [Bisig et al. 2008a], we have outlined some aspects of human swarm interaction in a somewhat speculative manner. We are well aware that this issue deserves a more systematic and empiric approach. Accordingly, the next research phase within the ISO project focuses on conceptual, technical and artistic aspects of human swarm interaction.

Finally, we believe it is important to concede a more significant role to artistic creation within our future research. Both members of the ISO research team as well as independent composers and musicians should de-emphasize short technical and aesthetical experiments in favor of dedicated musical compositions and public performances. This approach constitutes the only viable method to assess the capability of swarm based computer music to generate musically fertile results that capture an audience's interest over sustained periods of time.

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Generative features: a parametric approach for exploring novel potential in architectural design process

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Premise

The use of design generative technologies, parametric in particular, opens the ground for achieving at different scales a more immediate exchange of information, exploring new alternatives in spatial and formal features.

The production of a new generation of models that are parametrically generated has been creating novel design environments in which changing design choices, formal explorations, technological assessments and energy related aspects could be intensively connected from the beginning of the process and so not “in addition” to architecture. The possibility of constructing, redefining and updating feature components could generate synergetic models of production. Buildings become evolving configurations.

This text is looking at a comparison between the design of the built infrastructure of the Li Cuponeddi Viaduct in Sardinia (2005, Italy) and the parametrically generated proposal for the bridge on the Pertusillo Lake (Honorable Mention. International Competition 2007, Basilicata, Italy). This bridge is the first conceived green bridge that is an energy producing/storing machine. In the first project the parameterization has played in the design process a fundamental but more conventional role in the transition from drawings to construction and to satisfaction of the EIA (Environmental Impact Assessment) prescriptions. Innovative parametric and generative design systems, as GenerativeComponents™ exploited in the Pertusillo project, bring a novel generative potential, especially if applied to projects with a great complexity. The production of ‘components’ and their inter-relationship, instead of a more conventional design of a single form, could become a new generative potential to shift the scale and stimulate creativity in the design process.

1. Introduction

1.1 Re-designing architectural processes with parametric systems

Innovative design methods have been stimulated both at the professional and at the academic level by experimentation on tools and concepts very significant in the contemporary architectural discourse. Recently, substantial progresses in architecture have been made thanks also to the increasing presence of computational means in all the phases of design process, to new construction techniques enhanced by digital fabrication, to the research into innovative materials and building components responding in a more responsible way to the environment. At the same time some of the most cutting-edge design systems derive directly by the building industry, as an interesting non linear reaction process: a pressing demand for new regulatory paradigms, more economical, efficient and up-to-date, to guarantee the constructability of the non standard complex forms that mark largely contemporary architectures.

An important aspect of these feeding back trends, currently developing with very different timeline of urgency and degree of acceleration worldwide, is a mutating relationship between the intuition of a certain design idea and the execution of it, with a strong impact on architectural design. The sophistication of tools capable of linking and controlling simultaneously different aspects of the design makes more efficient the transition between design and construction, suggesting more productive modalities of working that needs still to be investigated.

In our experience with parametric design systems – in particular with GenerativeComponents™ of Bentley Systems [1] - we observed a facilitation of an ongoing exchange of thoughts, ideas and actual activities. This went beyond the relevance of gaining accurate model simulation and the information-based organization of files typical of digital design technologies.

Robert Aish observes: “Many CAD applications claim to be parametric. Typically these applications use discrete elements or components that represent some application domain. For example, in an architectural domain, these elements or components might be walls or floor slabs. Each type of elements might have a series of defining properties, for example, ‘thickness’. The user gives a numeric value to define this property. Subsequently these values for the properties of one element can be changed, and that element updates (in isolation), but there are no logical connections between the components and no algebraic connections linking the value of one elements property to another element’s properties…At the next level of sophistication we find ‘solid modelling’ applications such as: Solid Edge, Solid Works, Inventor and Topsolid. These applications can correctly claim to be parametric. In these packages, complicated ‘feature trees’ can be built using geometric primitive (or features) such as rectangular slabs, cones, spheres, etc. and ‘boolean’ operations such as union, intersection difference. These applications also implement domain specific features for mechanical engineering such nuts and bolts, countersunk holes, and other typical machining operations...” [2]

In GenerativeComponents™, continues Aish: “You can draw relationships that are complete graphs…In most cases you are building a propagation network that represents your design. You are deferring the final decisions on size shape and design until later on, allowing instantly updateable change later on.” [2]

We are surrounded by many interesting applications of computational languages that drive design development in architecture and art. However, a parametric environment seems to us particularly suitable for creating a highly controlled and structured process that simultaneously enhances creativity. A parametric model built through a series of constructional steps opens the possibility for the designer to intervene to make choices in the evolution of an initial conception nurtured by multidisciplinary agendas (formal definition, structure, landscape impact, energy awareness, fabrication process). This stimulates an attitude towards exploring alternatives and updating the first assumptions.

In our practice, the use of generative and parametric design tools was definitely an interesting testbed not only to investigate modalities to spin off the potential of this new family of advanced design systems, but also to open up the research on re-designing the *course of formation* -instead of the form- in the process.

1.2 System of interrelated components

In the CAD programs we generally use, the elements don't have a memory of their generation process. The features generated in GenerativeComponents™ conserve the information on the logic of their creation. It is possible to go between the set transactions that control the geometry definition and the parameters that regulate geometrical relationships, from the basic connectivity to more complex behaviour. Thus, the feature can be regenerated with an updated logic.

Transactions describe through a set of 'constructional steps' the organization of "components" and the *design* of their inter-relationship through variables and algorithms generating *seeding files* with differential layers of immediate real-time accessibility.

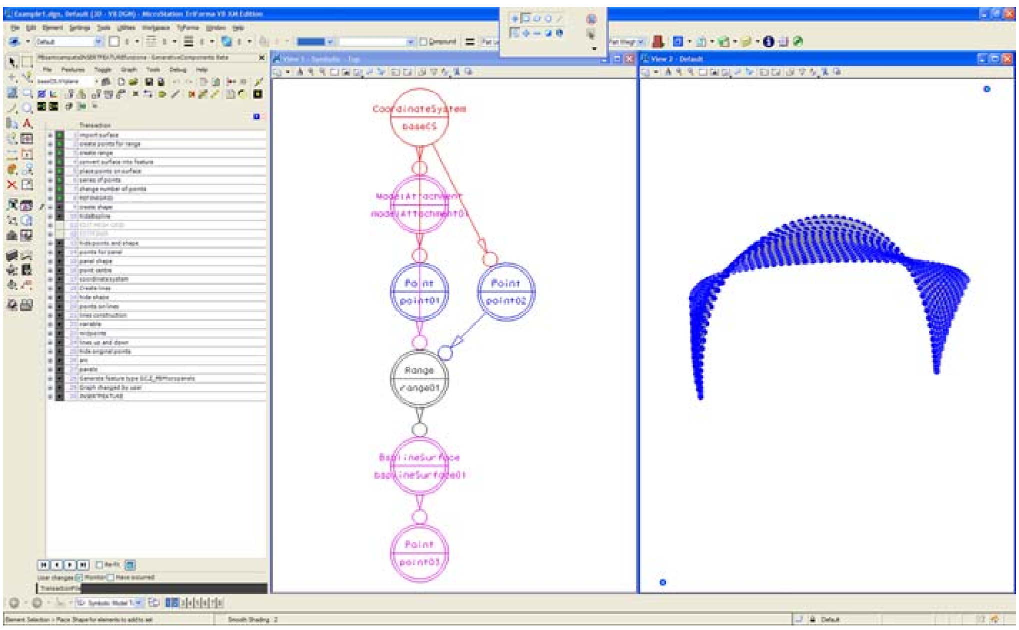

Figure 1: GC Tool Bar, Symbolic Model Window, Geometric Model Window. Screenshot from a study model in GenerativeComponents for the Pertusillo project proposal

Instead of the more conventional *design of a form*, the digital storing of information and its verification by structural, construction and environmental post-considerations, the possibility of constructing, redefining, updating, and reapplying feature components by multiple users breed actual activities of intervening into the information flow as the design advances. Various generations of models can be parametrically generated in this progress. Scale-control and measures-storage assumes changeable characteristics. The systems can be controlled with an ongoing testing of the propagation of change spreading from the updated component(s) automatically to the other interrelated components.

In addition, advanced design systems if thoughtfully channeled into the design process can heavily act for mediating the contacts and accelerating international sharing. The design, adapting to novel environments produces evolving building configurations to respond with alternatives immediately testable to site constraints, environmental issues and program demands.

The new potential to shuffle more easily the scale assumes particular relevance when dealing with complex projects involving energy production and environmental remediation - see the combined use of Ecotect™ and GenerativeComponents™ in the Pertusillo project proposal - in a advancedly coordinated fashion without losing systematicity. Particularly compelling is the possibility to generate a synergy of ideation/production of form/structure/energy and construction that sprouts from the first initial conception design, accumulating or shrinking information depending on design phasing and requirements.

These systems allow the possibility of arranging a wider number of components and calculated their interferences and mutual adaptation. The relationship between the part and the whole gets also reconfigured if adaptability to environmental factors can be thought into the same model. One of the most intriguing idea offered by a parametrical re-configuration of the endeavour in design process, seems to us the possibility to pass from a building system based on serial production to a system based on adaptable series that is potentially variable depending on the variability of the planned parameters. A systematization of the process should engender much debate to make actual a direct interaction of the geometry of complex forms with the elements of the production/factory, leading to new experimentations on spatial innovation in architecture with competitive costs of accomplishment.

We will examine in this text ways of managing the arrangement of complex set of components we experimented in the construction of the built infrastructure of Li Cuponeddi viaduct of San Teodoro in Sardinia, through a computer process that allowed pre-control of dynamic actions and construction tolerances. The final assembly resulted satisfactory for the operating traffic standards and for the EIA prescriptions. We tested a further step in our proposal for the competition of a bridge on the Lake Pertusillo in the Region Basilicata, Southern Italy. Since the first design idea, the bridge had been thought as a generative system parametrically. The first case focus on the parametric set up of the components in relation to the construction process and to the environmental requirements. The second case look at the incredible potential of re-generation and adaptation of features parametrically generated, with strong implication for constructional issues and environmental responses.

2. Parameterization of the bridge profile - Li Cuponeddi viaduct

2.1 Description of the project

The project to which these images refer is relative to the Li Cuponeddi viaduct that connects the S.S.131 DCN highway to the city of Olbia (Sardinia, Italy). This was opened to the traffic in June 2005. The main structure resulted from a combined construction technique made by paired corten steel girders and reinforced concrete. The architectural configuration of a 'double wave' both in plan and in elevation has been driven by special prescriptions for the infrastructure mitigation of Enviromental Impact Assessment (EIA).

Figure 2: View of the Li Cuponeddi viaduct

Figure 3: View from the lagoons and the belvedere

Since the first steps of the design process this operation has implied an intensive relation between the effective design production site (Cagliari), the engineering (calculation) consulting firm (Turin), the construction location of the industrial formwork (Milan) and the prefabrication factory of the ribwork of the enveloping shields (Forlì).

The Li Cuponeddi viaduct shows two separated lanes; it begins with the greatest 27 meter span between the decks, at the level of the banks, and continues with ascendent and descendant converging carriageways. The descendant 635 meter span is split into eight 70 meters long central bays, plus the two lateral ones 40 and 35 meters long respectively. The ascendant 623 meter span is split into eight central bays; the last two edges are respectively 28 and 35 meters long**.** The deck, in addition to the two lanes, is provided with a parking lane, 3.50 meters wide, separated and protected by a raised kerb 50x20 properly marked, with a 3 meters wide sidewalk, in the middle, to allow the stop of the birdwatchers. Therefore the deck shows, in the horizontal plan, a variable section due to the dimensions of the sidewalk. The lateral shield that has mainly the function of a balustrade, is constructed in precast concrete adapting to a curvilinear path, both in longitudinal and in transversal section. The shape of the shield allows veiling the main steel structure confering to the architecture an appearance that remembers a wavy motion.

The system pier-capital is similar from an aesthetic point of view to the deck course. The pier shows an elliptical section that is variable and increasing from the capital, where it presents the shortest transversal section, to the insertion into the plinth. The capital is constructed with two brackets embedded at a straight angle in correspondence of the transversal axis of the pier, forming, in the superior plan where the deck loads are expected, a cross of about 9,20x2,90 meters. The insertion of the two brackets into the pier is obtained with curvilinear connections to confer to the architecture the appearance of a goblet. The viaducts, with a continuous girder frame, are bounded to the lowest banks.

2.2 Parametric construction of the precast concrete reinforced shields

The viaduct shows a mixed construction system steel-concrete with a structural diagram of a 10 span continuous beam. The steel girder frame is constituted by two adjacent beams, with a 7.20 meter span, realized with a framework scheme of costant height and crossing diagonals. The beams are then connected by means of horizontal bracings above and below and vertical diaphragms, in a way that they can constitute a box beam stiff to torsional stresses following the Bredt model. The slab collaborates structurally with the metallic structure below by means of electrowelded connectors type Nelson on the above longitudinal edges of the frameworks.

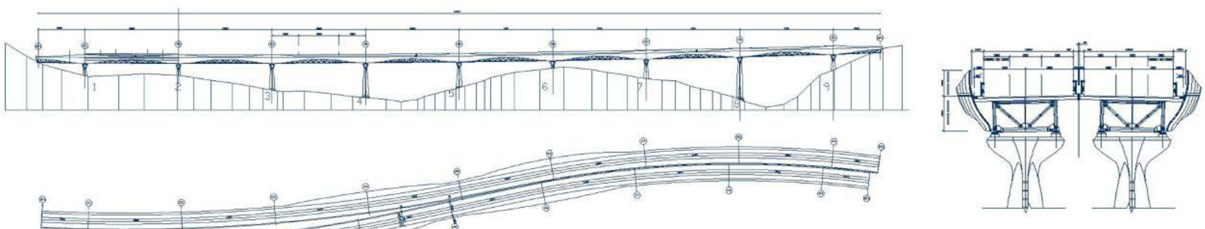

Figure 4: Li Cuponeddi viaduct: plan, elevation and section

The parameterization in this project played a key role in the normalization of the drawings of the girders and of the industrialized formworks relative to piers and capitals through the exchange with the various actors involved and the optimization by consecutive phases due to the specific technologies involved in the process.

Another significant application of the work in this project was related to the construction of the enveloping shields. The design was done in the office in Cagliari and transmitted to the prefabrication works, with particular care to the gain joints into the spatial bend, which drives to an architectural configuration in a “double wave” shape.

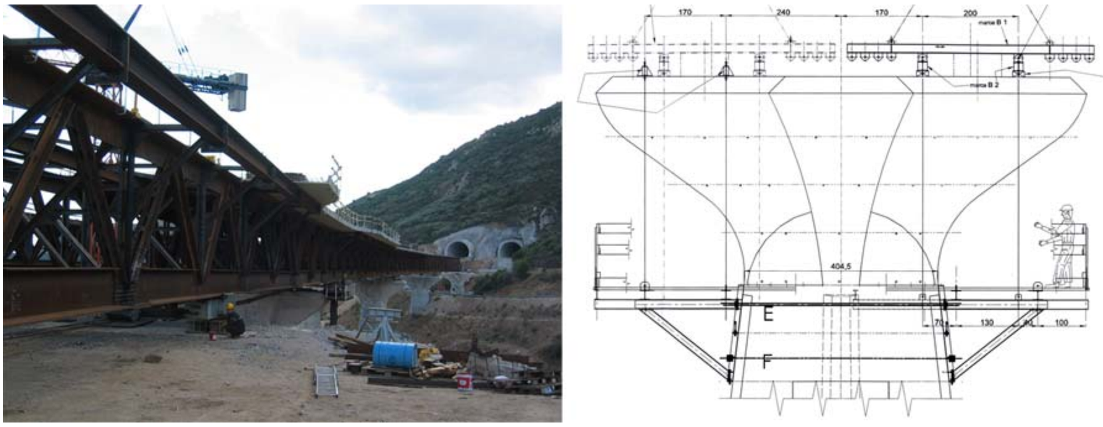

Figure 5: Corten steel girders and capital formworks

Particular attention for the design, construction technique and assembly logic was made at the factory in Forli for the prefabricated shields with a height range from 2,90 meters to 7,50 meters. Their joint chair welded to the edge of the deck marks the center of gravity of the individual shield to accomplish the difficult traverse assembly due to the strong winds blowing through the Cuponeddi deep valley.

Figure 6: Construction and assembly of the sinusoidal concrete shields on site

Figure 7: View of one concrete shield component and the overall sinusoidal enveloping shape

3. A generative approach driven by parametric methodology - The bridge on the Pertusillo Lake[3]

3.1 Design concept

In the project for a 700 meters span bridge for cars and pedestrians situated in a natural protected area on the Pertusillo Lake, (Potenza, Italy), parametric design plays a critical role in allowing a synthesis of the formal, structural and energy-related premises of the proposal. This affects both the effective design model production and the team operational work as the project advances.

The model developed in GenerativeComponents™ facilitated in fact extremely an ongoing investigation of alternative solutions during the competition phase. After defining the main model relationships, the team working in different locations (Cagliari-Italy, London-UK, Munich-Germany) has been allowed to continuously adjust design scenarios as an interplay of form/structure and energy considerations. This process results in a still open balance between design imagination and efficiency of the production.

The technical and structural features of the bridge actually define an experimental formal solution that integrates the insertion in the environmentally sensitive context with energy strategies innovative for a road infrastructure.

[3] Honorable mention at the International Competition for design project of the bridge on the Pertusillo Lake in Val D'Agri, May 2007. Project team: ASPX/ Ludovica Tramontin, Vittorio Tramontin, Giuliana Secchi, Alessandro Uras + Kristine Mun. Structural engineering: Asko Fromm. Fabrication algorithm for the physical model: Davide Madeddu.

The impact on the landscape of the Pertusillo Lake, characterized by particular aesthetic and environmental valence, is controlled sensitively with a low profile course, slightly curvilinear to simulate a phyto-morfology of a stalk of a lacustral plant. The phyto-genesis creates a metamorphical appearance thanks to ligh-tech and photosensitive metallic and transparent materials used for the skin. This brings a continuous artificial built / natural landscape variance depending on the incident rays of light and the reflections modulated by the waves of the water, varying in the day and night, with the change of the local climate, and with the seasons that follow one another.

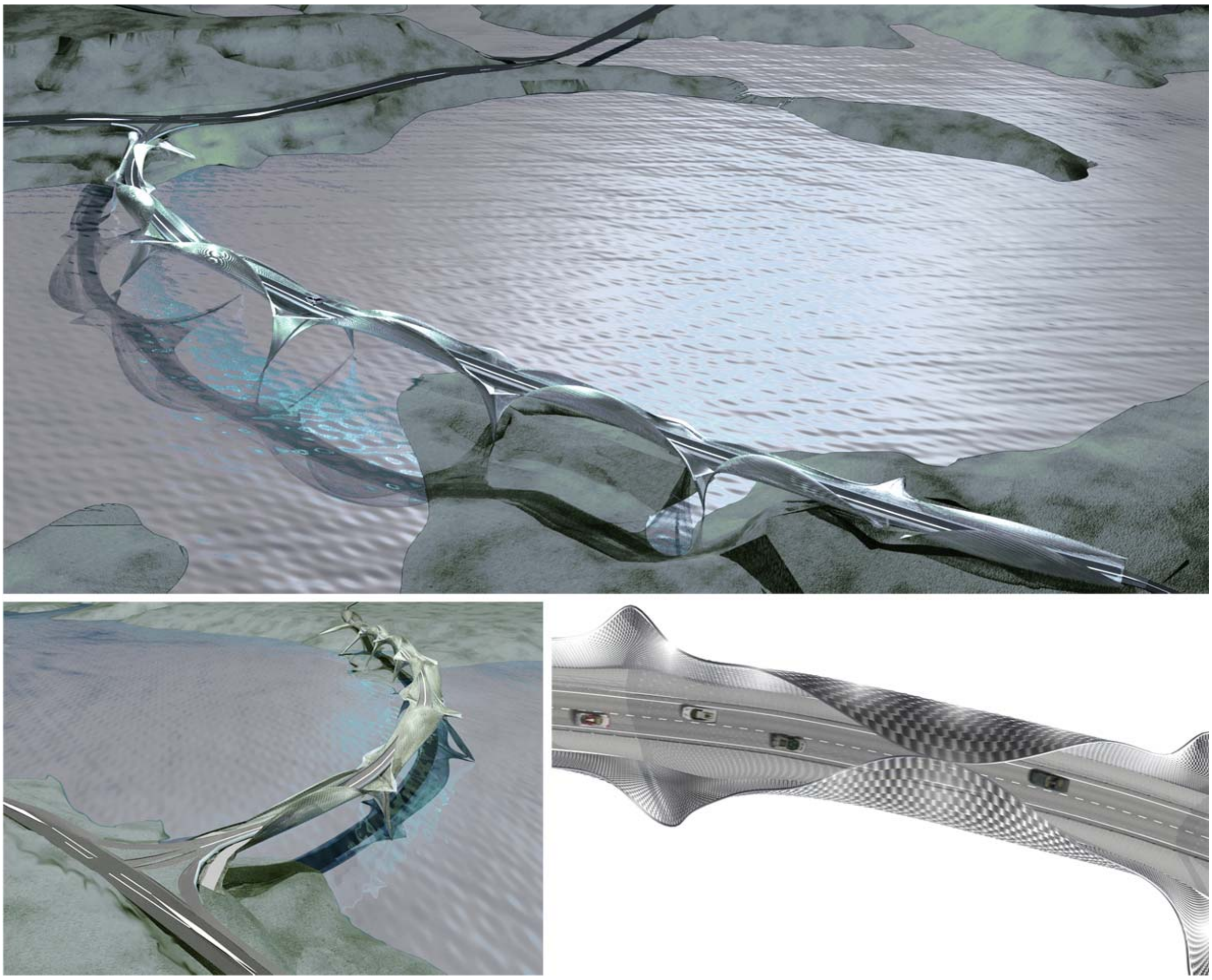

Figure 8: Views of the proposal for the bridge on the Pertusillo Lake

The architecture of the bridge so defined wants to become an interaction environment hosting the possibility of a hybridizing process that changes the built in landscape and the architecture into a temporary geography. The search is therefore orientated to a naturalistic condition of the infrastructure characterized both from physical and virtual duality.

Thus the project discuss how to establish in the insertion of the bridge a novel alliance with the landscape that, starting from fixed category of reference, becomes almost by paradox necessity of a continuous mutation for the project and more generally for the established conditions of architecture: multiple design scales, sustainable transformation processes, building technologies.

The formal configuration derives by tubular steel arches that constitute the ribbed support of the continuous steel mesh generating a homogenous shell structure resisting to eventual seismic stresses. The arches show different spans and different profile heights standing organically out in the the lacustral landscape. The tubular steel is founded in subalvee concrete caissons on pilework.

Figure 9: Views from inside the bridge shell structure

3.2 A photo-sensible skin for the bridge

The ‘visible’ skin of the architecture is constituted by light wavy and modular screens in aluminum and polycarbonate that alternate to favor the enjoyment of the landscape as one drives/walks across the bridge, reducing the impact of the vehicles in motion at the same time.

The skin was calculated in GenerativeComponents™ by a parametrization of the digital model of the surfaces in modular components, allowing an interactive relational work between structural, energy hypothesis and variables controlling the geometry of the form generation. The parametric analysis was deployed towards a discrete understanding of more elaborated geometries into relational connections between individual modules, through the analytic control of parameters programmed on the solar exposure of the different parts of the surface and on the structural behavior of the shells.

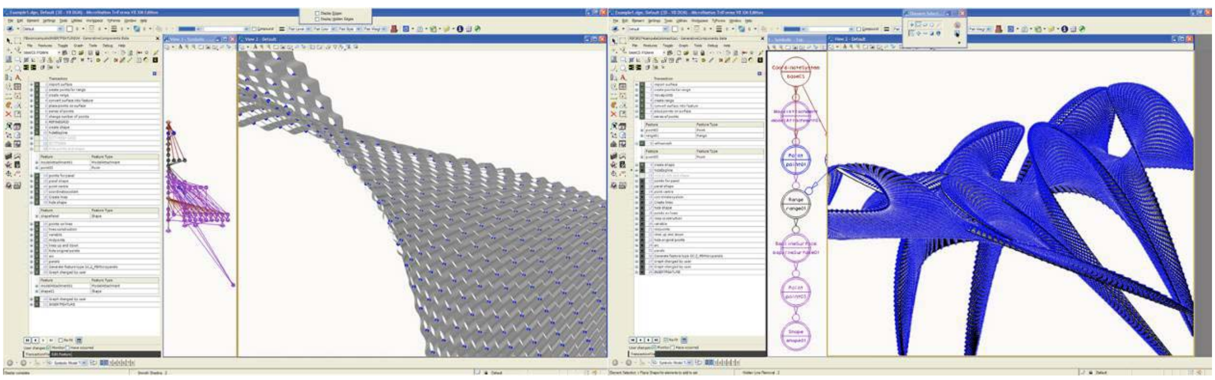

Figure 10: Generative diagrams of the envelope and the structural shells

With a parametric elaboration of this model using the powerful replication algorithm in GC, element multiplication, scale variation and details implementation affects the overall organization by gradients or continuous variations.

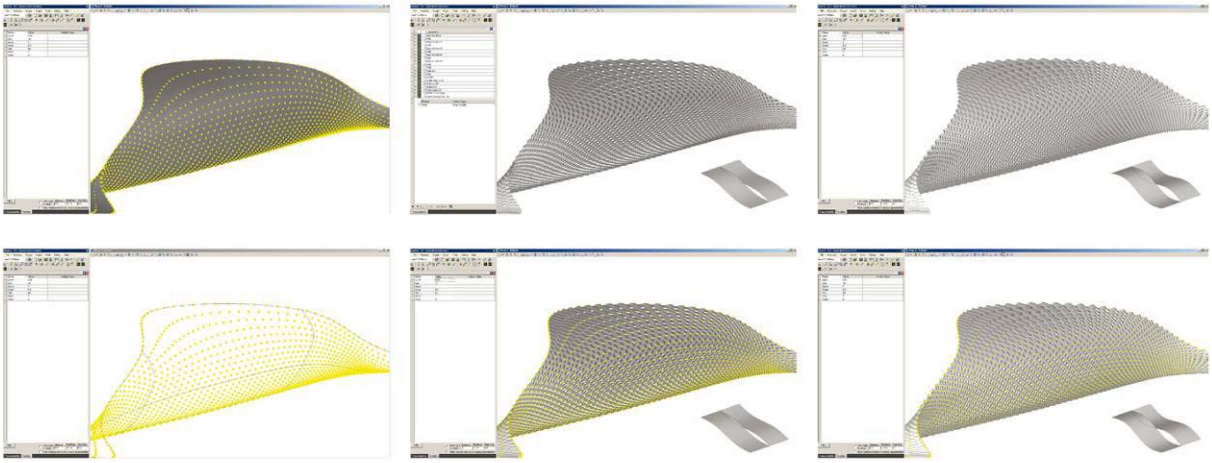

Figure 11: GenerativeComponents™ diagrams: parameterization of the skin

A parallel analysis with the software Ecotect™ of building environment design allowed defining the shape in base to the best exposure to the solar radiation. The most irradiated surfaces are provided of semi-integrates photovoltaic modules for the electric production of energy. The choice of the wavy envelope in aluminum derives also from energy considerations. It allows three different orientations of the photovoltaic modules inside a singular component of the envelope according to the better exposure in the three-dimensional development of the surface. It results in the possibility of exploiting the greatest surface of the envelope useful for the integration with photovoltaic modules.

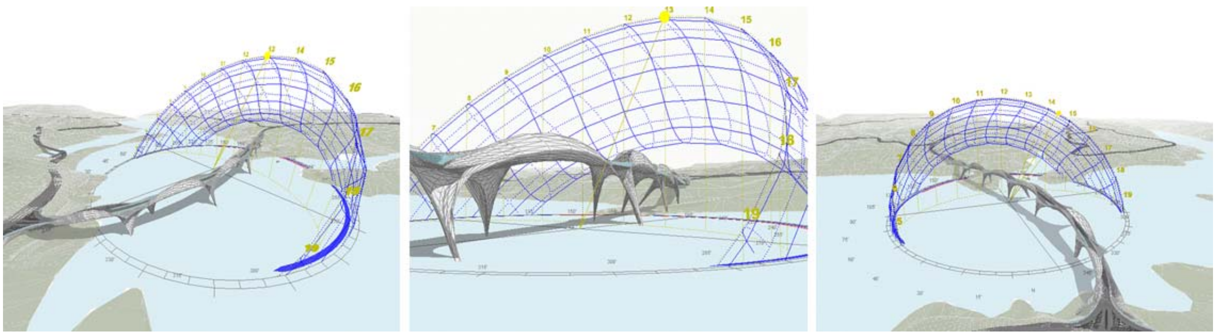

Figure 12: Model of the bridge in Ecotect :the parallel analysis GenerativeComponents/Ecotect allowed a form generation process based on energy aspects

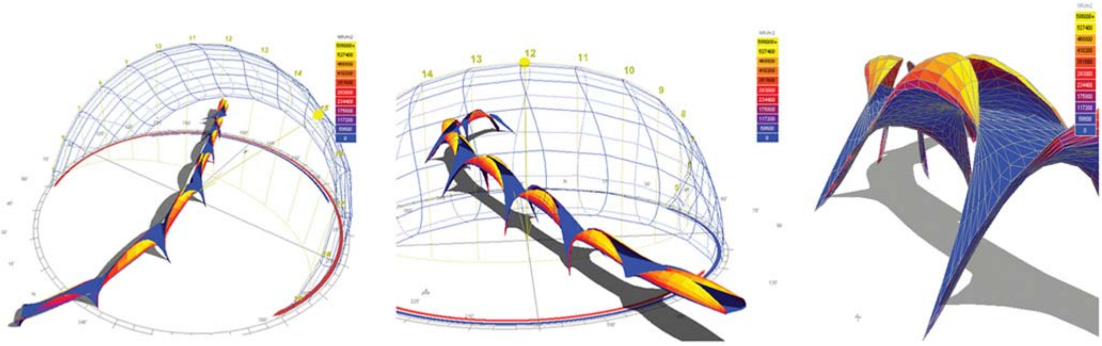

Figure 13: Diagrams of the solar radiation incident on the bridge envelope, which defines the best zones to apply photovoltaic modules

The orientation of the microlouvers - the double wave components of the modular aluminum skin - is totally reflective in the surfaces at high energy incidence and produces an effect of 'evanescence' and darkening of the photovoltaics. The concavity of the microlouvers favors the reflection of the sun rays conveyed partially in the photovoltaic cells for the production of energy, increasing so the global efficiency of the system.

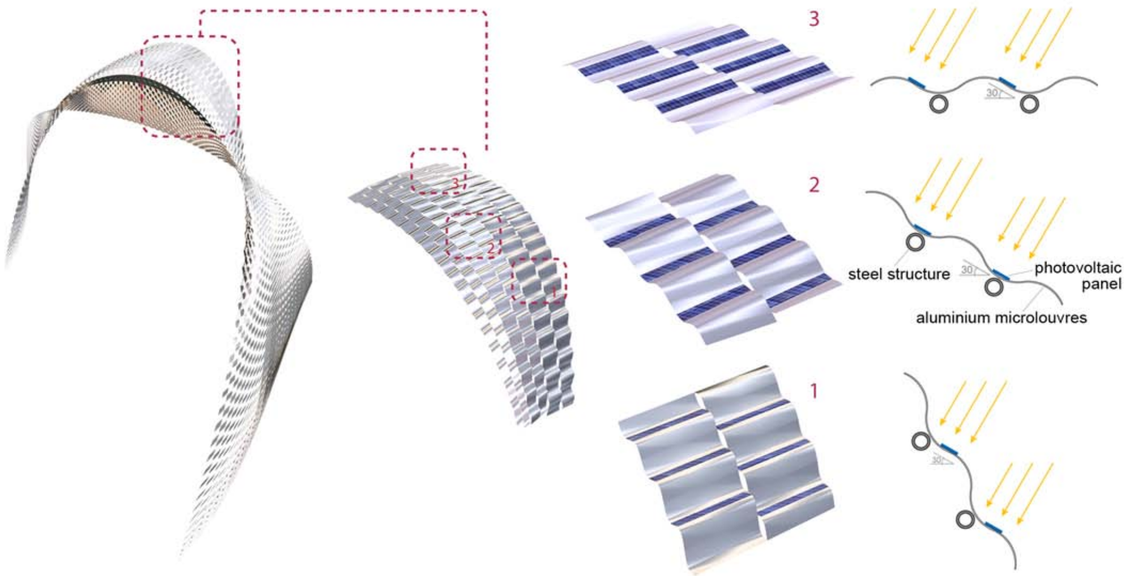

Figure 14: Different positioning of the photovoltaic modules in the curve aluminum microlouvres depending on solar exposure

The structural mesh of the bridge and the photo-sensible skin is therefore derived by a parametrically driven mediation between static considerations, formal analysis aimed to reduce the impact on the landscape and energy evaluations. This trial is reflected both on the global scale of the three-dimensional unwinding of the shells and to the microscale of the individual component of the skin.

This bridge is conceived as green bridge that is an energy self-producing/storing machine, with many important social and economic benefits. A preliminary estimation shows that though the energy harnessed by the bridge can be directly used for lighting the bridge at night, the majority of the power produced can be sold to the network and nearby customers. The big investment necessary for the photovoltaic plant may be paid back reasonably quickly considering the incentives and subsidies for the renewable exploitation. The sustainable energy concept in turn contributes to alleviate the negative impact of the bridge of the cars' emission by globally reducing pollution.

4. Conclusion: widening the horizons of the research

In this paper we report our experience in deploying parametric design –different systems applied to two projects spaced out over 2 years- as our contribution in addressing the question of how advanced parametric design systems can be channeled within the different stages of the architectural design process as a generative potential.

In the built infrastructure of the Li Cuponeddi Viaduct project the parameterization has played a fundamental role in the drawings normalization, especially in the transition to the construction phase and the satisfaction of the EIA prescriptions. The most recent parametrically generated proposal for the bridge project on the Pertusillo Lake offered the opportunity to the team to work, more than with a univocal solution, with alternatives of mediation between exploratory formal solutions sensitive to the delicate context, logic of structure and materials, energy and environmental performance, and to convey these investigations into architectural constructs from the first design conception. A relational setup of the initial model brings the possibility of adjusting changes easily, if compared with transmission of a more conventional digital model.

In Li Cuponeddi viaduct of San Teodoro in Sardinia, the parameterization involved only particular factors of the projects related to the geometry of shields, to the impact on the landscape and to the specific methods of construction. We feel we gained a more advanced experience in our proposal for the competition of a bridge on the Lake Pertusillo. Since the first design idea the bridge had been thought and developed as a generative system parametrically. Allowing the flowing of information, through parametric design, in a continuous fashion across the design process, from the initial planning to the accomplishment of a prototype, increases the chance of the connection between data and geometry and reverberation of a local change on the global system. A large number of features parametrically controlled - not drawings but families of mutational generative elements - can be created, updated, re-informed and eventually integrated into more conventional design environment, at different stages and scales.

In our opinion the application of the latest parametric design systems to projects with a great complexity create an actual chance to work not on the *final form* but to intervene *in the formation of the design process* with multi-disciplinary influences. Changing the environment in which contemporary architectural practices can recognize their contemporary physiognomy and stimulating imagination towards a generative endeavour in virtual and actual adjacencies, seem to be the most challenging aspects to explore.

References

[1] Aish R.; GC Workshop – Erica Calogero_ notes from March 17th; 2005.

[2] Aish R.; Bentley's GenerativeComponents. A design tool for exploratory architecture; Bentley Systems; 2005.

Emerging factors and irreversibility

Predictable future and events of becoming

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ISIA Roma Design; Italia

1. Functions and Roles

The paradigms of design are changing quickly because their role in designing human environment is changing profoundly. For this reason ISIA ROMA created years ago an international brand called "beyond the product" to communicate through some of its designs, the passage from the product towards more complex themes, towards scenarios studied and described by the Sciences of Complexity.
In dealing with the theme of the relationship between generative processes and irreversibility it is essential to clarify whether we are dealing with functions to resolve or new roles in emerging processes since systemics, Sciences of Complexity generally, adopt strategies aimed not so much at resolving specific functions, as much as identifying and managing relations. We think this is the vision in which to set design of the future - new designs, new objects, new spaces and services.

The economist Julian Simon (1) creating the theoretical premises for low cost flights, appliced a systemic strategy extraneous from the process of dominant economics to resolve a rather complex problem of airline companies for which it would never have been possible to find a solution using the variables of classical economics.

Nor is generative design a random event. Designing, talking about design, architecture, places, spaces or installations, airports and living-rooms of apartments, taking an interest in new functions nearer the needs of contemporary society today means having relationships in mind.

Having in mind a systemic model means cultivating a feeling of complexity and responsibility but at the same time not forgetting the role of subjectivity because the characteristic of abstraction, conceptualisation, communication and transmission, leaving a place for signification even when the message is addressed to no one in particular. As J. Lacan said, every letter is addressed to someone, even if it is never sent (2).

2. Future and becoming: the latent state.

Initially let us look at some of Jacques Derrida's reflextions (3) on the difference between Future and becoming, in the light of systemic principles.
The future, Derrida says, presents itself as what we think should happen on the basis of trends, processes which can be reconstructed and predicted, using precise models, based on growth and decline parameters, plans, economic analysis and so on.
Becoming, on the other hand, is more complex. It is simply what happens and what we have to come to grips with. In one way becoming is exactly that unpredictable

datum which determinist linear thinking is unable to explain. The definition of “future” is still a semantic, linear-type definition linked to the *governing of prediction*.
On the contrary, becoming is simply what comes, what happens with all the sociosemiological human repercussions which give birth to new economies, new language, new life styles and ways of expression, networks of relationships unforeseeable before, with complex effects at other levels of society. This definition is closer to Systemic Emergences.
The most interesting thing is that because of its unpredictable nature becoming can occur *before the future*, even though the timeline includes both but in a profoundly different way. We can say then the future depends on us in a fairly visible way while becoming depends on us in a more invisible way.
The problem arises however when we realise that the knots to untie are not only very complicated but are also intertwined, *whole* interrelated *together*, because global, social change involves them in a complexity never seen before and this invisible fabric of problems has the power to involve the visible fabric.
The design of functions in general takes no interest in this but the design of relationships has to keep it in mind. It is another way of saying that the design of being is closely linked to the design of becoming which is what we are living. It is as though we were saying that we are living in two “nows” at the same time, the one that has been defined as “sliding doors”.
The irreversibility or not of one is linked to, or coincides with the irreversibility of the other since Object and System are closely linked.

3. Controlling and learning together

For this reason we should clarify whether we are in some way calculating to what extent we can control the process in our architectural project or design or if we are learning the process at the same time.
This question is important because it highlights the contradiction between paradigms. Between the form-function paradigm typical of the product culture of modern times, and the immaterial paradigm of complexity where the visible and the invisible are intertwined in a relationship which will emerge as dominant.
Although this relationship is valid if we have in mind an addressee, it is impossible not to see how this involves practices and design categories which are very different from one another, instruments, in our opinion which are duty-bound to cooperate to provide answers as things change. This is a contradiction that those who are designing today are well acquainted with.
We have to reverse the point of view and from our role as *observer* become the *observed* - in a position to influence design processes from inside. Putting ourselves inside processes bottoms up gives us the benefit of a privileged *listening* position towards the relations of *use and efficacy* which is created on the edge of *order and chaos* (4), that is, when the principle of coherence is beginning to take form.
In a wonderful essay, F. Nietsche (5) explains the role played in our lives by the different types of “histories” which we live constantly: the Epic, history of Antiquites, the Autobiography. In the end the course of history leads to this kind of present-day complexity where everything is interwoven and nothing can be resolved by isolating and separating. In other words we have to match our designs and generative protocols today with complex social phenomena, intertwined and in movement.

4. Irreversibility

If the structural stability which signals irreversibility can be verified in morphogenesis as for example in fractals and in the theory of catastrophes, in the social processes we are addressing, that stability involves an element of greater complexity because it depends on an emergence which contaminates and deviates the already far from simple morphogenetic process to a conceptual level.

The more generative the project the more complex it is. Not in the sense that its algorithmic potential is increased enormously but in that it tries to confer a significance to the processes it perceives and catches a glimpse of, using for example, the conceptual categories analysed by Nietsche, each time. Or remembering a speech by Derrida: Abstracting to see rather than insisting on enlarging the telescope?

For this reason recognising the emerging factors, the change of paradigm or Gestaltic reorentation (6) proposed by Tomas Kuhn is the first action to be carried out. Above all, observerer, system and emergence are an integral part of a precise theatre of possibilities and the role played by the observer influences which paradigm to adopt since it is a question of an observer-actor-observed. Not someone neutral.

There is therefore a moment in which, finding ourselves in a specific process we note the forming of a *situation in the situation* which shows a principle of coherence outside the generalised coherence which moves the whole system. Let us try to reflect upon some of the characteristics which should or could be present and observed as proveding rules in those circumstances.

What we are studying is how to design open and generative systems capable however of becoming self-formalising at every stage, that are capable of transmitting something that makes sense, keeping in mind the story of coherence of signs even when they can revert to being reversible.

A. Principle of Coherence

Suddenly, a relationship among some components of the system showing coherence is created. As we have said, it is an organising principle of a different nature, something which did not exist before, something different regarding which it is even difficult to express judgement. Something is being born. Exactly as the flight of a bird has no resemblance to the flight of a flock, and so studing the flight of a bird, one by one, doesn't explain the flight of a flock. (7)

B. Continuity of time and speed of propagation

This relational coherence resists and remains – therefore begins to have a time dimension. For this reason it is also subject to measurement which leaves a door open to the story of signs and to the geography of meanings, since the space component is certainly involved in this theatre of events.

C. Genome of the relationship at the micro, macro and meso level.

Emergence is neither magic nor esoteric but happens because something living in a latent state is able to link the components and at a certain point emerge. As a result of reciprocal interaction, the components become arranged in a different way but that does not mean that they do not have a structure even from the theoretical profile.

Gianfranco Minati for example talks of micro, macro and meso levels of emergence. (8)

D. Systemic inductions: a hypothesis

Let us try to look for something in the emergence - traces able to *create memory*. If we superimpose on these traces a pattern or a code, for example colour, we immediately lead it to assume a different conceptual meaning which can be "semantised" because emergence contains at this point a metadesign seed. It becomes a model.

We are inserting into a combination of phenomena, different in nature but linked by a principle still unknown, an elementary alphabet, patterns taken from a metadesign catalogue of primary design which acts as a catalyst for the initial elements. The initial principle of coherence is redesigned (and even highlighted) by the map, abstract, constructed and applied thanks to a colour-memory code. This map will make from the first coherent whole a second coherent whole, that can now be memorised. According to our vision, it is so important that the model applied to the emergence spring from a careful reading and interpretation of the history of signs.
The colour memory is a decidedly plausible systemic induction inasmuch as it expresses a relationship totally extraneous to the nature of all its components; for example no one will study an apple on the basis of the fact that it "could fall" but rather from the viewpoint of its organoleptic qualities. Not only. This second map already has *place* characteristics typologically similar to those places where memory of past works is generally kept - a Museum or a Library. A library of Emergence.
The memory produced becomes readable thanks to the fact that it is written, inscribed, or rewritten in a pattern which has the power to attract a future user who is no longer the giver of the systemic induction but another person.
This new user is expanding and implicitely organising a new emergence library.

E. Ability to change from reversibile to irrerversible

The new paradigm for reading reality comes close to the theory of complex systems which teaches that we are always living in the same scenario at different spatial and temporal levels, between future and becoming. The intersections of these levels are not always predictable and "anything" can happen ever before the "future". Design guides reversibility according the nature of emergence and not according to the nature of control also because we would not have the certainty that the design tool of control which we use is the suitable instrument.

Note

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(3) "L'écriture et la difference"Jacques Derrida; Seuil,1979
(4) "At Home in the Universe" Stuart Kaufmann; Oxford University Press, 1995
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A Knowledge base System for Carton Package Design

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Abstract

The purpose of this paper is to build a knowledge-based system for carton package design to solve the package design problems and satisfy designer's requirements. This study of the participants is package designer. In order to gather the package design problem and design knowledge, we interview the package designer at first. Requirement analyze is taken after interview. Then, to gather the related research and the package design knowledge are for planning of knowledge design. When make sure the requirement and the prototype, and then we do the system develop and implementation. Finally, we'll to do the system evaluation. The findings revealed the knowledge base system of computer-aided design can support the designer easy to design, and reduce try-and-error times and costs. In this study, the main of the knowledge is the paper material and thickness, and the paper material using corrugated paper for an example. In the future, the system can input other knowledge for package design, like color, typography, graphic and other paper materials to make the system more completely

1. Introduction

In the package design domain, one single product can have variable geometry and complexity. Therefore, when designer design the carton box, it requires lots of innovation, and the ability of the three-dimensional concept, and imagination from the designer to create various 3D packaging structures and the corresponding flat pattern layout [19]. However, internal package designer usually uses unprofessional vector software that is not major in the package design to do the 3D packaging structures design and to draw the proportional unfolding layout. It's to create the internal package designers have a lot of problems when they are doing design. Based on this reason, there are five problems exist in package design process when designers work on it: 1.The professional package software is expensive and the interface is not good to use plus not having the specific designer of using this software; 2. At the design initial stage, designer doesn't have suitable software to support designer to thinking about the design idea; 3. During the design process, designer need to do heaps of try-and-error to produce the corresponding unfold flat pattern layout; 4. It is not easy for designers to imagine a 3D result from the unfolding flat pattern layout in operation stage; 5. During the design process, because of the thickness of paper, designers needs to do the prototype without the visual design again and again. 5. When designer finishes the design, it is unable to store the package design knowledge. So of that, in this paper we aim to build a knowledge-based design system for paper packaging design, and assists package designers to build and design unfolding flat pattern layouts in an easy, fast, friendly, and intuitive way.

2. Background and Related Work

2.1 Background

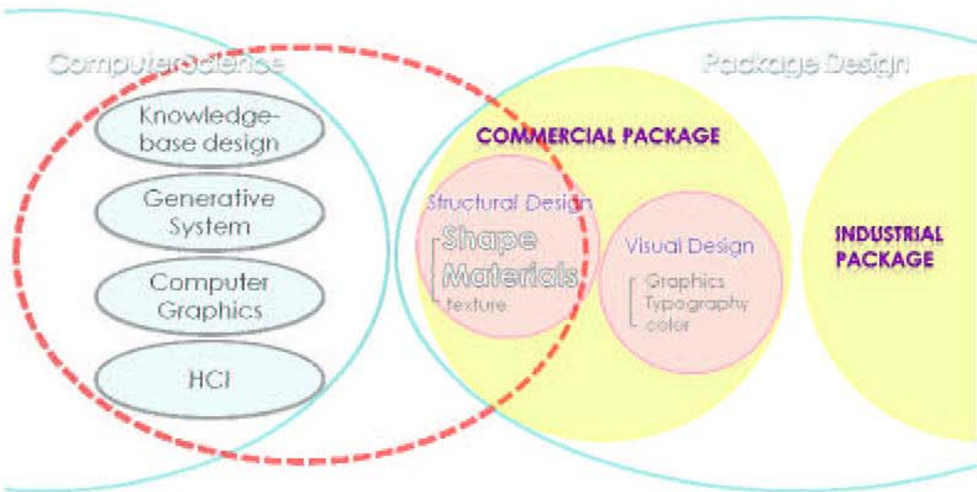


Fig1. Background Architecture

This research will discuss the factors of shape and materials of the structural design of commercial package of package design, and major to talk about the shape of carton box and the corrugated paper of materials for the most part. The purpose of current study was to consider how to using the knowledge base design, generative system, computer graphics, and the HCI of the computer science domain to assist the carton box package design.

2.1.1 Package design

'Package' is a quiet salesperson that is a tool of marketing. It can attracts customers sight and sales by itself [18]. Nowadays, related research shows the package itself affects two-thirds of the customer expenditure decision [17]. In the marketing domain, packaging abreast of price, product, place and promotion jointly called as '5P'. Package design is very important. It affects the value of customer [27, 30]. So, it shows the package design is valuable of daily life.

2.1.2 Present position of package design

Present package connect with production and consumption. Package integrate with science technology and art thinking of business acts to protect product, encourage consumption, and increase the storage and transportation [28].

Most of researches classify the present package design by the purpose. It mainly differentiates two parts: commercial package and industrial package [23, 28, 30]. In this research, we aim to talk about the carton box package design of commercial package. Commercial package also called consumer package, and mainly retail-based business transactions. It point on the sales of easy to sell, so the beautiful appearance of the packaging is important in order to arouse consumer desire to buy [23, 28, 30].

2.1.3 The essential factors of package design

The visual design of packaging includes two parts: structure design and graphic design. The message and information through the visual comprises structure design of packaging is the shape form design and the graphic design of the container surface [31]. This research will talk about the shape of structure design of carton box, and the paper material using the corrugated paper for an example.

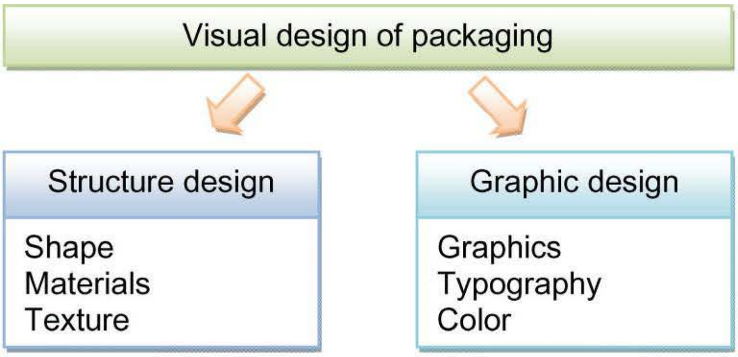


Fig2. The factors of package design

2.1.4 The structure design of carton box package design

In the packaging materials, paper products is one of the commonly used materials, including carton packaging [28]. The structural design of carton packaging means the paper will be the plane into three-dimensional form, and using cut, folded, adhesive, insert into paper method such means as the use of friction with other auxiliary materials assembled out of commodity structures and patterns [24]. Carton box to start the process by a number of the mobile surface, piled up, folded, and surrounded by the box body.

In the structural design of packaging, ‘form’ design is often the important key to the success or failure of packaging. A successful form of packaging can attract enough attention form consumers, and to promote the sale of goods [29].

During the design process, in addition to the design process must be have flexible and creative design idea of professional package design, and also need the computer-aided design process. If a lack of computer-aided design process, it will take more time and cost, and even may be a result of the calculation error which led to more wear and tear and increase the cost of a burden [29]. It can be seen computer-aided design is very important.

2.1.5 Knowledge base System

The structure design of carton box is a professional knowledge and it includes many complex procedures during the design process.

A knowledge-based approach broadly means to build up a system, usually called a knowledge-based system (KBS), for solving complex decision problems in a specific domain [3]. A KBS, normally in the form of an intelligent computer program, uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution [3]. KBS supports the user's actions or controls and prompts the user's intention so that the user can design drawings according to the standard or the best way [21]. The knowledge-base system consists of two parts: rule base and inference engine. The system includes the task storage and the trace recorder too [21]. The figure 3 presents the knowledge-base system architecture.

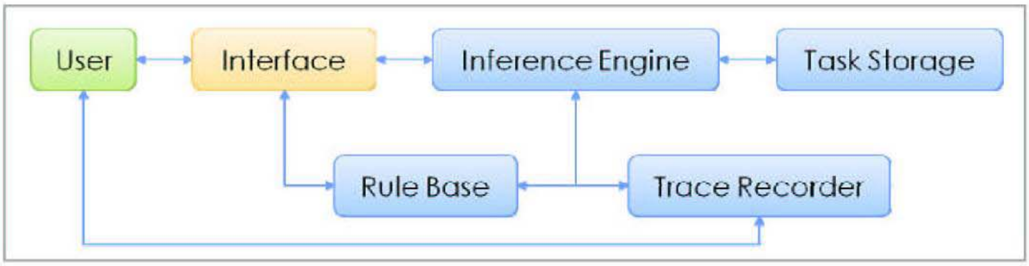


Fig 3. Knowledge base system architecture

2.1.6 Reuse Design

Design company is the industry which is to production and to provide knowledge. In the process design also makes use of knowledge to generate knowledge [32]. The reuse of previous design knowledge is a potentially important way to improve design efficiency [12]. From an empirical perspective, considerable evidence exists indicating that designers do attempt to reuse previous concepts and prototypes in both routine and non-routine design work [6, 10, 12, 20].

2.2 Related research and works

2.2.1 Related research

2.2.1.1 Basic shape and structure of carton box

Classification the carton box according to the basic shape can divide into three parts: main structure, partial structure, and special structure [25, 26].

Main structure means the folding carton box form of the three dimensional structure. In accordance with the way of molding can be divided into straight carton, tray carton, and other type. Partial structure refers to the structure of the folding carton in the form of partial structure, such as the lid, bottom of the box, noodles, box angle, and so on, and also if lock, dig holes. The special structure is the performance of the features of the structure of the carton box, and most of the special structure is the local structure generally.

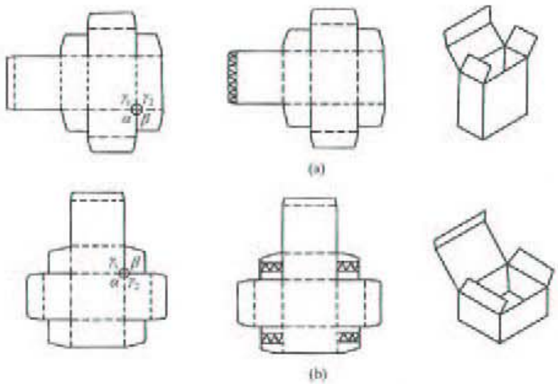


Fig 4. (a) Straight carton (b) Tray carton

2.2.2 Corrugated paper

2.2.2.1 Classification and characteristic of corrugated paper

According to the corrugated paper shape and different characteristic, it can be classifying five corrugated paper types: A, B, C, and E. In order to fit in with variety of packaging requirement, carton box need to be an appropriate choice of shape of corrugated paper type in order to achieve the purpose of packaging [16]. Its features are as follow table 1.

Table 1. The type and characteristics of corrugated paper

Characteristics \ Type	A	B	C	D	E
Corrugated number of every 30cm	36±3	51±3	42±3	63±3	93±3
Corrugated height mm	4.5~4.8	2.5~2.8	3.5~3.8	1.8~2.0	1.1~1.2
Shape of corrugated paper	U or V	U or V	U or V	U or V	U or V
Pressure strength	Optimal	Bad	Better	Worst	Worst
Side pressure strength	Worst	Better	Bad	Optimal	Optimal
Flat pressure strength	Worst	Better	Bad	Optimal	Optimal
Shrink variant volume	Biggest	Small	Big	Smallest	Smallest

2.2.3 Structure design of folding carton box

Folding carton box is the widest range of carton box sales packaging, and its having variety of structure and form shape. During design, designer can base on volume of carton and the weight of contents to choose the appropriate thickness of corrugated cardboard [25, 26]. Designer can follow the table 2 to choose.

Table 2. Folding carton paper thickness selection table

Carton volume /cm^3	Contents weight /kg	Thickness /mm
0~300	0~0.11	0.46
300~650	0.11~0.23	0.51
650~1000	0.23~0.34	0.56
1000~1300	0.34~0.45	0.61
1300~1800	0.45~0.57	0.66
1800~2500	0.57~0.68	0.71
2500~3300	0.68~0.91	0.76
3300~4100	0.91~1.13	0.81
4100~4900	1.13~1.70	0.91
4900~6150	1.70~2.27	1.02

2.2.4 Related unfolding algorithm

The folding of paper or sheet materials is treated in the mathematical studies of origami [7, 8, 15] and also in computational algorithms for developing the crease pattern for folding into various origami designs [11]. However, in origami, the sheets of paper are usually folded into objects which are flat or piecewise flat structure [19]. Another related work is the geometric modelling and simulation of pop-up books [22] and origami architecture [9] in such work deal mainly with shape and motion information of the popup mechanisms and not the topology. But it can process the box detail part, like the pup-up of broken line of unfolding flat pattern. Graph search algorithms (such as breadth-first, depth-first or A* algorithms) have also been proposed to arrive at a flat pattern of a given object [14]. But it just supports one kind of flat pattern. W.Liu and K.Tai bring up a suggestion of optimal unfolding flat pattern design of corresponding 3D object in the 3D unfolding structure. Enumerating all possible patterns allows for a subsequent interactive selection by the designer to choose the best pattern [19]. However, this algorithm not includes the paper thickness factor. The algorithm can support our research in the 3D object transfer into the corresponding 2D unfolding flat pattern, and we will add the paper thickness factor into it.

2.2.5 Related woks

Nowadays, there are many professional package design software such as Artios CAD [2], Impact Design Software [13], KASEMAKE [1] using the international corrugated/FEFCO and folding carton/ECMA standards. Although these software have powerful capability, it doesn't have internal package designer to use them. Because of the software is not suitable for internal requirement. For example, the professional vocabulary is too complex, the software is expensive, and interface is not intuitive for designers. The software, Fold UP! 3D [4] and BOX-VELLUM [5] from Connect Company in Japan. The design process of this software is design the unfolding flat pattern at first, and then shows the corresponding 3D structures in Adobe Illustrator. However, this process is different from internal package design process. It is hard to provide idea thinking, and unable to store the package knowledge database for effectively re-use. Moreover, most of internal research mentioned from the visual design aspects, but not computer-aid design aspect in package design and less structure design aspect of package design. Also, these related works not having the knowledge mechanism.

3. Methodology

3.1 Research architecture

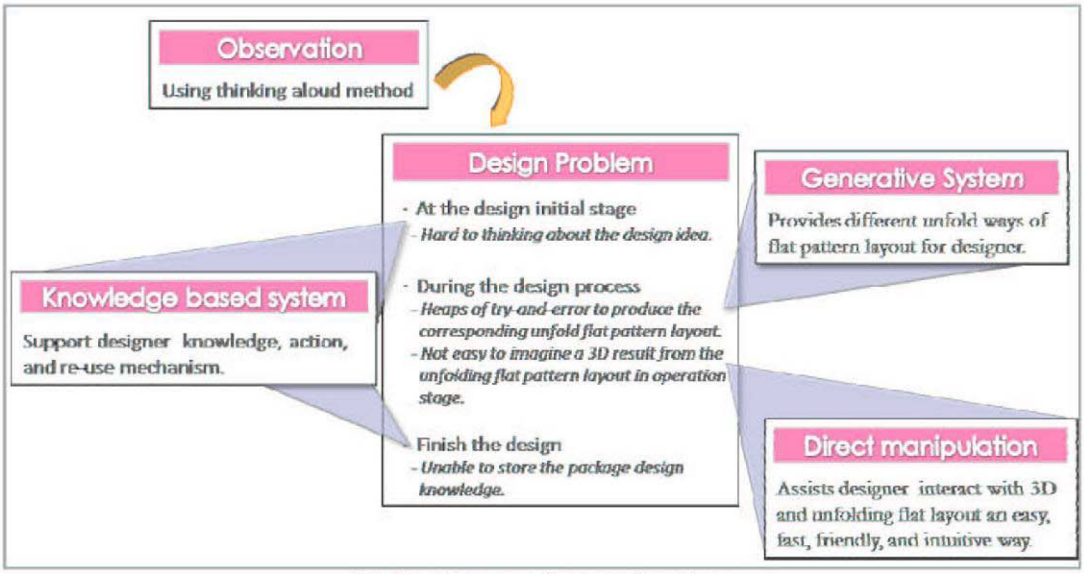


Fig5. Research Architecture

Here is the research process: Firstly, this research deeply interviews with internal package design experts to confirm the needs and problems. Then, requirement analyze is taken after interview. Then, to gather the related research and the package design knowledge are for planning of knowledge design. The relationship is between important variables such as the use of packaging use, length, width, height, the basic type, the type of lid and base, etc. to build an abstract conception of trees, and then using this structure to do classification according the purpose. At next step, it will build a package of knowledge conceptualization standard. When make sure the requirement and gather enough knowledge and the prototype, then we do the system develop and implementation. Finally, we'll to do the system evaluation.

3.2 Requirement analyze

After the interview with the package design experts, the result shows that internal package designers need a package design system with the following requirement: 1.

when package designer build the basic 3D modal or to set the classification, the system can provide the recommend 3D package structures to support the designer to think about the design idea; 2. The interface must shows the interaction of the 3D view and the unfolding flat view; 3. The interface need to have mark of dimensions, length, wide, high, etc.; 4. The interface should be simple and intuitive; 5. The vector software can read unfolding flat pattern layout design format from this system created; 6. Build up the knowledge-base system for reusing the design knowledge; 7. The system can add the paper thickness and material for calculate the paper thickness for unfolding flat pattern.

In order to improve the designers encountered various problems and needs during the design process, this study proposed a design process to improve the design of the solution, follows the figure 6.

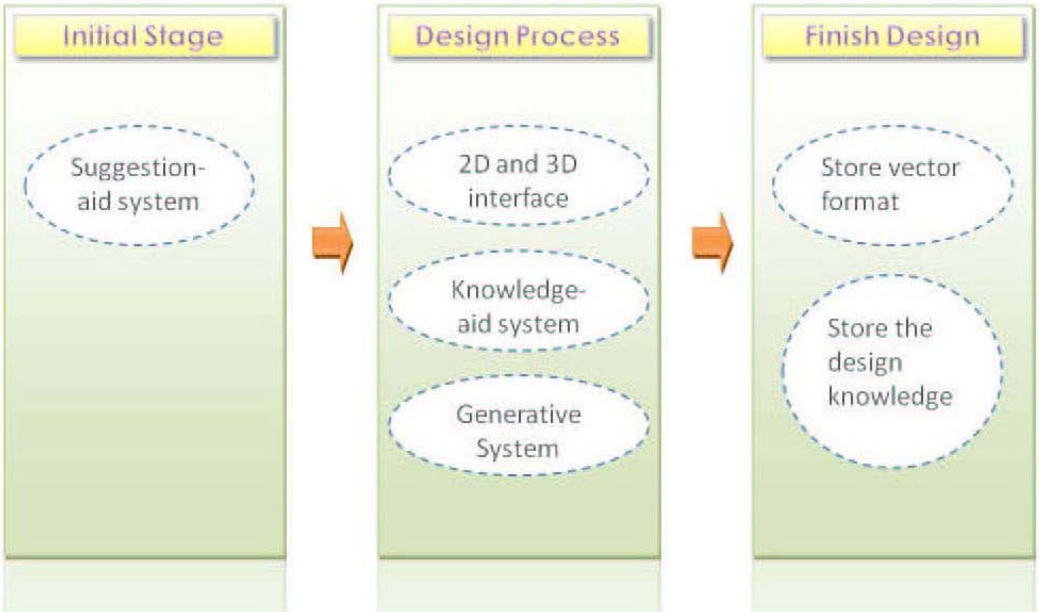
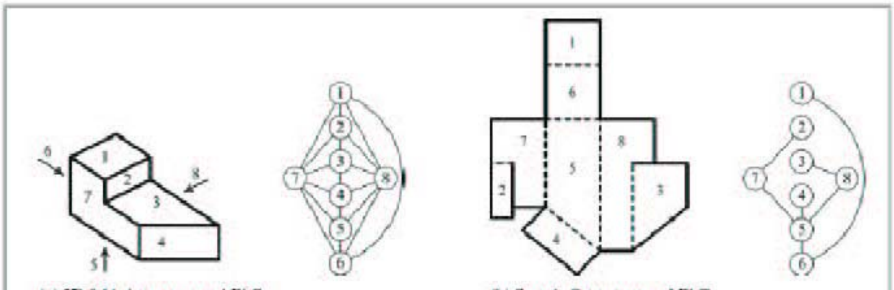


Fig6. Computer-aid design process

3.3 Unfolding algorithm

Enumerating all possible patterns allows for a subsequent interactive selection by the designer to choose the best pattern [19]. This research will based on this algorithm from W.Liu and K.Tai, and add the paper thickness calculation.



(a) 3D folded structure and FAG. (b) Sample flat pattern and FAG.

Fig7. Manifold L-shape structure

To facilitate unfolding and the construction of the flat pattern, an appropriate geometric representation of the 3D structure (as well as the flat pattern) must contain two types of data: one is shape geometry data which defines the shape and position of the structure; the other is topological data, which defines the connectivity between faces [19]. A hierarchical data structure similar to that often used in a boundary representation (b-rep) model is applied to define the 3D folded structure with each stratum in the hierarchy containing a list of data.

The complete procedure can be listed according to the following steps [19]:

Step 1 Read input of B-rep model data of 3D folded structure.
Step 2 Form the FAG of folded structure.
Step 3 Identify any hyper-common edges and determine their sequences.
Step 4 Identify any inadmissible or exclusive links.
Step 5 Compute total number of spanning trees.
Step 6 Remove inadmissible links (if any) from FAG.
Step 7 Enumerate all spanning trees.
Step 8 Check topological validity of each spanning tree (check for any overlapping paths and correct splitting of hyper-common edges), and discard invalid trees.
Step 9 Geometrically construct flat pattern for every valid spanning tree.
Step 10 Detect and discard any flat patterns with overlapping faces.
Step 11 Compute the three compactness measures for every flat pattern, and maintain three separate lists of the top thirty highest-ranked patterns based on each of the three compactness criteria.
Step 12 Output resulting lists and plot patterns upon request.

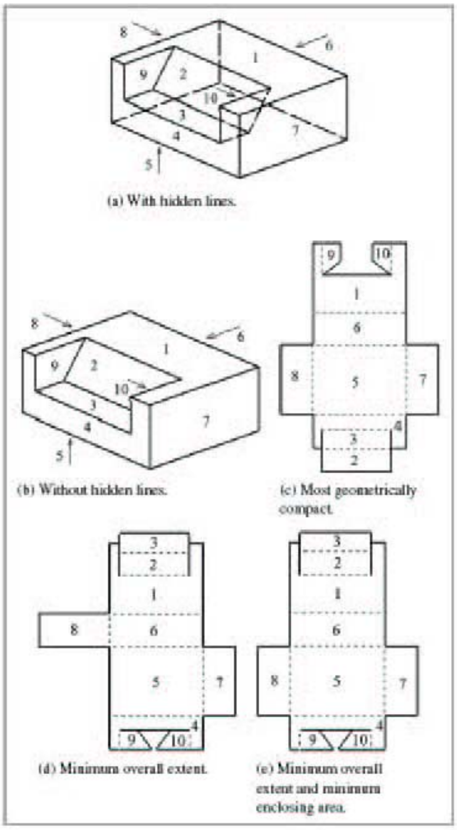


Fig8. Non-convex manifold structure example

3.4 Knowledge base system design

The knowledge-based module has three steps: 1. Knowledge acquisition— Knowledge should be validated, structured and relevant. Validation specifies the kinds of question can be solved. Structuring confirms how the knowledge is arranged and stored. Relevance refers to relationships among the knowledge. 2. Knowledge inference and representation— Knowledge should be expressed in specific form. It should be inferable and applied in logical manner. 3. Knowledge-based module should pass evaluation, verification, and test. Knowledge should be confirmed as enough to achieve the system goal. If not, the developer would need to acquire more knowledge to fix the module.

4. System Plan

4.1 System design process

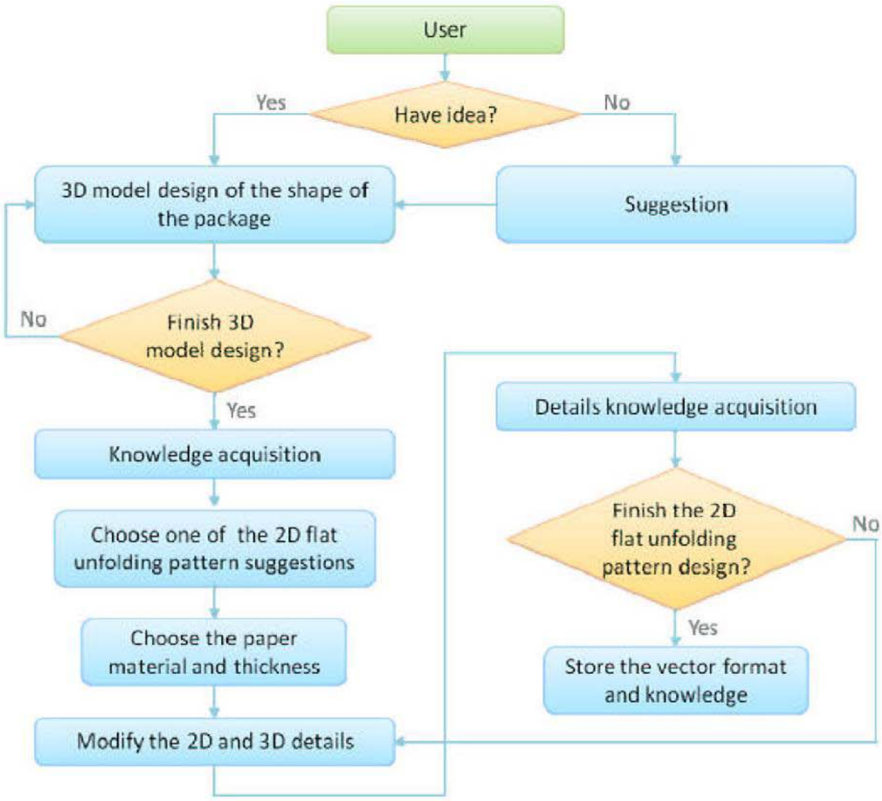


Fig3. System design process

In the user manipulate part, when the designer doesn't have idea, designer can choose and set in the interface, then the system will give the corresponding shape of box, knowledge and suggestion support the designer to make design thinking. And then user can to do the 3D model shape design. Otherwise, if the designer has the design idea about the shape, then designer can to design directly in the 3D model view. If the designer finished the 3D model design, the system will to do the knowledge acquisition to gather the initial knowledge and information. After that, the system will provide several corresponding unfolding flat pattern for designer. Designer can choose one of the unfolding flat patterns, and then to choose the paper material and thickness, the system will calculate the unfolding flat pattern according to the paper material and thickness setting. Next step, the designer can modify the detail part, and then do the knowledge acquisition about the details. If the designer finished the 2D unfolding flat pattern, designer can store the vector format and knowledge, or designer to modify the 2D and 3D details.

4.2 System architecture

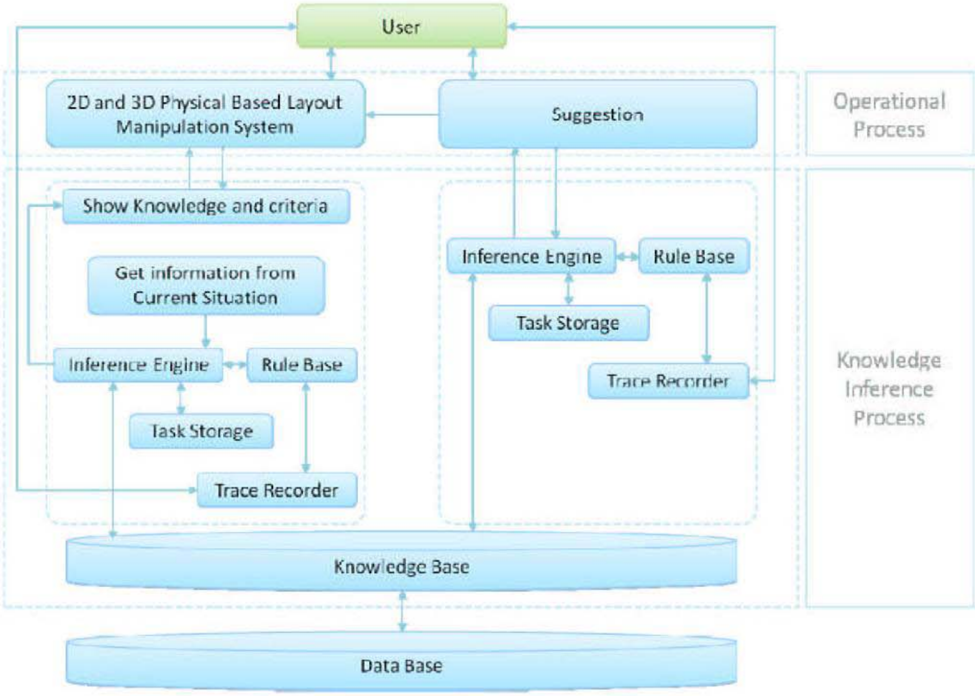


Fig4. System Architecture

This research will implement a knowledge-based aided system for carton box package design. According to the designer requirement to do the system plan and implement. The system will include two parts, one is the user interface, and another one is the knowledge engine. The system architecture can see figure.

4.2 Interface draft

The interface will include the simple basic 3D model and the type of the box for package designer build 3D model sample and intuitional. Then, the system will show the recommend shape of paper box and package knowledge from the knowledge database according to the set of the package purpose and the 3D model that designer builds. The system also provides different unfold ways of flat pattern layout for designer. The interface will show the 3D view dynamically and the 2D unfolding flat view immediately.

5. Summary

Expect of the benefit about this research can bring the initial package designer as below points: 1. In the design early stage, package designer can refer to the package design knowledge and the 3D packaging structure from its knowledge base system to support the designer to thinking about the design idea; 2. It is convenient for designer to choose similar 3D packaging structures model to modify, setting, and design using the intuitional interface; 3. Following the3D model decision, this system will provide some different unfolding ways of flat pattern layouts to designer to compare. And the system supports the designer to calculate the unfolding flat pattern according to different paper thickness. It greatly reduces time of try-and-error and increase accuracy; 4. After the designer chooses the one of unfold flat pattern layouts, designer can store the vector format that vector software can read for package designer to do the visual design of the package design; 5. The system supplies re-use design mechanism to allow the package design knowledge re-use effectively.

Future related research can aim at doing the following description to go further discusses, research, and development: 1. This research only discusses the shape and the corrugated paper of material of structure design of commercial package design, but not parts of texture and other materials; 2. In graphic design of package design domain, there are still lots of knowledge such as graphics, typography, color, CIS, which can be stored into this knowledge based system; 3. This system based on the paper packaging box, canned, packaged hoses and bottled are excluded; 4. Hereafter, related research can probe into the collaboration design of the interaction between the package designer, customer, and the printing personnel and the marketing.

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Visual-communication representative system

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Abstract

Visual communication via mobile devices has increasable become an important factor. Even with 3G/MSN network, the limited computing resources can't compete with a desktop 3D computing system to represent the delicate face impression. Further with the emotional interface design, the face expression has grown more in its intuition as well as intelligent support. Face expression, an important part of visual communication, has become an emotional expression for personalized representation online such as MSN network. By restricting the face expression into a set of shape and pixels, face expression with a built-in grammatical approach can then be analyzed and implemented. A computational design theory called shape grammar has adapted for this purpose. The facial expression for certain emotional express has also analyzed and classified into a set of classes and shapes with transformation rules. Each devices/messengers can apply these rules and present animation during communication.

1. Introduction

1.1Background

People have communicated behaviour in everyday life. By communicating, everyone can send or receive messages from their friends or family member in any place and any time. Communication becomes convenient and efficiency. People can have various ways to express themselves. For example the message forms could be the text, voice, pictures, and video, etc. People use various message forms to express their thought, idea, feeling, and emotion, and then get reply from other people. They can understand gradually by exchange message or change another communication ways to express clearer. However people still looking for new way to communicate to others, for example to chat through internet or to see each other by web cam. No matter what kinds of device or form used to communicate. The only purpose is help people express message clearly.

1.2 Design Problem

Hardware constrained people express facial emotional during the process of communication. The device conveys that facial expressing without a webcam to capture the facial change. Even though the user can use a webcam to convey the image, but still limited by transit speed. Now many people like using msn or mobile to chat through the internet. The new media help people can express freely and creatively, such as using text to show emotion, recording voice to convey, a sequence of image, and emotional icons. Although the text can convey their meaning directly, people still like using various expressing icon to show more emotional. The expressing icons have various kinds to help user express the emotional, but each icon just can express specific emotional. The user can't use icon express facial emotion as clear as the webcam, and can't dynamic change the facial real time. The study aims to generative facial express change during the process of communication.

2. Reviews

2.1 Shape Grammar

In 1980, Stiny pointed that shape grammar, and using algebra to analyze shape. Shape grammar brought a new way to think of shape.[6] In shape grammar using finite set of shape, symbols, rule, and initial shape to analyze the shape then generate new shape. For example, ice ray. Then more research case about shape grammar applying in architecture as The Palladian grammar, Frank Lloyd Wright's prairie house, Taiwanese traditional vernacular dwellings, and Japanese Tea-room, etc.[2][3][4][5][7][8] In 1990, structure grammar discuss about relationships between parts in configurations.[1] The shape grammar explored the shape can be describe in formal language, and then define the rule to general new shape. However, this study not aware other research discuss shape grammar apply in facial expression.

3. Methodology

The purpose of this study in order to help people can have more emotion express in limited hardware or device. The study assumes facial express change can be present by shape grammar. When people communicate to other people through internet or mobile phone, they can see the facial express dynamically and automatically reply during chat to each other. The study steps have three steps: analyzing emotional icon, defining rule, and generating facial express. Firstly, we will analyze the msn emotional icon, and then classified the emotional icon into happy, sad, anger, fear, and amaze, then transform the icon to pixel (Table 1). Secondly, define the facial express rule. The rules are describing the pixel general from initial to final shape (Table 2). The relation of the pixel and pixel can be defined as the pixel grammar (Fig 1). The rules is used to constraint automatically reply function. The facial express can be gradually transformed from any emotion facial to another one.

4. Implementation

4.1 Analysis

Analyzing emotional icons, then classify icons into 5 kinds of emotional expression. The standard facial pixel is used to set the initial shape.

Table 1

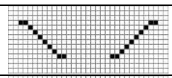
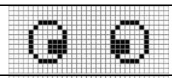
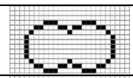
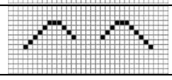
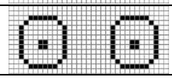
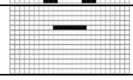
symbol / Emotion	Icon	Pixel	Input
Standard	None		None
Happy			:-) , :) :D , :d
Sad			:(:'(
Fear			8-)
Anger			8o|
surprise			:| ^o)

4.2 Define the shape

Simplified icon to pixel style, and therefore the pixel could be computed and defined the grammar. The set of emotion pixel include four parts face layout, eyebrows, eyes and mouth (Table 2). The rule only applies in eyebrows, eyes and mouth. Face layout will keep the same shape. All emotion pixel graphics are the maximal shape (shows in Table 1), thus to constrained the pixel generative from initial to terminal.

Table 2

Part / Emotional	Eyebrows	Eyes	Mouth
Initial shape			
Happy			
Sad			
Fear			

Anger			
Surprise			

4.3 Rules

Emotional icon consists of eyebrows, eyes, and mouth. The emotional icon is derived from initial shape by the define pixel grammar (Fig 1). The initial shape starts to derive from the pixel which set a triangle symbol. The rule 4, 6, 7 define the pixel can overlay next pixel; also the pixel can appear again. When the triangle symbol meet the “X”, then the grammar will terminal. The pixel can transform, rotate, mirror, and scale. The part of facial that eyebrows, eyes, mouth will change at the same time.

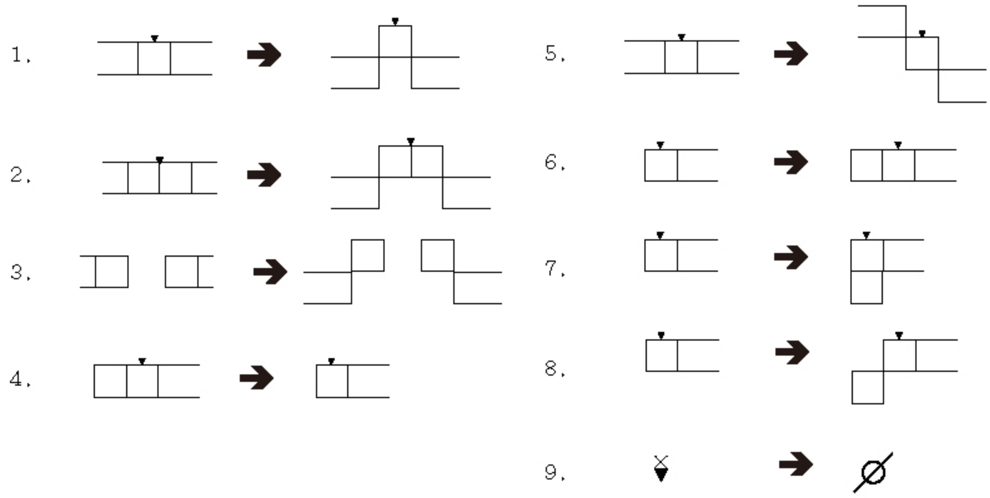


Fig 1 Pixel grammar

5. Generative Results

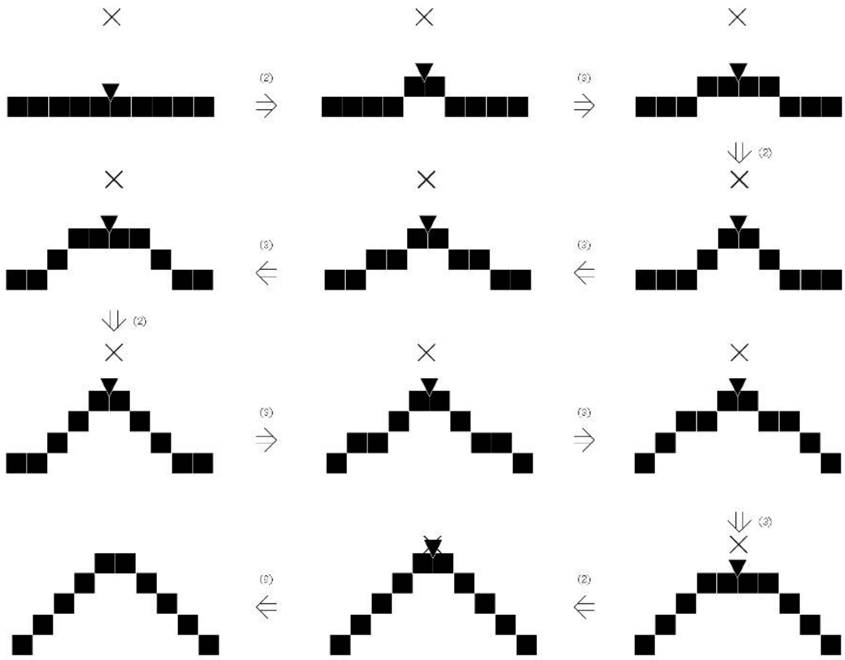


Fig 2. Using pixel grammar to generative eyebrows.

The Fig 2 is to explain how the eyebrows derived from the standard shape to smile shape. The pixel derived from the triangle symbol, and then used rule 3 to upper the pixel. Repeat the steps until to meet the terminal point.

6. Conclusion & Future work

This study is aim using pixel grammar derived from the shape that consist pixel to present procedure of facial change. The procedure of generation can present different level of facial emotion and animation. The purpose is to present the dynamic sentiment performance, and automatically change facial emotion. In the future, the pixel grammar aid implement in different messenger and mobile device. It will help people to present facial express during communication.

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What is Complexism? Generative Art and the Cultures of Science and the Humanities

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Abstract

In previous papers I've discussed complexity theory as a context for generative art theory. This paper extends that discussion to consider the lessons learned from generative art about the cultural conflict between science and the humanities. It is argued that generative art is uniquely positioned to negotiate between science and the humanities, and suggests a new paradigm called "complexism" as a subsuming synthesis of modernism and postmodernism.

I've previously noted that both simple-highly-ordered systems, and simple-highly-disordered systems, are accepted as generating works in the standard art cannon. Generative art using complex systems, however, is much less understood or accepted. It is argued that generative art using complex systems, especially where it participates in a new form of dynamism, holds great promise to be particularly transformational.

This leads to the introduction of complexism. Complexism is, in a sense, the projection of the world view and attitude suggested by complexity theory into the problem space of the arts and humanities. Complexism uniquely addresses the problems of uncertainty and incompleteness introduced by science and mathematics in the 20th century. In addition, complexism offers a higher synthesis that reconciles the disputes behind the so called "science wars" of the late 20th century. While the modern/postmodern polarity seems to only offer irreconcilable differences between the cultures of science and the humanities, complexism provides a unique meeting ground for both. And generative art provides complexism with its most compelling voice to date.

1. Defining Generative Art via Complexity Theory

To define art is to propose a theory of art. In a similar way, to define generative art is to propose a theory of generative art. There are a number of theories of generative art in popular circulation, including the following:

> ***Generative art involves the use of randomization in composition.***
> ***Generative art involves the use of genetic systems to evolve form.***
> ***Generative art is art that is constantly changing over time.***
> ***Generative art is created by running code on a computer.***

In a previous paper [1] I introduced a theory of generative art that offered the following as the now possibly most widely cited definition of generative art:

> *Generative art refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art.*

This theory of generative art casts a very wide net that is independent of any particular past or future technology. It certainly includes, but is not restricted to, all four of the previously mentioned notions regarding generative art.

By including systems such as symmetry, pattern, and tiling one can claim that generative art is as old as art itself. And indeed the earliest known art objects are generative products. This view of generative art also includes 20th century chance procedures as used by Cage, Burroughs, Ellsworth, Duchamp, and others. This helps to tightly bind generative art to the standard art canon rather than leaving it isolated as an awkward art world orphan.

Given that this theory turns on the use of systems it should not be surprising that the contemporary scientific paradigm for the general study of systems, complexity theory, provides a context for the consideration of generative art. In brief, scientists such as Murray Gell-Mann [2] classify simple systems as being either highly ordered or highly disordered, and hold that complex systems exhibit a dynamic tension between order and disorder. This is illustrated in figure 1.1.

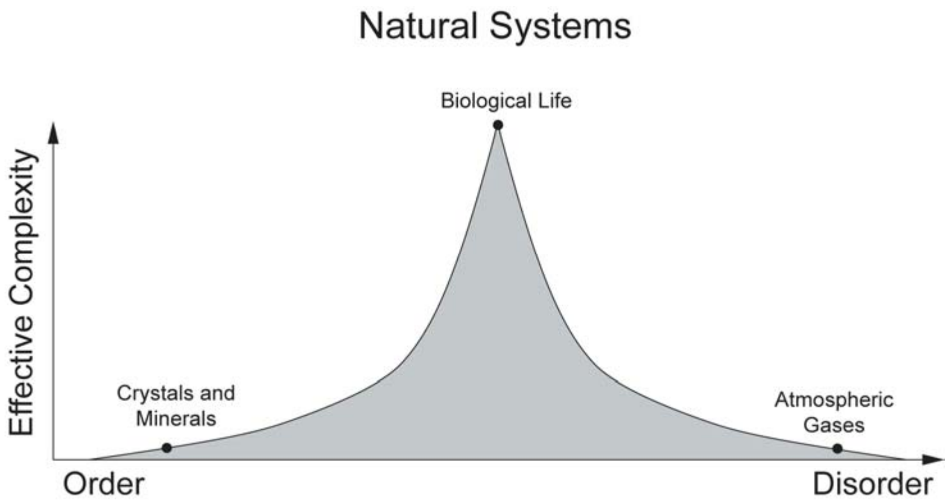

Figure 1.1

The earliest forms of generative art, those noted above as involving symmetry, pattern, and tiling, exploit simple highly ordered systems. In the 20th century the use of chance procedures, i.e. randomization, introduced highly disordered systems in generative art. Arguably the most active area of research in contemporary generative art involves complex systems such as genetic algorithms and evolution, artificial life, chaotic systems, emergent behavior in networks, and so on. As illustrated in figure 1.2 the effective complexity model from complexity science provides a context for generative art.

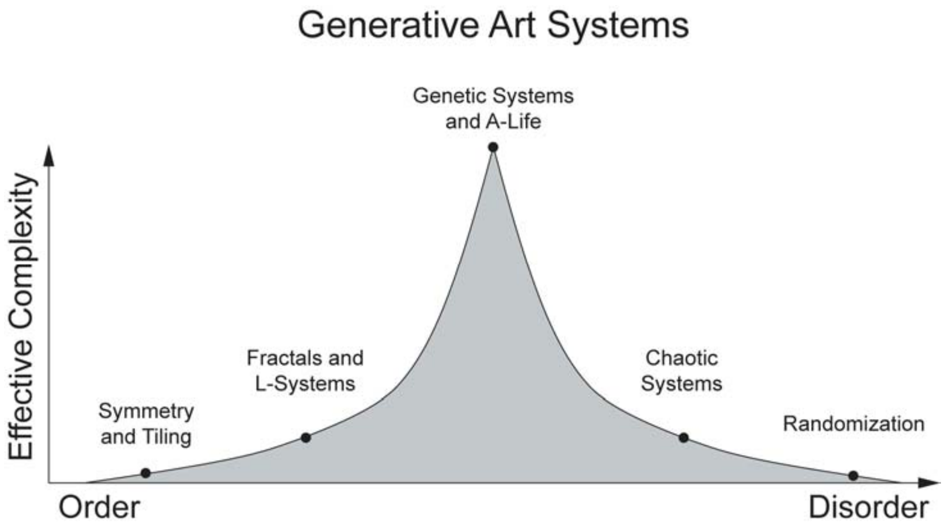

Figure 1.2

2. An Improved Definition

In the context of the full paper in which the related theory is introduced, the previously noted definition of generative art is fairly unambiguous. When standing alone, however, this definition has been misinterpreted and misunderstood. Again, what is important here isn't a definition per se, but rather a theory of generative art. To that end the definition could stand some improvement.

The first confusion is that many who are already of a mind to consider generative art as a subset of computer art tend to interpret this definition in exactly that way. They may allow that algorithms can be executed manually or by machines other than digital computers, but they all too often ignore or disallow biological or chemical processes, self-organizing materials, or other physical processes as being alternatives for the creation of generative art.

A second confusion has to do with rules-based art. In a previous paper I've outlined a number of types of rules-based art noting that some are generative, but some are not. [3] For example, Josef Albers and Piero Manzoni created paintings within self-imposed constraint rules. Albers created color studies but only used concentric rectangles, and Manzoni created paintings that were all white. Ed Rusha created an art book of photography with a thematic constraint rule allowing only photos of small fires and milk. Richard Nauman and Richard Serra have created minimal performances by following rules in the form of instructions. On Kawara has created a series of boxed paintings consisting of that day's date lettered in paint. The rule calls for making such a painting every day.

Each of these rules-based art works cannot be considered generative art because the artist never cedes control to an autonomous system. There is an in-principle dependence on the artist from moment to moment, and at no point does the artist lose control of the art making process. As these examples show, it is a mistake to use the phrases "rule-based art" and "generative art" interchangeably.

A third confusion involves the required use of an autonomous system for making generative art. Some complain that no mechanical system can be considered as being autonomous because such systems are wholly dependant on humans for their continuing operation. Others insist that autonomous systems require free will and consciousness, and that pulls this theory of generative art into debates about complicated and contentious philosophical matters.

In the context of this theory of generative art the notion of an autonomous system is simple and modest. It follows the use of terminology from robotics. Some robots are controlled moment by moment by a human operator at a console not unlike those used to control model cars or airplanes by radio. More sophisticated robots have sensors, GPS units, image processing computers, and other technologies which allow them to navigate and adapt to their environment without a human driver. Robots such as these are referred to as being "autonomous" without any implications or claims regarding free will or consciousness.

It is in this sense this theory uses the term "autonomous." Generative art systems do not require moment-to-moment decision-making or control by the artist. These systems are autonomous *relative to the artist.*

In an attempt to avoid these theory-related misunderstandings the following improved definition of generative art is offered:

> *Generative art refers to any art practice where the artist cedes control to a system that operates with a degree of relative autonomy, and contributes to or results in a completed work of art. Systems may include natural language instructions, biological or chemical processes, computer programs, machines, self-organizing materials, mathematical operations, and other procedural inventions.*

3. The Cultures of Science and the Humanities at War[4]

The first popular airing of the growing 20th century rift between the humanities and science is usually attributed to C. P. Snow's 1959 Rede lecture "The Two Cultures." In this lecture he captures a difference in attitude that has only become greater in the intervening years.

> *Literary intellectuals at one pole – at the other scientists, and as the most representative, the physical scientists. Between the two a gulf of mutual incomprehension – sometimes (particularly among the young) hostility and dislike, but most of all lack of understanding.*
> …
> *The non-scientists have a rooted impression that the scientists are shallowly optimistic, unaware of man's condition. On the other hand, the scientists*

[4] Parts of this section also appeared in a chapter I wrote for [4] Romero, J. and P. Machado (2008) The art of artificial evolution : a handbook on evolutionary art and music. Natural computing series. 2008, Berlin: Springer.

> *believe that the literary intellectuals are totally lacking in foresight, peculiarly unconcerned with their brother men, in a deep sense anti-intellectual, anxious to restrict both art and thought to the existential moment. And so on. [5]*

At least part of Snow's critique seems to be a prescient concern about the coming conflict between philosophically rational modernism (science) and irrational post-modernism (the humanities).

Postmodernism, deconstruction, post-structuralism, critical theory, and the like introduce notoriously elusive, slippery, and overlapping terms and ideas. Most adherents would argue that this must be the case because each is not so much a position as an attitude and an activity; an attitude of skepticism and activity that is in the business of destabilizing apparently clear and universal propositions. [6]

Relative to the modern culture of science, however, the postmodern culture of the humanities can be starkly contrasted. This polarity is summarized in the table shown as figure 3.1.

Modernism	Postmodernism
Absolute	Relative
Progress	Circulation
Fixed	Random
Hierarchy	Collapse
Authority	Contention
Truth	No Truth
The Author	The Text
Pro Formalism	Anti Formalism

Figure 3.1

Exercising Enlightenment values, science and modernity move towards the absolute with a belief that the laws of the universe are real, stable, and knowable. Those in the postmodern humanities voice the kind of skepticism that can be traced back to the Scottish philosopher David Hume, and view any competing theories as ultimately unverifiable, leaving only difference without dominance. [7]

Modern science posits real progress in understanding by replacing old theories with new theories that offer more in the way of explanation and prediction. The postmodern humanities recognize a plurality of theories in perpetual circulation by way of discourse.

Modernity seeks fixed points of conceptual stability while post-modernity celebrates the random in an unanchored world of traces. The modernist culture of science has a tendency towards the hierarchical, expressed, for example, as taxonomical systems of categories and reductionist research methods. The postmodern culture of the humanities seeks to collapse hierarchies. This can be seen in the arts, for example, with the leveling of high art and low art, the ironic appropriation of both, and the creation of arbitrary cross-cultural mash-ups.

While it provides venues for conceptual competition, the culture of science creates and embraces authority both in terms of expert practitioners and totalizing theories.

The culture of the humanities embraces never-ending contention through deconstruction and other post-structural strategies.

Ultimately this leads to a state of affairs where the culture of science expresses a modern optimism that Truth is within the reach. And the culture of the humanities takes the opposite position; a postmodern pessimism that no single truth can ever be arrived at. At best, one can be aware of a multiplicity of equally valid different truths.

At the extreme postmodernism reduces the entire Enlightenment/scientific project to mere social construction, no better or more certain than the mythologies of other cultures now or in other times. [8, 9]

Not surprisingly modern art and postmodern art are also directly at odds. In modern art the author, meaning the writer, painter, composer, etc., is the center of attention. In postmodern art post-structural concerns emphasize the text, meaning the book, painting, music, etc., and the way it can lead to multiple, possibly contradictory, readings via deconstruction. And where the modern heroic artist pursued formal beauty to ever-higher levels of the sublime, the post-modern artist disavows any such claim to privilege, and at most eclectically appropriates formal styles and places them within ironic quote marks. These points are further detailed later in sections 5 and 6.

Art students are steeped in postmodernism without explicit exposure to its derivation and development or the philosophical alternatives. At this point postmodernism has become for most young artists uninspected received wisdom, and a conceptual box from which they can find little escape. And so generations of art students now take as axiomatic the conclusions of postmodern writers, most often in the form of slogans such as:

> *Science is not objective discovery, it is merely social construction.*
> *(after Lyotard)*
>
> *Language has no fixed meaning. There are only traces and word games.*
> *(after Derrida)*
>
> *The author is dead, and any meaning is created by the reader.*
> *(after Barthes)*
>
> *There is no truth, merely discourse and (political) power.*
> *(after Foucault)*

The schism between the arts and humanities reached a new high with the so-called "science wars" of the 1990's. Seeking to problematize science as the last bastion of modernity, "science studies" was established as a branch of humanities research to fully explore Lyotard's vision of science as social construction. The debate reached fever pitch when physicist Alan Sokal's essay, published in the fashionable academic journal "Social Text", was revealed as a content-free parody of postmodern critical theory. It was intended to demonstrate by way of a hoax the lack of rigor in postmodern science studies. [9, 10]

For better or worse postmodernism, deconstruction, post-structuralism, and critical theory form the context within which contemporary art theory and criticism operates. One might think with the rise of "new media" and technology-based art, that artists could find shelter from postmodern skepticism. But contemporary commentary on technology-based art is firmly rooted in the postmodern critique.

For example, in "Postmodern Currents – Art and Artists in the Age of Electronic Media", Lovejoy reiterates the popular claim that somehow contemporary media technology is the physical manifestation of postmodern theory.

> *George Landow, in his Hypertext: the Convergence of Critical Theory and Technology demonstrates that, in the computer, we have an actual, functional, convergence of technology with critical theory. The computer's very technological structure illustrates the theories of Benjamin, Foucault, and Barthes, all of whom pointed to what Barthes would name "the death of the author." The death happens immaterially and interactively via the computer's operating system.* [11]

Another example is Wilson's encyclopedic survey "Information Arts – Intersections of Art, Science, and Technology." His embrace of postmodernism as a context for the artistic exploration of science is less committed, but he leaves no doubt about its nearly universal effect on the field, and is candid about his use of critical theory as an organizing principle for his book.

> *In recent years, critical theory has been a provocative source of thought about the interplay of art, media, science, and technology. Each of the major sections of this book presents pertinent examples of this analysis. However, in its rush to deconstruct scientific research and technological innovation as the manifestations of metanarratives, critical theory leaves little room for the appearance of genuine innovation or the creation of new possibilities. While it has become predominant in the arts, it is not so well accepted in the worlds of science and technology.* [12]

In general the art world has moved from the modern culture it once shared with science to the post-modern culture it now shares with the humanities. Artists who embrace Enlightenment values and science find themselves in the minority, and all too often the objects of dismissal as remnants of a long discarded modernism.

This is a problem, but also an opportunity. Generative artists, especially those working with complex generative systems, are standing right where the foundation for a new bridge between the sciences and humanities must be built.

4. Complexism – A New Paradigm for the Arts and Humanities

The arts were once a full partner in modernity, the thesis that is still operative in the sciences. The arts are now primarily associated with modernism's antithesis, the postmodern culture of the humanities. However, even though modernity and postmodernity as outlined above may seem irreconcilably opposed, complexity based generative art can both lead to and suggest a synthesis that subsumes both.

The term I've suggested for this synthesis is complexism. Complexism is the projection of the world view and attitude suggested by complexity science into the problem space of the arts and humanities. Complexism provides a higher synthesis that subsumes both modern and postmodern concerns, attitudes, and activities.

4.1 Epistemological challenges from 20th century science and mathematics

With the 20th century move from classical to modern physics, the Laplace clockwork universe was replaced by the statistical universe of quantum mechanics, Heisenberg uncertainty, and chaos theory. Meanwhile Hilbert's program to formalize all of mathematics surrendered to proven limits in logic and mathematics as revealed in Gödel's incompleteness theorem [13], and expanded in related work in computation theory by Church [14] and Turing [15], and later work by Chaikin [16, 17].

At times postmodern science studies has appropriated and misinterpreted these epistemologically loaded ideas in an attempt to undermine the stability of the very modernist institutions that produced those ideas in the first place.

Complexism can provide a corrective account that contextualizes scientific uncertainty and mathematical incompleteness. This requires providing understandable explanations for lay audiences, and in particular presenting these explanations to students in the humanities. So far the epistemological challenges from 20th century science and mathematics have yet to be put in an accurate and useful cultural context. The accurate assimilation of these powerful ideas into the general culture will provide complexity artists with subject matter for many years to come.

4.2 Complexism as a new synthesis

Without any specific commitment to literal Hegelian philosophy, complexism's reconciliation of modernism and postmodernism can be best understood as the final stage of a thesis-antithesis-synthesis process. As a paradigm for the arts and humanities complexism is informed by contemporary science, but is put into practice as a form of qualitative cultural study.

Complexism is shown here as a point-by-point synthesis that in its totality suggests a new paradigm. A synthetic attempt like complexism should be expected to take many years to develop, but a first approximation is offered in the table shown as figure 4.1 and the following discussion.

Modernism	Postmodernism	Complexism
Absolute	Relative	Distributed
Progress	Circulation	Emergence & co-evolution
Fixed	Random	Chaotic
Hierarchy	Collapse	Connectionist networks
Authority	Contention	Feedback
Truth	No Truth	Statistical truth known to be incomplete
The Author	The Text	The generative network
Pro Formalism	Anti Formalism	Form as a public process and not privilege

Figure 4.1

Modernity, whether in the sciences or in the hands of painters such as Rothko and Pollock, reflects Enlightenment values in reaching for the absolute, the sublime, and the fixed. The postmodern attitude rejects the absolute, and instead posits a multivalent view of arbitrary relative positions that are functionally random. Complexism reconciles the absolute with the relative by viewing the world as a widely interconnected distributed process. Complexism posits processes that are neither fixed nor random, but are instead complex feedback systems that often lead to deterministic chaos. In the broader culture complexism can nurture a visceral appreciation of how the world can be mechanical and yet unpredictable.

Where modernity posits progress, and postmodernity rejects progress for multiple contingencies in perpetual circulation, complexism looks towards the emergence of co-evolved solutions. Co-evolved entities achieve real progress in the relative context of each other, even while success remains a moving target rather than a fixed end-state.

Modernism posits hierarchies, and postmodernism seeks to collapse them. Complexism doesn't erase relationships, but it doesn't mandate hierarchies either. Complexism emphasizes connectionist models and networks, creating systems of peer agents rather than leaders and followers. Modernism aspires to absolute truth while postmodernism denies any possibility of a single final truth, Complexism embraces known limits to human knowledge, but takes seriously the incomplete and statistical scientific truths that are achievable.

As suggested in Figure 4.2, complexism views both modernism and postmodernism as committing similar and yet opposite errors. Modernism moves towards understandable simplicity by creating crystal-like systems that are highly structured and highly ordered. Postmodernism moves towards understandable simplicity by breaking down and leveling structures leaving behind something like an undifferentiated cloud or mist. In other words in trying to gain partial understanding the modernist seeks to avoid the disorder that is clearly part of our world, and the postmodernist seeks to avoid the order that is also clearly part of our world. Both modernism and postmodernism commit an error of reductionism leading to oversimplification.

Complexism embraces both order and disorder and in doing so addresses all of our experience in all of its complexity.

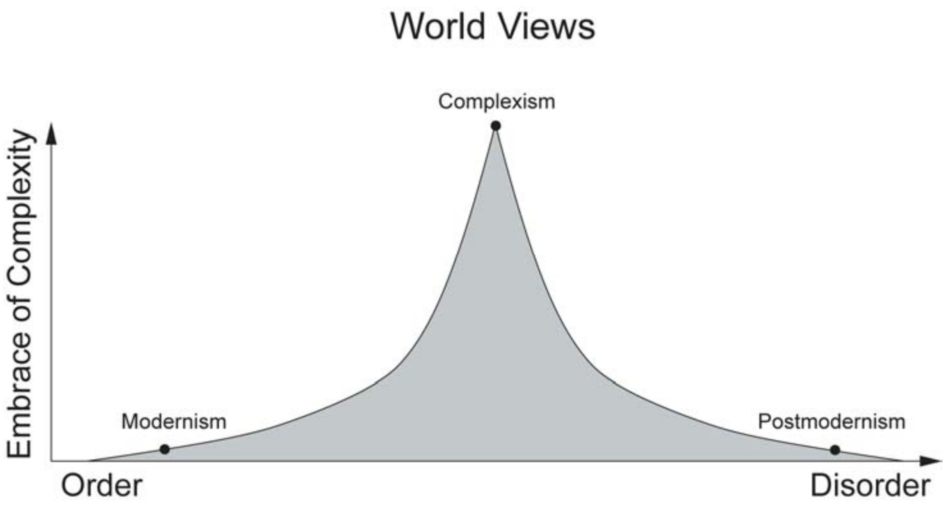

Figure 4.2

5. Complexism and Texts

When considering social communication the modernist ideal is the heroic author in a high-stakes battle to create what will become a timeless a masterwork. The reader doesn't enter the picture except as an afterthought as the fortunate beneficiary of the author's genius and labor. (In this usage an author can be a painter, a composer, an architect, and so on, and the text the created painting, music, or building design.)

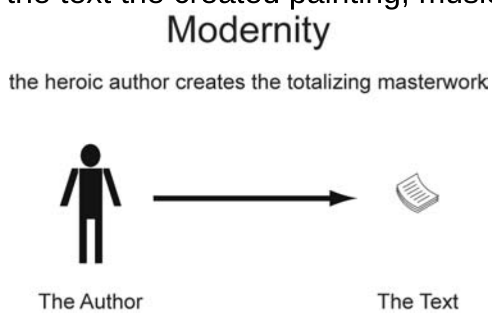

Figure 5.1

The postmodern attitude questions the privileged role of the author, and the stability of language itself. For Barthes "the author is dead." This means that the text itself is the object of central interest. In his formulation of deconstruction Derrida leverages the poststructuralist break with structuralism. He denies the notion that language corresponds to innate or otherwise absolute mental representations, let alone the noumenal world. Rather, at best, language is an unfixed system of traces and differences. And regardless of the intent of the author, texts (i.e. all media including art) always reveal multiple, possibly contradictory, meaning [18]. It is the reader that creates meaning, and that is best done by intensively close reading, i.e. deconstruction.

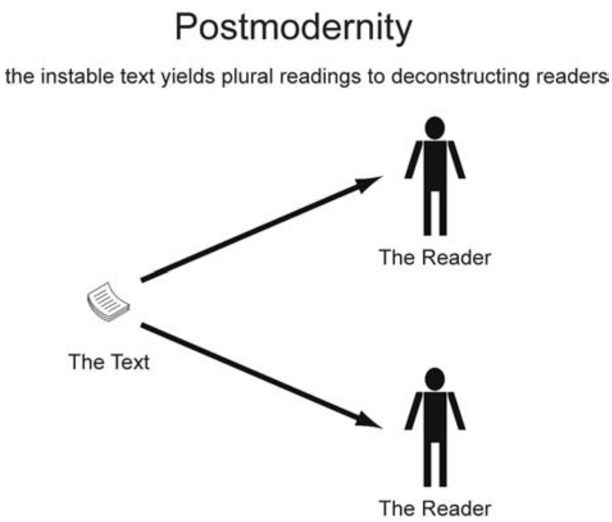

Figure 5.2

Complexism doesn't privilege the author, the reader, or the text itself. Rather these are viewed as parts of a system, and the removal of any one of them renders the system inoperable. Even the smallest unit of social communication requires an author, a text, and a reader.

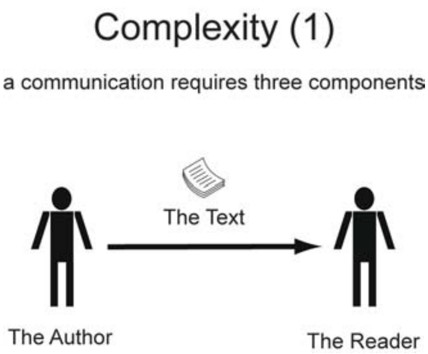

Figure 5.3

And usually individuals act at times as authors, and at other times they act as readers.

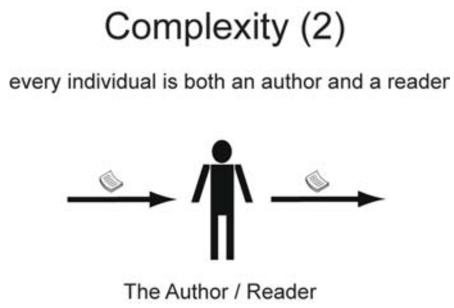

Figure 5.4

Finally, as illustrated in Figure 5.5, large numbers of individuals acting as author/readers form complex feedback networks.

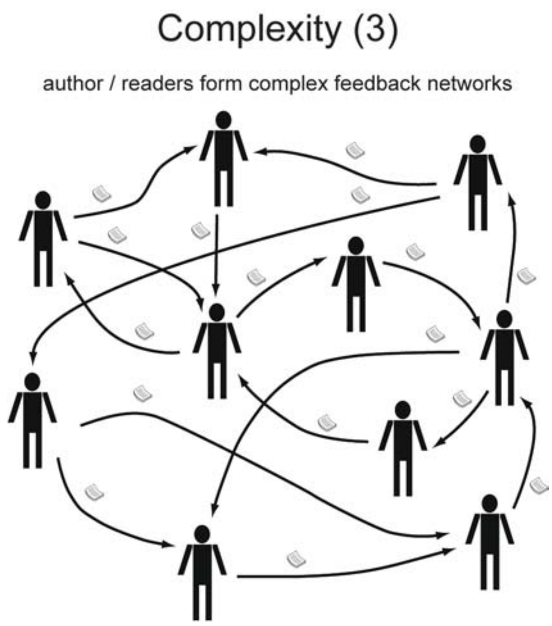

Figure 5.5

The challenge for those in the humanities is to come to understand the cultural implications of these communication networks. Some of this has already begun as those in the humanities consider the impact of the Internet, social computing, and so on. Unfortunately most of this analysis is rooted in the postmodern paradigm and is therefore commits the kinds of reductionist errors noted earlier. The research is yet to be done, but perhaps concepts from complexity science such as scale-free networks will yield greater insight into not only the cultural implications of the internet, but all human communications as viewed from the perspective of complexism.

6. Complexism, Formalism, and Dynamism[5]

Complexism has revolutionary implications for art. For example, modern art embraced formalism, i.e. the study of significant form. Whether by representation or abstraction, formalism was celebrated as a heroic pursuit of the specially gifted artist. Postmodernism rejected formalism as a fetishistic pursuit of meaningless beauty that makes false claims to authority and privilege along the way.

Complexism rehabilitates formalism, but not as a privileged view. Complexist formalism is a public process where form is an understandable property created by underlying generative processes. Static form is no longer meaningless but rather serves as an icon for, and instantiation of, the systems from which it emerges.

Using generative systems in the studio is of great utility. It can be done to create artifacts that would be difficult to design and/or fabricate any other way. But as useful and interesting as that may be, it is the generative works that expose their systems running in real-time that best communicate what is revolutionary about complexism. In its purest form generative art displaying complex systems can most directly and viscerally communicate about the dynamics of complex systems.

But complexism not only rehabilitates formalism. It also, perhaps more importantly, reintroduces the artistic notion of dynamism. As originally introduced by the Futurists, dynamism celebrated the aesthetic of the locomotive and the racecar, and called for the exploration of motion and process rather than portraying objects as being frozen in time. [19]

Dynamism in complexity art is the visceral appreciation of the beauty of dynamics as more fully revealed in the context of complexism. In a sense, formalism is to nouns as dynamism is to verbs. With its focus on complex generative systems, complexity art encourages artists to move from art objects to art processes, i.e. from nouns to verbs.

Up through the 19th century generative artists primarily used simple highly ordered systems. The 20th century saw the rise of generative art using simple highly disordered systems. In the 21st century we are starting to see an explosion of generative art using complex systems in the realm between order and disorder. Complexity art, and complexism as it relates to art theory, completes the full spectrum and future history of generative art.

Presented in its purest form rather than as a means to some other end, complexity-based generative art takes complexism as both its content and working method. In this way generative art demonstrates the reconciliation of the sciences and humanities by providing a visceral experience of the distribution, emergence, co-evolution, feedback, chaos and connectionism that are the hallmarks of the new paradigm of complexism.

Generative art, especially when offered as an ongoing process rather than a static object, presents the dance of formalism and dynamism. It underscores how each

[5] This section also appeared in a chapter I wrote for [4] Ibid.

arises from the other, and marks a radical rebalancing of emphasis away from nouns and towards verbs.

In short, generative art creates the dynamic icons by which complexism can become known and understood, and in doing so creates a new paradigmatic meeting place for the sciences and humanities.

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Mnemonic Descriptors as Generative Principles in Digital Type

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Abstract

This paper analyses the craft methods responsible for determining the relationship between key visualizing mechanisms in the manifestation of language-determined symbolism from both objective and subjective perspectives within the parameters of a systematic metamorphic generative type-strategy, and explores the consequences of evolving fundamental principles associated with the visual requirements of a reciprocally introduced process defining the characteristics of experimental word definition.

Fundamental graphic concepts invite intuitive symbolic dexterity as a consequence of intersecting and dissecting the alphabets revealed by Phoenician merchants, Islamic visionaries, and key polemic demonstrators; these in turn prompted the adoption of free-styled creativity within the craft-maker/designer towards a transformation involving defined areas of tension between intertwining elemental responses and what were to become standard type processes; “ideas have to be massaged into reality” [Fletcher, 1995, p. 19] [1].

An evolutionary visual route through preliminary figurative development is shown to predict the inherent vectorization and digital patterns responsible for the fecundity surrounding formative progressions in systematic reasoning within the field of type design; “there is an invisible line that divides every sign” [Calvino, 1997, p. 269] [2] and by reflecting the impact of each successive relationship “between genesis, formal properties, and the possible reactions of the interpreter” [Eco, 1989, p. 166] [3] generative mnemonic devices are identified as defining catalysts in our conceptual appreciation of communication design.

Introduction

The sum total knowledge of any social network prior to the evolution of writing, would have been what its cleverest and most intelligent members could remember [Daniels & Bright, 1996]. “Primitive oral narratives, like the folk tale that has been handed down almost to the present day, is modeled on fixed structures” [Calvino, 1997, p. 10] [4], principles that formed a logical means of repetition and memory-retention; these were phenomenologically sound mnemonic devices for continuing information transference within primitive social groups. A culture has always been synonymous with the perceived collective quantity of understanding within its society, evidenced by its ability to retain and pass on learned knowledge.

The advent of the written word made it possible for ideas to be stored, transmitted and shared; for records to be retained, and for the first time it was possible to hold onto more knowledge than one person or a single group alone could remember - transforming ideas of transitory experiences passed linearly from generation to generation, to potentially permanent collections, allowing inter-tribal dialogue and the sharing of ideas. “Cognitively as well as sociologically, writing underpins ‘civilisation’, the culture of cities” [Daniels & Bright, 1996, p. 21] [5]. The expansion of populations, travel and the sharing of information led to an increased demand for copies of whatever forms of visually recorded material were available. The problem was, that once writing did evolve, a suitable material was needed to complement it.

Craft Methods as key visualising mechanisms

“Various people at various times exploited the few geometric shapes that are relatively easy to make in clay” [Zimansky, 1985] [6], and the earliest true writing forms found to date, are the Vinca signs and the Near Eastern clay tokens. It is clear from examination of these scripts, recovered from the ancient Near East, that both are closely related, and were either adapted or intentionally influenced by each other [Daniels & Bright, 1996] [7]. As linguistic analysis demonstrates, the identification and location of common threads shows there were considerable similarities across the region, and these themes are to be found throughout recording devices such as the Sumerian cuneiform samples, largely translated during the last century.

The earliest unearthed formed ‘signs’ from 3100 BC to be identified are these cuneiform characters; they were impressions marked upon wet clay by a pointed stylus, formed from an individual reed, and involved a deliberate, conscious, linear action for drawing the shape. [Daniels & Bright, 1996] [8]. Subsequently, this method of forming cuneiform figures was superseded by a quicker impressing action, that was not only generative in nature, but aesthetically preferable and faster. This individual action produced the first true analog printing system, and was due to an expression of man’s inherent will-to-form through intuition. Unlike the organic degradable composites of the craftsman’s other domestic creative practices, e.g. garments, baskets and shelters, all of which were naturally recycled and decomposed quickly, the clay’s durability was to be significant.

The only comparable medium to damp clay for the cuneiform-maker was wax; boards produced from wood were covered with wax and impressions made by a stylus created texts from the third millennium BC onwards. While the Persians developed tablets of clay, the Greeks made boards of ivory or precious metals, and the Romans used wood, beech and fir. Once completed, the boards could be joined with hinges forming ‘polyptychs’, in other words, early forms of books.

The cuneiform clay tablets and polyptychs provided clear examples of two distinct characteristics of printing in analog form; that is, “reproducibility and immutability” [Daniels & Bright, 1996, p. 884] [9], and once it had become general known how to reproduce texts, man was one step nearer the discovery, or realisation, of how to print using movable type.

For this leap to occur, a number of craft practices already in daily use had to come together, aggregated in an inspirational manner - a form of true cross-disciplinary collaboration; (a) ink technology, (b) paper technology, (c) block-printing technology, (d) wine press technology, and (e) goldsmiths’ and jewelers’ technologies. To understand how these various disciplines were emerging, it is necessary to view the individual medieval craft practices from a number of different perspectives. The insight that led to the printing-press phenomenon in the fifteenth century, originated from these crafts that were widely practiced throughout Europe during the Middle Ages, and it was therefore not one single invention, but a coming together at the right time, in the right place of multiple disciplines during their evolutionary cycles.

(a) Around 2500 BC both the Chinese and Egyptians developed an ink made from carbon, lampblack; the scraped up particles were mixed with glue, an animal/fish-based gelatin, for use around stone and on walls when it became necessary to develop an alternative, permanent and more fluid process for visual expression. The Roman word ‘encaustunt’ derives from the Latin ‘incaustum’ i.e. ‘burnt in’ [Lindquist] [10], and translates literally as ‘burnt ink’; the French name for ink is ‘encre’, the Old French word was ‘enque’, while the Old English for ink was ‘enke’. The subsequent transition from carbon based ink to its successor, iron gall ink, was a lengthy process. Between the eighth and eleventh centuries a superior ink, iron gall ink, was produced from gallnuts.

These nuts originated in Syria and China and resulted from insects laying eggs at the stems of leaves on oak trees; swellings appeared on the trees called galls, and when gathered and soaked in water, tannin and gallic acid were released. By combining this solution is combined with iron salt, a dark liquid forms and increases in depth as it oxidises, i.e. dries, on paper or parchment. Theophilus, a German Benedictine monk in his “An Essay Upon Diverse Arts” [Theophilus, c.1125, ‘De Diversis Artibus’] [11] described ink preparation from a similar process involving dried thorn wood, that had been previously soaked in water thus releasing tannin, and after drying was mixed with vitriol or iron sulphate; also Albertus Magnus (AD 1193-1280) describes ink preparation using green vitriol in ‘De Rabus Metallicis et de Minerabilus’ [Magnus, 1280] [12]; Pliny mentions ink produced from soot, charcoal and an unspecified ‘gum’, though he also records the use of acetic acid or vinegar as a good medium for sticking the solution to papyrus [Pliny, AD 77] [13].

(b) Paper making as we know it today originated in China AD 105, with Eunuch Ts’ai Lun, and was produced from linen and diluted cotton fibers [Hunter, 1943] [14]. It was so highly prized, that the craft was originally kept secret from the rest of the world. After the Chinese defeat at the Battle of Samarkan, in Turkistan, A.D. 751, many skilled paper-makers were found among the prisoners, and thereafter, the art of paper making spread helped by the high quality flax and hemp growing along the River Tharaz at Samarkan. The first true paper-mill was reputed to have been built at Baghdad, and the skill soon spread to Egypt and through Morocco during the tenth century [Fuller, 2002] [15]. High quality paper, made predominantly from linen, was polished and buffed, providing a smooth writing surface. Early paper was also known as ‘cloth-parchment’, and often contained straw and wood, all mashed to a pulp before being formed and pressed into paper sheets. However, as demand grew, the quality of the paper also deteriorated as more and more cotton plus whatever vegetable or rag fibers were available, was included, to spin-out the pulp-base. Although paper was superior to parchment in its flexibility, durability and strength, the cotton-rich paper that was mass-produced was still rough, thick and the polishing procedure known to the Persians appears not to have been adopted in Europe during the thirteenth and fourteenth centuries. As a result, the Church decreed that paper was forbidden for use by copyists for manuscripts, as it was deemed an unworthy medium on which to carry the word of the gospels, and Frederick II of Germany went so far as to forbid any official documents to be produced on paper from 1221 onwards. Makers of playing cards and image-prints, however, continued to use the mass produced paper, and as popular demand increased, this crude paper was gradually superseded by a more refined, linen-rich paper. Therefore, by the fifteenth century, paper-making had reached a position where it was ready for inclusion in the imminent new printing process [Carvalho] [16].

(c) Wood-block printing, was a popular traditional craft form in China, and travelled to Europe from Asia at the end of the thirteenth century with Marco Polo. The adaption of this process by artisans in the West, had reached a stage of refinement where it was influential in shaping contemporary visual ideas and image application onto fabric. As a result, by the fifteenth century, it was an ideal time for these design solutions to cross disciplines from traditional wood-block printing to the new printing press.

(d) Wine production has been traced back to the Macedonians around 6,500 years ago, and wine making technology continually improved from the two-stone constructions found in Sinai, with burnt pottery piping [Hosney, 2008] [17], to the screw-presses depicted in medieval tapestries and miniatures. Wine presses also improved significantly during the time of the Roman Empire, and thereafter the Catholic Church’s requirement for wine as part of its celebration of mass, meant that wine surpassed beer in popularity as the sophisticated option across Europe. Therefore, by the fifteenth century, wine making skills and the presses were considerably well developed.

(e) Gutenberg himself was primarily a goldsmith, and it was his finely tuned craft-skills combined with the knowledge and technical expertise of the jewelers’ collectively in Europe at that time, that paved the way for his development of a punch and mould system for manufacturing type. What Gutenberg’s conception of movable type produced was a revolutionary system for not only creating precise, finely mechanised pieces of type, but most importantly, he presented a means for mass producing them. Therefore, for the first time, not only could type be mass produced, but also fine paper and specially developed ink for printing could be mass produced as well. Due to a soaring demand for books at the increasingly popular European book fairs of the fifteenth century, a significant market opportunity was also emerging. Although the printing press has become synonymous with the rise and spread of information, reading and ideas, it also, "resulted in the destruction of the clergy and nobility and allowed the rise of new forms of political, economic, social, cultural and religious systems" [Altschull, 1984, p 4] [18].

Defining the printed word

During the early colonisation of the Mediterranean area, the Phoenician linear process of writing generally became referred to as the foundation of the alphabetic writing form. The freedom with which these images, or letter-symbols, were produced does not suggest any reduction in aesthetic discipline; what it offered was a "selective affirmation of some aspect of the organic world" [Read, 1968, p. 261] [19], an idea transformed into the germ of a concept that required to be understood and adopted generally in order to evolve and become the premise for subsequent future configuration, becoming a, "hypostatized autonomous entity" [Eco, 1989, p. 162] [20]. The symbolism associated with the earliest alphabets, according to Ernest Jones [Gombrich, 1963, p. 30] [21] can be seen to comprise "never-ending series of evolutionary substitutions, a ceaseless replacement of one idea… by another". What was becoming available was a system for transferring idealism, storing and exploring and understanding earlier symbolism with the ability to continue, to re-represent the truth from one era to the next; combined with intellectual development this came to signify the capacity to reflect, to reason, and for the first time realised a method of expressing this knowledge to a wider audience.

A craftsman, like any artist "depends on the community – takes his tone, his tempo, his intensity from the society of which he is a member"; his natural will-to-form is instilled within his distinct personal make-up, and this intuition ensures that he "use materials placed in his hands by the circumstances of his time" [Read, 1968, pp. 261, 267] [22]. This forming concept involves a realisation that a 'work' steers its own creation by an act of self-centered empirical formation [Eco, 1989, p. 161] [23]. It also opens the continuous possibility for analysis or interpretation; which can only be realised by "retracing its formative process, by repossessing the form in movement and not in static contemplation" [Eco, 1989, p. 163] [24].

The development of a writing system required mnemonic devices in order to teach and learn the alphabets associated with it. Logo-syllabic writing systems, e.g. Chinese, include semantic and graphic sets of patterns situated linearly across both groups and characters; while, logographic systems rely on graphic similarities as a logical means of acquiring alphabetic knowledge. The Arabic order combines Levantine and graphic similarities, whereas Ethiopians incorporate a type of Phoenician-Hebrew order [Daniels & Bright, 1996] [25]. The alphabet when viewed as a mnemonic device works by its simplicity, the fewer characters or symbols, the better. The number of letters is what matters; up to 30 is relatively simple to learn, while the linguistic nature of words themselves appears to be of limited importance.

Fundamental graphic concepts & free-styled development

Man's receptivity to the intellectual implications of cuneiform practices and alphabetic systems is governed by his sensibility; it is this sensibility that informs his intuition and forms his understanding of concepts. Through conceptualising these early responses he was supplied with instinctive generative principles that allowed him to influence and determine his future path as a literary progression. To understand how important it is to limit the number of letters in an alphabet for developing communicable systems, we can examine a series of situations that came about from extreme situations. For example, at sea, great distances and restrictions on visibility meant a way had to be found for passing on information, thus semaphore was developed using two flags, with one flag in each hand, the combinations of these geometric shapes produced alphabetic variations that have since been adapted for further methods of communication. The telegraph required an even simpler transformation, comprising just three elements; similarly morse-code devised by Samuel Morse was based upon a series of dots,dashes and spaces which interpreted letters and numbers into flashes or sounds.

Learning to write is a challenging process, whatever the system, and involves numerous mnemonic devices to assist the memory in recognising shapes and forms. Little wonder then, that the cuneiform writing, ‘cuneiform’ derived from the Latin ‘cuneus’ meaning wedge, - so literally ‘wedge-form’, prevailed in the ancient Near and Middle East regions amongst several different language-groups for over 3,000 years until the Jewish Diaspora (70 AD) [Daniels & Bright, 1996] [26].

Figurative development

The ability to visually interpret signs and patterns, led to a fecundity which unified cultural experience. “The capacity to obtain representations through the way in which we are affected by objects is called sensibility. Sensibility alone supplies us with intuitions” [Kant, 1781, p. 20] [27]. Once style is instrumental in the forming process, it can be said that the notion of form is informed by its structure and that the act of communicating is a result of the subsequent interaction between two people. Pareyson [Eco, 1989, p. 164] [28] informs us that a cultural universe is open to communication as a result of the similarities that exist between people. A ‘form’ is not capable of possessing an impersonal entity, “rather it actualises itself as a concrete memory of both a formative process and a forming personality” and these only come together through “objective texture… i.e. its style” [Eco, 1989, p. 164] [29].

“There is no definitive or exclusive interpretation, just as there is no approximate and provisional interpretation” [Eco, 1989, p.165] [30] that can define the graphic symbolism that evolved from the cuneiform era, but what it produced, was a communication process situated between the receptor and the addressee [Eco, 1989, p.196] [31]. This area of tension defines a unifying code, the interpretation of which is universally understood and consequently results in an interaction of creative descriptiveness and personal objectivity. What evolves is a psychological disposition achieved as a result of differences in operative forming and openness against a backdrop of historical context. Any ambiguity experienced by the addressee or the receptor can only be overcome by a common interpretative technique or a mutual commitment to understanding the newly formed codes.

What writing systems preserve is language, and its application and conveyance, not only across distances, but also time. Their development has systematically moved into carefully managed systems that subsequently enable people to make sense of, and construct order within the world in which we live. The fact that writing systems convey language, and the manner in which the alphabet it configured, i.e. its order, are two distinct, yet highly important phenomena [Baudin, 1993] [32].

For man to attain literacy, it is necessary for the order and sequences within the alphabets to be succinct, and within the grasp of his mental capabilities. Prior to the development of movable type, all documents had to be produced manually; using either ink with pen or brush on paper or papyrus; by stylus or reed on wet clay; or by chiseling into stone - and to produce a copy the craftsman could make a rubbing over the surface of the latter. What this meant was that for a print of anything to be manufactured, it entailed an ‘analog’ method of reproduction, but once movable type was discovered (by Pi Sheng in mid-11th century China; and by Gutenberg in 15th century Germany) [Daniels & Bright, 1996] [33] all of that changed.

Digital Type

"In terms of their fundamental principle of modularity, there is no difference between the latest digital fonts and the metal typefaces cut by Gutenberg"; what is clear is that 'type' is not the same as 'lettering', as "type… was from the outset designed for duplication and reused to set other messages" [Baines & Haslam, 2002, p. 72] [34] i.e. type is generative, whereas it is the letter-writer himself who is the generator.

Ellen Lupton states, "typography is an interface to the alphabet" [Lupton, 2004, p.75] [35], and that the current capacity for the dissemination of digital information and communication is as significant for us today, as the impact made by the print revolution was during the fifteenth century. While Maximilian Vox described the "two great means of human intercourse…speech… and the written word. Deflected from its natural course as soon as Gutenberg dissociated them" in his "La Mort de Gutenberg" or "La Revolution du demisiecle" [Baudin, 1993, p. 120] [36], Roland Barthes for-saw the unstructured chaos that would ensue once the internet's decentralisation had taken place within communication design [Lupton, 2004] [37]. Barthes also described the reader as the former consumer who now transformed the produce into meaning [Chow, 2008, p. 373] [38]. George Landow's view is that the internet is capable of realising this post-structuralists' dream by means of 'hypertext' [Aarseth, 1994], while Genette describes "hypertext… a kind of generative text" [Chow, 2008, p. 375] [39].

Conclusion

The measure of success for any piece of written work is a combination of its 'linguistic grammar' and its 'visual grammar'; and the problem with computers is that "ready-made alphabets achieve such a degree of precision, and are so attractive as a result, that even educators may be tempted… to use them" [Baudin, 1993, pp. 126, 127] [40]. Though, "good typography tries to make the messages as legible and accessible as possible …typography will consequently have to be regarded as a 'psychological' problem" [Zachrisson, 1965] [41]; it is also true that, "typography is concerned with the transmission of linguistic material through the medium of visual patterns" [Sassoon, 1993, p. 150] [42]. When it comes to linear versus spatial, the database with its non-linear definition of structural quality is one of the most significant forms of information storage space we possess. Lev Manovich describes "language itself as a kind of database, an archive of elements from which people assemble the linear utterances of speech", thus, if "database and narrative are natural enemies… competing for the same territory of human culture" [Manovich, 2001] [43], then, the growing desire for designers to utilise and address the manifestation of space is in sympathy with typography's location within the digital era. Since the end of the last century, our ability to program as a limitless form of societal communication has meant that "the machine had already evolved from a tool of programmed computation to a means of cultural expression" [Chow, 2008, p.373] [44]; the internet has become subsumed by text, and simultaneously digital type has become revolutionised by the dynamics of text-perception. So, while digital type can be described as the generative manifestation of letter-forming, because Gutenberg's printing press was the generative realisation of movable type, it must be true that cuneiform was the generative process that transformed spoken language into written words; and therefore the craft methods used for changing language into its written form are also the same practices responsible for its metamorphosis into digital type.

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Alive Codeness

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Abstract

A Vision identifies how to transform the existent, the past into the future. It can be born, like in Renaissance, only from a deep knowledge of human cultural heritage in Art and Science. This knowledge allows us in setting up the rules for shaping the future. Leonardo da Vinci teaches at the best this need to define a code before defining a result, a solution.

Generative Art refers to this cultural heritage. Generative Art works with transformation rules and not with solutions, as forms.

Generative Art, as my Argenia soft, defines Alive Codeness. Following a Logical Interpretation of Nature and of great Masters of the Past, I designed a set of rules able of managing the transformations inside creative process. The Alive Codeness, as "artificial DNA", defines a Vision identifiable as poetics. Poetics is the summa of Visions. The result is the generation of endless Variations.

*# **Metodology**: the creative path is a not-linear sequence of moments of discovery.*

It is based on a starting moment, not very important for the final recognizability of the own poetic result but important for the individual identity among variations. The discovering path is the flow of subsequent answers to upcoming needs coming from the artist's Vision. Each answer is shaped with the use of transformation rules, strongly linked to the Vision, applied to the precedents.

*# **The starting point of transformations** is the topological paradigm drawn as catalyst, where the set of transformation rules, the artificial DNA, performing Alive Codeness, will operate.*

*# **Complexity** is the main character of generative processes. It is the result of stratifications, contaminations and iterations that happened during the discovering path. In Argenia the approach to complexity refers mainly to Nature: the complexity of an olive tree comes from its DNA that is able to manage transformations facing different unpredictable events like storms and rain and increasing, with these transforming acts, its uniqueness and recognizability as individual and as species. In imitation of nature I am referring to Baroc for transforming and fractal geometries, to Piranesi for stratification of meanings and perspective points of view and to Gaudi' for complex events like movies of dynamic transformations.*

*# **Identity and recognizability** must be the main characters of generative artworks. There is a strong relationship between a well-identified Vision and the necessary*

generation of Variations. Identity is defined in the type of path to increase complexity, in the character of the synthesis and in the recognizability of each different variation.

Recognizable Visions

Vision is the expression of how each artist manages his creative process. : Kandinski, Picasso, Van Gogh, Borromini and Gaudì are recognizable artists and architects. If you look at one of the artworks of Kandinski, Picasso, Van Gogh, Borromini or Gaudì you will identify it as belonging to their own Vision, also if you never have seen the particular artwork that you are looking to.
When visiting cities and architectures and looking at objects and artworks, people appreciate and easily remember their impression, that is their interpretation of the artist vision. People don't remember forms, but Ideas.
Many architects or artists made wonderful artworks and architectures. They reached the beauty but their works are not recognizable as belonging to a vision. May be that they refers only to a collective style or cultural moment or to a fashion moment. But this is not enough. Each person has subjective needs and he likes to identify, interpret and interact with recognizable subjective Visions. If not, it’s boring.

Designing own vision with generative approach

My generative approach was ever focused in identifying how this recognizability, how each vision can be expressed in creative processes. Starting from my first generative work, Basilica. It was the software I designed in 1987 to generate endless 3D models of Medieval Italian towns, all different and unpredictable but all recognizable as belonging to this strong cultural identity. But also they are expression of my interpretation of Italian Cultural Heritage. It is not a case that I used, for setting up the transformation rules used in this software, the Giotto frescos and not only the existent medieval towns. Giotto Vision is strongly significant about the identity of these cities than reality. Subjective interpretations are more rich and complex than objective data. Staring from artworks it’s possible to go ahead with subsequent interpretation of artist’s visions as Picasso made with Velasques, because the Past, the precedents and their interpretations are necessary for reaching complexity.
The following versions of Basilica and Argenia, my subsequent generative software, were written increasing the complexity of their generative engines: each new design occasion was important for creating new interpretation of my cultural heritage, new possible transformation rules linked to my Vision. Now, after 20 years of subsequent increasing complexity made with my subsequent interpretation of Nature and of our Cultural heritage made in different moments, with different moods and facing different needs, my generative Soft reached an unpredictable strenght. It has, inside, the memory of how I interpreted each different architectural project. These codes help to face new projects because they have found, after the contingent use, further roles for increasing the complexity of my architectural Vision and of my architectures.
When I work in different contexts of different Cities Identity, I can set up the software tuning the code to my interpretation of the context, performing new tranformation rules if necessary and changing a bit the role of existing rules. The aim is to consider the Identities as the main quality of natural and artificial environment: Identities can be stratified through the design process without loosing them. More, architectural variations coming from subjective interpretations of a peculiar city could increase the

recognizability of its cultural identity.
I verified this possibility in all my generative architectures, from Los Angeles to Chicago, from Rome to Hong Kong, from Washington D.C. to Shanghai.
With my last software I tried to enlarge this generative approach to other designers by creating the possibility to write and develop the own vision.

How a Vision can be transferred into a design rule

Vision is how to approach to existing environment for creating incoming scenarios. The vision of upcoming events can exist only if we refer to the existing events, to our past with the knowledge of our cultural heritage.
Following our interpretation of human cultural heritage in the fields of Art and Science, we can design some rules able to be applied for shaping the future. Leonardo da Vinci teaches at the best this need to define a code before defining a result, a solution. Generative Art refers to the cultural heritage of Italian Renaissance. It works with transformation rules, with codes, and not with the form of the result.
Doing that, Generative approach can define a Vision, it can identify a Poetics

Renaissance approach to Codeness.
In these pages, Leonardo da Vinci, identifies a code from multiple variations of how the water transforms its own form when flowing.

New, Beautiful and poetics

When people design an object often people search for something "new", for an unusual shape, looking for a new form in fashion-magazines or in unpredictable random events. This is not a generative approach. And this is neither a creative approach, it is only the typical approach of buyers.
Generative approach, interpreting at the best the creativity, defines a new approach on how to transform forms. Every form is good as starting point of subsequent transformations but it cannot enter in the final result(s). I identify this starting form as "catalyst": it helps to run properly the transforming path, by using subjective transforming rules, but it cannot enter in the final result, as the catalyst in chemistry. Catalyst can be the copy of something that exists; the copy, the false in front of the truth, but after the generative transformation process, the result forgot the used forms: if the creative process will be sucessful, *it will be the truth.*
If we use forms without transforming them with our logics and our Poetics, we can reach to something "new" and "beautiful", as happens when we look for the emerging forms in random processes, but these forms will be not recognizable as belonging to an artist. With this approach we forgive our identity. No one will identify

a Vision in these "random" results. They will be “mechanical”. Only stuff.
We cannot identify the Generative Art as the Art of Buyers, waiting for the random emergence of unexpected and beautiful forms. We can reach only approximately to what is not enough for Art.

Argenia, from Forms to Transforming Rules

Argenia, my generative software, utilizes forms only as starting point. At first each generative project, architecture, object or artwork, is defined as paradigm of organization of incoming possible events: as organic system of relationships, not as a form/solution.
This paradigm defines a dynamic topology. The form of the starting events is not important. It's important the identification of their character and of their mutual relationships. In my last Argenìa, it's possible to identify and define the catalysts (the starting forms for each event), the functional / symbolic / aesthetic character of each event and the rules to be used in transformation processes.
Results will appear after subsequent transformations that happen several times in each event and in the whole system. The rules used for developing the system are a set of logics strongly representing the subjective vision, the identity of the designer.
At the end we can easily identify that the starting forms are not so important to construct the design character like the transforming rules. As normally happens with fractal subsequent processes. So I can say that the set of subjective transforming rules are the operative representation of the artificial DNA of each designer. This is my Alive Codeness.
(With my last generative software Argenia, opened to different designers, each designer can create his peculiar artificial DNA. I have not yet published a commercial version of Argenia. My aim is to use this software in "Domus Argenia" the international research centre about Generative Art that we are establishing in Sardinia whose activity is starting from next summer)

Generative Art is a Philosophy

If Generative Art is to design a creative process, to define its peculiarity, identity and recognizability, to set up the generative rules for getting (from 2D-3D-phisical and more) scenarios belonging to desired characters and to construct a software as dynamic not-linear system able to generate unpredictable but recognizable endless results. If so Generative Art is, in other words, to discover and design the own poetics: as a philosophy of a creative process.
As a philosophy, Generative Art can define a very useful way to teach design because *it can identify some logics of a creative approach*. Therefore I discovered that, starting from the creation of my first generative software, my teaching activities in the topic of Architectural Design and Industrial Design improved clarity and ability to involve my students. This because the aim was to help students to identify and create in progress their own vision by running on generative creative paths.
I learned that it's possible to teach "how" to interpret their own cultural identity, the surrounding environment and Nature for tracing a vision and generating incoming future scenarios. My last teaching experience was with Enrica Colabella, last August, a travel-workshop around China for teaching to the students of Hong Kong Polytechnic University how to use their Chinese Cultural Heritage for designing the

objects of the future. Following our generative art process.
Architectural and Industrial Design teaching, using Generative approach, could be more full of significance for upcoming architects and designers than the teaching of functional analytical approach.

Complexity and Quality

Complexity is the main character of generative processes. Generative Art shows its power only through complexity because Generative Artworks are processes of self and resonance iteration of logics and complexity is the result of a "long" and repeated not-linear process.
Although beauty can be reached soon, poetics needs an increasing complexity path, using subsequent transforming logics. Only when we define “how” to apply, for example, the golden-rectangle relationship we can define our poetics.
We can reach beauty in two ways. Soon with an existing form or with a minimalist approach: also a natural stone could be used as paperweight. But, in this case, the identification of a vision will be impossible. This quality can be reached only with an increasing complexity process. We need a very long path for arriving to a result, also a "simple" result, where forms are not simplified but distilled into a full-of-sense event. Simplified results, like common results of our era, are not more acceptable.
Full-of-sense results are complex results where we can identify a poetics. And where we can find and identify our possible interpretation of future. Complexity, as endless meanings, defines the best quality that we can reach in the contemporary: the possibility to give focused answers to different unpredictable requests of each-different unpredictable customers.
Simplified architectures had got their time in the last century. They destroyed the cities identity, especially in the surroundings, where equal repeated simplified architectures have constructed new towns and new districts.
We need Baroc approach in our time. We need complexity. We cannot ever more accept minimalism if this is associated with simplification, with no-project, with repetition of all equal, with the obsolete legend of optimization. But we cannot appreciate complexity if it is created with random approach. It’s boring. At the best it can be only a decoration.

Generative approach and Cities Identity.

With Generative approach we could support the increasing identity and uniqueness of each city, discovering its poetics, its peculiar vision that we can call its "ideal city".
When we have identified this "ideal city", or, better, one of possible interpretation of it by defining a code, an artificial DNA, as its unique way to look at future, we could use this code for the incoming transformations and for managing its increasing complexity.
Architects, by designing many different architectures identified by different recognizable visions of the same "ideal city", can give to each citizen the possibility to mirror themselves in the increasing complexity of their environment, in the multiplicity of possible interpretations of their city, of their cultural heritage represented by the city variations.
My research work is in this direction. I discovered that the transformation rules could be contaminated, increasing their strenght, with the identity of each city. Sometimes

only little contaminations a minimal variation of parameters, could represent own interpretation of the identity of a particular city. Identity of architect and identity of environment are not one versus the other. The best way to get complexity, and to get quality answering to different unpredictable requests of customers, is working by stratifying different identities, even their contamination.
Particularly the complexity is the common table to put together new and ancient. The time patina of ancient architecture came from having lived through different cultural moments and from being contaminated, like happened in Italy. This gave to these ancient architectures the power to have a beauty without-time but in harmony with the flow from past to future. The Piranesi's engraves, representing ruins of classic Roman architectures and their subsequent transformations during the time give us the knowledge of how the time patina is strongly linked to complexity, beauty and recognizable identity.
In my Argenìa software I tried to run an increasing complexity path similar to the natural time path of ancient environments. This using stratification of meanings and characters, contaminations of different creative moments, subsequent transformations following subsequent aims, multiple references, also contradictory reference in paradigms and transforming rules. Like Baroc. Or, that's similar, like Nature.

Vision generates Variations

The recognizable Identity of each possible result is the identity of a species of results. There is a strong relationship between a well-identified vision and the necessary generation of multiple variations. A set of variations identifies better a vision than only single results. Variations, like in the history of music, from Bach to Jazz, are strictly linked to a recognizable creativity.
Generative software is like a DNA of a species of possible results. In my Argenia, the variations spring from unpredictable contamination among different transformation engines working together. Contaminations define the identity of each unique result; Logical Transformation Rules define the Vision.
Technically, in my generative software, individuals are defined by the time when the software begins to run. This clock, ever different, defines different speeds of parallel transformation sequences, it creates unpredictable contaminations.

Questions regarding the structure of Argenia, my generative software.

Argenia is my representation of the design logics as path of discovery: a complex non-linear system where many different codes work together. The transformations are controlled by a paradigm that is a topologic system of relationships.

A.**Methodology**

A.1.*My approach to design*. I consider the design path as a not-linear sequence of subsequent discovering moments. It is based on a starting moment, not very important for the final quality and for the identity of species, but important for the uniqueness of each result among multiple variations. The path of discovery is developed through the utilization of subsequent transformations strongly linked to the subsequent requests of the client and of my vision, but which results are unpredictable because of unpredictable reciprocal contaminations. The possibility to have many different alternatives during this process is important because quality springs from creative freedom that is to be free from "only one possibility" when the development process is going ahead.

B.**Topology and Character**

B.1.*The use of a paradigm*. In each generative project the definition of the topologic system and of the characterization system is normally not "generative" but is one of the inputs for "generating" variations. Argenìa can also generate paradigms using Cellular Automata, but this possibility cannot easily be used if we need to fit exactly the needs of the customer.

B.2.The paradigm doesn't define the results but is the creative representation of the system of customer's requests, of their mutual relationships and of functional, aesthetical and symbolic aims. With the paradigms the aims are transformed in an open system of constrains. Constrains don't limit the generation possibilities; they don't fix only one character by destroying the alternatives. Better, constrains increase the number of variations. If the constrains are a lot, the generative system has more matter to explicate and represent its peculiar characted and uniqueness. Constrains are requests and each request asks to the generative path to work for answering, by increasing the complexity of results and, together, increasing the possibility to follow and recognize a Vision.

B.3.In Argenìa there are two sectors of open system of constrains: the topological, that is the orientation of events and the definition of point of congruence among events, and the field of "open" functions, that is the definition of the role of each event in the global system of the project. Each "open" function defines that an event must have, for example, the role of an "end", like the dome in a space, or the role of "connection able to manage a corner", or the role of "organizing the division", and so on. This constrain asks to the design generation process to use, one after the other, different sets of codes of transformation that are written for managing "how" the event ends, fold itself, is divided, and so on.

C.**Identity**

C.1.*The management of the identity of my Vision in the **complexity of details*** is the design of the codes of transformation to be used in all the generative projects because they interpret, in a subjective recognizable way, how each event can manage the design needs. That is, for example, how an event folds itself, how the end of the object could be created, how an event divide itself for creating a sequence of events like windows or columns, how an event could manage the relationship with the ground, and so on. The approach is similar also in a simple generative work for drawing 2D scribbles: how the drawing line fold itself facing the surrounding events, and so on.

C.2.*The management of the identity of my Vision in the **synthesis of the total image** of possible different results* is the design of the codes of transformation to be used for transforming the global system or a significant part of it. These rules define the character of the geometrical system keeping active the topological geometry of each part and their relationships.

C.3.*The management of the **identity of each variation*** works as in Nature, where individual identity doesn't overcome the species identity but, where the difference among individuals increases the identity of species.

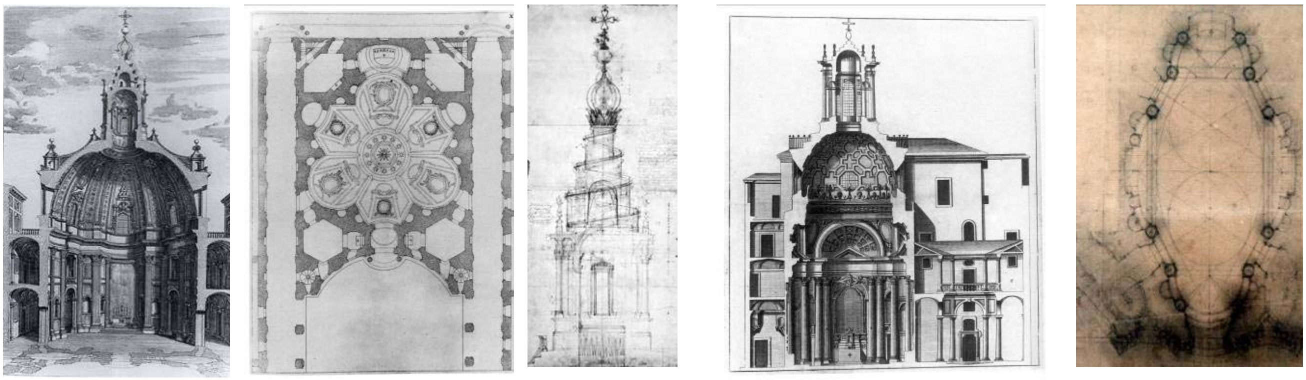
C.4.*The management of the **identity of the context** (city for architectures or/and brand for product design)* is the definition of "new" transforming rules focused on each peculiar project by considering the identity of different cities, of different brands, if the project is focused on an industrial design production, or other identities belonging to the market. This management works with little changes of some parameters in the algorithms representing structural transforming rules. Little variations of parameters inside the transforming rules work as "fly effect" in complex dynamic systems. This can change, or better increase, the identity of the results by arriving to represent, in each possible variation, my subjective interpretation of different city identities. I have done that in the exhibitions of my generative architectures where I verified this result by asking to each visitor in which visionary image of architectures he has found the increasing Identity. I.e. regarding architectural future scenarios of Hong Kong, by asking in which one HK seems more HK than before.

D.**Complexity**
The philosophy of Generative Art identifies how to design complex systems. In Argenia this aim is reached with three approaches, everyone belonging to the Nature. The first one refers to Baroc, mainly to Borromini; the second refers to Piranesi, the third to Gaudì architectures. Piranesi, Borromini and Gaudì are my masters, my main references for Generative Art.

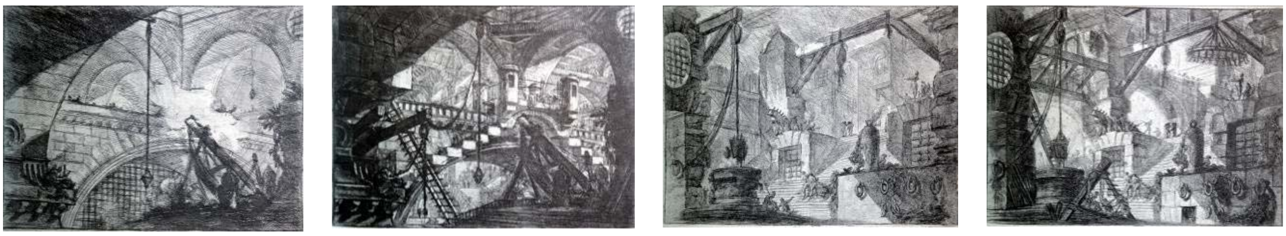
D.1.*Baroc complexity*. Referring to Baroc and, first, to Borromini we can interpret these architectures like the result of a generative process. The paradigm was based on the use of "new" geometries, as a rectangle, a double square, in Saint Carlino and the equilateral triangle in Sant'ivo, that no one used before in the same way. The system of increasing complexity refer to the knowledge and use of classical architecture heritage but, using these unusual geometric paradigms, results are unpredictable and, in the meantime, unique and strongly recognizable. More, the Baroc approach to complexity uses fractal sequences. The omothetic symmetries support the increasing complexity path through detail not by enlarging to the subjective multiplicity of different stonemasons as in Gothic but by using the scaled similarity as in fractal images. In Argenìa I used all these possibilities and I like to consider my architecture as Baroc new generative architecture.

D.2.*Piranesi complexity*. When Piranesi have done his more famous engraves, the "carceri d'invenzione" he used the possibility to stratify, one after the other, different moment of interpretation of these visionary environments by drawing again in the same engraved plate. This different-in-time stratifications was realized not only with increasing details and events one over the previous one but, and this is really interesting, also changing the point of view of the perspective system of representation. In Argenia I used this increasing complexity path. Transformation events can be easily stratified, by using the codes of transformation one after the other. This process is impossible if we use forms because we cannot stratify forms. But in generative approach, using transformations, we can stratify all the process by keeping alive the character of each transformation. This is the more interesting process of increasing complexity because it belongs exactly to a generative process and cannot be done if the process is different. Following this important reference I tried to go ahead with this process inside some Piranesi's engraves. (See images)

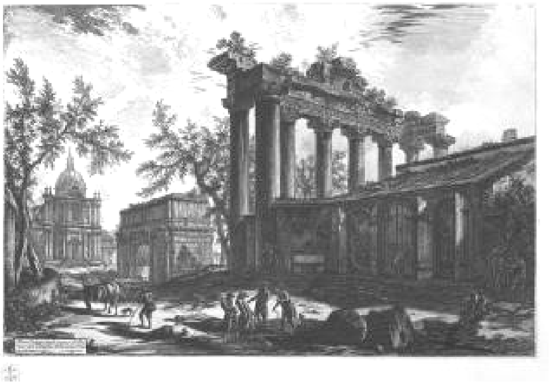
D.3.*Gaudì complexity*. It was the more complex way to gain complexity, also because this complexity comes directly from a strong creative activity. The complex geometries of Gaudì are the result of contaminations among "structural" geometries like the chain geometry ("catenaria") and dynamic transformations of subsequent sections where each point can run its particular transforming path. In my generative approach singular algorithms managing different entities of the same system easily represented this increasing complexity system. In Argenia these contaminations, that are the main engine of my interpretation of Gaudi' reference, were managed in an unpredictable way by running the different parallel codes of geometrical transformation all together. Results are unpredictable but not random. And I like to think that results belong to my recognizable Vision.



Borromini, Original Borromini drawings of Sant'Ivo with the triangle geometry of the space and its helical lantern; Saint Carlino, with the double square geometry transformed in ellipse.

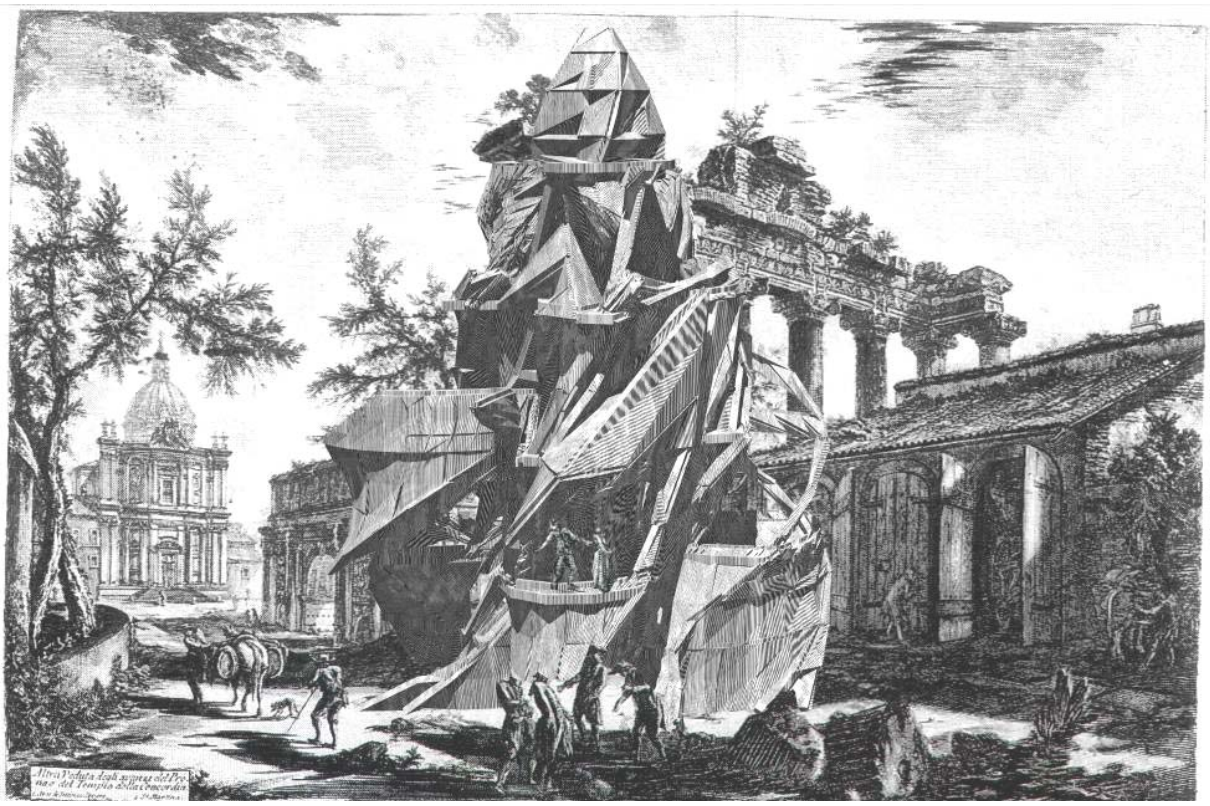


G.B.Piranesi, the "carceri d'invenzione" engraves. The first artwork and his subsequent increasing complexity in two of his more famous engraves.

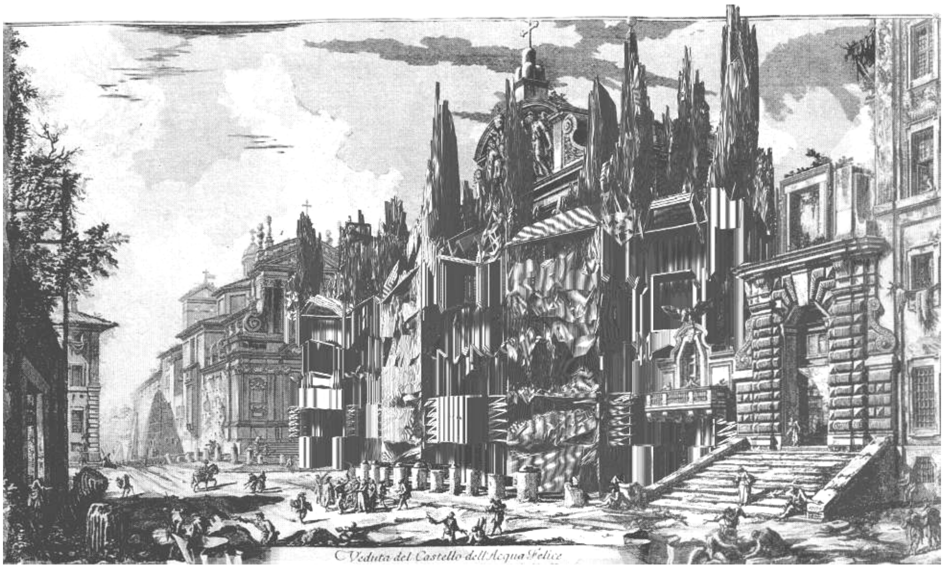


The original engraves of Piranesi.

The "Babel Tower", generated architecture using helical codes from Borromini and The Piranesi increasing complexity. C.Soddu, 2008
In the image the Variation #1



“The Babel Tower”, This generative projecy was made generating 50 different unique Variations. The artworks were given to the 50 participants of GA2008 as gift of Celestino Soddu.
In the image 15 variations.



The original engraves of Piranesi.
Inserting a generated architecture using codes from Gaudi' with the reference of Mila' house and The Piranesi increasing complexity. C.Soddu, 2008

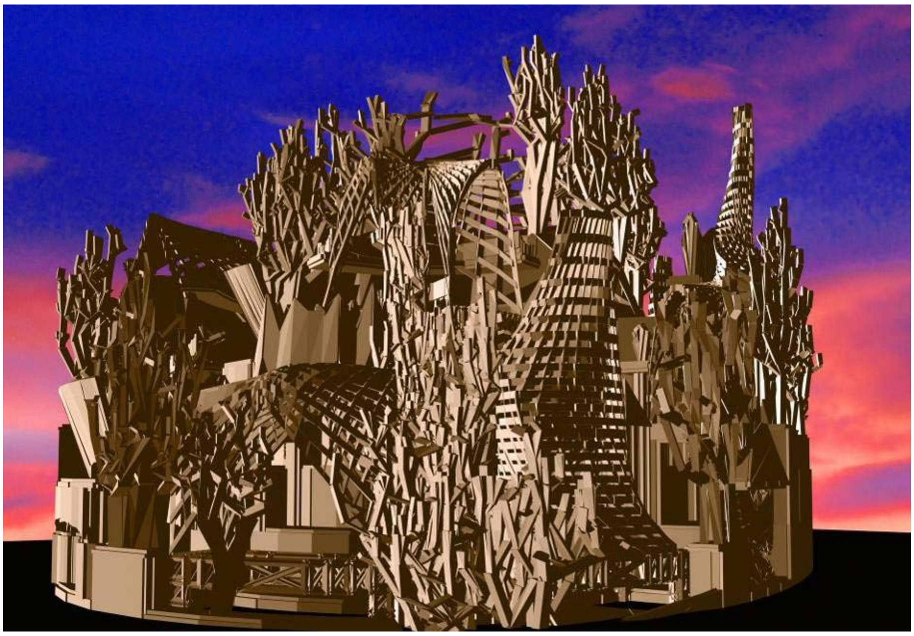
The original engraves of Piranesi representing the "portico d'Ottavia".

Inserting a generated architecture using codes from Borromini' and The Piranesi increasing complexity. C.Soddu, 2008

Italian Garden, var #1

Italian Garden var #2

Following Italian Cultural Heritage, two generated Natural/artificial projects.
C.Soddu, 2008



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Chance and generativity

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Abstract
This paper is about the meaning and use of chance (randomness, hazard) in artistic generative processes.
In biological processes, nature relies on chance to promote diversity and novelty, without giving up identity : in sexual reproduction chance is involved in the combination of the two DNAs of the parents which produce the DNA of the child ; chance intervenes also in the alterations of the DNA (mutations) which allow life to evolve.
We human beings don't generally like to rely on chance, we like to control our life and our productions as much as we can, unless we believe in fate, or prefer to abdicate our responsibility by throwing dice or consulting the I Ching... Using randomness seems to be an abdication of our power of decision. However, chance isn't opposed to rationality, as the idea of *serendipity* in science shows us. Chance has been used by artists in many ways throughout the ages, and may be a powerful tool, *when well used*, in a way similar to that of nature itself, for producing diversity as well as identity.
We'll discuss and illustrate first the different meanings of chance relatively to probability, combinations, imprevisibility, coincidence, chaos, disorder, control, intentionality, etc.
Then we'll examplify the use of chance in generative processes leading to forms and spatial configurations, especially in architecture.

Un coup de dés jamais n'abolira le hasard[1]
A toss of the dice never will abolish chance

Chance and unpredictability
Among the many objects that surround us we may discriminate between those that are *natural* and those that are *artificial*. This is how Jacques Monod begins his famous book titled *Le hasard et la nécessité* (*Chance and necessity*) [2]. Even if some other animals build objects, man is the one that builds the most, and we can

1 Stéphane Mallarmé [1]

assimilate artificial objects and man-made objects. *Art*, in a very broad meaning, is man's ability of making objects, or forms in general, whether material or immaterial.
Of course, art may have a more limited meaning, relative only to human productions that are not practical (like literature or music), or that are not strictly practical and go beyond usefulness to provide aesthetic pleasure: all that we build is not architecture (considered as art); making food may become art when performed by great chefs... We may distinguish between art and craft, between invention and simple reproduction of routines. But all these distinctions are difficult to establish firmly, and even the aesthetic criterion has been shaken up at least since Duchamp; beauty is no more what art aims at...
Trying to define generative art supposes that we have first defined art, which, as we just saw, is difficult. Let's admit that we know what is art... Then what is *generative* art? For Philip Galanter: "Generative art refers to any art practice where the artist creates a process, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is then set into motion with some degree of autonomy contributing to or resulting in a completed work of art." [3] We can adopt this definition, which is both concise and not too restrictive; we'll focus on the autonomy of a process created by the artist. There is a shift in the place generally acknowledged as that of the artist, who is no more the author of the object, or form, as such, but who delegates to some device (duly instructed), the task of producing it.
In a way, and if we consider (irreverently) nature as such a "device", we could say that gardeners are generative artists: they set into motion a process, which has a certain (even a great) degree of autonomy, and it results in a work of art (the garden)... Except that gardeners obviously don't create the process of plant growth itself, even if they may intervene in it a lot. However, gardening may be a good metaphor for generative art: generative artists sow seeds too, and watch them grow and develop, their own will being partly replaced by the degree of autonomy of the process they have set into motion. It's a good part of the pleasure felt in generative art: like gardeners, generative artists may have surprises, good or bad ones, according to the relevance of the results with regards to their intentions.
This relative independence of intentions and results is a first link between generative art and chance: writing an algorithm, setting a process into motion, we can guess what the result will be, but we cannot absolutely and exactly describe it in advance. Otherwise, we should directly design the result, rather than taking the pain to think of a process. It is not randomness which is the point here, because the algorithm, the process, may be absolutely deterministic, but it is our inability to think the complexity which can result from simple rules. The ability of generative artists lies in their learned skill to foresee at least approximatively what will be the result of the process, but there remains always, and fortunately, a margin of uncertainty.
That relative unpredictability, which is patent in generative art, is not foreign to art in general. Even without machines but only with their own body, artists may set into motion a process without absolutely knowing what the result will be. We can say that Jackson Pollock, for instance, has invented a "device" (including the setting of the canvas on the floor, the use of liquid paint, and his own body gesture) which he sets into motion without actually knowing, or even wanting to know, what the result will be (obviously he doesn't do preliminary sketches of his paintings). However, the result is not "anything" (*n'importe quoi*), even if we can call it "informal". We recognise a

painting by Jackson Pollock, in comparison with a painting by Mark Tobey or Cy Twombly, for instance. The process is the signature, in a way, this process including not only the technique, but the range of gestures germane to one particular human being, in one particular mood. A good part of these parameters escapes from the artist's will, from his intellectual will anyway; the process has its own part of autonomy... Even going beyond abstract painting, we could say (and that would be a contribution of our reflection on generative art) that *art* may be defined (versus craft, commercial design, fabrication, etc.) as *a productive activity where the result escapes in some way from its author*.
People which don't like abstract art, or who don't understand it, usually say that those paintings have no meaning, that they are insignificant, that they "resemble nothing" ("*ça ne ressemble à rien*", which doesn't only mean that it's not figurative, but that it has got no sense, and therefore no value at all); and they may add that those paintings could as well have been made with a totally random process. Let's recall the hoax by French writer Roland Dorgelès, who sent a painting to the 1910 *Salon des Indépendants*, titled *Coucher de soleil sur l'Adriatique*, supposedly painted by one Joachim-Raphaël Boronali - and which had actually been made by attaching a brush to the tail of the donkey of the Montmartre Cabaret *Le lapin agile* [4]... This sarcastic "happening" was aimed at impressionist painting, but analogous ideas have certainly crossed the minds of unconvinced viewers of expressionist abstract paintings.

Chance and insignificance *or* Painting by numbers

Let's consider this very simple calculation: a painting, or any picture, may be considered as a bitmap of a given size, where pixels have got given colours. Let's consider a very small one (10 by 10 pixels, i. e. 100 pixels), and only white and black as colours; even with so few parameters, the number of different pictures is colossal: there are 2^{100}, or $(2^{10})^{10}$, so about2 $(10^3)^{10} = 10^{30}$ (1 followed by 30 zeros) different pictures3... Such a number is inconceivable! If one tried to see all of these pictures, at a rate of, say, 3 by second, one would need approximatively 10^{23} years4, i. e. very much more than the current estimations of the age of the universe (which differ, but are all in the range of 14×10^9 years). And we took only a 10 by 10 bitmap in black and white...
Amongst all of the configurations of 10 by 10 pixels, there are some that we recognise as "forms", that correspond to some pattern: for example, if the picture is all white or all black, or the bottom half white and the top half black, etc., or if the pixels are organised in a way that makes sense for us: if we see a letter, a digit, a "sign", something that looks like a portrait, etc. The connectivity of the pixels is certainly a criterion, but it's not the only one; considerations of symmetry are important too. Besides, many of these occurrences are privileged only by our cognitive system, and by a cognitive system in a given cultural environment. We'll not go into these cognitive issues. Let's just admit that we recognise some configurations

2 we know that $2^{10} = 1024$, so about 1000, or 10^3.
3 Such a 10 x 10 bitmap corresponds to a binary number of 100 digits.
4 There are 31 556 926 seconds in one year, so we could see about 10^7 pictures in one year; as there are about 10^{30} pictures, we would need 10^{23} years to see all of them.

as forms, versus other ones that we call "informal". The more informal, indifferent ones are those that display a totally disordered, but uniformly distributed, configuration of black pixels. To say that the configuration is uniformly distributed means that there is no part of the picture that is privileged, that one pixel has got as much *chance* to be here as to be there5. The minimal definition of what we can call a form, is to decide that a form exists as soon as we don't get such an indifferent configuration; an interesting research would be to determine when exactly it arises.
Let's consider those bitmaps that correspond to a given density, that is to a given proportion of black pixels, for instance 1/2. There are $100!/(50!)^2$ such configurations, i. e. about 10^{29} (a little less than the whole lot). To get such configurations, starting from a white bitmap, one starts at the first pixel in a corner and explores all the bitmap pixel by pixel, turning black each pixel according to a probability of 1/2. Typical results are shown in fig. 1.

Fig. 1: indifferent distributions of black pixels in a 10 x 10 bitmap (density 1/2)

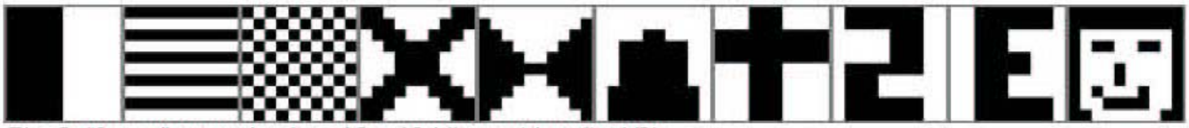

Fig. 2: "forms" occurring in a 10 x 10 bitmap (density 1/2)

Actually there is a (very scarce) possibility to get a real, recognisable, form (as the ones shown in fig. 2 (which have not been made at random!)) by this random process. But let's acknowledge the fact that such recognisable forms, even if they are many, are very scarce in regard to the monstrous number of non-recognisable ones, and that the probability of getting one by setting black pixels at random in a white 10 by 10 bitmap is very tiny. All configurations are different, but we don't differentiate all the ones that don't correspond to a pattern, those that we have called indifferent; and such indifferent configurations are astronomically numerous; so generating such a configuration "at random" means actually generating an indifferent configuration because those are so much probable than the ones corresponding to some pattern (which may occur, though, with a very great lot of luck).
This issue has been illustrated by Jorge-Luis Borges in his short story "The library of Babel" [5], where he imagined a library which contains all possible books of 410 pages, written with 25 characters (22 letters, point, coma, and space); in such a library you could find a lot of actual books, but the probability to find them by chance would be very scarce, almost all of the texts would mean nothing... Numbers obtained through combinatorics are huge, but they are not, strictly speaking, infinite, as they concern finite sets of things (pixels, colours, characters, etc.); it's the reason why we can imagine such a library as the one told by Borges. But the hugeness of

5 Let's note that in physics, such a configuration is considered as "symmetric", even if we don't recognise any familiar symmetry in it; in that context, what we call symmetry is considered as a symmetry breaking: among all the symmetries which are implied, some are privileged, as for instance in crystals.

those numbers is such that it gives us, anyway, a kind of vertigo, a (sour) taste of infinity...
To decide whether to paint each pixel in black or in white in the bitmap, we can toss a coin a hundred times and affect black for heads and white for tails. The use of coins to get randomness is very ancient, as is that of dice. In French, to express randomness, we can use the word *aléatoire*, which comes directly from Latin *alea*, which means *dice* (as in Caesar's famous sentence: *Alea jacta est)*. We (French people) more commonly use the word *hasard*, which comes from the Arab *az-zahr*, and refers also to a game of dice. In English *hazard* may mean the same, but more currently, it is used for risk, danger, bad luck. The English word *chance* comes from old French *cheance* (which refers also to a game of dice). In French, *chance* means mostly good luck, while in English it has the same meaning as French *hasard*. *Random* comes also from old French *randon* (meaning rush, disorder), though in modern French this world has disappeared, only to evolve into *randonnée*, which means *hiking*: there is a sense of random travel in it, even if hikers don't really want to get lost (and have a compass). We see that there are at least two meanings involved in randomness and chance: the notion of disorder, like in Brownian movement; and the notion of arbitrary, of (bad or good) luck, of fate. Random events may occur that will have a bad or good consequence: the famous tile that falls upon the head of the doctor who could have saved your life; and the same (or another) tile that falls upon the head of the murderer that was about to kill you...
Anyway, tossing coins, what we look for is an equal probability to get either heads or tails (1/2 for each), and to get a chain of results where each one is totally independent from the previous one. The way to prove that a coin is fair, that it is well balanced, is to flip it a great number of times; the frequency of each event (heads or tails) must tend towards 1/2. To paint the 10 by 10 bitmap, you can toss a coin 100 times; the problem is that tossing a coin 100 times is long and fastidious; and moreover when you want to produce not only one, but many pictures. You can also take, for instance, the decimals of π (or of any irrational number), and affect black for even and white for odd. Or, for that matter, you can take any data you want, as long as it can be considered random. Obviously, if you don't take a random sequence of numbers, the picture won't display uniformly distributed pixels, and some sort of order will appear. It's even a way to determinate whether a sequence is random or not, in the same way that you prove a coin or dice to be wrong. And you can also use the random function of any programming language. This randomness is only a pseudo-randomness; however it produces what we want: a sequence of independent numbers, with the required frequencies. It is fast, and produces a great number of different bitmaps rapidly. Moreover, as each sequence of generated numbers depends upon a seed, we can reiterate it if we want, which is very useful.
One could think that our example of “painting by random numbers” would be too poor to have be used by artists. But French painter François Morellet [6], besides more sophisticated works, made in 1961 a series of paintings, very similar (but bigger) to our 10 by 10 bitmap, called *répartition aléatoire de 40000 carrés*, where he painted grids of 200 by 200 little squares with two colours, depending upon a “random” data source; actually this source was the phone book of Maine-et-Loire department, where he lived: the colour was determined by the parity (even/odd) of the phone numbers.

It's "random", because the alphabetic order of the names in the phone book does not have any link with the parity of the phone numbers.

Chance and diversity

If you don't define any rules, randomness won't give you any available result; or, more precisely, it's the insignificance of the result which is the proof of the randomness of the data. But if you define a process, if you edict some rules, randomness may be useful to provide *diversity*.
Let's begin with an example that continues in some way our metaphor of the gardener. We'll experiment with L-systems, those formal grammars which have been very proficient to simulate the growth of plants [7]. L-systems may be very sophisticated but we'll experiment with a very simple one, which provides rather a sketch of a plant than an actual plant (in particular, this scheme develops itself in 2D). The axiom and rewriting rule for this example are:

$\omega = F$
$F \rightarrow FF\text{-}[\text{-}F\text{+}F\text{+}F]\text{+}[\text{+}F\text{-}F\text{-}F]$
$a = 22.5°$

Fig. 3: 4 first stages of L-system $\omega = F$ $F \rightarrow FF\text{-}[\text{-}F\text{+}F\text{+}F]\text{+}[\text{+}F\text{-}F\text{-}F]$ $a = 22.5°$

Let's note that the result at the 4^{th} generation is complex enough to resemble something "natural", and even to suggest that some randomness has been introduced, though it is not the case.
There are two very different ways to introduce randomness in such a process. The first one is a kind of *hybridisation*, the second one has to do with *inaccuracy*.
To hybridise the process, we have to mix it with at least another one. Let's note first that this scheme is right-trended, and has got a "sibling", which is left-trended: to get it, you have only to replace all the "-" by "+" in the rewriting rule.

Fig. 4: 4^{th} stage of L-system $\omega = F$ $F \rightarrow FF\text{+}[\text{+}F\text{-}F\text{-}F]\text{-}[\text{-}F\text{+}F\text{+}F]$ $a = 22.5°$

With these two rewriting rules we can produce new plants by setting a probabilistic (or stochastic) L-system:

$\omega = F$
$F \rightarrow FF\text{+}[\text{+}F\text{-}F\text{-}F]\text{-}[\text{-}F\text{+}F\text{+}F]$ (prob = 1/2)
$F \rightarrow FF\text{-}[\text{-}F\text{+}F\text{+}F]\text{+}[\text{+}F\text{-}F\text{-}F]$ (prob = 1/2)
$a = 22.5°$

Fig. 5: 10 results of 4th stage of probabilistic L-system

At the first generation, we get either the left-trended or the right-trended scheme: 2 possibilities; at the second, there are, for each of the two, $2^8 = 256$, so there are $2^9 = 512$ different results; each one corresponds to a string with $8^2 = 64$ "F", so leads to 2^{64} possibilities for the third generation, and so there are $2^9 x 2^{64} = 2^{73}$ different results; each corresponds to a string with $8^3 = 512$ "F", so leads to 2^{512} possibilities; all in all, there are $2^{73} x 2^{512} = 2^{585}$ different results altogether at the fourth stage... There is the one that corresponds to the first rule applied at each stage everywhere, and the one that corresponds to the second one; among the (very many) others, there is a great diversity, even if the first choice remains as a sort of skeleton of the whole: we can detect those that come from either of the first choices.
Let's state the fact that complexity[6] is not at stake here, but diversity and identity. Results of hybridisation are not more "complex" than the schemes from which they come, they borrow from both. In a much more simpler way, this kind of hybridisation is similar to what happens when parents' DNA are combined to produce children's DNA. Children are not more complex than their parents, but they are *different* from their parents, and all different from each other; they more or less look like their parents, and look like each other.
With one rule you get one result, with 2 or more rules, you get (very) much more results. Now, it is obvious that you have not to use randomness to produce results. Any sequence of binary digits of the right length will give you one particular result; if you want to use a repetitive pattern, or anything you want, you are free to do it. It will give you one result, and that's it... Randomness allows you to get a great lot of typical results. *Randomness is only one way to explore a world which you cannot, actually, cover entirely.*
The other way to introduce randomness into the L-system has to do with the issue of accuracy and inaccuracy (or "an-accuracy"): the scheme provided by the L-system is absolutely exact, all lengths of branches are the same, all angles are equal to 22.5°. In real plants, even if there is a pattern, lengths and angles are not exactly equal to some value even though they may be *statistically* equal to it. So if we introduce some margin of error in the value of angles and lengths, we'll get more natural-like results; and it is another way to obtain diversity without loosing identity (fig. 6). In this case, randomness is required, it mimics the multitude of events that happen in real life, and that we generally call randomness, or chance: a plant develops along some scheme, but one day there is less sun, another less rain, etc., and the aspect of the plant reflects all this very long and eventful history.

6 On complexity see [8]

Fig. 6: 10 results of 4^{th} stage of ω = F F → FF+[+F-F-F]-[-F+F+F] 12.5° < a <32.5° 3/4 l < l < 5/4 l

Hybridisation and inaccuracy provide diversity without loosing identity. The use of randomness is a way to produce variations inside a theme, to produce series. Many artists have played with theme and variations, and not only musicians; contemporary artists are particularly adept of series. Among them are those that are sometimes called "algorists"[9] and are precursors of generative art: as soon as the sixties (of 20^{th} century), they used computers to produce art through algorithms. One of them is Vera Molnar [10], which was (and still is) one of the greatest. She for instance produced series of paintings by introducing random discrepancy within the theme of concentric squares.

Formal research

We present here some examples of formal research which don't pretend to be architecture, but may lead to potential architecture.

These experiments are based on IFS (Iterated Function systems [11]) but also on the spatial operation of voiding, of form and counter-form. IFS are an efficient way of producing fractals, by iterating a set of contracting transformations (mainly affine transformations, composed of scalings, rotations, ans translations), fractals being attractors of these iterations. One algorithm consists in starting from any set of pixels, and applying the transformations to it, and then applying again the transformations to this new set of pixels, and so on.

We only consider the first stages of this algorithm, doctored in this way: starting from a black filled square, at each stage during the transformation pixels of the set are turned white if they were black, and black if they were white. Configurations of black and white may be interpreted as full and void.

To experiment hybridisation, we have worked with two very simple IFS, which consist each in 4 transformations: all scalings have a rate of 0.45; there are no rotations. The first IFS translates the scaled shapes up, down, left and right; the second one translates them to the corners. Attractors of these IFS would be a fractal cross for the fist one, a grid of points for the second one. Each of these IFS has four axes of symmetry. The result of each IFS is shown on left side (resp. right side) of fig. 7.

Hybridisation may occur in two ways. The same IFS may be chosen for the 4 transformations at each stage. At each stage n, it yields only 2^n = 8 different results, so, as we go only till stage 3, we can show all of them (fig. 7). The results exhibit the same symmetry as that of the IFS from which they come. It's interesting to see how each intervenes in the process.

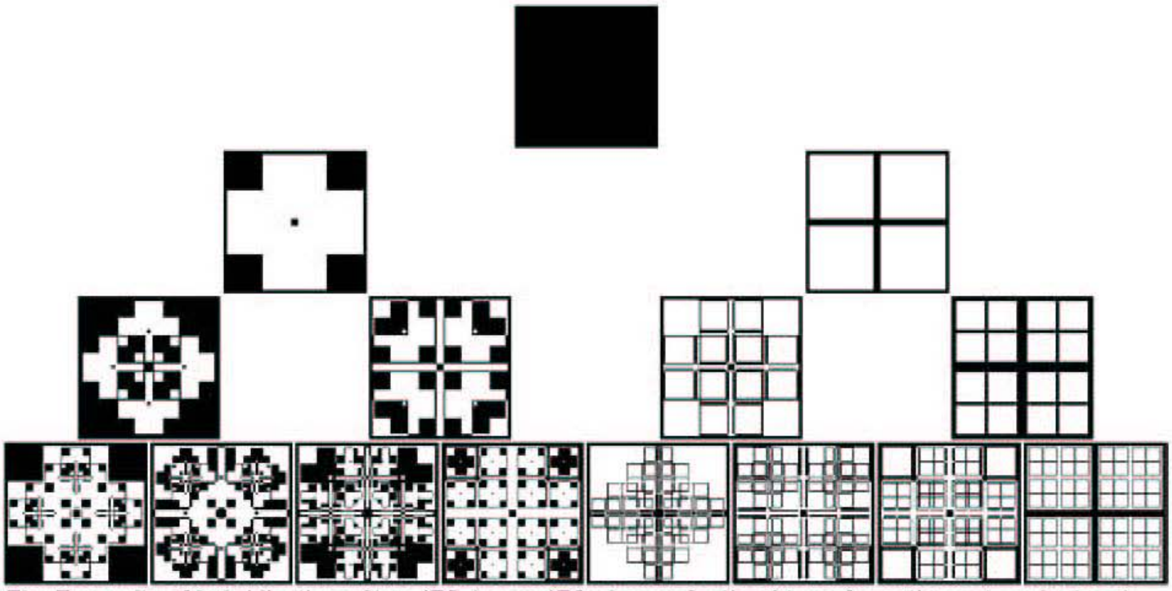

Fig. 7: results of hybridisation of two IFS (same IFS chosen for the 4 transformations at each stage)

The second way to hybridise consists in choosing a different IFS for any of the 4 transformations at each stage. The number of different results is then much bigger (2^4 = 16 at stage 1, 2^{16} at stage 2, 2^{64} at stage 3), and we use randomness to produce some of them which are shown in fig. 8. Results are much more asymmetric, though we can still discern the role of each IFS in the results.

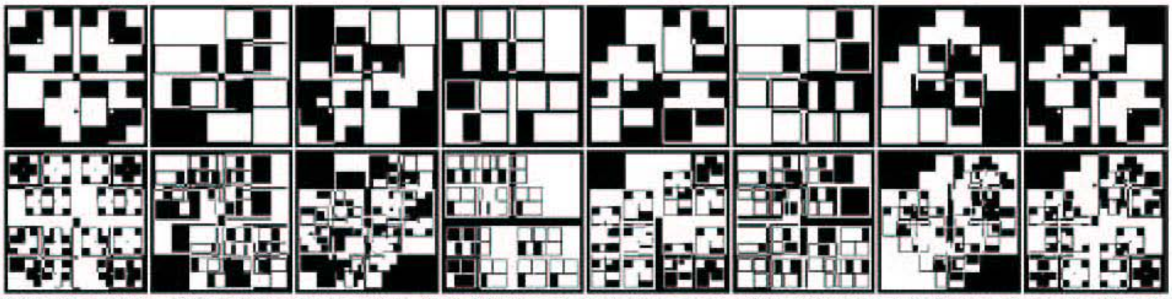

Fig. 8: results of hybridisation of two IFS (different IFS chosen for the 4 transformations at each stage): stage 2 and 3

Concerning inaccuracy, we could have worked on the rates of scaling, or introduced some rotations. But we have only changed the translations, and even changed them only slightly, by shiftings which produce IFS intermediate between the two previous ones (we introduce 4 new ones; see fig. 9).

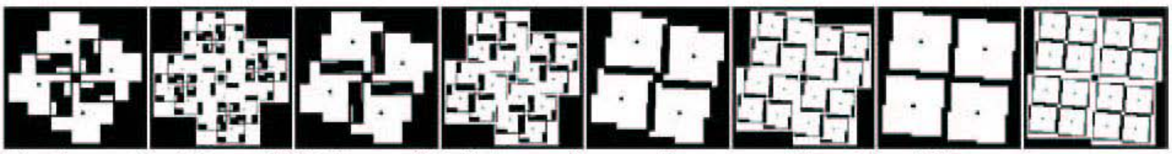

Fig. 9: results of 4 new IFS intermediate between the previous ones (stage 2 and 3)

This new experiment may be interpreted as inaccuracy or as hybridisation between 6 different IFS. Now the number of possible results implies to use randomness to show some of the results As before, we can apply the same IFS to the four transformations at each stage (fig. 10), or we can apply different IFS for each of the four transformations at each stage; some results are shown in fig. 11.

Fig. 10 Some results of inaccuracy (same IFS chosen for the 4 transformations at each stage) stage 2 and 3

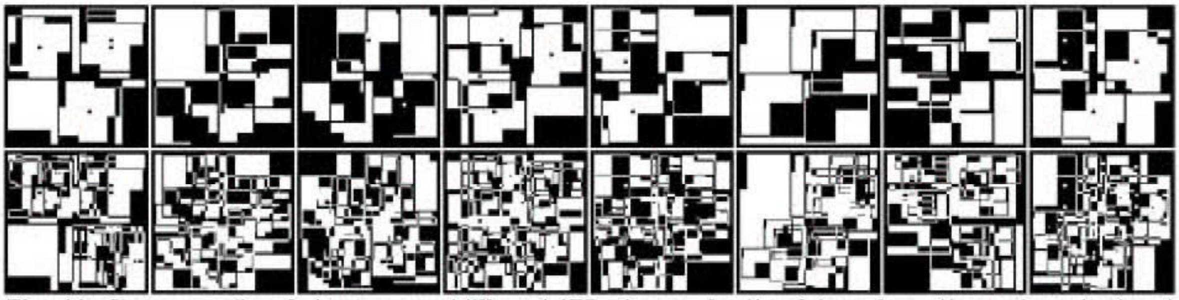

Fig. 11: Some results of inaccuracy (different IFS chosen for the 4 transformations at each stage) stage 2 and 3

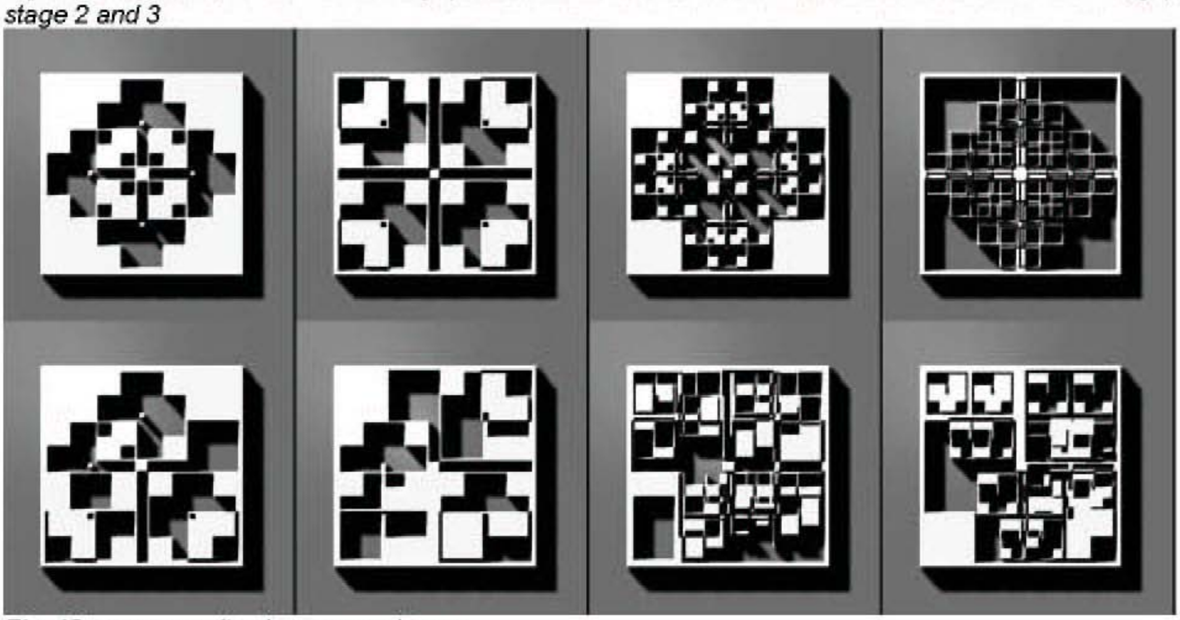

Fig. 12: some results shown as volumes

These modest experiments show how diversity may be obtained, without loosing identity. More research could be made with the same IFS, by exploring more change in the translations, or by working on the scalings and rotations. Or we could also choose different IFS to start from, which would not have the same symmetries, for instance. Obviously, more elaborate work can be made about diversity and identity in architecture, see for instance [12].

Randomness has often been discussed in the course of GA conferences [13]; we tried to establish that chance as relative unpredictability is relevant in art and that hybridisation and inaccuracy within rules allows us to get diversity as well as to preserve identity.

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The Language of Motion in Communication Design

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Abstract

This paper investigates motion as an integral component of design. The notion of time—intertwined with motion—is considered the organizing principle to which all other design elements must relate. The paper defines the “language of motion” as a tool of communication and “motion literacy” as the act of understanding how motion can be used to communicate more effectively.

The work presented in this paper result from experimental and multidisciplinary approaches to investigating the language of motion within code-based systems and interactive environments.

These case studies, developed at the Dynamic Media Institute in Boston, range from a participatory installation that investigates the role of physical proximity in interpersonal communication, to an on-screen dynamic visualization where natural metaphors of microbes are used to represent the structure and attributes of an email inbox.

1. Motion and Communication and a “Language”

Motion—as integral to design—should be considered and explored as a language of communication.

At the Dynamic Media Institute in Boston the concept of a “language”—understood as a system of elements combined according to the rules of a grammar for the purpose of communication—incorporates the challenges of synthesizing multiple “dialects” and “codes” that have traditionally been segregated into distinct disciplines [1].

Similarly to the concept of “visual language,” that so profoundly influenced design and its education in the 20th century, we should apply the metaphor of linguistic structure to exploring and teaching the fundamentals of dynamic media—specifically the application of kinetic form and expression that can be defined as the "language of motion." Moreover, similarly to promoting “visual literacy” in design curricula we need to foster "motion literacy"—the understanding how motion can be used to communicate more effectively.

Communicating with the language of motion involves issues of “what” is moving (and in what environment—on screen or in space), and “how” that something is moving. The “how” question refers to the kinetic form and its grammar, defined by both space and time dimensions of motion such as velocity and amplitude. That, in turn, refers to a kinetic “behavior” of an object. That object is the “what”—typography, an illustration, a diagram, video content, 3-d object—virtually anything. And these objects carry the meaning expressed in their native language—material, pictorial, verbal, numerical, cinematic, etc. Therefore motion—or kinetic behavior—applied in combination with those native languages of pictures and words and numbers, etc.—amplifies and multiplies the potential in making meaning [2].

2. Motion and Sequence and Interaction

Kinetic behavior is one of the central issues of the language of motion and motion literacy. But of course kinetic form and the meaning of motion have already been explored within various disciplines of art and science. In those multiple disciplines, various expert languages and codes and dialects of motion have been developed.

One of the most spectacular historical examples of the design process for a dynamic media structure is a post-production diagrammatic storyboard for *Alexander Nevsky*, a 1938 film by Sergei Eisenstein [3], a Russian film director and one of the first theorists of the medium. That storyboard is a timeline in which visual representation of the film components are precisely synchronized into a sequence of “audio-visual correspondences” including film shots, music score, a “diagram of pictorial composition”, and a “diagram of movement.” The “diagram of movement” represents specifically the camera work resulting in on-screen motion. Choreographed very precisely, in fact to a fraction of a musical measure, this “diagram of movement” attests to how essential for the cinematographer was on-screen motion and its meaningful integration with all other elements of his vocabulary. The same challenge of integrating motion as a meaningful component of communication design should remain the focus of research and practice for contemporary designers.

Exploring the concepts of kinetic behavior requires the same awareness as studying cinematic vocabulary—the awareness of the system of communication that combines the visual, sonic, and kinetic aspects into a synchronized, multi-sensory experience. Especially, the kinetic behavior triggered interactively— which occurs in response to pointing, dragging, clicking by a user—is one of the central issues of motion literacy.

Another spectacular example of an expert language of motion is the language of music. In this case [4], music conductors Boulez, Eötvös, and Robertson rehearsing Karlheinz Stockhausen’s “Répétition” for three orchestras, use the language of precise gesture to translate the musical text into musical experience. They communicate among themselves in a very precise language of motion. They communicate—without producing any sound—their musical concepts (and the interpretation of that specific piece of music) to more than two hundred musicians and eventually to hundreds of listeners. **Time** is the structural element of music and sound, and of cinema, and of any time-based media—and of motion itself.

Sound design has already become a part of communication designer's vocabulary. Gesture—understood as motion that has meaning—is next to be explored and adopted by designers.

Informational "gesture" plays a meaningful role in on-screen interfaces. As users, we widely accepted the computer on-screen icons move or jump certain way, in order to tell us something. The kinetic behavior of icons may be user initiated or computer initiated. Through their motion, icons notify us, warn us, advise us, orient us, and prompt to action. These behaviors are not formally codified—but perhaps they should be, in order to become even more precise in what and how they communicate.

But the challenging issues of the language of motion and gesture in multi-touch screen environments—are still in front of us. We are just scratching the surface—literally. The success of multiple-touch displays has elevated gesture to a new role in interface design. The sci-fi movie "Minority Report" becomes reality—and perhaps in its better version. Better, because it is proven that purely gestural interfaces—like in "Minority Report" movie—perform rather poorly. The human body prefers a tactile feedback. Multi-touch screen technology delivers that tactile experience and is now migrating to the desktop—and away from the desktop. Current popularity of "Wii" interactive platform, as well as most recent MacBook multi-touch pad—are precursors of things to come, where integrating gesture and touch may actually be more successful that each one on its own.

That is why, parallel to research in technology, more research and exploration in interface design is needed. The dynamic vocabulary of motion and gesture must contribute to a universal language of communication.

3. Case Studies

3.1 Proximity Lab

Evan Karatzas's work, entitled "Proximity Lab" was developed as masters' thesis requirement at the Dynamic Media Institute in Boston in 2005.

Proximity Lab is a participatory installation and experimental interface platform designed to visualize relationships between users and mediated spaces. The system directs attention to the intersections of physical and computational interaction.

An 8-foot by 16-foot by 7-inch by 7-inch walkable platform, fitted with radio frequency ID (RFID) technology, sits at the center of the Proximity Lab system. Participants wear shoes fitted with RFID tags, enabling the system to track and record their positions in real-time. System outputs consist of a ceiling-mounted video projector pointed down onto the platform and amplified speakers positioned at opposite ends of the platform. Images projected directly onto the floor are accompanied by stereo sound as a continuous response to the actions and interactions of participants.

The study seeks to stimulate inquiry on the concepts of physical proximity, social interaction and computational mediation. Semi-facilitated experiences involving algorithmic logic, system observation of behavior, and dynamic role assignment are offered to participants for contemplation and discussion.

"Proximity Lab" case study

Two program modules have been developed for Proximity Lab: "Social Circles" and "Loop Holes." Each program runs for three minutes.

Social Circles deals with the visualization of social activity and physical proximity. Small shapes bustling with movement surround users and follow them as they navigate the platform. The molecules orbit around participants and react kinetically when users approach one another.

Molecules are color-coded to distinguish individual users. Molecules can be exchanged. As the session progresses, molecules mix and the distribution of colors reveals the unique interactions of the group.

Loop Holes is a sound instrument that reconfigures itself based on user interaction. Sound spots are represented as simple shapes that reveal kinetic and sound properties when activated. Chance sound performance and composition coexist. Each of the eight spots represents a note in a fixed scale. Each time the spots reconfigure the timbre and distortion of the sound set changes. At first, the notes are undistorted with short attack and sustain. As the loops progress, sustain gets longer, creating overlap and chordal opportunities. Frequency modulation also adds to the variation.

First configured in a simple and organized manner, the sound spots gradually separate into scattered arrangements. Are these configurations random or based on the behaviors of participant? The progression and location of sound spots is based on interaction with the system. The user who interacts with the system the least are targeted by the system. Sound spots reposition themselves around this user, encouraging more active users to approach less active users.

3.2 AnyMails

Carolin Horn's work, entitled "AnyMails" was developed as masters' thesis requirement at the Dynamic Media Institute in Boston in 2007.

"AnyMails" is an application written in "processing" programming language that visualize the structure and attributes of the user's email inbox, using the metaphor of microbes. Each email is represented by one animal, each category of emails correspond to a species of microbes, the status and age of an email is indicated by the size, as well as kinetic properties—specifically, the velocity of the microbe.

"AnyMails" case study

All incoming emails in the "AnyMails" system are categorized in six groups: family and friends, school, job, e-commerce, unclassified, and spam. These categories are represented by six species of "animals," which are different in color and form. The age of an email (when it was received) is visualized by the size and opacity of the animal (for instance, a new email is big and opaque, an old email small and transparent). The status of an email—unread, read, or responded—is shown by two animal attributes: the number of hair/limbs and velocity (for instance, unread email is "hairy" and swims fast; a read email has less hair and does not swim so fast anymore; a responded email is "hairless" and barely moves).

In its initial state, all animals are swimming freely. Users can then apply various filters (by category, by status), browse the system by time (day, week, month) or visually group animals based on various criteria: the user can group by "species" or by status; the user can make certain "species" visible or invisible (fade in and out); the user can go back in time to see email received over different periods of time; the user can scroll through timeline to preview inbox in search of certain patterns formed by certain attributes of the mail arriving in the past.

Last, by not least, the user can group emails continuously. In this mode all emails are grouped in the form of strings, defined by selected properties and customized arrangement in each group.

4. Postscript

The author of this paper is interested in collaborating with colleagues who may share the enthusiasm of researching the language of motion in the context of dynamic media. Please stay in touch.

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Generative Art

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"Cognitio indefinita, et quia indefinita, nomine digna est"
Giovan Battista Vico, Diritto Universale

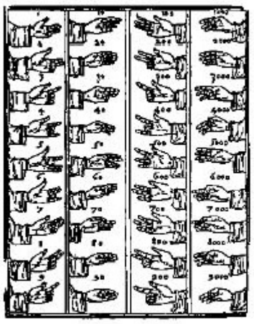
Abstract

Generative Art is the Art of process and not only of result. GA works using the rules of the alive world, as a mirror of Nature. In line with the motto by Jean Vignot, 1392, *Ars sine scientia nihil est*, the process is performed as a chaotic not linear system, in order of a methodological procedure structured following T. S. Kuhn, Ilya Prigogine and R.Thom. This structure, defined as a math problem, individualizes an hypothesis, able to define a code, that performs generative results , running in AI sites. The results are all unique ad continuum. These are variations of the same hidden codeness, as a transforming vision of an interpreted "reality". For the first time the word generative was used by Bauhaus, defining very well their organic vision. The cultural power of that time recalled it degenerative. The same happened when we start in 1990 calling our creative approach generative! GA marks the passage of the last 30 years from *homo faber* to *homo creator*. Overcoming the artefacts characters of the last century, industrial, serial, component, standardized, quantified, optimised, anonymous, obsolete etc, synonymous of generative are unique, digital, organic, complex, meta-poetical, recognizable, endless, experimental, morphogenetic, variable, mirroring, imaginary etc. Precedents of GA are Michelangelo Leonardo, Piero della Francesca, Pacioli, Mantegna, Borromini, Piranesi, Gaudi, Caldano, Mozart , Schubert, Wordsworth, Coleridge, Rembrandt, Bruguel, Swift, Bach, Goethe, Leopardi, Flaubert, Florenskij, Van Gogh. Melville, Baudelaire, Poe, Seurat , Cézanne., Matisse, I Futuristi, Picasso, Klee, Kandinskij, Eisenstein, Pollock, Mondrian, Pound, Auden, Bacon, Borges, etc. The list is long and open. Here it will be investigate: the codes of Harmony; the proportions; industrial era and Le Modulor; Generativism, startind from the Chomsky structure; Bacon; "Il non finito"; my tale "The child, father of man"; the GA structure. Dedication and wish.

1. Generative Art philosophy

This paper tries to outline *how walks* Generative Art. This kind of Art is a philosophy, a way of thinking able to produce a set of variations of a performed idea/code related to a defined problem. It walks using at the best in Art the tools of our time ascomputers, robotics, rapid prototyping machines, AI software etc. An enough necessary condition of GA philosophy is knowledge in understanding. This is a double dynamic system, that works in resonance with our ability for memorizing our impressions. It is something very closed to our knowledge process that each of us peculiarly activated in his childhood, trying to discover the world running around our touching vision. Through this cognitive process we learn to interpret *"reality"* as a mirror of our own code, structuring *"our heart rudder, able to guide our memory, our intellect, our will"*. (S: Agostino).G. A. walks generating an unicum ad continuum, as a mirror of Nature. We can use in evolutionary way the verbal substantive generativism, coined by Chomsky in 1953 in his great systematic work about the semiotic rules of language. For the reason that the G.A. process is strongly connected in similarity to a generative process of language in: 1. It is similar to a sound, that we memorize in connections of sequences, outlining differences in a not linear schema. 2. It is linear, adapting the memorized sequences to the linear schema of writing, in different versus up/down, right/left and viceversa. This represent the most adaptable tool for our eyes, used in all culture. Now in a evolutionary step of Chomsky significance, the word generativism can describe the process for gaining the result of complexity. In our time we are over the Hegel dialectical vision of the world. After last studies about, we can affirm that the relation between the opposite black/white, far/near etc. are not in one dimension system, but they generate a dynamic asymmetry. So this explained generative process is not necessary for activating a creative process, but it is a good methodology that works in experimental way by gaining complex results, the main question of our time.

2. The codes of Harmony



A tale from the past time," The child, father of man".

"L'eau claire:comme le sel des larmes d'enfance" Rimbaud,Memoire

At the entrance of two Maestri, the rustling of their dresses generated a murmur on the child's face, fast ended on his astonished eyes. For an instant the pars triangularis resounded with the opercularis part in the area of Broca on the brain of the child: mirror neurons were activated. The empathy was perfected, just at the beginning of the lesson. After a fast but so deep discussion they agreed to use as mental memory image for their lesson their own room in which they died.
Leonardo, proud walking toward the room in which the child was waiting, reminded the softness of his bed, the color of the candle, that he asked always on for lighting the corners darkness, the mirror just covered with a pitying veil. The books, on the wall, very closed to his bed Dante, La Divina Commedia, Ficino, Lucrezio,Pico, De hominis dignitate, Pacioli, De Divina Proporzione, his last drawings on "The end of the world". His casket with the secret, opened from a week, on the table with his last will and with his love letters, that he asked in his will to put into the fire after his death. And, finally the unique great grace comfort of his life: la Gioconda. At once he decided to start from her. Michelangelo, in the meantime, was singing in his mind his preferred Madrigale, the same that was singing in his heart when he died. His closed eyes, in his last room in veiled dim light, were able to figure the smell of Roma, in that evening.
Leonardo, sitting fast as an eagle just back to his nest:" I will start from my last thoughts in my death room". An immediate blush went down the child eyes as for a pitying act of love.
"For many years I take with me, in my bed room wherever I went, my painting "La Gioconda". I was not able to dream without given to her my last looking of the night. After my death she was pilgrim until she resides now in the dark, submerged in an unrelated vacuum odorless and

without any radiation of the sunlight. But how did raise the idea of this so wonderful painting? I was really depressed after my big mistake of too much water in material color for the fresco for the battle of Anghiari. My mind was fixed at the night spent with fire trying to preserve paintings, that inexorably disappeared. So I felt myself nothing after seeing also his David *walking* and in pause in the same time! He was able to put the infinite inside the space of the statue feet. I worked in silence for a long time, walking in the woods of the mountains, hearing the mute sound of Nature and crying for discovering the right street of my life. I took conscience that tools are precarious, the main real alchemic process is to transform alive nature music in a mirrored sound of heart. So I designed in my heart La Gioconda. I gained the infinite in her smiling. The code idea rises as a mute music, kindly heavy of significance, that suddenly performs a *sgomento*, able to leave you without any breath. With *hostinato rigore* you must pass through darkness if you want to see the splendor of Beauty. La Gioconda is the smiling side of my melancholy. She is the lightness on my darkness. With her veiled colored light she is the maternal code of my heart".

Expert in variations, Michelangelo started: "Dear child, you represent double a terrific vection of my time and of my eternal hope. Image a blind man, until he moves inside his home he feel free inside his space, but if he moves outside in an unknown space he needs an helping tool. This can be a dog, a stick, a friend. This tools can leave him free to recognize with his other senses, touch, smell and most of all hearing, the discovering space. The same happens in our creative process. We need a tool. Each one of us chooses his more peculiar tool, belonging to his own attitude.

How can we be sure that is the right one for us? There is only a way, by trying, more and more in an experimental process. Until it happens that we recognize a familiarity with this tool, like an artificial hand of our mind. The most complex simple one is the pencil for writer. If you are a good writer you need a pencil as a part alive of your hand. Life is not a game. And also if it is, we all are loser, for the simple reason that we all die. I got it in my soul three times, surrendering for rising again with indelible signs. So I tried to remember each days of my last alive time the imperfection of our human condition. I worked every day until I died, but I lived with strong intention and pain not finished "La Pietà Rondanini", et alea opera, but this only one I take in my bed room until my death. As in the most of all my works I looked for discover a mirror of my screaming vision hidden inside the stone. I tried to perform harmonic proportions, structured in dynamic relations, following a anthropomorphic concept, that was the main center of my poetic. In this work I tried to perform a mirror of my own condition. There is evident the code ready to generating endless variations. The act of reader becomes the being born, an alive embryo, that represents inside the dying action. The inseparable figures of Maria that embraces Her dead son Christ seems to rise from a water mirror. They tale a soul condition, a tension of mind, that is possible to understand only with emotions. This my maternal code is the representation of my humble mood and of my melancholy as artist.

"Per fido esempio alla mia vocazione
Nel parto mi fu data la bellezza
Che d'ambo l'arti né lucerna e specchio"

You, child, must walk hearing your own music that indicates your street of life. If you want to discover your identity, silence and attention are the basic tools for focusing clearness in your emotions. Don't trust yourself to people that give you fast explained solutions, especially if they looks so much sophisticated".

"Any questions?" asked Leonardo, known very well that the child had spoken all the time with his eyes, also a kind tear, with his mouth, with his hands, also with his feet, emulating a passage walking. The child said:" I am real very curious, Maestro Leonardo, to know the reason why you wrote every script of yours in reverted way".

"Oh, a good question. So you give me the opportunity to talk about the veiled mirror in my death bed room. So if you see in a mirror my written words you can discover the good side of their

significance. They are the results of the same generative process of La Gioconda. She is the other side, the good one, of my soul. My reverted scripts represent the process that reader must active for reading them. After the process, the raider of a noble investigation street can follow the enchanted, discovering the words sound. I can give you a very simple example. You learn numbering on the fingers of your hands. You can use the right or the left one, naturaliter. But if you start in numbering until ten starting for example from the left hand and you restart for twenty starting by the right hand, in your mind you will see the numbering until twenty as a mirror of the precedent ten. Following nature, that is figurative and also abstract, you wrote also in reverted way *,indigitatio* in the illusion of time"
"Oh, it is so deeply wandering!" exclaimed the child in a fast murmur.
"Good lesson" thought in his heart Leonardo.
Michelangelo:" So, sweet child, now you are the only skipper of our visionary ship. Take care of us, child forever…………Please where is my hat?"
"Sitss.. Be silent !"said Leonardo, speaking with a low voice" I hided it into the coat pocket of the child, I knew that you would just appointed him the only skipper". While a suddenly amused astonishment was designing on the face of Michelangelo, a strong wind opened wide the door, banged back with a terrible noise. A moment later a nice girl, with a kind of cheeks red for the mountain cold, entered into the room, slight as flying with the wings of a white butterfly. Smiling she asked:" Are you the skipper of the ship of dreams?"…….. *ad continuum*

		
C. Chaplin, The kid, 1921	**J. Tati, Mon oncle, 1958**	**A.Tarkovskij, A.Rublev,1966**

3 great examples of "child, father of man." In Tati the uncle is the child too.

3. The GA methodology

In past Art had a deep configuration of ambiguity, so our imagination in front of artworks were strongly activated. Now we are object of a total sequence of media visual information that all time represents our reality. For this reason our mind is full. For activating an actual process of imagination we need two basic things: 1.Poetic dimension 2. Complex reading of reality. So our Generative Design Lab, founded by Celestino Soddu and me in 1992 defined a generative methodology for gaining complexity. Complexity, *a poetical vision of the complex reality*, becomes a new area of investigation, performed on several multidisciplinary sectors of science, mathematics, physics, A.I., chemistry, cognitive sciences, etc. All can start from Renaissance, Leonardo, Michelangelo, Raffaello, Mantegna,Luca Pacioli, Bramante, Brunelleschi, Pico della Mirandola, Alberti, Palladio, going ahead Borromini, Piranesi, Gaudì, Van Gogh, Picasso, Bacon, and so on. A new scientific approach was founded by the mathematical discovery on the continuum hypothesis on the set theory, activated by Paul Cohen at the middle of the last century. There are following: the theories about the paradigm of Kuhn, the morphogenesis of Thom, the theory of catastrophe by Prigogine. The discovery of fractals, the colors of infinity by Mandelbrot. The research about attractor by J. Crutchfield All these new approach were investigated by us relating them also to the concept of measure in Lagrange, to the last thinking about hypothesis in Poincarè, to the concept of topology in On growth and form by D'Arcy W. Thompson, and to the reverted prospective by Florenskij.

As in Nature GA works looking for a figurative expression in abstract way. This is the main character of complexity. In our time, if you are looking only for an abstract result, doubling in abstract the process, you are realizing a simplification.

A voice of complexity: to use dynamil time for gaining future connected to past, i.e. to discover the smile of your grandmother in a mirroring unknown face, or in an artworks, feeling a dejà vu. The consciousness of an instant, just lost.

The knowledge is the distance between subject and object. In Japanese is called wakaru, that means to be divided in the 2 parts of a whole. A GA process is like a man that for walking gives a deep importance to his *conscious* breath for his steps.

GA process is expressed in the mood of the oral tradition of philosophy, that we can resume in a singular image of a poet more aedo, as a singer of a poetry in performing, traced in the heart memory. The experience of the process performs a codeness, able to generate endless variations, as in Nature. Codeness is a poetic measure of results, in imitation of alive structures. The quality of measure is a possible relation that we define between reality and our imaginative vision of a possible scenario. The main question is to gain ability in defining a problem, as a performing order, that follows a possible idea, working in a chaotic system.

4. The formal logic

"It is necessary to start from the mistake and to convince it of the truth. It is needed, that is, to discover the source of the mistake; otherwise don't aid anything to hear the truth. This cannot get in if something else takes up its space".

4. 1. Tools and aims of a GA process

there is from me and the over side neither space nor time, only song

1th aim: performing attitude: GNOTI SEAUTON. *From impression to expressions* In this first step it is necessary to discover each one his own tool, as Michelangelo docet. – Exercises: translations, these need an interpretation.

2th aim: defining a problem; tool: interpretation performs idea/hypothesis. Interpretation is an our delineating knowledge of a mirrored reality , cfr. Coleridge.

3th aim: generativism as basic studio process from impression to expressions. The process is in the first step in discovering and later in structuring matrices/codes Tools: the geometric/arithmetic/harmonic codes of proportions: Vitruvio Leonardo, Chinese code, Le Modulor. Words as attributes. 3 attributes define a not linear character as a measure of quality. Performing algorithms as transforming rules.

4th aim: improving imagination – Tools: memory, silence/ music. Abduction as a interpretation of precedents. Good feelings . The rediscover of our childhood.

5th aim: conscience. Tool: the “non finito” (unfinished) in Leonardo e Michelangelo, in Schubert, in Turandot by Puccini, in The Art of fugue by Bach.Keats more books!

Plinio, the elder wrote” We are sad when we see an unfinished work, Inferring that the sculptor has died, and are then stimulated to imagine it completed in a perfect way as a masterpiece. “
Vasari: ”Michelangelo’s various passage, about different works, tend to have in common a defensive quality, to assure that the unfinished factor should not make us view the works as without value, as we otherwise might be likely to do…He finds that the imperfezione of the rough we can see the perfezione of the complete work. We probably must combine the two overtones of the world perfezione, as completeness and perfection”.

5. About imagination

Eternal singular/collective codes, are the expression of our imagination. They are able to perform various evolutionary styles, following historical times. As in Nature.
The four verba *moueds, endues, abstracts, combines,* used by Wordsmorth for defining how is and how works Nature/Imagination, are very closed to the Gian Battista Vico definition of the rule of memory, called ”the mother of Muses” in his Degnità 819 «è memoria mentre rimembra le cose; fantasia, mentre l'altera e contrafà; ingegno mentre le contorna e pone in acconcezza ed assettamento». (“ She is memory, while she is remembering things; fantasy, while she changes them or disguises them; intelligence while she surrounds them and put them in character and in system style”)

Coleridge focused mainly on imagination as the key to poetry. He divided imagination into two main components: primary and secondary imagination. In *Biographia Literaria*, one of his significant theoretical works, he writes:

> The primary imagination I hold to be the living power and prime agent of all human perception, and as a repetition in the finite of the eternal act of creation of the infinite I AM. The secondary I consider as an echo of the former, coexisting with the conscious will, yet still identical with the primary in the *kind* of its agency, and differing only in *degree*, and in the *mode* of its operation.

It is the imagination involved in the poetry that produces a higher quality verse.

The primary imagination is a spontaneous creation of new ideas, and they are expressed perfectly. The secondary imagination is mitigated by the conscious act of imagination; therefore, it is hindered by not only imperfect creation, but also by imperfect expression. *Secondary imagination dissolves, diffuses, dissipates order to recreate a new one.*

To further subdivide the act of imagination, Coleridge introduces his concept of fancy. Fancy is the lowest form of imagination because it "has no other counters to play with but fixities and definite" . With fancy there is no creation involved; it is simply a reconfiguration of existing ideas. Rather than composing a completely original concept or description, the fanciful poet simply reorders concepts, putting them in a new and, possibly, fresh relationship to each other. Coleridge also writes that poetry "reveals itself in the balance or reconciliation of opposite or discordant qualities" . Through juxtaposition ideas, concepts, and descriptions are made clear. The more imaginative the juxtaposition is, the more exciting the poem becomes.

5.1. A teaching exercise about imagination

In many other papers of GA conference, I investigated about tools and aims of a GA process (see GA 2000,2005,2006). Here I want to show an experimented generative exercise made by me in a workshop at HK PolyU last summer. The aim was a generative students experience about imagination. I focused it on the concept of mirroring in the natural world. Starting from the famous allegory by Coleridge on Time, Real and Imaginary, a basic poetry of my investigation in generative process, I structured the exercise in this steps:

1. I selected by signing 8 words inside the text.

2. I defined a system connecting the character of the site, *the mountain head*; the aim of acting, *endless race*; the people, *a sister and a brother*; the female character, *reverted;* the acting, *behind;* the discovering of male character, *blind*; the indefinable result, *first*, or, *last*.

ON the wide level of a mountain's head
(I knew not where, but 'twas some faery place),
Their pinions, ostrich-like, for sails outspread,
Two lovely children run an endless race,
A sister and a brother!
This far outstripp'd the other;
Yet ever runs she with reverted face,
And looks and listens for the boy behind:
For he, alas! is blind!
O'er rough and smooth with even step he pass'd,
And knows not whether he be first or last.

3.After this first crossing from the text to the description of the generated system, I asked students to remind in singular mood this performed site.

4. Going ahead in this knowledge process of discovering, I designed the structure of the Brunelleschi perspective, with a line of horizon, with a second ground line and a point a view, representing the sister behind, and another point for the brother, on the ground line. So I asked student a singular answer to my question: " Between sister and brother, who is real and who is imaginary?". The collective answer for addition (only 3 guys on 19 students) was the sister is imaginary. This is not my opinion.

5. So, I said, you selected the sister imaginary, but if I put a mirror inside the ground line, she imaginary becomes real in mirroring, so who is at last the winner? Good question. An answer: mirroring in reality, sister and brother are the two parts of a whole, that is our mind, in resonance with our heart,

5.2. Words for forms: generating *dynamic asymmetry*

"Vivo autem iam non ego" *S. Paolo*

The expanse in 3D space of the spiral is an helical line. The ordinary curve of life is an example of helical structure. The movement from the beginning to the end inside every process follows the line of the spiral from periphery to center. Egg crystallizes growing according to a spiral movement, of energy, of matter, of conscience. These words don't indicate not related realities, but coincided combinations of being. The movements and the macro order cycles in the universal continuum are not different from those that interact with the conscience continuum, but they are their mirrored image in us Every circular movement translated in 4 dimension becomes spiral. Also the earth's orbit around the sun is a spiral of time, of which every year is different from precedent. On the spherical vortex *"the hidden"* is the point of the origin. (see C.Soddu*"Gencities and visionary worlds"* 2005 GA paper)

The same happens in a GA process. For performing an idea a good tool is to focus the character of the sound in our mind, how it is talking, with the *ondulante imprecisione* of an imaginary line. So we need to discover a friend port, where we can find a not linear DISTONIC system of similarity. *"…the question is that each writer creates his precedents. His opera modifies the our concept of the past, as it will modify the future" Borges," Kafka y sus precursors". Otras inquisiciones*

5.3. Plausibility of similarity , diversity in equality. To translate himself in another.

The imaginary time of art

In "The garden of paths that fork" in Finzioni Borges said *"In all the fiction works, each time that we are in front of different alternatives we decide for one and we take off the others; in that of the perhaps insoluble Ts'ui Pen it is decided, in simultaneous way for all."*

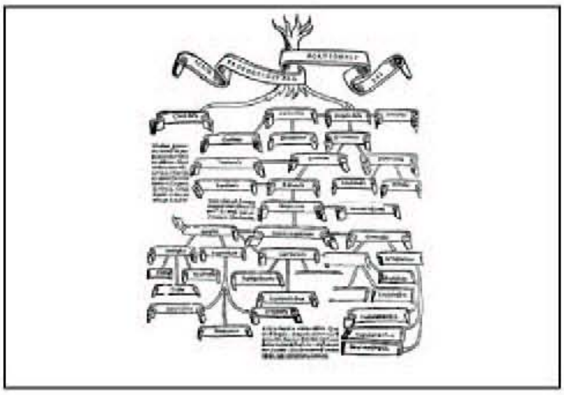
This is a great example of a performing GA structure of our system totally open. We work in a imaginative campus of relations, following the boundaries, just described more than one century ago by Wordsworth. Chomsky grammar and syntax outlined in a deep semantic structure are strongly necessary for our investigation about a generative process, but in the same time they are not enough for the reason that the results of complexity that we can gain with a G. A. process are very fast obsolete for the new requests just performed in the meantime. We work now in a aleatory system in generative process The main request of Art is to give a possible answer to the unshaped questions of our time. Starting from Futurism Art time is Achille' time.

When we define an order following a possible idea inside a chaotic system, we are working in Generative Art. Conditions are to know how works a chaotic system and how our order is performing rules inside. An easy way to gain fast results is to use transformation rules. These can be organized in an open system as a set of algorithms able to generate not linearity in our process. A first result of this process is some (numbers are not significant for the reason that results are expressions of a performing quality, so the quantity is at least not significant) generated variations/results identified by our idea/hypothesis. Some considerations: 1. For gaining complexity we need to start from a precedent, able to configure our knowledge about or also only a real expression of our fascinating impression. This becomes our theme of investigation. Our idea of performing a generative process can start also in a very simple way, like a first embryo of explorations rules to organize.

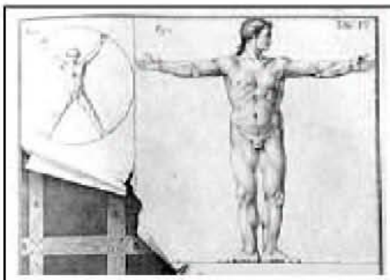
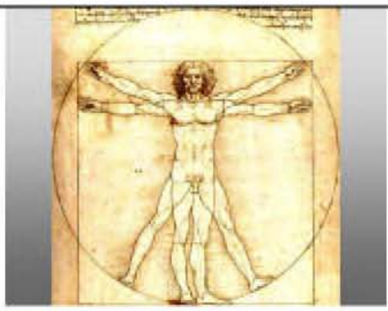
6. Tools for order

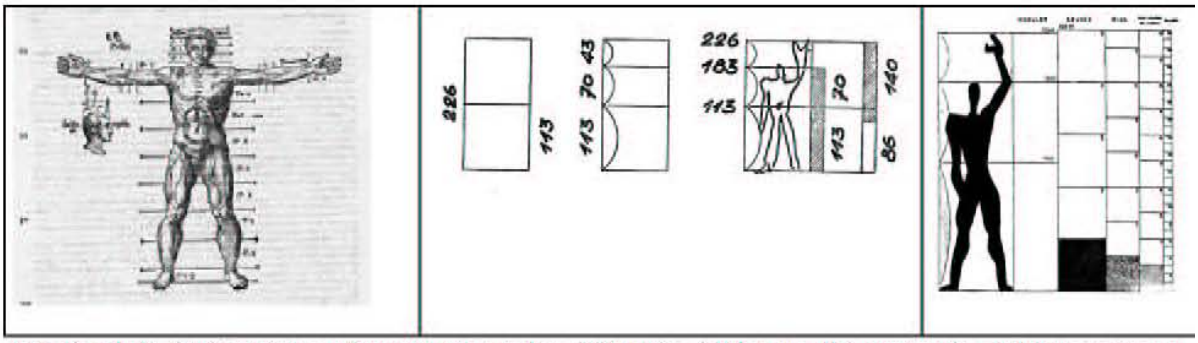
"The gyres! The gyres! Old Rocky Face, look forth;
....and all things run
On that unfashionable gyre again."
William B. Yeats, Last Poems, 1937

The concept of order and in species of mathematical order is on the base of our psycho physical conformation. Our interpretation of Nature is mainly mathematical: we express the rules that steer all phenomena, from those more closed to the other ones universal in mathematical terms. Wittwoker identifies in Athens the rising of a rational theory able of transforming mathematics in a theoretical science. Greeks were the first in defining a systematic mathematical interpretation of Nature. Pitagora discovered extraordinary numerical relations with music, both of ratio arithmetical relations and geometrical proportions. Ratio is a relation between two quantity, instead proportion is a ratio equality between two couple of quantity, that needs a medium. So there were generated 3 proportions: geometrical (1:2:4) that defines octave in music; arithmetical (2:3:4) octave performed in fifth and quarter; harmonic (6:8:12) the inverted of precedent, octave divided in quarter and fifth. Following the harmonic vision expressed by Plato in Timeo, Alberti in his "Ten books of Architecture" said *"Those same certain numbers, able to perform the voices concert as very appreciable, those are the same able to fill yet both eyes and soul in wandering pleasure"*. Also *the* measures written by Palladio for the plan of Villa Thiene are proportioned following the harmonic series 12-18-36, that contains inside the ratio 1:2, 1:3, 2:3. The musical harmonic proportions were the fundamental theory for designing height, length, depth in Architecture. "The right measure" by Durer. The arithmetical proportions are all expressed in rational numbers, instead the geometrical proportions are, in a lot of cases, expressed in irrational numbers. In Renaissance the principle of measure was the main aesthetic aim. Leonardo worked a lot about proportions defining in a dynamic process relations between frames and whole between rational numbers, as 1:2 and 1:3. Different from this organic metric vision was the medieval pre delineated structure not connected with the generated shapes of figure and of building. The opposite between Villard de Honnecourt and Leonardo was in the first the projection of a pre defined geometrical rule on his forms, in the second the abduction from natural ware of a metric rule, by using rational numbers and by applying the Vitruvio rational system for building. The tree structure Arbor proportio et proportionalitas performed by Luca Pacioli defines in a systematic picture the complex relations between proportion and proportional parts.



"Nissuna umana investigazione si pò dimandare vera scienzia s'essa non passa per le matematiche dimostrazioni, e se tu dirai che le scienzie, che principiano e finiscono nella mente, abbiano verità questo non si concede, ma si niega, per molte ragioni, e prima, che in tali discorsi mentali non accade esperienzia, sanza la quale nulla dà di sé certezza"Leonardo da Vinci ("No one human investigation is possible to call true science is it doesn't walk through the mathematical demonstrations, and if you will affirm that sciences, that rise and finish in mind, belong to true, this is not admitted, but it is refused, for many reasons, and, first of all, that in such mental talks don't happen experience, without which nothing generates of itself certainty"). Starting from XVIII century subjectivity performed the process of Art. The philosophical research about origins of Beauty and Sublime by Burke is theoretical emotional subjective vision of Art. Mathematical tools were lost. Survived crossing the new century the work of A. Zeising about The Golden Section, The Dynamic Symmetry by Hambidge and Le Modulor by Le Corusier. This was a very important tool used by architects after the second part of '900. But it represents only the arithmetic part of tradition. Also Chinese Vitruvio man is structured by geometrical devices. May be it was connected by Marco Polo in his incredible cultural interchange between China and Italy.

On the left, 2 drawings of proportions by Vitruvio, L'Uomo di Leonardo, Chinese man proportions, 2 drawings of arithmetic proportions for Le Modulor by Le Corbusier.

7. GA in Evolutionary Time process

GA marks the soft passage of our time from homo faber to homo creator, able to rediscover the broken historical line with the tradition, following a digital revolution and performing a deep innovation in Art. With the use of technological devices GA artists are rediscovering a poetical approach toward complex results. This is a new not linear process overcoming the dialectical position of Modern and Postmodern. The homo faber is strongly connected to a mass anonymous vision around man consumer of industrial products from the house to objects, all equal, built in series. This strong idea of industrialization performed the globalization time. In my impression one of most beautiful art expression of this industrial passage is the movie "Mon oncle" by J. Tati.

In modern the main focus seems to be the concept of time. For Le Curbusier, a very skilful watchmaker, time means only exactness, that it is possible to gain only by quantity measure of arithmetical systems. Le Modulor was the best tool for gaining an analytical detailed and optimized solution for the Modular City. In this way were lost harmonic and geometrical proportions, with the concept of imitation of nature. The dominant rule is abstract versus figurative. This conflict is in reality only an academic question. It is enough remember the incredible movies of the same time, that overcome the question, for the simple reason that in imitation of real life are the representation figurative of a poetic vision. The Lady from Shanghai by O. Welles, in the sequence of mirrors, is a deep example of an abstract figuration. Paul Klee said "The question is not to represent the visible, but the rendering visible". The concept of time in GA is continuum, following alive world. It is in the same time imaginary, connecting an interpretation of reality, following a visionary impression. May be also random, connected in running software to real representation of day time.

8. Precedents of the GA philosophical structure

What thou lovest well remains,
the rest is dross
What thou lov'st well shall not be reft from thee
What thou lov'st well is thy true heritage
Whose world, or mine or theirs
or is it of none?
First came the seen, then thus the palpable
Elysium, though it were in the halls of hell,
What thou lovest well is thy true heritage
What thou lov'st well shall not be reft from thee

EZRA POUND, PISAN CANTOS, LXXXI

8. 1. A Dostoevskij note

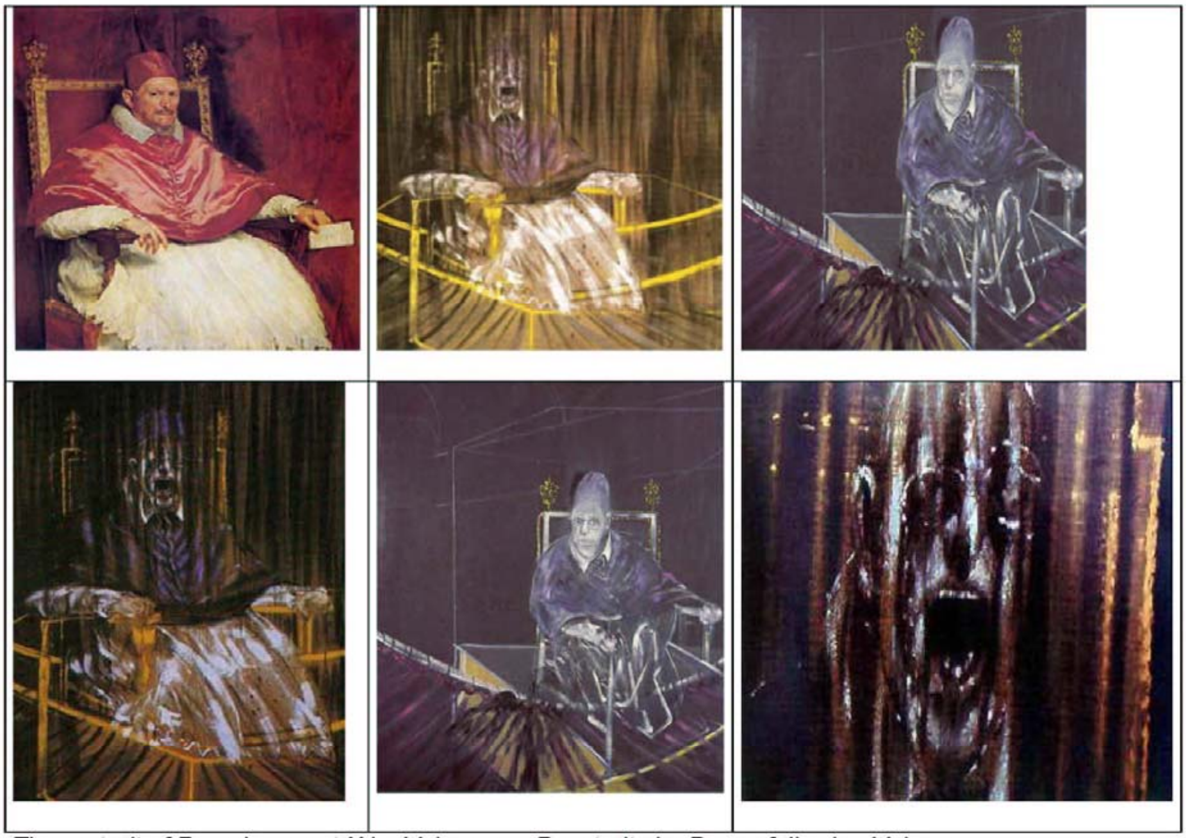
I selected this notes by F.Dostoevskij as proof of his deep performing process in writing *The brothers Karamazoff*. In contrast Benjamin tales to us, in his book *Angelus Novus*, that Goethe putted into the fire all his performing material for writing *Elected affinities*.
Chaos for order. Chaos in order.

First of all we need to see texts,
Things that are seen, don't forget anymore

In Rome, at Piazza di Spagna, when Keats was ill and unable in writing and reading, he asked his friend Shelley to put closed to his bed more books, so he could see them.

8.2 In the depths of a figurative actions, Bacon, a metaphor of natural continuum

The great revolutionary people in Art had always studied deeply the tradition. Rembrandt, Picasso, Van Gogh designed again precedent painters following their own impression and performing a new personal imprinting. In the time of a rigorous abstractism, Bacon following Picasso designed Velasquez. The impression is totally coherent with the continnum of artworks, for the natural human exercise of rediscovering similarity. But the evident new is the depths of a metamorphic dynamic vision, as a nude body in the act of soul losing. A mute shot over the time. For more than ten years Bacon made deep intense variations of this painting theme. Bacon loved Valery book *"Introduction à la méthode de Léonard de Vinci."* dedicated a *"Les* *vies imaginaires* " by Marcel Schwob. By denying the concept of progressive time of relating, Bacon affirmed "*I want strongly do what Valery spoke: to give the sensation, without the bore of the its transmission*".



The portrait of Pope Innocent X by Velasquez. 5 portraits by Bacon following Velasquex.

8.2. About our time

The color of our time are variations of gray in anonymous sites

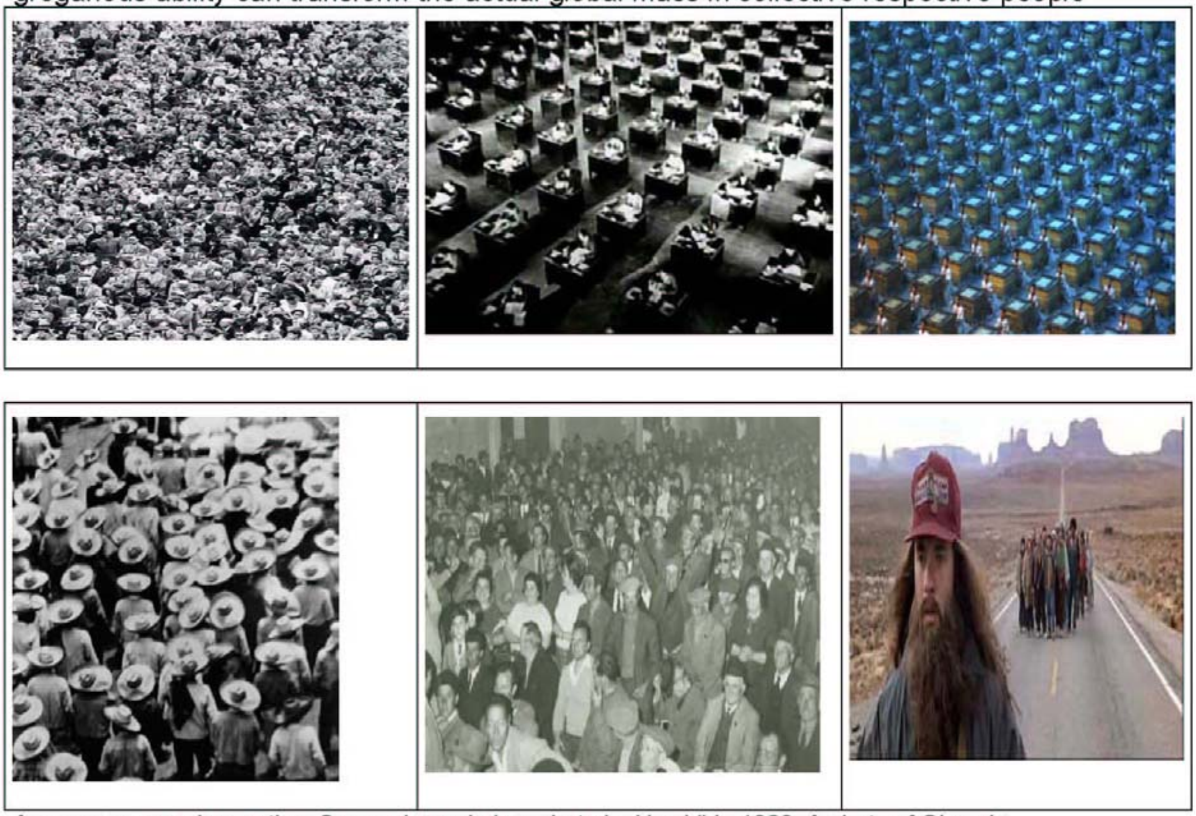
We are conscious that as human beings we are going in a new page of our history. This is not a revolution, something connected to our social political organization. But it is something related to our hidden essence, our own peculiarity. The door of our mystery that was opened without any respect of our natural idiom is broken without any conscience. People of power works in the mirror of their vanity. Going ahead on the street of success and money, that you know is never enough. No time for responsibility. If sometimes panic is rising, take yellow and blue pill and every thing will be under control. The main diffuse problem for young generation is to have a good connection with power people. Of every type of power. More connections = more money. The spectrum is aloud spent, for vanishing.

With usura hath no man a house of good stone
each block cut smooth and well fitting
that design might cover their face…
Usura rusteth the chisel
It rusteth the craft and the craftsman
It gnaweth the thread in the loom
None learneth to weave gold in her pattern;
Azure hath a canker by usura; cramoisi is unbroidered
Emerald findeth no Memling
Ezra Pound

8.3 Human gregarious character, collective codes

Quando il velo cade/ when the veil shot down
Siamo nudi, indifesi, senza scampo/We are nude,helpless, without any escape.
Una vertigine separa l'insieme,/A vertigo divides the whole,
Manifesta il possibile indefinito tra i capelli /It discloses the possibile undefined in the hair.

Mirror neurons of human mind perform one of the most our topic character: gregarious. The concept that I should like to perform is represented by the hendiadys heretical gregarious. The literal significance of heretical derives from greek airesic-airesis that means scelta (choise), from the verb airew= I choose, I prefer, I approve of an opinion, I pass a political candidate. Forrest Gump is a Ga Artist! Our human gregarious ability can transform the actual global mass in collective respective people



Anonymous people meeting. Squared people in a photo by king Vidor1928. A photo of Olympic Games in Beijing 2008. A photo of Campesinos by Tina Modotti. People at an election meeting in Lucera, my small town in east south of Italia. Forrest Gump running with gregarious people.

8.4.The GA community

Over all the world now a lot of people are working using the generative design approach. In architecture C. Soddu, John Frazer, Robert J. Krawczyk, Paul Coates, Manuel Baez, Renato Saleri Lunazzi, Nicolas Reeves, Chris Ceccato, Antony Viscardi, Bauke de Vries, Aant Van der Zee, in mathematics Philip Van Loocke, Marie-Pascale Corcuff, Carla Farsi, in art Harold Cohen, Celestino Soddu and Hans Dehlinger are following an abstract/figurative vision, with Alain Lioret, Bogdan

Soban, Yoshiyuki Abe, KevinMcGuire, Justine Marshall. There is too the group of Evonet, Adrian Ward and his group eu-gene with the theoretical collaborations of Philippe Galanter, the theoretic study by Daniela Sirbu. In robotics Leonel Moura, Greg Hornby, Daniel Bisig and Tatsu Unemi, Thomas Fisher, in music John A. Biles, Gabriel Maldonado, Brigit Burke, John Eacott, Gordon Monro,... The list is long and open. These are only a brief list , there are a lot of people that are working deeply and with enthusiasm in GA. You can find more than 400 papers in www.generativeart.com.
Finishing: 3words: breath, mood, smell. A conscious breath of unstable mood in spring smell.

This paper is dedicated to all children. My wish is that also Somalia and USA will sign asap the international agreement for the respect of the children rights.

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The Generative Audiovisual Narrative System

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Abstract

This paper documents the results of a research project that deals with the application of an artificial life (AL) approach to creating a system of cinematographic narration. This project investigates the possibility of producing an autonomous cinematographic narration system, in which meaning results from a kind of hypermontage, conditioned by genetic algorithms. The theoretical thesis lead to the design and construction of a generative system for the synthesis of audiovisual narratives, in which a genetic algorithm manages the collection of video fragments, that have been parameterized and stored in a database. The genetic algorithm's fitness criteria are being defined by the viewer, via the system's interface. During the presentation of this paper, the system and its audiovisual results will be demonstrated.

This paper investigates whether individual video fragments belonging to a database may be linked into numerous different successions in order to satisfy fitness criteria defined by the user. The aim is to create optimum sequences in accordance to specific requirements, instead of coming up with a closed predetermined unique sequence, as it's traditionally done by directors.

Fragmented videos as micro-narrations are composed to a greater whole which is unique, since the system has never given the same result twice. Taking the phenomenon of semantic montage as an axiom, the viewer attributes causality relationships to the succession of these fragmented micro-narrations which are seamlessly integrated in the sequence.

A traditional work of art may be read in multiple ways, which depend on the subjectivity and arbitrariness of the spectator-reader. In the case of AL, the multiplicity of the artwork mainly depends on the manner in which the artifact is being written. Having the same structural elements as a starting point may result in different readings. Having the same data as a starting point, may lead to different versions of the same work of art.

1. Introduction

During the 20th century the work of art has been repeatedly questioned, overturning the dominant perceptions of “beautiful” and “good quality”. The aesthetic object is often transformed into procedure, into a game between the author and the spectators, expressed as installation, performance or digital interactive application. The “degradation” of the artist’s role in favour of the spectator’s empowerment and the providing of dialogue between the author, the spectator and the art object, cannot be thought of without the active participation of all three of the above agents.

Digital interactive art projects in particular, are characterized by the potential of multiple choices during navigation, where the user is faced with hypertextual structures, called to act according to the interface and the system’s rules, which have been designed and defined by its author. The actions of the spectator – user, based on intuition and having a ludic character, influence the formal and narrative evolution of the piece through the function of feedback.

In the case of Artificial Life art, the author lays down rules materialized by the system-artistic piece, without being able to predict the forms that the latter is going to take. Author and spectator watch the “materialization” (representation) of the rules set by the former.

This paper documents the results of a research project that deals with the application of an artificial life (AL) approach to creating a system of cinematographic narration. This project investigates the possibility of producing an autonomous cinematographic narration system, in which meaning results from a kind of hypermontage, conditioned by genetic algorithms. The theoretical thesis lead to the design and construction of a generative system for the synthesis of audiovisual narratives, in which a genetic algorithm manages the collection of video fragments, that have been parameterized and stored in a database. The genetic algorithm’s fitness criteria are being defined by the viewer, via the system’s interface.

2. The example of dada

In the beginning of the 20th century, art had already begun to question the up until then established ways of narration, as well as their methods of presentation. The example mentioned is that of dada, set against the institution of art exhibitions. When in 1919 the director of Kunstverein in Cologne saw the latest work of the Germans Max Ernst and Johannes Baargeld, he called them to exhibit separately. They then exhibited not only their work but also paintings of amateurs and children, as well as “art objects”, like an umbrella, a piano key and African sculpture. Thus, the work of art became the exhibition’s mise-en-scene and not the individual objects of which it was consisted [1].

The provocative confrontation of the art’s establishment consists one of the first examples in combination of database and interactive art, given that the artistic value is attributed to the sum of exhibited objects and not to the individual objects themselves, fact that introduces the concept of collection as a synthetic procedure. Combining elements of minor importance for the articulation of an interesting whole lies in the centre of databases' logic.

The co-existence of works by famous artists, amateurs and children, gives an interactive touch to the concept of collection, which, instead of being an individual's private property, consists a team effort. Traditionally, the concept of collection is identified with the particular interest of a person in a specific kind of object (stamps, coins, wine bottle labels, etc.). The passage from individuality to collectivity, as far as artistic activity goes, signifies an important shift in the goal and interpretation of the art object, which is transformed from personal expression into procedure and social critique. Formally the transition is accomplished, from the individual object to the sum of objects that consist space and define to the spectator a path inside the collection.

In 1920 Ernst and Baargeld, by withdrawing pieces from a supposedly open exhibition, rented the Brasserie Winder, a yard half-covered with glass, which one could access only by passing through the men's toilets, where the visitors had the right to destroy anything they didn't like. It was an inversion of the conventional exhibition, demanding from the spectator active involvement and not passive watching, while it was parodying the artist's authority. In 1919, the "relatives" Dadaists John Hartfield and Georg Grosz declared that "the word artist is insulting and the doctrine "art" cancels the equality between people". In 1959, Allan Kaprow created the term happening that set a way of escape of the artists from their up until then starring role, empowering the spectator, or rather the participant [1].

The "degradation" of the artist's role in favour of the spectator's empowerment and the providing of dialogue between the author, the spectator and the art object, is characteristic of interactive art, which cannot be thought of without the active participation of all three of the above agents.

Digital technology provided the dialogue between author and spectator through the work, whose final form is defined by both. Author and spectator are involved in a game of writing and reading, laying down rules and discovering / revealing them, with the art object as starting point. The digital work as a field of experimentation contains the concepts of exploration, game and intuitive response, on behalf of the composer as well as the user.

Digital technology suggests tools that are registered in the continuation of the traditional tried and tested practices, enriching them with new possibilities. The artistic practices seek new ways of application, following the rules of "writing and reading" introduced by games and game machines, promoting the spectator to a participant, since the interaction tends to confront him with semiotic objects enriched with autonomous behaviours.

Hypertext consists a mechanism par excellence of digital interactive art, which allows and amplifies the correlation between cultural texts favouring new forms of reading them. The constructed net of audiovisual information is explored by the spectator – user, in a way that defines the exported narrative product.

3. Hypermedia narratives

Narratives supported by hypermedia systems adhere to a series of conventions that render them readable. However, we cannot suggest that a particular writing system, entailing grammar and syntax, that could totally condition the creation of digital hypermedia systems, has so far been established. For the time being it would be quite hard to create an analytic and strict writing code in compliance with a linguistics model.

It is suggested that a language of narrative that stems from representation through moving images and is supported by computers can be formed via the combining existing theories of cinematic language with theories that propose reconsideration or even change-over of conventional forms of narrative [2]. Becoming familiar with the grammar and syntax of cinematic language constitutes the first stage of reading, which is essential for conceiving and further comprehending the message communicated through new media. A person may watch the input and output of information between her and the computer, through a monitor or a projector, which constitutes the visualization field of moving images, accompanied by sound. The projected image follows, to a great extent, the visual and semiotic conventions already known to us, originally from cinema and later from television.

With reference to interactive narratives and more specifically in the case of interactive cinema, there exists a “live” spectacle, the narrative and duration of which are activated, controlled and affected by the viewer. The latter does not remain a mere observer: she is simultaneously assigned the role of director, editor and often the lead actor. The computer provides the potential for an interaction process.

Apart from interaction itself, the source of other elements of an interactive artifact, namely the shots and the montage, relate to a certain extent to conventional cinema. Interactive artifacts are hybrid systems constructed by directors as far as their contents and mechanisms are concerned.

New media are still using the cinematic language that recognizes the séquence as the structuring element of the audiovisual transmission system. Cinema differs from other narrative methods in that linear narrative evolves within time and space. The introduction of the time parameter in narrative has imposed a new writing method, able to establish a correlation amongst the protagonists, their surroundings, the story plot and time, via their representation through images and text.

The various potential forms of an interactive play are finite. The creator of the system is in position to forecast in advance the potential forms that the play may exhibit, as a result of interaction with the user. Even in cases when the system has been programmed to pick up an element over a group of elements at random, through the “random” command, it is easy to find all possible combinations that may be applied by the computing system, by means of probability theory. The number of options for interaction and navigation, as well as the consequent results are predetermined by the system creator.

The computation system that is adequate for exploring evolution as a creative process, entailing any random and indefinite elements of nature and culture, shall be more effective if it operates upon a mechanism simulating natural evolution stages. The discipline that attempts to simulate nature and living organisms in order to study and comprehend their mechanisms is Artificial Life (AL). Artificial Life is often depicted as an attempt to comprehend complex behaviors through simple rules [3]. The term AL was coined in 1989 by Christopher Langton, who defined it as “the study of man made systems exhibiting behaviors typical of natural living systems” [4]. Genetic algorithms, which are based on Darwin's theory of evolution, constitute the core method applied to simulate biological genetics through digital computation.

4. Emergence

An important concept of artificial life is the procedure known as emergence, through which simple ingredients interact to produce complex, lifelike results. Claiming that complex behaviours of a living organism emerge from its non living parts, artificial life attempts the recreation of this procedure into artificial systems, so that the sum of simple computational parts interacts to spontaneously produce lifelike dynamic structures [5].

Emergence is the idea on which is based the crucial distinction between life and non life. According to a bottom-up approach that distinguishes artificial life, the complex, lifelike behaviours are not totally controlled and determined, but they are born of small scale interactions. Emergence is the term and the idea used for the evaluation of these effects.

Emergence refers to something new or unexpected, something more that impresses in systems of artificial life, since, even though they are made of commonplace ingredients, they show complex, subtle and unpredictable behaviours. In brief, they seem to contribute more properties than the mere sum of their computational parts, manifesting them in the form of motif or space, specific behaviour or general tendency of the system. All the (artistic) systems of artificial life are based on a determined sum of computational rules and procedures, of limited interest compared to the rich, multiple, complex, emerging results that they support. The something more of emergence is central in the interest and charm of artificial life. Regarding the generative narrative system, every time it’s being activated it composes different outputs. It has never given the same result twice.

The concept of emergence gives to the work / computational system itself a ludic character, since it takes unpredictable, by the author, but also the user, forms. It exists and evolves based on specific and inviolable rules that have been set during programming, causing its author to explore the power of the rules he has laid down. In the same time, awareness narratives enrich the emergence’s obvious results.

5. The concept of collection

The effect of creation of a complex and basically unpredictable product through the combination and interaction of individual elements, which do not show particular interest by themselves, gives new perspectives to the concept of collection. Collection as a sum of similar elements can be of interest that surpasses the personal and emotional value attributed by its creator and owner.

The concept of collection as an artistic work dates from the middle of 20th century. When in 1960 Iris Klert asked from 41 artists her portrait for an exhibition, Arman gathered her personal belongings: a shoe, underwear and cosmetics, referring to the fetishism of Froyd and Marx (the shoe with its high heel), presenting the property of the artist as a collector and a pathological one [6]. In the case of Arman, the objects of the collection illustrate a conceptual portrait of Iris Klert, where the signified of the sum is completely different to the signifiers of the individual objects.

With the arrival of digital technology, where the collection is translated into database, the creation of complex works using the data of the base is feasible. The complexity of the works does not only lie on conceptual reductions, but also on formal, spatial, temporal and other transformations of the individual elements' sum, referring to an emerging behaviour, central concept of artificial life, which, applicated into artistic systems, can give new perspectives to the procedure as well as the result of artistic creation.

6. Generative narrative system

The creator organizes the database including the audiovisual materials that are to be used for the construction of the final product and also builds up the software mechanism, which will process the composition of the database constituent parts. In a "cinematic" work produced through genetic algorithms, the director's role is restricted to the shooting and organization of the footage as well as the creation and/or adaptation of the software mechanism of production. Editing is automatically conducted by the system. The role of the director is limited to the "organization" of material so that the computation system can begin and complete the process of narrative composition, without the need of any further assistance by the creator. More precisely, the role of the "director" should be appointed to the system, for the creator/organizer provides it with the resources required for the execution of this task.

Beginning from fragments of a specific narrative genre, the soapopera, we attempted to compose new narratives via the use of Artificial Life rules. As a scenario basis for the fragmented shots, we used the original scenario of the first five episodes of the Greek TV show "Filodoxies", written by Ada Gourbali, for Mega Channel. The phrases of the scenario were altered in a way that the various characters were reduced to 4, a man (Agis) and a woman (Niovi) who we see conducting a dialogue and a man (Frixos) and a woman (Rita), that we never see, but we come to know them because of Agis' and Niovi's references to them.

The aim of the system was the experimentation and the observation of its behavior, during the management of the above audiovisual data. The treatment of the initial scenario and the restriction of the characters into four persons, resulted to a destruction, a disorganization and a deconstruction of the story, since the alteration of the subjects paramorphized every sentence of reference. The initial dialogues had turned into independent and autonomous phrases articulated by two characters, Agis and Niovi, which can refer to themselves, to each other or to Rita and Frixos. The initial flow of the text was definitely gone.

The phrases of the scenario were recorded with the help of two actors, Jasmine Kilaidonis who in the role of Niovi and George Chrysostomou in the role of Agis. The shots were recorded by four cameras, two for each actor, capturing gros plans and très gros plans.

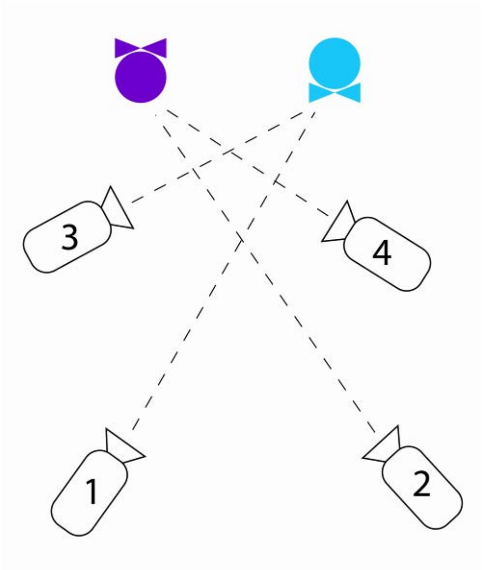

Figure 1

Figure 2

6.1 Tabbing of the shots – narrative audiovisual units

The tabbing system for the sum of the audiovisual narrative units should express their special characteristics on one hand and be readable by the computer on the other hand. The content suggests a methodology adapted to it, with syntactic and semantic parameters that respond to all of the units and can constitute the basis of the synthesis programming rules of the reproductive narrative procedure. For that purpose a special interface was designed, that comprises all the contents categories with their possible values for each unit, in order to introduce them into the database. Via the use of that interface, the designer gives metadata to fragmented shots and makes them part of the generative system's database.

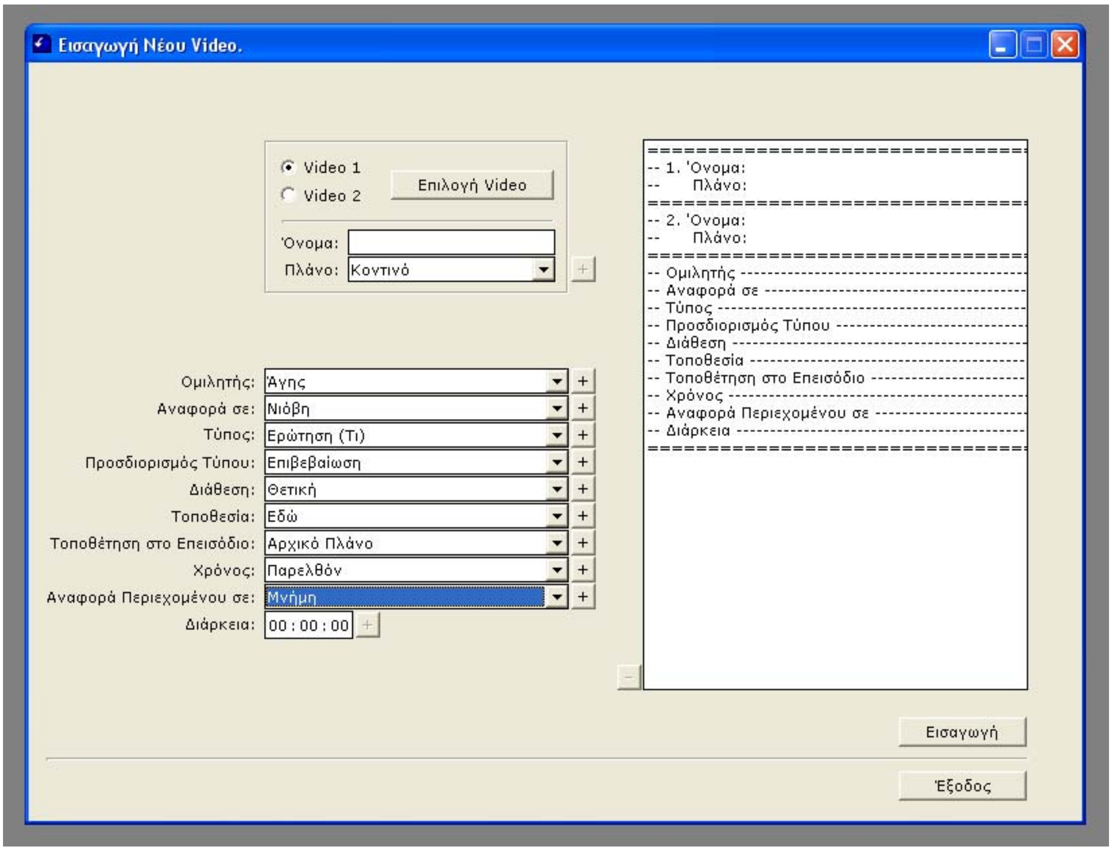

Figure 3

6.2 Basic programming principles

During the programming of the generative narrative system, basic principles of genetic algorithms are being followed, where the initial population, constituted by generative narratives (séquences), remains stable in every generation. The individual séquences mutate, crossover and survive selectively according to fitness criteria, parameterized by the viewer. The reproductive loop stops at the point where an individual fulfills the fitness criteria, which constitute the measure of evaluation for each individual, rendering it suitable for survival or extinction in the next generation. This second interface is designed in a way that every value can be parameterized by the user, so during the programming they are characterized as variables. All the menus appearing on the left side of the interface are the final narrative's properties which take values as decided by the user. In the field appearing on the right of the interface appears the raw of the shots in the fittest generative narrative, in the form of its découpage. Below we can see in which generation it belongs.

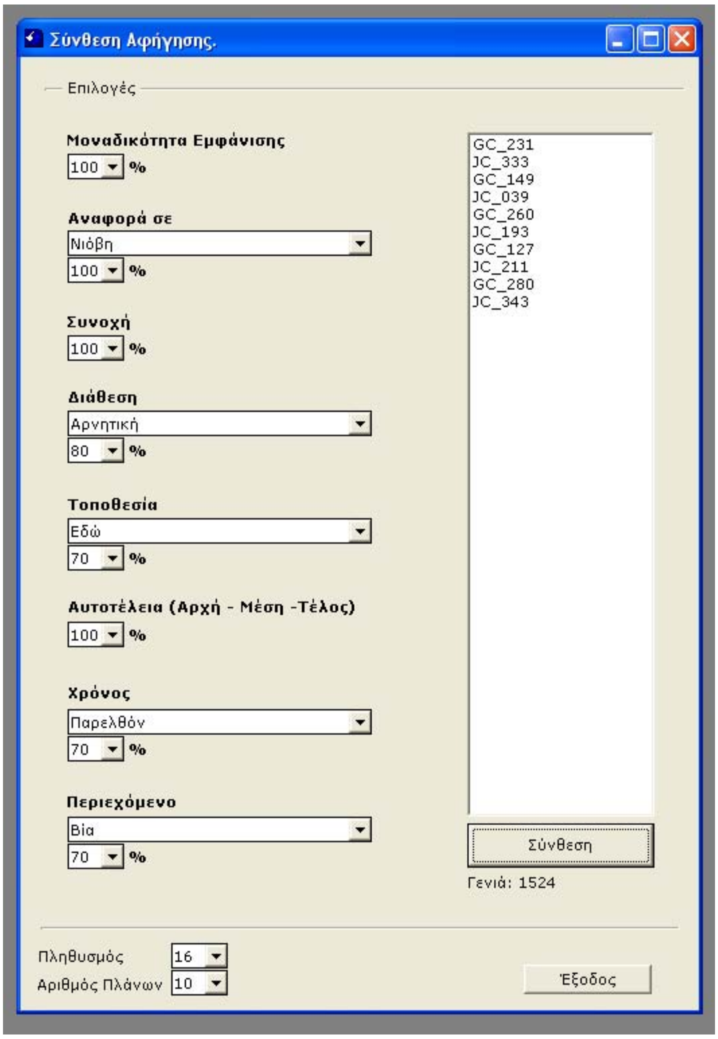

Figure 4

Fitness criteria are global and local, defined by the user. Global criteria include the basic structural rules of the system, that relate to the syntax of the narrative, such as the way that Niovi's shots and Agis' shots should succeed each other in order to conduct a dialogue, or which answer should follow a specific kind of question. Some shots that are considered as introductive should be placed at the beginning of the sequence and so on. Local and personalized criteria are those defined by the user, who selects them upon a list of possible values, offered by the user's interface (*Figure 4*). He can ask the system to create a narrative referring mostly to Rita, where love in the basic issue facts are being unfold in a past tense. He can also define the precise number of the shots of the final audiovisual narrative.

By the time where a séquence accomplishes all above criteria, global and local, the reproductive loop stops and the generative procedure is over. The system creates plot as a meaning administrator, since it juxtaposes narrative units according to their metadata. The sequences' succession defines the signified, leading the viewer's reading to specific conclusions, due to the phenomenon of semantic montage.

7. Reading of the generative system's results

As Bordwell [7] mentions, during the interpretation of a film, the signifier of every one of its parts corresponds to many different signifieds. The same thing stands for the generative narratives produced by the presented system, given that their reading follows the same conventions as for traditional film reading. Besides, the particularity of cinema as a language according to Collet [8] is due to the fact that it is being formed by the succession of elements. Combining the above statements, we conclude that the particularity of the narratives synthesized by the system is due to the fact that they are created by the succession of elements (fragmented narratives), whose signifier corresponds to various signifieds.

Since the shots of a system's narrative are fragmented recordings of a reality viewed by a particular point of view, their composition and decomposition forms different versions of a reality that might have existed once upon a time or never. Every shot's signified is translated into a different signifier according to the shot that precedes it and to the one that follows.

The most important difference between a narrative created by the generative system and one created by a human director is that, even though they both make use of cinematic language, the first one is only a possibility among several that can be created by the same mechanism, and the second one is considered as unique.

8. Conclusion

The presented system creates narratives starting by the juxtaposition of video fragments. Based on the phenomenon of semantic montage, the viewer attributes causality relationships to the succession of these fragmented micro-narrations which are seamlessly integrated in the sequence.

The process of a cinematic film production, usually results in the creation of a single product. No matter how many times it is screened, the film remains the same. In the system under study, the narrative products that could be built, as a result of the same work functioning, may be countless. Every time the viewer commands the system to start screening, it starts editing the database elements anew. Given the fact that the process is being conducted by genetic algorithms, which constantly alter the produced outcome, the composition of shot is unforeseeable and so is the number of the potential results. Due to the high complexity of the whole process, there is practically no chance of two outputs being the same.

Systems that "imitate" natural selection processes for the evolution of an entity, set strict rules for the control of the evolutionary process. The results after each stage of evolution may be unpredictable for the constructor but the rules remain unaltered. Computations applied to the management of the genome by transforming it, altering the genotype or handling user interaction remain unaffected by the evolutionary processes [9].

In an evolutionary cinematic system, the creator functions as a driving force, a stimulus of a process that goes beyond the scope of the creator's imagination and may acquire unpredictable forms, in compliance with strict and specific rules. The designer of such a system examines the potential, the limitations and the power of the rules she establishes. She also monitors the formation of the rules she has set.

9. References

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The 200 Year Continuum
Presentation for GA2008

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Premise

The 200 Year Continuum is a body of work which I have been working on since 2007. It exists as a narrative structure for advancing technologies and new futures for physical landscape, virtual constructions, nanotechnologies and human interactions. My practise involves Drawing as a mode of research, live installations manifest as artificial ecological sites and scientific experiments challenge ideas of new prosthetic mythologies. In my project '*The Amber Clock*' the premise of growing a ship within a Yew forest over time fosters the idea to achieve new ends within natural systems, while the exploration of Nanotechnology and Dark matter has the ability to reposition our understanding to material yet unseen. These projects act as middle stories within *The 200 Year Continuum*; often recorded through digital imaging, installation and text, the narrative acts simultaneously as a *Recorder* and *Producer* constantly updating its own continuation. The choreography of virtual data and natural laws, communicate a new disposition of society, future natures, environmental interactions, digital interventions and ideas for a new futurism.

1. Walk down the chalk road past the meadows.

We have reached a point in our evolution where we are now capable of creating design criteria to manipulate natural growth and development. Through stem cell research and making at the nano-scale, the spectrum of opportunity now open to exploration has reinterpreted our existing understanding of the natural world and our relationship to mortality. New architectures are finding spaces the behind the proton, they jump scale instantaneously; they are vigorously interactive and teeming with new ends.

With new technology, new mythologies emerge and man's relationships to these systems of organisation are encrusted with new understanding in our position daily routines. With digital systems, new spatial potential can rework the language of our surrounding environment. My work to date draws on these middle stories, as on seven projects titled: The Amber Clock, Plain Citizen: Solar Wind, Los Angeles Doors, The Mariners Obelisk, Deep Ecology and Dark Matter: New Blood.

2. Hidden Architectures find niches as Moist Technology

On the chalk downland North West Chichester is Kingley Vale, one of the last surviving natural Yew forests in existence. The forest covers roughly 300 acres in a combe facing towards Chichester. In the heart of the wood, the oldest trees stand at around 800 years old and the rest of the forest is approximately 500 years old. Legends say that many of the trees planted were to commemorate the death of Sygbert, King of the West Saxons, who was stabbed to death there by a swineherd in 894. Folklore regarding the planting of the forest, tells a tale of a marauding Viking war band which came to attack Chichester in the 9th century, while the attack was furious most of the warriors were killed by the defenders of the town. The trees in Kingley Vale are descended from those planted as a memorial on the site of the battlefield and four large barrows were built from the surrounding trees over the graves of the leaders on the ridge above the forest. The story is further embellished by the idea that the Danes, before attacking the Chichester men, first buried treasure in the form of a golden calf in an Iron Age hill fort known as The Trundle, which lies to the East of Kingley Vale.

Kingley Vale became the theoretical site for the first project, '*The Amber Clock*'. Defined as a symbiotic performance, growing a ship in the last remaining Yew forest over 200 years was choreography between a natural system of growth and the artificial presence of man made interventions.

For this mythology to play out, I propose to use technology as a way of controlling the growth patterns of individual tree sections. By placing a corset around the early growth of a new copse of trees, the designed device can begin to change the tree density and shape of the forest to create the hidden ship. Different modes of training devices shape and extrude the pieces of the ship inside each tree trunk.

In ancient Japanese culture, they see nature as an extension of themselves. The art of Bonsai is an example of how they order nature and beauty. Bonsai is one of the ancient union's of art and nature. The tree is alive and continually changing. In the image the slow manipulation of the bonsai trees is simple gesture in a relationship of two systems of organisation. The Japanese control upon nature is meant to evoke the essential spirit of the plant being used. The manipulation of nature is seen as a way of provoking perspective on their surroundings. The wiring of bonsai trees is to attain desired shapes in association with the training process. It is an ongoing process throughout the life of the tree plied the mind to believe in a greater possibility of this extension.

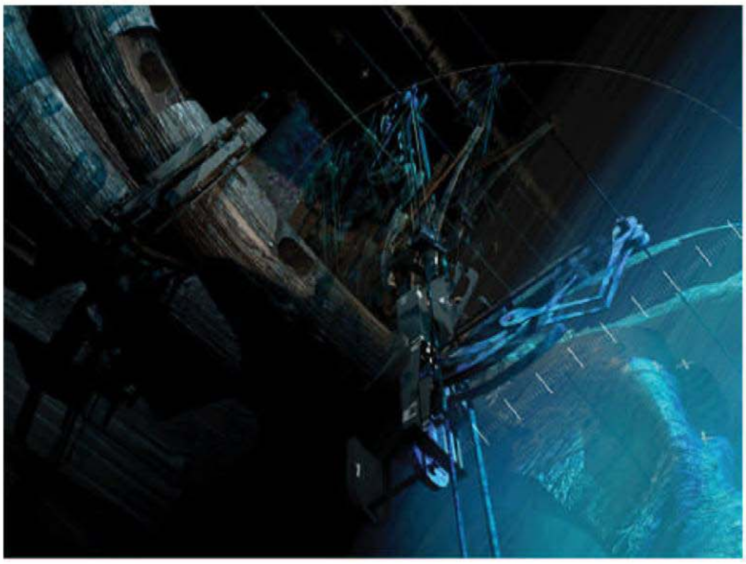
In this project, I interpret '**Nature**' as been the natural system of growth for the newly planted Yew trees at Kingley Vale. The planting, insertion and evolution of this site will choreograph nature and its hidden architectures.

Woodlands are wild places which often generate a sense of infinity through the ages. In the Yew forest it is the engagement of '*Time*' which makes a unique site with new spatial fields. The dynamic armatures choreograph a sustainable system of geometries and densities. Dali explained it;

"It was an instrument of high physical poetry formed by distances and by relationships between these distances; these relationships were expressed geometrically in some parts, and arithmetically in others; in the centre, a simple indicating mechanism served to measure the saint's death-throes. The mechanism was composed of a small dial of graduated plaster, in the middle of which a red blood clot, pressed between two crystals, acted as a sensitive barometer for each new wound. In the upper part of the heliometer was Saint Sebastian's magnifying glass. This was at once concave, convex and flat. " [1]

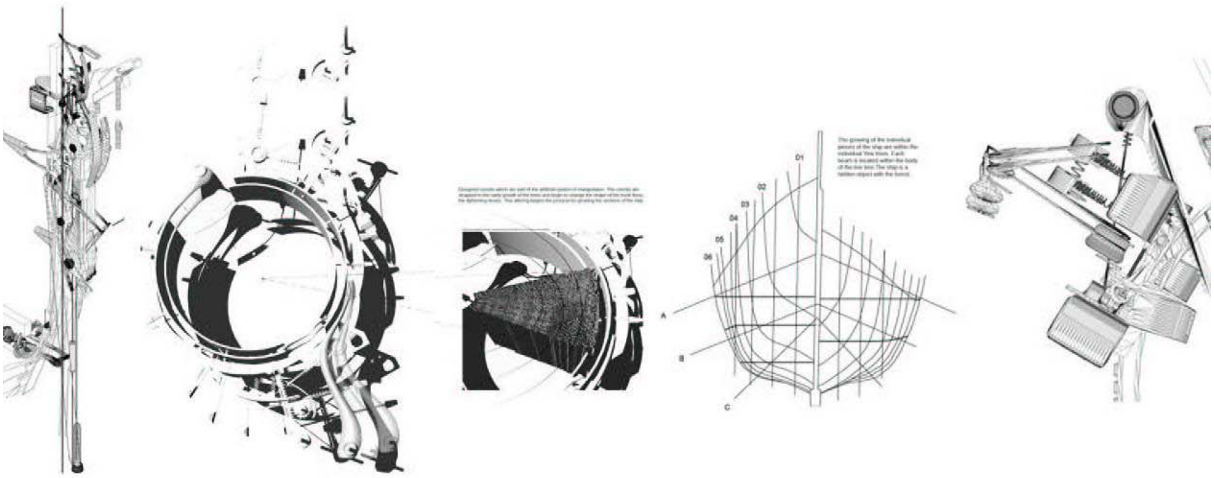
In a society organized more increasingly on short term basis this slow maturing evokes a powerful sense of technology as longevity. The mythology carried through two hundred years extended a life cycle beyond that of human life span. If we trace the relationship between man and landscape we can observe clues as to how a cultures wish to engage with their surroundings. The forest as a language for our environment created a source of great information, for both past and present knowledge.

'**Technology**' is interpreted as an 'artificial system' which is designed to fulfil a given task, in this case creating an imaginary world inside the natural forest. The ship generates the narrative for the system to alter and steer the natural world into producing a hidden vessel. The artificial system is calibration as a measured sequence of change within the devices which act upon the natural growth of the forest.

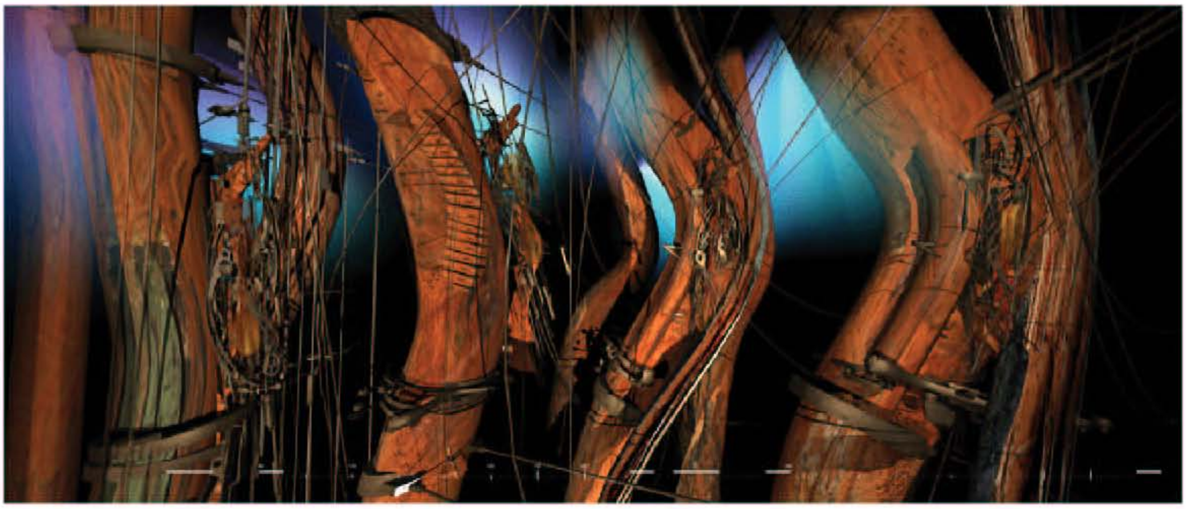


The designed corsets wrapped around the tree trunk to create extruded sections of the ship throughout the length of the each tree. The designed corsets create the various shapes through techniques of 'Bonsai' within the copse. Gunwale aperture: devices slowly create holes within the pieces of the ship. The artificial system is calibration as a measured sequence of change within the devices which act upon the natural growth of the forest.

"Our technologies have developed a series of interlinked spatial fields, each with differing qualities and with blurred boundaries. The objects that inhabit those fields are becoming schizophrenic…An object will have many selves, many simultaneous forms. Technology is forcing the object to become a subject, partial and anamorphic. The anamorphic object changes form when viewed from different view points, in different fields or in distorted mirrors." [2]



The Macresco harvesting the growth imperative of trees, structuring the launching pier, hull and rudder the wet system grows dense. Dendro-chronological sites of nano-systems revealing hidden trajectories. The Rudder Section: as the mechanistic piece later becomes embedded into the tree to become part of the navigation piece of the ships rudder.



The evolution of the system is manipulated to take the curvature of the ship. The 'Amber clock' will become consumed within the body of the tree trunk and will act as an artefact for a generation 300 years from now to reconstruct the systems history.

A view across the lake shows the silhouette of the ship within the forest. The ship is a hidden piece of architecture within the natural system of Yew trees. The mechanisms shown describe how the tree grows into the formwork to take the shape of the bow of the ship and how the natural system can be artificially trained.

3. No-one is ever seen entering of leaving.

The Yew tree played an important role in the formation of human culture and consciousness. It provided wood for shelter, tools and weapons, foliage and bark for every medicine bag. Its greatest influence on culture was its myriad spiritual associations with the goddess, the grave, afterlife and immortality.

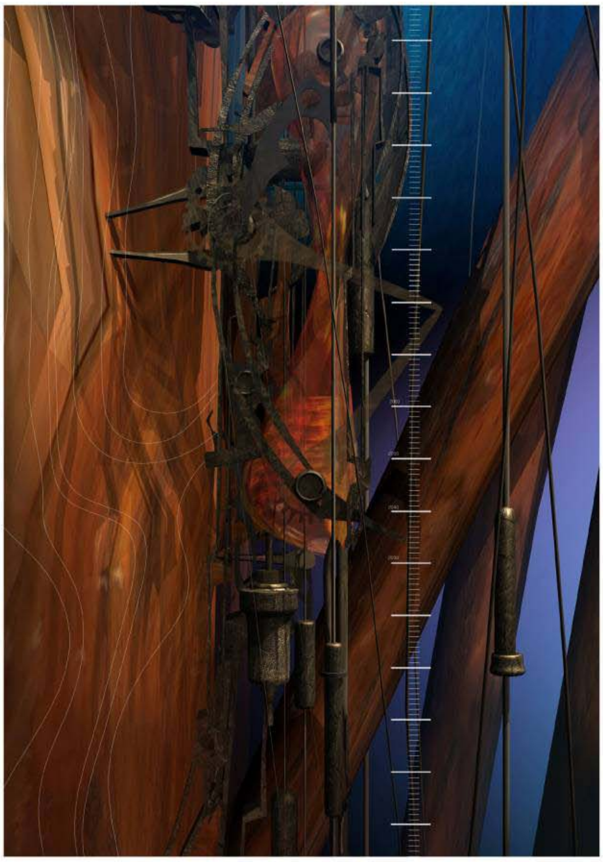
Although the yew tree was revered in nearly every culture of the northern temperate zones, yew trees were destroyed for their utility. Today, the remnants are threatened throughout the world because yew bark and foliage provide taxol, the most promising new anti-cancer drug in 30 years. With stem cell research, manipulation in society is extending to our inside. While we makes ideas for our futures with technology on a new edge and our future with technology is also making us.

The ship growing is the ship from the 'Rime of the Ancient Mariner'. This is a poem which talks about the death and immortality of human existence, it relates a story of the supernatural events experienced by a mariner on a long voyage at sea. The story is told as the mariner stops a man who is on the way to a wedding ceremony, and begins to recite his tale. The poem can be approached as a dream voyage to another realm, as a story of sin and redemption, or as the quintessential representation of the alienated, isolated modern individual.

"The mariner's tale begins with his ship leaving harbour; the ship is driven off course by a storm and, driven south to Antarctica. An albatross appears and leads them out of the threatening waters; even as the albatross is praised by the ship's crew, however, the mariner shoots it with a crossbow. The other sailors are angry with the Mariner and blame him for the change in weather that subsequently occurs as he killed the bird that was leading them to safety. This crime also arouses the wrath of supernatural spirits who then pursue the ship; the south wind which had initially led them from Antarctica now sends the ship into uncharted waters. When the weather becomes misty, the sailors change their minds and hail the Mariner for killing the bird that brought the fog. Eventually, the ship encounters a ghostly vessel, which murders the ships crew. The mariner manages to pray, the albatross which is hung from his neck for his act of slaughter, falls and his guilt is partially redeemed. The bodies of the crew, possessed by good spirits, rise again and steer the ship back home, leaving only the Mariner behind. In penance for his deed, the Mariner is forced to wander the earth and tell his story." [3]

The Mariners tale reinforces the idea losing touch with the world of ordinary existence and slipping into the realm of the imaginary? This ship navigating its path is an image for many of the lives passing towards mortal death; it is part of our human obligation that we are condemned both to hear out our fellow human beings in their extremity and to recognize in their stories, potential stories of ourselves.

Technology does not presume to act on mere practical reasons but facilitate new human conditions of possibility. How we position ourselves against this is very much a refection of how we see our ability within our future. Harvesting resin production as the forest matures, allows the Amber clock to slowly keep time.



The ‘Amber clock’ is strapped to the tree trunk to keep track of passing time. The resin from the tree bleeds into the 200 year hour glass, much like Egyptian water clocks, it slowly fills and when full the clock stops signalling the end of the system.

Much like Egyptian mathematics in the making of Water clocks, the passing of fluid from the natural system into a mechanical system such as a clock will monitor the time passed relative to the growth of the tree. The Yew tree produces resin as a viscous liquid on a daily basis in special resin canals; the clock breaks a wound in the bark and the resin will flow to heal the source. As the resin passes from the tree trunk into the clock; the hourglass slowly fills with resin at a seasonal rate which determines the clocks iterations. For the longevity of the system over two hundred years this constant production of resin will act as a clocking of the time lapse in order for the system to understand its relative evolution.

Each of the Yew tress fitted with an Amber clock informs the tightening devices how much they are to calibrate. This modality alteration within the system informs the ‘Amber clock’ it’s measuring of time outside of the natural system. This time based exhumation evokes an algorithm based on the tree growth as the amber hourglass registers the ships evolution. This clocking can register the longevity of the calibrating system and tweak the degree of tensioning with the maturing of the forest. As the hourglass fills over time the resin slowly hardens and begins to jam the clock. Ultimately the hourglass volume is filled and the clock stops, signally the completion of the system. The tensioning devices will no longer work and the system begins its second generation as a ruined piece of architecture slowly dying in the body of the forest, the resin clocks are consumed as a fossilized fragment of the system, creating amber clocks as the most notable time capsule of past two hundred year forest evolution.

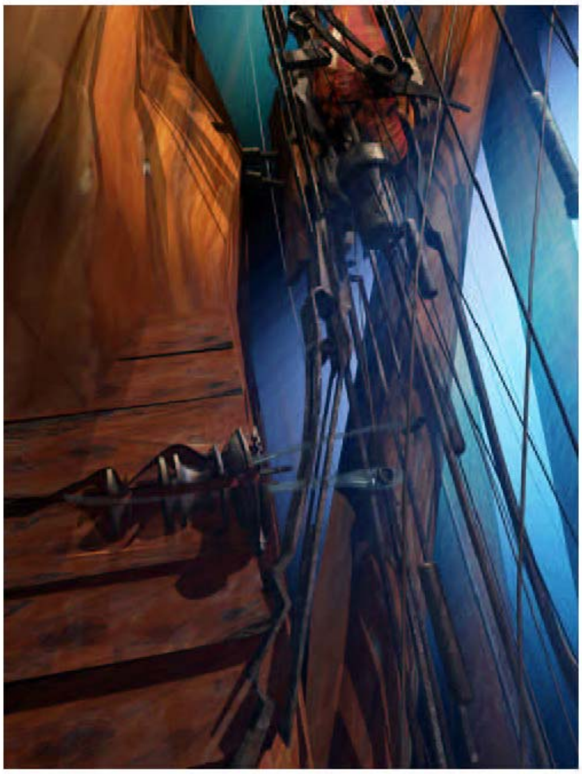
Objects have occupied worlds where the spaces around them change geographically. Dali saw the benefit of useless objects that perhaps have other meanings that the overtly mechanistic and functional; The museums will fast fill with objects whose uselessness, size and crowding will necessitate the construction, in the desert, of special towers to contain them. The doors of these towers will be cleverly effaced and in their place will be an uninterrupted fountain of real milk, which will be avidly absorbed by the warm sand. [4]

The Ships Figurehead is a carved ornamental and painted figure erected on the bow of ships, as an iconic symbol of its time. In this project the figurehead evolves from the splitting of the Yew tree as an iconographic piece between nature and technology. These materials become narrative seducers when describing the evolution of a natural and man-made system. These tame versus wild condition is often regarded as the territory for hybridization emergent systems. Take for instance the coupling of a steel corset wrapping the trunk of a tree, by the tightening of the artificial system symbiotically the natural forces the tree will take on new conditions of greater density while the technology will adjust to the movement of the tree growth.

If we call these materials prejudices, these incorporated results of past reflection are welded into the materials of next. They may become narrative seducers of detail and when discovered, reflect upon the evolutionary nature of the artificial system. Clarification and emancipation follow when they are detected within the trees. If they are not detected they often obfuscate, distort and are consumed by the natural order of the forest. The system takes on habits which it can wear in time and place, but the wearing of the system embodies erosion from which parts of the system dies off and takes on new forms of recovery and rebirth.

4. Tuning Trees for an acoustic ship

All trees have a natural acoustic frequency which is specific to the type of wood. The wood has a unique sound in each species. The system calibrates the density of the trees in the process of growing the ship the acoustic frequency of the forest will change. As the shape of the ship begins to emerge within the forest the Yew trees take on unnatural forms. With the alteration of the natural geometries of the forest comes the change of the acoustic properties throughout the forest. As with the forests natural acoustic frequency this would develop into higher density mature wood with higher reflection of sound within the wood. By manipulating the density of the trunks the alteration of the forest begins to take on the acoustic resonance of a ship. This new landscape of synthetically trained wood generates a ship acoustic which is tuned to the drifting vessel within Kingley Vale.



The weight of a piece of wood directly affects the performance in acoustic terms. The greater the density of a given piece of wood, the more it will weigh, at the same dimensions. The piece of wood has a natural frequency upon being struck, this frequency will rise as the weight or density of the timber rises. The lighter the top of the canopy will resonate at a higher frequency billowing acoustic sounds from the forest setting up a new acoustic landscape.

Tightening of the mechanical device around the tree creates this sense of tuning the natural system through artificial manipulation. The density of the wood has being increased for strength and is now involved as an inherent acoustic frequency for the tree. Each and every piece of timber will have its own characteristic resonances occurring at varying frequencies. This will have a marked effect on the sound that these pieces of wood produce as an instrument within the forest, each tree trunk acting as a container for various pieces of acoustic frequencies. The trees become individually tuned natural instruments within the body of the forest. Through the desired manipulation for each piece of the ship the trees themselves become tuned grain instruments.

The forest as an artificially trained acoustic system can be calibrated by applying different tensions to each forging corset. The strength and density of each piece of timber will be dependant on the specific part of the ship, the hull within the forest will embody a languorous ship of high density wood as it drifts through the yew landscape while the sound of the ships furniture will have variable lightness compared to the acoustic dampening of the heavy stern. The evolution of the forest can be traced as feedback sound which records the frequency of the wood. An acoustic resonance technique detects deterioration in trees with the sound of decaying hollow tree trunks. The acoustic feedback acts as a register for the frequency of the systems edges.

5. Obelisk in the Forest

Coming to the end of its system the armatures have the potential to alter again the geometries of the copse. Spliced into the hull of the ship, these armatures deal with its new end of the ships own cargo. As the ships leaves the edge of the forest it reconfigures itself to take root in the granite fields as it engages in the time based carving of its own obelisk. In certain cases the obelisk parameters exist hidden within the forest, prior to the process completion. The journey through the landscape reconstructs techniques of a natural system calibrated by artificial organisation creating new spatial arrangements between the interiors of the natural forest and the measured emergence of an arc.

6. The sloth is heard mapping out his shifting physics.

The shapes of the Earth's oceans have been influenced by plate tectonics, and as a consequence the distributions of fossil and extant marine organisms have a major role in determining biogeographic patterns. [5] A theory of Digital Vicariance explores an idea of bridging digital systems through our ever increasing virtual topography. Two systems we experience everyday which are hidden in our built environment and in nature, 'Gravity and the Internet landscape.'This installation is made as part of a story of our future natures and how our society will inhabit a world where technology is symbiotically active in our natural world and living systems.

In the live art installation, current solar weather conditions; as measured by the Advanced Composition Explorer (ACE) spacecraft and interplanetary magnetic field strength are directly transmitted to the Space Weather Prediction center in Boulder Colorado, USA.

http://www.swpc.noaa.gov/ http://www.pachube.com/feeds/256

The information is streamed live to project real-time environmental data to the Pachube website. Once this information is on-line it is downloaded, relayed and streamed to a micro-controller connected to the laptop computer in the art gallery. Translating this data to a series of air driven fans, the augmented air velocity choreographs a hovering cloud of box elder leaves. The box elder leaf has naturally evolved to fall slowly through the air to protect its fruit as it descends. The airflow will pass at the same resistance as that of the Box elder leaf and act as an equal but opposite force which suspends the leaves in a state of 360 degree revolution. While suspended in a constant air flow the leaves are seen in a momentary state of natural balance.

Adept at developing new algorithms the system creates natural flow patterns between the interfaces of the technology and nature exhibiting non-deterministic and emergent behaviours. For the purpose of this interactive installation, the intention was to reveal choreography between gravity, a natural hidden force, with patterns of internet information, as a hidden landscape. This unique environment for viewing two systems uncommon to interaction calls upon society's constant progress with advancing digital technologies and its communication with the natural world.

5. Drawing Dark Matter from our bodies the forest continues to move.

One of the universes biggest; mysteries in modern astronomy are the fact that over 90% of the Universe is invisible. This mysterious missing stuff is known as 'dark matter'. I am currently undertaking a project with NASA astrologist Roger Malina involving dark matter and its future relationship to society. We are working to produce an art project based on the role of dark matter/dark energy in our future society and environment. As proposed by the ancient Greeks, Quintessence (Dark matter) was to describe a sublime, perfect substance. In literature, Quintessence is the queen of a land of speculative science in Rabelais' Gargantua. Dark matter is described as the material which our universe exists in and forms 90% of the material in our solar system. Small clouds of dark matter pass through Earth on a regular basis. The clouds may be remnants of the first structures to form after the big bang. Dark matter interacts gravitationally with normal matter and appears to be seven times more abundant in the universe. But physicists do not know what the mysterious matter is made of or exactly how it is distributed through space.

Discerning the importance of dark matter and its connectivity to life on Earth as subject we would outline the possible transformation of gaining knowledge in this area and the installation would communicate this through the act of sensing, viewing and walking through the art piece. While deeply mined sites in Italy and the US continually test to explore the subject, it seems to have different opinions; I find it interesting how the planned exploration with S.N.A.P has the ability to create new dispositions and understanding to our existing knowledge of the universe.

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Releasing The Strength of Fibres and Density of Paper by The Application of Heat and Controlling Grain Direction to Achieve Paper's High Relief Pattern.

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Abstract

Relief pattern and depressed or raised form on paper has attracted contemporary architects and artists from many disciplines, linking in particular industrial design, architect, urban design, painting, sculpture and printmaking, but there have always been problems through the achievement of high relief. In spite of wide presence of relief works in all area of Art, no deserving study has been undertaken into the potential of papers as how to make very high relief. To date the highest printed relief on paper is no more than five millimetres and this paper intensely investigating to enhance the pronouncement of the relief forms.

The investigation of materials is often believed an important part of the process of making a piece of art. Close involvement with paper and production of high relief form through embossment and print making techniques was to lead this investigation to the eventual manipulation of the paper's fibre itself. As paper must be pulled or pressed in a mould to form a high relief pattern, printmaking press and techniques was chosen for this investigation. Through the utilization of pressing and also stretching the papers fibre under strain in order to achieve a raised or depressed form in high relief, two basic factors that were parameters of success identified. Firstly, the temperature of fibres and secondly; the grain within the sheet and the condition of papers' filaments on the mould. The effect of heat on fibres and its inherent qualities has proved to be quit a new and revolutionary phenomenon in printmaking. Since embossed patterns have created, the actual use of heat on paper was almost to a certain extent unknown. The application of heated tools to create depressed brand signs and symbols on the pelt and skin has been in use for thousands of years. In Iran this involved the application of heat to design leather, and to prepare book covers. In Persia embossment through heat also was used on the parchment that applied as paper.

This study managed to accomplish the goal of achieving high relief pattern on popular and normal papers through the application of heat and grain direction. The result of the achievement was the enhancement of the concavity and convexity of patterns by at least twenty times and was also able to resolve the problem of embossing.

Keywords: High relief pattern, paper's fibre, grain direction, filaments, paper mould.

Introduction

Relief pattern and concave or raised elements on paper has interested contemporary artists. In spite of the wide presence of relief works in all areas of Art, no comprehensive study has been undertaken into the potential of papers and their ability to support very high relief. To date the highest printed relief on paper seems to be no more than five millimetres. This research therefore, set out to explore how relief pattern involving paper could be developed. The investigation of materials is often believed an important part of the process of making a piece of art. Close involvement with paper and production of high relief form through the development of appropriate techniques lead the researcher to the manipulation of the paper's fibre. This was achieved through pressing the paper into moulds or formers, through while major issue arose.

In these experiments heat was the main factor in releasing the strength of the paper's fibre. Fibres commonly remain in balance where the average condition is 65% relative humidity and 24°c temperature. Through the application of heat in excess of 55ºc, paper fibres release and become softer and the structure of the paper allows a greater depth of relief under pressure, whilst still allowing the paper to remain smooth and crinkle free.

Grain direction among paper is another factor for determining forming and stretching. The grain of a paper refers to the alignment of the fibres within the sheet. The vast majority of fibres in paper follow the same direction during the process of paper production. When a sheet of paper is dampened for the purpose of embossing, the fibres absorb water and swell and, as a result, the paper is at the weakest when pulled at 90º to the direction of the fibre. When a printing mould is subject to a stripy, ribbed, or wavy design, paper has to be pulled in the opposite direction of the stripe, in this case the paper's grain ought to be located in the opposite direction to the mould. In other words, fibre stretches more easily along the grain direction than across it. Paper made from highly beaten (or hydrated) fibre is usually weaker and less dimensionally stable and also less able to stretch. Paper made from less hydrated fibre tends to be stronger because fewer bonds are formed between fibres, but as they are less dense each fibre has freedom to move under pressure, giving the paper a greater capacity to stretch.

Exploration of relief techniques

Emboss print

Raised and embossed image was used extensively in bookbinding prior to the advent of printing. Heat was used to make relief images on thin wooden board and also on sheepskin, deerskin and calf leather. For decoration, leather bindings were stamped in relief with heated panel stamps, and sometimes dyes were used in combination with blind images to accentuate patterns or titles. The main part of bookbinding's *finishing* was the lettering or relief images carried out by skilled craftsmen, using heated hand tools. Principally, relief patterns were made by heated wooden or brass letters [١]. Similarly, in some of the thirteenth century works on parchment and subsequently in early books, heat was used to create images. In holy books such as the Koran and the Bible, this is particularly evident in the relief detail that is applied to the leather covers. Moslem experts believe that a Koran written in 1286 in Marrakesh may be the earliest known example of tooling with heated iron to produce relief images[٢]. In Egypt these boards were made of papyrus pulp. In Islamic bookbinding, in the 10th century cut out patterns integrated with embossed text were used on the cover of a book to make a high relief. In this technique cut out patterns of papers were pasted as filigree on to the second pieces of different paper. Occasionally a Kufic inscription would be cut out and applied in this way. The use of this type of tooling in Persia may date from the first half of the 14th century. In early examples it is not possible to determine whether or not the decorative points and lines were first tooled in embossed image without colour (blind) and then painted with liquid gold as had been done in *Copti* in Egypt [٣].

Sculptural image

As far as high relief work in this study was concerned, Alberto Butters was almost certainly the only known artist who used heat to produce and form his paper or plastic relief and sculptural images. He also tried to transcend the confines of the two –dimensional surface through heat. It would seem that his work formed a bridge between the artists who used heat to discolour or change the appearance of their work and artists who worked with relief patterns. By the early 20's some artists such as Butters and Shimamoto started to use different materials, which had previously been considered non-traditional, for example polystyrene, fibreglass, polyester and plastic. By using artificial materials and with the development of modern plastics, such as celluloid, Plexiglas and Perspex, new mediums were at hand for the artist to exploit. Although Butters started to exploit plastic bags in his works, other artists such as Lucio Fontana (1899), Enrico Castellani (1930), Pieter Engels (1938) had used variety of them in their works. It was only butters who extended the relief possibilities of plastic through heat.

Around 1949/50, Butters experimented with various unorthodox materials, in his tactile collages, these materials included pumice, tar and burlap that is a type of thick, rough and strong cloth. At this time he also commenced his "*Hunchback*" series, which were humped canvas that broke with the traditional two-dimensional plan. A few decades later his innovations were followed by other artists, such as
Jos Manders (*Communicati,* series, 1968) and Anish Kapoor *(When I am pregnant* series, 1992).

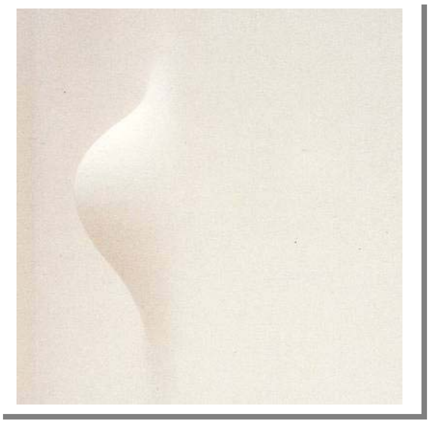


Fig.1. When I am Pregnant,
Anish Kapoor, 1992,
Fibreglass and pigment,
Dimension variable.

Butters' dialogue between the age old traditions of painting and the search for a new means of expression and representation led him to create various textures and surfaces with the topography of materials and the topology of abstraction.

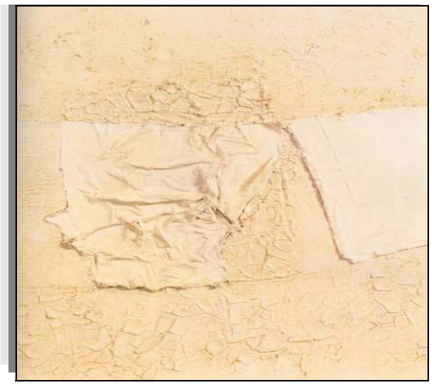


Fig.2. Muffa
Alberto Butters
1959-61
58 x 46. 2 cm

For the creation of relief and topographic images, he first constructed some compositions and placed a central swathe of fabric that added both depth and dynamism to the compositions. One example of this series titled *muffa (mould)* fig.4. alludes to the rapid outgrowth that mould as an organism displays, evoked in the lively, effervescent surface of the composition. Discussing Butters use of fabric in the composition to create topographic image, Bruno Mantura says, "[Laying] aside almost completely all paintbrushes, the artist builds his work with an *outré* material, the old and consumed sackcloth, creating painting therefore with what is one of the oldest bases of painting [٤].

Butters' compositions (fig.2), form, themes, metamorphosis, accidental processes, natural processes, reactions. and scientific relations have induced him to burn, to fuse and to carbonate, materials of common and poor use.

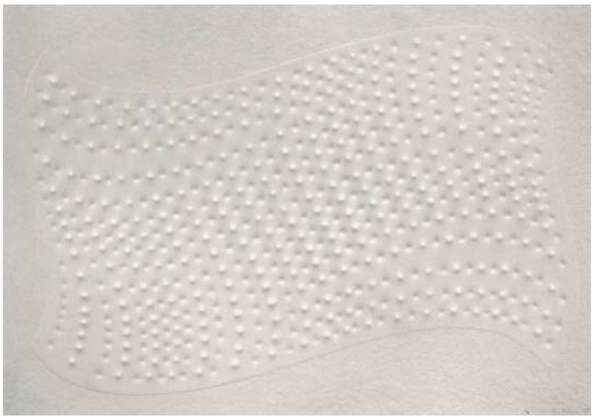
In the mid 1950s Butters began burning his materials, a technique he termed *Combustion.* With the torch flame, he burnt wood or plastic for the realization of his pictures. In this case flame makes marks, crackers, black spots or holes in the medium. There is a relationship between Butters and Klein's work. Both used flame from torch to create their work. Butter used flame to make crackers, spots and holes while Klein used heat to create imagery on the flat surface or discolour his flat work. Butters' experimentations were in Italy, in the same period and parallel with Klein in France. In the mid Sixties Butters continued to work with plastic, elaborate form with fire and applied it on a support of *cellotex*. In these works, the vision was simplified; the colour was given to the background and the plastic, burnt or left transparent, had the function of creating shades of the same colour. For the creation of relief and topographic images, he first constructed some compositions and placed a central swathe of fabric that added both depth and dynamism to the compositions. One example of this series titled *muffa (mould)* fig.2. alludes to the rapid outgrowth that mould as an organism displays, evoked in the lively, effervescent surface of the composition. Discussing Butters use of fabric in the composition to create topographic image, Bruno Mantura says, "[Laying] aside almost completely all paintbrushes, the artist builds his work with an *outré* material, the old and consumed sackcloth, creating painting therefore with what is one of the oldest bases of painting.

The Japanese artist *Shozo Shimamoto was* another artist, who with Alberto Butters, Lucio Fontana and John Cage used heat and fire as well as tearing and piercing in their work. He has executed a number of experiments during his burlap and pierce investigations. To do this, *Shimamoto,* painted paper and then pierced it with holes to reveal the different layers underneath and also to extend the limitation of two-dimensional surface[٥].

Another artist who investigated the surface in relief was Piero Manzoni. His idea for planning a composition was similar to Butters, Shimamoto and Fontana, he believed that painting should represent nothing but itself. He began his series of *Achrom* in 1957. His techniques and activities were interestingly parallel and nearly in the same period as Alberto Butters, Shozo Shimamoto, Yves Klein, Lucio Fontana and Johannes Schreiter. He exhibited some of his works in a group show with Klein, Fontana and Butters in 1957. Like many of renowned mid twenty minimalists who applied reliefed elements and raised the surface of their works with white materials; Manzoni utilized chalk, cotton, bread or polystyrene in his works. He applied only white materials in order to create an aria of liberty; a surface, which is, and nothing else.

Enrico Casellani was another artist who had artistic experimentation to the overcoming of the traditional limits of the painted picture [٦]. He works with reliefed image built up from nails. His works, together with the works of preceding artists, Alberto Butters' combustions, Fontana's slashes and Manzoni's *Achromes*, the surfaces in relief constitute one of the most outstanding stylistic developments – and one of those most charged with meaning of the end 20s. In 1959 Castellani executed his first *Superficie near in rillievo* (Black Surface in Relief). This was a decisive work for the development of his art, opening up new opportunities for expression using canvases with two-dimensional surfaces. Although he was working within the influence of the two-dimensional surface, as other mentioned artists, he tried to shift the focus of attention to the surface structure. Therefore he created a concave and convex space, positive and negative to draw attention to light and shade. The technique that he applied then became a characteristic of all his works and consisted of fastening the canvas or paper onto reliefs built up from nails; in this way, some part of the canvas projected outward, in contrast to other areas which form introflexions.

Fig.3. euro 1200,
Enrico Castellani, 1995,
Relief on paper,
41.5 x 69 cm.

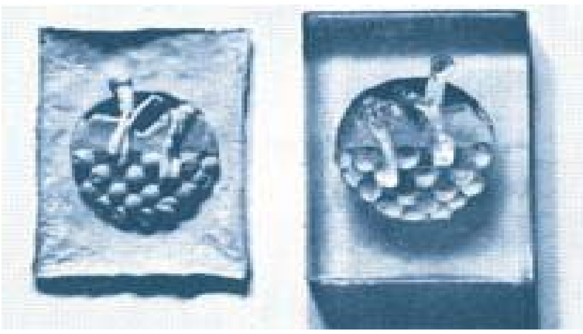


Castellani uses monochrome surfaces in his process and shapes it to form double curves with repeated elements. He utilises a series of points in relief and points forming depressions, negative and positive poles, and a series of minimal operative interventions. They are constituted by a flat membrane, the physical characteristic of which – elasticity and spatial continuity – are not altered by process of formation. The structures resulting from this operation are matched by others that are both equal and opposite and thus cancel each other out in the organization of spatial totality"[Y]. In 1963 Castellani also began to take an interest in the expressive possibilities of the diverse articulation of the monochrome surface in space: thus he made shaped corner canvases, projecting three - dimensionality.

Relief print

Several printmakers were also interested in expanding the boundaries of the two–dimensional surfaces in order to meet new artistic and technological demands. Among most attempts to create three–dimensional images through printmaking techniques, the sculptural print was remarkable. It was a challenge to explore the interaction between printmaking and sculpture in order to establish a bridge between the relatively two-dimensional world of printmakers and the three-dimensional world of sculptors. Sculptural etching can also range from deep embossment (5 mm) to etchings approximately (0.5 mm).

Fig .4. Print from resin mould.



In etching, the plate is simply pressed on the soft surface of the paper causing a slight emboss. The paper can be embossed through this technique either by being pushed out as intaglio printing or in as relief printing. Most embossed prints are designed not to be inked. Usually an inked plate is printed on plain white paper, resulting in an embossed form similar to Butters and Fontana's works that uses the play of light and shadow to reveal the image. Low relief embossing, whether on paper, canvas or plastic, is similar to low relief sculpture. Higher relief or additional areas of embossment can be made on a print with a second plate specially constructed out of layers of boards, woods, metals, resin or any suitable materials (fig.4).

Pulp image and Deep etch*

Pulp and paper sculpture can also be counted as a relief. The creation of a form of paper sculpture or relief utilized in this technique can be achieved by pouring liquid paper over a low relief shape or shapes. When the paper is dry the mould is gently removed revealing a negative or positive impression in the paper. Although achieving a high relief form through pulp and paper sculpture is easier, the most popular technique is *deep etch*. A deeply etched plate is printed in relief, intaglio or both together. It is the intaglio process that makes the most of the actual depth and even greater illusion of depth and the range of tone and colour. Similar technique to *deep etch* is r*elief etching.* When an image is drawn directly onto the plate by protecting material and leaving the surrounding area unprotected, the drawn image is left in raised relief. Technically, the etching process may be exactly the same as a deep etch, but visually the emphasis is on the more positive relief; the corroded metal has become the negative area.

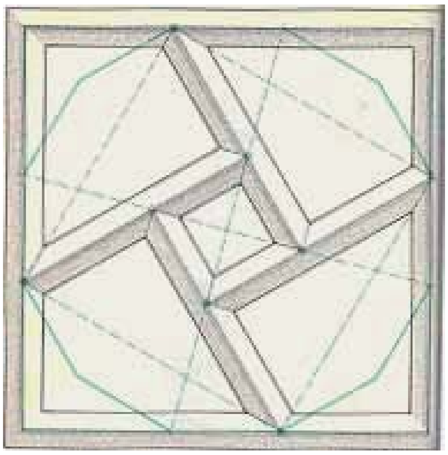
A number of other techniques such as inkless intaglio and blind image have the same style of plate and all are emboss prints, distinguished by the height of the relief. It is always possible to find a print in which the effect obtained and the actual materials and techniques used are virtually impossible to detect. Indeed, a more anonymous surface effect may be deliberately sought in preference to others that are recognizable. Most of these techniques and all relief prints can be taken from many kinds of surface other than etched metal, the most obvious being wood and lino.

Many artists and printmakers were also interested in making their own paper to expand their style. Paper is generally made by the layering of short vegetable fibres to form sheets. Materials such as cotton, artichoke, straw and bamboo are capable of being reduced to a state suitable for paper forming. The fibre must be shortened and separated into fine fibrous of strands similar to bamboo after it has been crushed and beaten with a mallet. After two to five hours of simmering the liquid is drained off and the pulpy mass then poured into a tube or tray and ready for casting or forming the sheet [٨].

Using of geometrical design for the basis in relief

Most Persian covers in the14th century are in relief and have geometrical ornamentation. A piece of perforated leather cut into an intricate pattern and superimposed on a board or geometrical design were used often in blind. To make a raised pattern, whole patterns were often stamped from a large heated metal block, while another technique was the embossing of designs with a heated matrix of toughened camel hide[٩]. Unlike Christianity, Islam rarely used pictorial representations of religious imagery[١٠]. The Muslim artist forbade the imitation of human and animal forms and was instructed to confine itself to plant and abstract motifs. It was for this reason that Islamic artists used the imagery of mathematics to discover the principal structures that are reflected in matter. Islamic art is essentially a way of ennobling matter by means of geometric patterns , there were contextualised through calligraphy[١١].The key to the construction of the complex geometric design *(fig.5.)* is through a grammar of mathematical principles and the constraints of symmetry and laws of proportion. The basic component for Islamic design is a simple square or a triangle derived from the square. Most design known as the "*repeat*", rational system of growth generation[١٢]. As the square plays central role in Islamic design, the square was selected for the practical work in the studio investigation of this research. In the final stage of the studio investigation a series of relief curved elements were also designed based on the proportion of Islamic ratio. The ratio of the elements within these works were based on the relationship between one element to the others and the surrounding space. For instance, a relationship between a positive element to negative space based on a specific ratio or comparing one element which is half of another double the former. In Islamic design the ratio is expressed as (a: b) or represented as a fraction (a / b), where a and b could be any number. Proportion is the equality of two or more ratios which can be either:

Fig.5. The basis of the square in square.

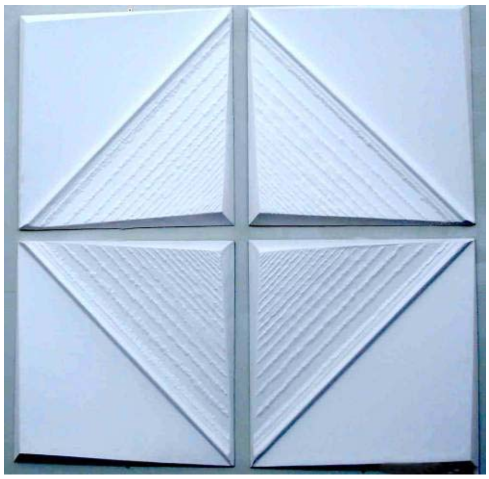


For continues: a / b = b / c = c / d etc., 2/4 = 4/8 = 8/16 etc.
For discontinues: a / b = c / d = f / g etc., 2/4 =3/6 = 5/10 etc.

Both have a constant characteristic ratio, in this case represented numerically as ½.
The rectangle is also commonly used in Islamic design. Its characteristic ratio is expressed by the measure of its short side (a) to its long side (b); a:b could be any ratio, 2:3, 3:5, 5:6, 5:8 :

As the symmetric patterns are the most commonly used pattern in Islamic design, some practical work in the studio investigation was designed based on repetition of an element or symmetry*(fig.6.)*. "Symmetria" in classical terminology meant the proportionality between the constituent elements of the whole. Since the concept of "Symmetria" are based on harmonic proportions, the linear numerical methods of analysis of geometrically constructed designs invariably result in approximations or inaccuracies because of the irrational numbers derived from the proportions of the geometric elements of the design[١٣].

Fig.6. Author's experiment Symmetria Relief, four squares, paper relief, examination of 10cm depth Cartridge paper 220gr, Size 160cm x 160cm.



Studio and practical investigation of relief

During the studio research various processes for printing high relief pattern were examined such as emboss print, pulp image and inkless intaglio. The processes of pressing paper was of central importance, as was the amount of pressure applied. Instead of an actual printing plate the latter became more like a mould consisting of two slabs, one with the positive, the other negative (male and female respectively). The actual relief on the slabs was usually produced with layers of card, hardboard, MDF or wood. The most successful results were achieved by moistening the paper which was placed on top of slab(Fig.7.). Before pressing, heat, was applied to the paper by a heat gun, directing the gun line by line over the paper, vertically and horizontally. When the moisture began to evaporate, the paper was covered by a printing blanket to keep it warm. This enabled the fibres and filaments to release so that the paper became softer and ready for stretching.

Rules of proportion based on Islamic geometric design were chosen for the studio research. This was because no figurative elements were appropriate to the research, instead the purpose of the research was to concentrate on the aesthetic possibilities of relief pattern, in conjunction with fields and bands of colour that also mediated by heat. Initial studio practice began with a series of experiments into the development of the mould and slab in order to print high relief(Fig.8.). Various materials such as cardboard, wood and hardboard were used to make the moulds and different type of paper such as Fabriano 220g, Canson 300g and Cartridge 200g were used for printing.

Fig.7. Author's experiment Negative & positive slab, paper relief, examination of 10cm depth on cartridge paper 220gr, Size100cm x 100cm.

Fig.8. Author's experiment Double rectangles, Examination of 9cm depth on cartridge paper 220gr, Size 100cm x 100cm.

Conclusion

Prior to this study I was familiar with the work of Lucio Fontana. In the summer of 2004 I saw his work for the first time in the Tate Gallery where I was not only intrigued by the simplicity of his motifs, but also inspired by his technique. For me, the creation of the sculptural form on a flat canvas was exciting. This suggested the idea of how flat paper could be formed and defined as a sculptural concept. Fontana's exploration of the method of producing holes and concave form, which he called *Buchy*, became an important part of my studio research. This involved bringing a third dimension to the works by piercing, cutting, and slashing the surface, thereby, breaking the membrane of two dimensionality of the paper. The fact that , Alberto Butters applied heat to raise his relief and detail, that he termed *Combustion*, led me to believe that it would be possible for this research to produce sculptural form with paper through printmaking techniques and heat.

The studio experimentation of producing high relief pattern on paper began with a concave form similar to what Fontana had used. This was then extended to the convex. In these experiments heat upon wet or damp paper was successfully used to increase the height of relief. This was because the combination of heat and moisture, caused the paper fibres to release so that a greater depth of relief was possible whilst the paper remained smooth and free from creases. This resulted in an extensive exploration of tearing, puncturing paper and printing burlap techniques and two successful compositions of high relief that show, a concave and a convex element. Diagonal lines and textures on the top of curved lines was a further experiment prompted by Fontana's diagonal slash and pure lines. As the studies progressed, curved lines, which were derived from previous studies, led me to use and print parallel convex lines based on relational composition and serial elements in a square structure. The final stage of the research progressed with the development of compositions based on a proportional system that is derived from Islamic architecture(Fig.6). These compositions, that rely on actual convex and concave relief, in combination with coloured stripes, were influenced by Barnet Newman's 'Stations of the Cross'. However, whereas Barnet Newman's paintings are physically flat, the work that I have produced relies on the tension between the actual concave and convex, and the coloured band. Since the latter has an almost atmospheric quality through being heated, they can appear almost as shadow, thereby implying depth. This consequently adds to the ambiguity and tension between that which is actual relief and that which is flat.

Because these compositions rely on bands of colour and concave and convex relief there is an absence of narrative, and they increasingly rely in terms of their aesthetic quality on the formal arrangement of these elements, together with subtle changes in texture. As discussed earlier in relief, the disposition of these elements was based on $\sqrt{2}$ and $\sqrt{3}$. This subsequently determined. two focal points, around which the elements were located within the composition, one for the concave and convex element and another for the bands of colour.

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*The term "deep etch" is relative to the thickness of the metal plate and even with 16-gauge zinc, only
a fraction of an inch separates deep from shallow.

Re-envisaging Texture

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Abstract

Today's professional designers are experienced in exploring new product forms, specifying innovative materials, and utilising new colour palettes with interesting surface finishes and textures, whether applied to consumer products, interiors/exteriors of buildings, or fashion garments. However, what do we really understand about the nature of texture? Is it purely an objective property, or a kind of subjective experience, or the combination of both? What's the difference between our perception of texture via differing sensory channels such as vision and touch? What relationship exists between texture and other formal elements such as colour, pattern, and spatial structure? Perhaps less understood is the concept of texture and the recognition of the importance of the impact texture can have on the aesthetic experience. This paper will address these questions from both theoretical and practical perspectives. We propose that texture has both objective and subjective attributes. The essence of texture in the objective aspect is STRUCTURE. We will also look at the interconnection between scenes at the micro-scale and those at the macro-scale? The discussion in this paper will provide insights and highlight the importance of texture, to encourage designers to be more exploratory in generating texture effects thus increasing the aesthetic appeal and perceived value of their design work in the future.

1. Introduction – What is texture?

As designers, we use textures in almost all our design practices and take the use of them for granted. Hundreds of thousands of textures can be generated from different resources such as insights from nature, fantasy of mind, innovation in materials and processes, virtual reality, and daily & social life etc [1], However, we would ask a basic question: what is texture indeed? Someone might doubt the necessity of discussing the concept of texture, thinking it suffices to know directly the big menu of textures, e.g., abundant material surface finishes, being told what they look like, how they can be used, and where they can be provided etc? Practically, this is correct. However, understanding the essence of texture will give you insights of the fundamental mechanism of 'how texture can be formulated', so that you can appreciate, manipulate or create texture effects more sophisticatedly, just like the benefit of giving you a fishing rod instead of giving you a basket of fish. A recent article about texture by Ziggy Nixon [2] has further driven us to re-envisage the concept of texture. Without intending to compel an authoritative clarification of texture concept, we would like to have a speculation on a series of issues relevant to texture and texture perception, based on our research in material texture over the last a few years.

The definition of texture varies, depending on the level of cognition, the range of topics, and what purpose these definitions will lead to. Generally speaking from the cognitive perspective, textures are ubiquitous. A piece of silk cloth, a fluid of melted chocolate, a chapter of music, a painting, a poem, soil, water...almost all matters can have a texture. They have texture because they have the structure in which the constructive components (silk yarn, food ingredients, music notes and pitches, pigments, words...) are piled and organised in a certain rule. This is the objective side of texture. On the other hand, people realise and appreciate textures through our senses and perception, which can differ significantly from individuals.

In the case of a material or an object, we differentiated previously the concepts of two terms 'texture' and 'perceived texture' [1].

> **Texture**: the geometrical configuration and physical-chemical attributes of surface (2D) or bulk (3D) of materials/objects.
> **Perceived texture**: a synthesis of physiological and psychological response and impression to the geometrical configuration and physical-chemical attributes of the surface or the bulk of materials/objects. In this definition, the 'synthesis' means it is not simply 'A plus B' but 'A fusing with B', therefore the subjective responses to A (geometrical configuration) and B (physical-chemical attributes) would interact. Although under certain conditions (e.g. by vision), the response to geometrical characteristics may be dominant over physical-chemical attributes of texture, or the inverse, under other conditions (e.g., by blindfold touch).

However, the objective aspect of a texture cannot be separated from the subjective perception of texture, they form the two sides of a coin. Particularly, when we describe, communicate with each other about texture, perception becomes the main tool. In many cases, when we talk about texture, it actually refers to as the 'perceived texture'. Therefore, we usually use the terms 'visual texture', 'tactual texture' or 'tactual feeling of something' etc. The Chinese translation of 'texture' is '质感'. 质 means matter or material, and 感 means sensation or perception. Therefore, '质感' is a united entity of both objective texture information and the perception of it via our senses and in our brain. Forgetting the subjective aspect of texture perception at the moment, which we will discuss in Section 2, let's look at the objective side. What is the essence of texture that account for other secondary texture features, including the perceived attributes (perceived roughness, stickiness, warmth, lightness etc). We propose 'structure' as the key factor.

Texture vs. pattern

Perhaps we are familiar with another similar term 'pattern'. We propose, when the elements or components of a structure are in tiny size that you will mainly be led to the global features of the structure (thus e.g., an overall surface), we tend to call this structure 'texture'. An example is the bottom of the TV screen in Figure1-a. It consists of aluminium mesh (Figure1-b shows the enlarged image of this mesh structure), which visually, in balance with the black screen, gives an overall warm grey and soft texture feeling when you observe it from such a distance that the mesh structure is hardly recognisable. On the other hand, when the constructive elements or components of a structure are in such a big size that your attention will be focused on both the global and local spatial characteristics, we tend to call this structure 'pattern'. An example is the chair in Figure1-c. However, in both cases, pattern and texture are both dependent on structure. We will also justify later that, when perceive texture, not only visual but also tactual features of texture will dependent on structure as well. From this comparison, we propose the distinguishing between the concept of pattern and texture, from the objective perspective: texture is sum of features coming from a structure on the micro scale; pattern is sum of features coming from a structure on the macro scale. However, it should be pointed out that micro scale and macro scale are mutually relative. For example, when observed from outer space, the surface of the earth has scaled down its size by hundreds of thousands of times thus may form a texture (Figure 2). On the other hand, a normally smooth surface, when etched and observed from microscope, appears to be randomly rough and forms a pattern.

a b c

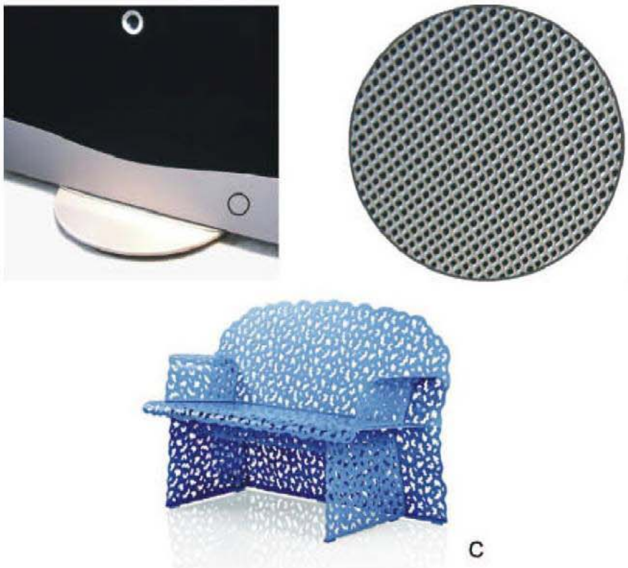

Figure1 Pattern vs. Texture

Figure2 Earth surface as a texture when observed from outer space

Thus the image shown in Figure3-A can be regarded as a pattern consisting of two different textures: matt and gloss. However, the differentiation between pattern and texture may not always be so clear, as the example shown in Figure3-B, C, and D. Probably more people tend to call them as 'texture'.

Although usually most people use 'texture' and 'pattern' as two convertible terms, the distinguishing between them we propose here is to help designers realise the concept of structure scale and its effects on texture feelings or perception. Texture, in relatively tiny structural scale, has more overall, atmospheric, evenly distributed features; pattern, in relatively larger structural scale, is more graphic-like, grabs more attention on details. Now we are going to explain the role of structure on perceived features of texture such as 'smoothness/roughness', 'warmth/coldness', 'gloss/matt', etc in the case of material texture.

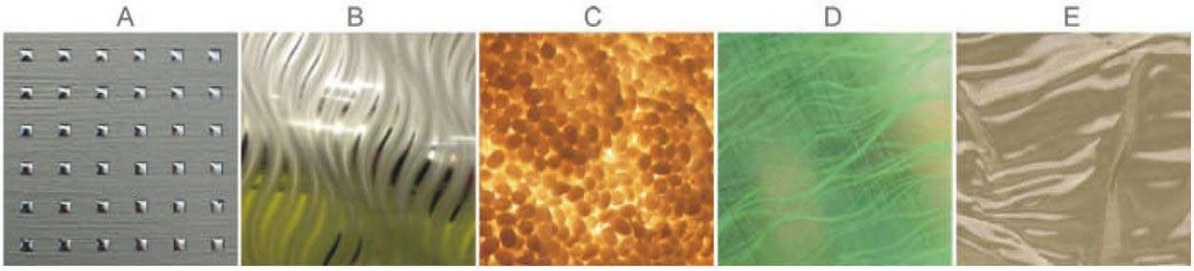

Figure 3 Structures in Patterns or Textures

Structure vs. perceived roughness/smoothness

Perceived roughness or smoothness, either by vision or touch - if forgetting the subjective differences (e.g., characteristics of eyes or skins) and the external environmental conditions (e.g., lighting, which is essential for visual perception) at the moment - will depend dominantly on the geometrical/spatial structure of a material/object's surface (the shape, size, density, direction distribution of constructive elements). This kind of structure can be two-dimensional or three-dimensional. However, apparently similar matt surfaces judged by vision can be felt significantly different by touch. Our fingers are more sensitive to any tiny difference in the structural changes, particularly in a three-dimensional case. Figure 4 has shown the magnified surfaces of four thermoplastic elastomer samples (A, B, C, D) that only differ in the surface morphosis, resulting from different moulds. Subjects feel sample A as the softest and the least rough surface, whilst sample C as the roughest and the least soft surface. The size of the surface structural elements along the horizontal dimension (e.g., *Rsm*) in sample D is the largest, but it is not perceived as the roughest. There will be a series of parameters such as Ra, Rsm, Rsk, Rku etc that reflect both the horizontal and vertical information of a surface. Investigation of the relationship between a surface structure (represented by the parameters combination) of a particular material and human tactual feeling is a trend both in industry and academy to facilitate design decision-making.

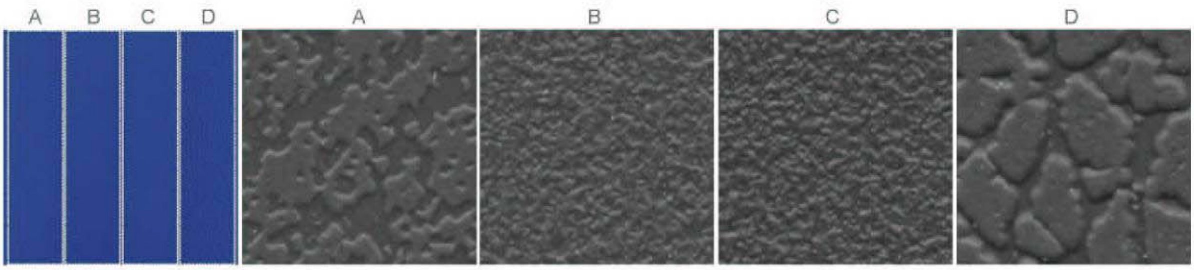

Figure 4 Microstructures of four thermoplastic elastomer samples

Structure vs. perceived stickiness

Here we define perceived stickiness as the extent of impediment of moving skin (mostly, finger skin) away from a touched surface along the direction vertical to the surface (normal line direction)[1]. Since the stickiness defined in this way results from

[1] In differentiation to another concept of *perceived resistance* or *perceived abrasion* of a surface, which is defined as the extent of impediment of moving skin (mostly, finger skin) along the surface while remaining the touch under certain pressure.

the interface or interaction between skin and a surface, it will depend on both the features of a material's surface and the skin characteristics. From the aspect of material surface, our previous research has revealed that a *smooth* surface corresponds to a more *sticky* feeling than a *rough* surface. Possible reason is the touch areas between skin and the surface where sweat adsorption plays a role. However, even with the same surface roughness/smoothness, two different materials can feel different in the perceived stickiness, the reason from the material side is the different surface energy of materials, which influences the adsorption and adhesion of external substance such as the sweat from skin thus influences the perceived level of stickiness. It is the physical structure, the crystalline lattice of atoms that determines the level of surface energy. We are not going to have a deeper discussion about this, which is within the material science area. What we are trying to say is the perceived stickiness (as an aspect of a perceived texture) of a material surface objectively will significantly be dependent on the geometrical/spatial macrostructure of a surface and the physical microstructure of the material itself.

Structure vs. perceived lightness and colour

Texture and colour are twins. For instance, it's difficult to separate colour from the texture for a piece of wood. They are biologically twisted together during the whole growing process. If taking away the brown colour from chocolate, can you still recognise that the image shown in Fig z can still be easily perceived as the texture of melted chocolate? We talk about lightness and colour together, because to perceive lightness or colour of an object or material, both need one of the pre-requisites – light. Essentially, lightness is one element of colour. However, the information carried by the light that reaches our retina is the result of interaction between the material/object's (surface) structure and the original incidence light. This interaction includes reflection, transmission, diffraction, random scattering etc and the combination of them. That's why we see diamonds shiny, glass transparent, or some plastics translucent. This seems to be commonplace knowledge, but again, we would just like to emphasise that structure is the key factor. An extreme example is the so-called structural colour, which forms due to optical microstructures found in the wing scales instead of using pigments. Light hit this structure will then be scattered and split into different colours. A number of such structures have been identified in animal systems such as a butterfly (Figure 5A). Scientists from Southampton University have developed an Opal polymer with a structure consisting of billions of 200 nanometre spheres (to mimic the gemstone's iridescent properties) that shimmer like a butterfly wing when it is turned or twisted (Figure 5B-E) [3]. This new material can be used across a range of applications including food packaging that changes colour if its contents spoil and banknotes that are hard to counterfeit. It is the structural colour and the dense surface that result from the nano-structure of the material that objectively formulate the texture effect of such a material.

Similar interrelationship between structure (either macrostructure or microstructure) of materials and other perceived features of texture such as warmth, moisture etc can also be found, but we are not going to discuss these further. From the above discussion, we can see the key factor that plays an intrinsic role in the formulation of a 'texture' from objective aspect is – structure. When understanding this, designers can generate endless texture effects in many innovative ways.

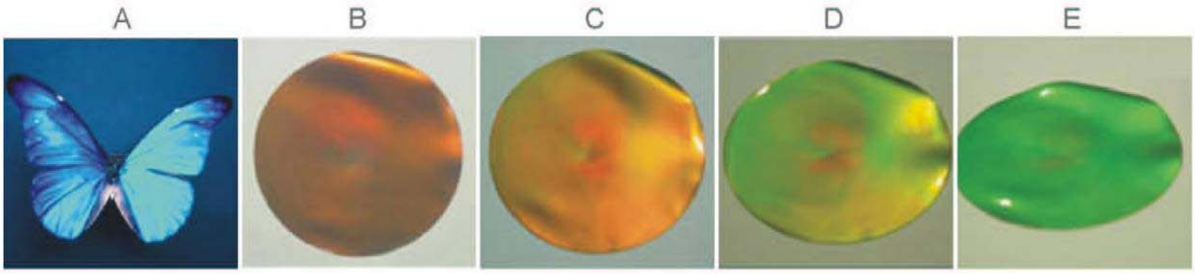

Figure 5 Structural Colour – Opal polymers developed by Southampton University

Figure 6 shows a decoration light in V & A museum, London. The translucent effects of the texture when viewed from a distance actually result from the permutation of 16,000 Swarovski crystal beads.

Figure 6 'SWARM' CHANDELIER by Zaha Hadid, lent by Established & Sons

2. Sensory differentiation and interaction in texture perception

As talked in section 1, texture can usually be perceived via the sense of vision and touch. However, when applied singularly, both vision and touch have their limitation in texture perception. Vision usually provides more information on the global impression of texture, but will depend upon the viewing field and distance, and may not reveal the real situation of the nature of an object or material with regard to the three-dimensional roughness, the warmth, the moisture, the abrasiveness, the softness, etc. Touch, on the other hand, can more subtly explore the local, tiny features of a surface or the body of a material/object. The tactual feelings of material are actually more honest and richer than the feeling by vision. However, when vision is blocked while touching, the identification of objects/materials on a global basis can be impeded or become slow, as dominant information that contributes to our memory is obtained via our sense of vision. On the other hand, visual judgement of texture can cheat our other senses, which sometimes is called visual illusion. But it is this visual illusion that can be and have been utilised as a tool to produce fascinating effects when vision is the main channel when users engage with a product. Many designers are experienced in doing this.

In the case of tactual perception, most of tactual feeling cannot be specified unless you are engaged with the material/object in an interactive mode. It is rarely the case to feel a texture by a static touch on the surface without any movement. It will need you to twist, press, squeeze, or knock the object or material in order to get an overall judgement of a real texture.

With regard to the interaction between vision and touch in texture perception, our experimental research has found that, qualitatively, good consistency exists between visual touch and blindfold touch. Quantitatively, difference lies in the sensitivity of subjective responses to material textures and the strength of the correlation between those responses. It is proposed that this result would not be casual as it can be explained by existing and other emerging related theories. Psychologists point out that people are usually unable to attend to one dimension without suffering 'intrusion' when they are presented with different sensory modalities. Two types of intrusion exist. One is *Garner interference*, which is characterized by poorer overall performance (or judgment), the other is *Congruence effects*, which entail superior performance (or judgment) when values on attended and unattended dimensions 'match' rather than 'mismatch' [4]. Our research has shown that, when the subjective response to texture by vision matches that by touch (in the direction of judgment), congruence effects result. For example, participants can visually feel a *smooth* steel surface and perceive it as *moist* while touching due to the finger sweat mark left on the material surface. This matches the *moist* response to a *smooth* surface only by touch. As a result, the correlation 'a *smooth* surface feels *moist*' tends to be stronger for visual touch than for blindfold touch.

On the contrary, when the response to texture via these two sensory modalities mismatch, then the Garner interference effect occurs, resulting in the synthetic judgment/rating being quantitatively reduced. This then influences (reduces) the correlation strength under visual touch conditions. For example, when perceiving a surface as *shiny* or *non-shiny*, it is not always consistent between vision and touch. A *smooth* surface which is perceived as *non-shiny* or less *shiny* by sight might be perceived as '*smooth and shiny*' by touch because of an illusion 'a *smooth* surface is usually *shiny*' in the memory. That is why the correlation '*smooth* corresponding to *shiny*' turned out to be slightly stronger for blindfold touch than for visual touch.

Considering another example, the perception of temperature is essentially touch-dependent. When touch is the only modality, the sensation will be more focused on this sensory route. When vision is combined with touch, some uncertain or even contradictive factors may intrude the perception of temperature. For example, the colour of the steel samples used in the tests differed together with the surface treatments. Therefore, it is conceivable that the correlation between a *smooth* surface and a *cold* response will be less obvious in the case of visual touch.

Another example is the difference in sensitivity to the discrimination of roughness between visual touch and blindfold touch on TPE samples in the tests. The roughness of a material surface is essentially touch-dependent. When touch is the only modality, the sensation will be focused on this sensory route. However, as all the TPE samples shared the same milky white colour, they tended to be easily perceived as equally *rough* by vision. In this instance, when vision is combined with touch, the ability to discriminate roughness is weakened.

On the whole, the cross-modal interaction in the above two cases can be unified by borrowing the physical concept of interference. The sensation of vision and sensation of touch can be analogously compared to two interacting waves. When they are in the same phase, the combined/synthetic result is that the amplitude will be increased. On the contrary, when their phases are reversed, the combined/synthetic result is that the amplitude will be reduced. However, when vision and touch are combined, whether the visual data is consistent or contradictive with the tactual data, the combined effect still tends to be dominated by touch. This is based on the evidence that most of the correlations found for visual touch is qualitatively in the same direction as blindfold touch but only differ in the correlation strength. This interaction model can be illustrated in Figure 7.

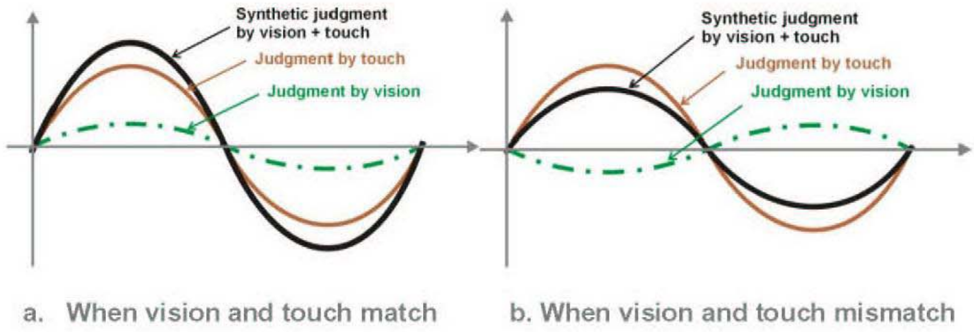

Figure 7 blindfold touch and visual touch conditions comparison.

Evidence from neural scientists reveals that visual cortical involvement (and presumably, visual imagery) may facilitate tactile judgments about 'macro-geometric' object features such as orientation, shape and size, but not 'micro-geometric' features such as surface texture, which depend on the size of constituent elements and their spacing [5]. Therefore it is understandable why most of the texture perception results in this research were found to be similar under both visual touch and blindfold touch conditions

In addition to the interaction between vision and touch, other senses can also contribute to the appreciation and perception of textures. When you are listening to a music played either by a singular instrument or an orchestra, you might be attempted as if you are seeing something or touching something. Cognitive psychologists have also explored the processing facts of human brain to multi-sensory stimuli, which will be helpful for designers. For example, *in the brain at least, your hands are connected to your ears, which send signals to your mouth, which takes information from your nose, which depends upon your eyes to tell it what it's sensing. A pack that looks appealing doesn't just seduce the eyes. It can make the mouth water and the hands expect.* It would be wrong if you consider all the senses in isolation. Nowadays, Manipulating multi-sensory appeal is one of the trends in almost all design fields, particularly, in food industry, garment industry and now interior and consumer products.

3. Emotional cues of textures

It is very often to note that some products make us feel emotionally happy or cheerful, and some products make us feel bored or depressed, or some entertained or relaxed. The process of our emotional changes while we are engaging with a product can be quite complicated like a black box. Although indirect factors might be your mood on the day before you use the product, the way you are given the product (say, a gift or not), and even the weather, the environment etc, direct factors usually still come from the product's features themselves including the interface between the product and the user. But how this can be related to a material or texture?

There may be such a question: does a material or a texture have emotional features? The answer is yes and no. Firstly, we would like to give a metaphor. The role of a material in a product can be metaphorised as actor in a film, whilst the texture of the material in such a product context is like the character of the persona the actor plays in the film. We like a film perhaps because we are touched by the story or attracted by the amazing aesthetic screening and the vivid and subtle performance of the actors. Similarly, we appreciate a product perhaps because we are convinced by its function or we are conquered by the astonishing aesthetic appeal, colour, texture, sound etc. Just like an actor has his or her own temper, characters, a material has its own properties that can evoke emotional feelings as well. That's why usually wood feels natural, warm, and fragrant; leather soft and luxury; steel cold, hard and industrial etc. However, like an actor can change and manipulate different characters according to the film scenario, the emotional cues from a material can alter significantly according to different product contexts: strengthened, lessened, or completely changed. Figure 8 shows a wall radiator made in polished stainless steel with a pillow-like shape. The traditional dark, grey, matt texture of a radiator thus a depressing emotion has been replaced by a fresh, soft, cheerful feeling that matches a family life atmosphere. Although there still is sometimes limited matching between actors and the characters for a Director to find, those actors who are more flexible and versatile in sculpturing various characters will be more welcome. Similarly, as designers, it is our mission to find a wide range of every material's aesthetic features including their texture effects.

In recent years, we have conducted research on the sensory perception of materials both by controlled experiment where materials with different textures serve as samples and by case study where materials are applied in contexts.

> The emotional response to a material's texture can be defined as people's affective, hedonic and valuable feelings, which are evoked by sensing (viewing, touching etc) the material surface.
> The emotional response to a product can be defined as people's affective, hedonic and valuable feelings, which are evoked by engaging with the product.

Figure 8 Radiator in stainless steel

Under the controlled experimental conditions, with material samples being presented as plates and/or bars within the normal environmental context (lighting, temperature, humidity), some general conclusions about the correlation between the emotional responses and the perceived surface attributes (the responses to material texture's geometrical and the physical-chemical dimensions) have been found and might be proposed as reference for designers. Just giving an example, the experimental results reveal that the surface texture attributes, which mainly correlate with the positive feeling of mood (*dull/depressing vs. lively/cheerful*), turns out to be surface shininess, i.e., a *lively/cheerful* response mostly corresponds to a *shiny* surface. This is consistent for different material categories and under both visual touch and blindfold touch conditions (although, when people are blindfolded, a shiny sensation is derived from an illusion). More results can be found in our material-aesthetics on-line database (www.material-aesthetics.com).

Emotional cues of a material/texture, to a large extent, are related to the association that a material/texture can have with people's experience. Fundamental forms are given meaning through association with previous knowledge of the world stored in long-term memory [6]. When your senses encounter external stimuli, there will be something underlying your instinctive response to these stimuli that will share an association with an image or meaning you will have stored in your memory, no matter how vague the recollection. For example, the colour of green might remind you of freshness, purity, hope, or the curvaceous lines resemble organic lives or the form of a beautiful etc. This can be termed as 'association'. With certain associations, meanings and emotions added to the primary sensory experience, the overall aesthetic experience could be enriched to a greater extent.

In one of our contextual research for a UK-based industrial company, we have analysed the materials and textures of a series of domestic electronic products such as hairdryers, kettles. One of the sensory tests was about the associative description of the handle materials/textures. Some of the descriptions are shown in Figure 9.

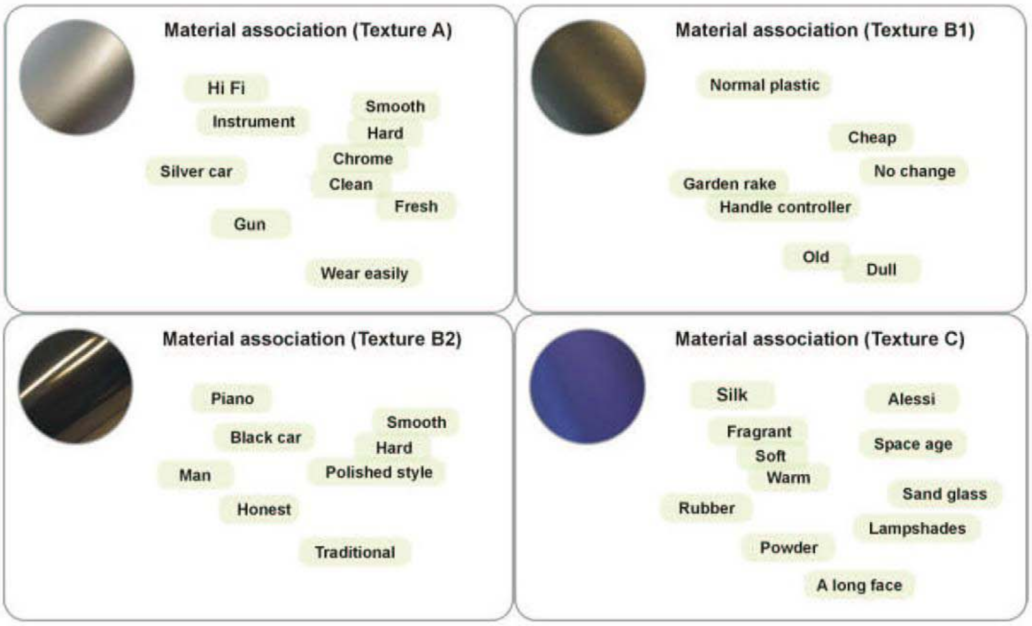

Figure 9 Associative description of material textures for hairdryer handles

The associative description of materials/textures and its connection to emotional feelings can be much individual-dependent. Therefore the descriptive words are random, but they are rich. Though, some commonality can still be found within particular focus group. Understanding of the emotional and associative cues from materials/textures either as samples or more importantly, within contexts of particular product categories will provide designers with valuable reference in order to create products that enhance the positive user-experience and added perception value. This is one of our targets to further expand and enrich our on-line material database that is free for designers to access.

4. Summary

- The essence of texture is structure. It is the structure, either macro- or micro-, either spatial/geometrical, or physical, chemical, biological, or even social, that is objectively embedded into and determines the texture of a piece of material, a painting, an image, an apple, a biscuit, a melody.
- To perceive a texture, you can see it, touch it, listen to it, smell it, taste it, and you can IMAGINE it. All these are linked to your memory and experience.
- Understanding cross-sensory or multi-sensory perception, for example, the interaction between vision and touch in texture perception, will be beneficial for designers to achieve subtle and fascinating effects of textures and much more beyond that.
- Associative and emotional cues can be found from materials and textures both in isolation and when applied in contexts, though that later provide more chances to strengthen, lessen, and completely change the original material/textures' perception.

Acknowledgement

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"McSoundscape" – A Soundscape Project to Represent The Spatial Identity of McDonald Restaurants In Hong Kong

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Abstract

The word "McSoundscape" refers to the Soundscape recorded from the interior space of McDonald restaurants in Hong Kong. Soundscape is the major medium of research and creation in this project, which allows audience to investigate the details of the surrounding environment, the actual activities, and all aspects of lived experience in our city space while making them a journey to the space of McDonalds.

Through Soundscape, our audience can explore the space for themselves by an acoustic approach, get a realization that is detached away from the routine life in reality, and examine how the users of Hong Kong McDonalds have actively performed their sense of locality through some creative tactics. The goal is to demonstrate how the commonly practiced appropriation of space, as a visual spectacle in Hong Kong, could re-articulate and govern the changing identities, characteristics and meanings of our social space temporarily and transitorily.

Research materials and sound data from McDonalds have been re-structured and visualized in the form of Information Design. Graphical representation of the data in those interface designs may allow us to discover any patterns or correlations between those different activities, which could otherwise be hidden or neglected in the forms of real-life photo, video or text.

Digital media offers us the chance to visit a particular space/site and to run through the space without physically being there. The technology helps to express and re-present the space of McDonalds in Hong Kong and further connect such space virtually with anybody from the world through the World Wide Web.

"McSoundscape" has been selected to exhibit in Japan during the recent Dislocate 08 Exhibition in Yokohama, Japan on September, 2008. http://www.dis-locate.net

(1) Introduction

Space appropriation is a very common practice in Hong Kong. When we go to the Central and Causeway Bay on Sunday, we can easily find many Filipino domestic workers who are actually camping on the street and doing all kinds of activities that they would have otherwise done at home. Many public spaces or even some privately-owned public spaces have been transformed into some sort of semi-private spaces temporarily by the users. The characteristic and identity of space is always temporarily shiftable in many places in Hong Kong. When people appropriate the space, it actually exhibits people's cultural resistance against some unfavorable rules or some customs of the place in a clever and innovative way. It sometimes also helps to unfold the social problems behind such phenomenon, for instance, as in the above case, there could be a severe lack of private space and entertainment areas for all the Filipino domestic workers in Hong Kong.

Since Apple Daily covered the story about the emergence of the “McRefugees” and “McGamers” phenomenon in Hong Kong (2007-04-30), a brand new spectacle has been illustrated in front of us in Hong Kong. And this project aims at examining how such new phenomenon of space appropriation at McDonalds represents the practical re-presentations of space in Hong Kong, in the form of a new media interactive project for the World Wide Web.

(2) Rationale & Objectives of the Project

2.1) To illustrate on how the McDonald restaurants, as an example, have been appropriated by the users for their private or even personal use and purposes;

2.2) To identify, categorize and analyze the practical strategies and powerful tactics (as forms of cultural resistance) of Hong Kong citizens over the daily use of space in Hong Kong and further identify how exactly Hong Kong people have the ability to change or even “lived” the meanings and identity of the social space, even in a temporarily and transitory manner;

2.3) To demonstrate how a cultural issue could be utilized as both a process of ethnographic research as well as the final output of a new media and design project itself through the experimental art of Soundscape;

2.4) To grant the novelty of treating visual culture in a different sense – through our acoustic sense instead of the visual sense in the development process, but at the same time deliver and display the final outcome by visual formats such as an information design and interface of an interactive website;

2.5) As a supporting source of information for other related research or practical projects in areas such as the interior design, information design, public space research and development, or even for the overall urban space design and planning;

(3) Conceptual Framework

The space in Hong Kong

In Hong Kong, when you browse around no matter the city centre or some peripheral regions, the architectures of many buildings and shops are almost the same and are very similar to those from foreign countries. We can no longer perceive any obvious identity of our cityscape. This is due to the highly standardization and homogenization of needs and consumption patterns in the contemporary industrialized world where there is a kind of "hollowing" of places everywhere, especially under the influence of globalization (Marc Auge, 1995:6). Marc Auge use the term "non-places" to delineate places where there is a lack of personalities and special characteristics.

> "*If a place can be defined as relational, historical and concerned with identity, then a space which cannot be defined as relational, or historical, or concerned with identity will be a non-place*" (Auge, 1995:77-78).

By living under Auge's concept of "non-places" in the contemporary state of "supermodernity", many places in Hong Kong are actually being eliminated with any historical meanings, and we are, in fact, left with no impressions or memories about the characteristics of the places anymore. Our emphasis on mobility in the society is another reason for the rise of "non-places" because the frequent traveling has transformed many places into "eroded" places which have been seen by many as merely passages to somewhere else, which neither can give us any impressions nor memories.

McDonaldization

Same as the idea of "non-places", McDonaldization has been promoted due to the high priority of mobility among urban citizens in the modern world. McDonaldization is "the process by which the principles of the fast-food restaurant are coming to dominate more and more sectors of the American society as well as the rest of the world" (Ritzer 2001: 162). Due to the growth of globalization, McDonald has spread its chains to many other Asian countries, which allow them to bring with the model of McDonaldization into Asia as well. Fast-eating has been a growing trend in our lives of a modern city such as Hong Kong because we all emphasis the importance of mobility, efficiency, expectancy in quality, convenience, etc. According to George Ritzer (2001), such model depends on its characteristics as efficiency, calculability, predictability, control, as well as the substitution of non-human for human technology. These are all based on the ideology of rationality, through which the whole process of the food delivery and services at McDonald should all be highly rationalized.

The space of Hong Kong's McDonalds as "non-places"?

Following the wide spread of globalization, many places with gentrification nature or characteristics are exported to other countries and being globalized in the rest of the world, which encourage some "world culture" as a result. McDonald, as a huge fast food chain from the United States, has demonstrated as a significant example of how the US culture has been exported worldwide. Since the business model of McDonald is highly standardized, which is also the major reason for their success financially, customers going to the McDonald in Paris would not feel any difference from the one they visit in the US, because the environment is very similar, the food is highly expectable and standardized, the staffs are trained with the similar scripts and rules to follow, etc. Basically, there are very little local color and sense of local identity in the interior environment of McDonalds everywhere, in order words, there is a lacking sense of place.

However, some may argue that McDonald's identity has been constructed through the illusion of fun, which was promoted mainly by its enormous commercials (Douglas Kellner, 2003:39). It is because McDonald made used of themes and images throughout those commercials, such as family or youngsters' gatherings, which further promotes such symbolic meanings for the food as well as the environment. Such collective experience of happiness was further combined with the American culture while the McDonald restaurants were being imported into Hong Kong. Nevertheless, such projection of a fun image is nothing but JUST AN ILLUSION through which some of the target customers, especially the children, have equated with the identity of McDonald. They attracted customers by many collections of cartoon characters as gifts, the clown image of "Uncle McDonald" (name of Ronald McDonald in Hong Kong) as the avatar to welcome customers, some colorful interiors and furniture, etc. All these help to remind children of the atmosphere of fun and happiness, or even mimic the look of some playgrounds, instead of a conventional restaurants or café.

McDonaldization strives to control customers in every ways (such as queuing up for purchase, the range of food choice to be made, etc) and ignore their particular needs and desire, so as to maximum the level of efficiency and their profits. However, customers nowadays are NOT highly predictable and they always have their different individual demands and needs towards the producers. There is actually a vast variety in the type of customers who eat in the McDonaldized fast-food restaurants. [6] Therefore, we have to consider the fact that there is a huge variation on the type of consumers at McDonald who has their own needs and are highly "unmanageable" (Ritzer and Ovadia, 2000:41), needless to say customers from different cultures are showing different kinds of behaviors.

Temporary appropriation of space and concept of "Lived Space"

In Hong Kong, a lot of space appropriation had created some visual spectacles in the society. The boundary between public and private can be blurred or even collapse due to such invasion of the private properties. Originally, our private space of home has always been established in the interior environment. Since space appropriation occurs, some of us used the exterior public space for some private activities and the result is the collapse of distinction between interior and exterior spaces.

As far as the identity of place is concerned, the space of Hong Kong's McDonald is NOT one of the typical extreme as a non-place region. Nevertheless, these different roles of customers at McDonald are often temporary and could overlap with each other. In fact, space in Hong Kong has become a "renegotiable commodity" as there are a lot of intense temporary spatial appropriations and some of which are even for commercial usage (Leach, 2005:174). For instance, a great example Leach has given was the fact that thousands of Filipino girls have transformed the privately-owned public space in the open ground floor of the Hong Kong and Shanghai Bank in the Central District into a private space which is just like "a collective living room" on every Sunday. Similarly, today we spend an ever-increasing proportion of our time dealing with private matters in some open public space, which gradually affects our public and private experience collectively. In fact, the distinction between private and public sphere has gradually broken down, and the relationship between them is becoming a non-fixed, highly dynamic and mobile one in Hong Kong. In order to differentiate the characteristics of a space from the others, Leach has used Judith Butler's notion of "performativity" to explain the way people can "act out" the identity of space (Leach, 2005: 174-176). Instead of being given with a certain identity or characteristics, a space has gained its identity through the process by which the participants engaged themselves with different kinds of performance and activities and further established a commonly recognizable identity of the particular space.

In fact, such concept is very similar to Henri Lefebvre's concept of "Lived Space", which actually makes the major focus and argument on the case study of this research project. In his book "The Production of Space", Lefebvre (1991) had identified three different concepts for the production of social space: the first one is "Representation of Space" (or Conceived Space), which is the space being identified and conceived by our urbanists and planners as some dominant and controllable space in the society. It is "revealed through the deciphering of its space" (Lefebvre, 1991: 38). The

[6] Ritzer and Ovadia (2000) have pointed out that there is actually a vast variety in the type of customers who eat in McDonaldized fast-food restaurants. It includes consumer as "chooser, communicator, explorer, identity-seeker, hedonist or artist, victim, rebel, activist, and citizen. For more details, see George Ritzer and Seth Ovadia, 2000, p40-44.

second one is called "Spatial Practices" (or Perceived Space) which "embodies a close association, within perceived space, between daily reality (daily routine) and urban reality (the routes and networks which link up the places set aside for work, 'private' life and leisure) (Lefebvre, 1991: 38). This is the way by which the space is being appropriated and actually being used in our everyday lives. The third one is called "Representational Spaces" (or Lived Space), which defines space as something "directly lived through its associated images and symbols, and hence the space of 'inhabitants' and 'users'… (Lefebvre, 1991: 39). It is the practical and directly experienced social space, and transformation of space take place through bodily lived experience of some daily activities, which is sometimes even against the original conceived space. These experiences and practices are believed to be able to transform the characteristic and identity of our own social space. In fact, there are many different kinds of practical resistance in our everyday lives which reveal to us on how people actually do not consent to dominance in space.

Therefore, the concept of "Representational Spaces" (or Lived Space) is actually the focus of this project in the sense that the local people have been resisting to the original design of the conceived space by practically experiencing a totally different kind of daily activities and thus further "lived" and re-construct their own spatial identity and giving new meanings and characteristics to the space at the McDonald restaurants in Hong Kong. Nevertheless, if McDonald in Hong Kong is not on the extreme of being a hollowing non-place, then, what is the actual kind of spatial identity that Hong Kong Mc-Goers are trying to "live" and "experience" in their real daily-life practice?

(4) Research Problems

Since a local Hong Kong newspaper, the Apple Daily, covered the story about the emergence of the "McRefugees" and "McGamers" phenomenon in Hong Kong (2007-04-30), a brand new spectacle has been illustrated in front of us in Hong Kong. It actually shows just one of the evidence of space appropriations in Hong Kong. It is an interesting issue to look at how the Hong Kong customers utilize the space in McDonald because it could be a certain kind of local resistance to the giant corporation of McDonald and its culture of McDonaldization. **"McRefugees"** refers to the term which was imported from Japan to Hong Kong now, as these people are being called "McRefugees" after McDonald's, the fast food chain, providing many of them with their homes. Another term **"McGamers"** could be defined as people who play wireless handheld games at McDonald. They are usually young people playing online games together with their PSP or NDS consoles for overnight at McDonald and such phenomenon is unique in Hong Kong. Both of these new terms have demonstrated a certain kind of new social and structural transformations which has been taking place tranquilly under the Hong Kong cultural ecology. Social and cultural changes can affect the way we distinguish between the use of private space and public space. The temporary shift in the use of these spaces can represent some new forms of cultural practice in the society.

The major theme of this project is to examine how such new phenomenon of "McRefugees", "McGamers" as well as many other groups of people who appropriate the space at McDonalds represents the modern way of space consumption and re-presentation of spatial identity in Hong Kong. When people go to McDonalds to do all kinds of stuff and appropriate the space, it actually exhibits people's cultural resistance to some unfavorable rules and customs of the place in a clever and innovative way – as they use their "practical knowledge" to "twist" the use of space and adapt themselves to the environment comfortably, which is nevertheless against the big corporation's rules.

This research-based new media project tries to demonstrate the followings aspects:

4.1) As a research-based new media artwork, the final output aims at illustrating the multiple, temporary and transitory characteristics regarding to its meaning and identity of space for McDonalds in Hong Kong.

4.2) It also shows the way such distinction between private and public sphere has gradually broken down, and the relationship between them is becoming a non-fixed, highly dynamic and mobile one in Hong Kong.

4.3) By questioning the notions of "non-places" through the medium of Soundscape, we can also make the audience a journey to the ACTUAL space of McDonalds in Hong Kong and explore their transient connections and communications among each other and within the space by allowing the audience to listen to the ACTUAL process of spatial appropriation themselves. Therefore, people listening to the soundscape data on the website can examine themselves on how the social space has been practically "lived" and "experienced" by the users of McDonalds.

(5) Significance of the Project

The website itself can serve the communities and Hong Kong as a whole by illustrating the current cultural phenomenon of space appropriation through an interactive new media platform. This is a total merge between the new media artform and the research data of a significant cultural issue, and the general public can get to know more about our city and such cultural phenomenon in a much easier and accessible way, through the popular platform of the World Wide Web. Besides, the research findings and report on the website could also provide an alternative and supplementary source of information for the mainstream mass media such as newspapers and magazines.

Why using Soundscape for this project?

Digital media allow us to visit a particular space/site and to run through the space without physically being there. It compressed the time and space in such a manner that it helps us to revisit ourselves and our actual daily experiences. Soundscape is the perfect choice of medium for this project, both as a research method and as an artform itself, because it can gives us an idea of the exact kind of activities and movements of the space (if there is any) and therefore proved to us directly the kind of spatial meaning that has been practically "lived", experienced and transformed by the people at McDonalds.

Through Soundscape, the following goals are likely to be achieved:

5.1) To investigate the surrounding environment in details and take the viewers on a journey through the actual Hong Kong city's space by Soundscape , which is the major documenting tool in the project;

5.2) As an interface for us to understand and explore on the cultural phenomenon behind those activities and movements;

5.3) To unwrap the daily activities and the use and production of space through a less commonly used and refreshing sense – acoustic, instead of our dominating sense of the visual, which allows a new and innovative experience of these immediate spaces;

5.4) To allow re-discovery and re-examination of OUR OWN ways of living by inviting each one of us to listen up carefully the sounds of the others' everyday activities and consuming behaviors, while allowing us to reflect on our own experience in return.

(6) Research Methodologies

6.1) Qualitative Research – Soundscape Recording

The major part of this research project is to study and record some identifiable Soundscape data from some selected McDonald Restaurants in Hong Kong. The locations include places in the Hong Kong Island, Kowloon, the New Territories and even some outlying Islands. The aim is to record any kinds of movements and activities that can be found in the restaurants, including some environmental sounds, the verbal conversations between customers, McDonald staffs, people who appropriating the space, and any other types of activity that have been carried out inside the McDonald restaurants, and most of them can help to define the actual characteristics and identity of space at McDonalds in Hong Kong.

6.2) Qualitative Research – Ethnography Research, Interviews and Sound Recording

Another source of information mainly came from the sound files of a few verbal interviews conducted in some of the McDonalds restaurants. Interviews are recorded in the form of soundclip data, with both the customers from all ages and all walks of life, the McDonald staffs, and more importantly the people who appropriate the space in the McDonald restaurants. These interviews and observations could further help to identify the different kinds of space appropriations and for our understanding of the reasons and backgrounds behind these activities. However, the interviews would not be addressed as a separate categorization, since the major focus of this project is to let the participants to take the active role in experiencing and performing their actual everyday activities in the sound record, rather than concentrating on how they explain and defend on their behaviors or so. (Some data of the interview could be found in the form of text in *Appendix E*, while other interviews in the form of sound data could mostly be found under the categorization of “McRefugees” and “McGamers” on the website).

6.3) Qualitative Research – Ethnography Research, photo-taking & observations

Moreover, some supplementary source of information such as the field visit observations report (on *Appendix D*) and photo-taking of McDonald Restaurants were used to record some situations that the can hardly be presented or observed in the form of Soundscape. Although emphasis would not be placed on visual elements and the appearance of them would be minimal in the final outcome (the website), nevertheless, these images and other informative text, would also become part of the actual contents on the website and through out this analytical report, so as to supplement for the constraints of the Sound data.

(7) Observations & Findings

The following is a report on the research data from different sources:

7.1) From Literature Review

James L. Watson had also noticed such kind of space appropriation by secondary school students in Hong Kong, who often sit in McDonald for hours and treat it like a “youth club”. Instead of dining at McDonald, they come here for studying, gossiping, and picking over snacks. He also pointed out that there is a shift of target customers from those children of wealthy elites twenty years ago to the working-class people now, who are attracted to come to McDonald because of its low cost, convenience, and predictability.

Of course, it is not to say that customers from the other categories are all excluded, as it has been mentioned above that there is a vast diversity of customer types always. Nevertheless, it is a noticeable trend that the low-income class is now attracted to visit McDonald as more often than they do before. McDonald’s International says that the goal of the company is to “become as much a part of the local culture as possible.” (Watson, 2002:222-232). Instead of giving pressure to shorten or even limit the table time for customers to stay at McDonald, Ritzer (2004) pointed out that McDonald in Hong Kong is a more human setting and customers take it as a place for hanging out, especially for those teenage group, so that they feel it like “home.” (Watson, 1997:77-109).

7.2) From mass media (newspaper or magazines)

Since the fast food franchise McDonald has extend some of its stores into 24-hour operation in August 2006, the number of McDonald operating around the clock has now been increased to more than 60 stores, which account for almost one third of the total number of McDonald restaurants in Hong Kong. On 30 April 2007, the term “McRefugee” was imported from Japan into Hong Kong by a report from a local newspaper, the Apple Daily, which caught our attention both locally and internationally. Reporter has found more than 20 sleepers at the Cameron Road store at midnight and while some other customers are described as “McGamers” as they gather or meet randomly at McDonald and play PSP or NDS network games together. After that, some newspapers from the mainland China and Taiwan also give an account on such phenomenon.[7]

Photo from Apple Daily (蘋果日報), 2007-04-30

Caption translated: At 4am, there are a huge group of McRefugees at the corner of the Cameron Road Branch, as more than 20 people are actually sleeping in the restaurant.

Original caption in Chinese: (凌晨四時，麥難民重災區的尖沙嘴金馬倫道麥當勞分店的角落，約有二十多人在店內呼呼入睡。)

(For more photos and details from the Apple Daily on 2007 April 30, see Appendix B)

The original idea of McDonald to extend the opening hours to 24 hours is to adapt to the increasing demand of Hong Kong night owls after clubbing night, people with long working hours, or even people in night shift, who want to come and eat “breakfast”. Now, McDonald has now been filled with people who appropriate the space for their private use, such as playing wireless online games, sleeping or reading newspaper overnight. Some other people are even stuck at McDonald because of the lack of overnight transportation in some districts, which reflect the inadequacy of the current transportation services for the public.

7.3) From the Internet (Bloggers’ opinion)

Generally speaking, McRefugees and McGamers seem quite commonly accepted by most bloggers, especially by those who also play games and appropriate the McDonald space themselves. Some of them have pointed out that such phenomenon of public sleepers has existed since a long time ago in the city, such as the “Airport Refugees”. They are encouraging each other to make best use of the 24-hour-operating “free space” by bringing as much of their personal belongings to McDonald as possible, so that they can make themselves like living at “home”. One of them even suggest to bring with the PSP handheld, MP3, electricity charger, newspaper, magazines, towels, tooth-brushes, clothing, backpack, etc. As long as the sleepers “do not disturb the other customers”, they feel that it is alright to take the advantage from large corporations like McDonald, through such a way that McDonald can fulfill part of their social responsibilities. *(For details of bloggers’ comments, see Appendix C)*

[7] They include the TVBS-N (2007-04-30, 2007-06-05) from Taiwan, China Times (2007-05-01) from mainland China, Lianhe Wanbao (2007-05-02) and Lianhe Zaobao (2007-05-02) from Singapore and Wen Wei Po (2007-05-23) from Hong Kong.

7.4) From participatory observations & field study

From the research data of participatory observations (details report on *Appendix D*) and sound recordings (on the website), we can conclude that many customers are giving the space of McDonalds some new and temporary identities which are listed as follows:

7.4.1) McDonald as free mobile office, workshops or tutorial rooms

- Commercial appropriation – McDonald almost functioned like the mobile office of broadband service promotion workers as well as salesperson of insurance companies;
- Some insurance or property salesmen even appropriate the space for selling their commercial products and services to their potential customers;
- Some customers discussed about their own financial plans or even sharing the information on the stock market;
- Some parents were giving private tutorials for their own children;
- Primary and Secondary students were doing homework together or holding some group discussions.

7.4.2) McDonald as free entertainment arena

- Some youngsters held a private birthday party of their own;
- It was very common and easy to find customers reading newspapers, magazines, books, etc;
- Some were attracted to the TV for the entertainment and news report;
- Others were listening to music that they brought with themselves;
- Customers came to meet at McDonald for social gatherings, private birthday party, family gatherings or even baby sitting;
- Different age-group and different types of customers treat McDonalds as some community centers, they include youngsters, Filipino domestic workers, middle-aged group, old-aged group, housewives, students, etc;
- Many McGamers were playing PSP and NDS games as connected groups or individually;
- A vast number of customers had brought with their own laptop computers, by which they would be able watch movies together in the public;
- A few could even get connected to internet through the free Wi-Fi services (although only 20 minutes free service for each time logging in.

7.4.3) McDonald as free shelter from rainy days, cold night or hot weather

- The poor and the low-income group came to get accommodation and slept overnight in order to save the rent;
- Other travelers came to get a temporary shelter while waiting for some transportation services;
- Some old aged people come to McDonald for sense of community and to spend their extra leisure time even at mid-night.

The following table (Table 1.0) shows the percentage of space appropriation observed during the six field research in 2007:

Number of Visit	Name of the Branch	Space Appropriation Percentage
1st Visit: (11-12 Nov 2007)	Un Chau	48%
2nd Visit: (12-13 Nov 2007)	Argyle	40%
	Cameron Road	22%
	Hillwood	78%
	Jordan Road	50%
	Un Chau	40%
3rd Visit: (14 Nov 2007)	Un Chau	72%

4th Visit: (16-17 Nov 2007)	Sai Yeung Choi	39%
	Sing Shing	25%
5th Visit: (17 Nov 2007)	Sai Yeung Choi	25%
	Un Chau	65%
6th Visit: (20 Nov 2007)	Un Chau	25%
	Average percentage:	**44%**

Table 1.0, Percentage of space appropriation observed during the six field research in 2007. For details of information, see *Appendix D.*

The above data were obtained mainly by the method of participatory observations and they were further being quantified by calculating the average percentage. The final average percentage of space appropriation from all the six visits in 2007 is as high as 44%. It shows that the phenomenon is definitely reflecting some significant trends and changes in Hong Kong's social and cultural ecology. What could be concluded from these observations is that a few major types of activities were found among the Mc-Goers.

They have been taking advantage of the free service and space provision of McDonald and have identified this place temporarily as "efficient", "fun" as well as "safe and comfortable" respectively. Firstly, Mc-Goers who treat McDonald as their free mobile office identified it as an "efficient" place like their home office, or SOHO office, where they can deal with their small business efficiently. Since 24-hours McDonalds are easy to find in many places, their effectiveness and efficiency are improved by these highly mobile offices. Secondly, for those who treat McDonald as an entertainment arena such as McGamers, McDonald provides them with a sense of "fun" definitely. Young people hang out at McDonald and make it functions as a youth club, while the elderly also feel very comfortable and convenient to spend their leisure time here or meet here for social gatherings. Lastly, for McRefugees and other flaneurs, McDonald provides them with a sense of "safety and comfort" because it is a free sleeping place and good shelter against any weather condition outside, day and night. Most importantly, everything discussed above are all for free! All these are very similar elements or characteristics that our home can provide us. Thus, McDonald has given different types of Mc-Goers, at a diversity of age group, an identity of "home", regardless of its temporary and transitory nature.

7.5) From the interviews (with customers and working staffs)

During the field visits, seven short interviews were conducted with some customers, a McDonald staff, a McDonald Manager, as well as McRefugees. During the interviews, the McRefugees do not admit to their appropriation of space in McDonald. For example, the group of university students knows that it is inappropriate to hold a private Birthday party without following the arrangement of McDonald and pay for the service fee. However, they still say that it is okay, as long as they have bought some drinks with them. Even though they should know that it is considered as space appropriation, however, they persuade themselves that it would be alright, as long as they do not interfere with other customers or make too much inconveniency to the others. It shows the fact that many customers are quiet easy about everybody else's appropriation of the place. When being asked about their opinion towards McGamers and McRefugees, they do not hate either type of people in particular.

For the staff of McDonald, they basically are following the policy of tolerating such phenomenon. However, it was obvious that the staff, especially the managers can hardly endure the McRefugees who sleep around the place. This could be shown by the obvious tactic of blocking some gloomy areas during midnight after media reports. This is an interesting contrast to their level of tolerance towards McGamers, who actually occupy more space and create much noise and interruptions to the other customers than McRefugees. This could be explained by the fact that McDonald always target the young people as their major customers and attracting more youngsters to the restaurants actually aligns with their basic policy and principle. Besides, McRefugees are usually the poorest and the middle age group who hardly have any purchasing power. Therefore, it is not difficult to understand the intension behind their behavior, although both of the types are appropriating the place in a different way. (For details of the information, see *Appendix E*)

(8) Analysis of the phenomenon

McRefugees and McGamers shared the same characteristics in the way that these customers have actually transformed the 24-hour-opening McDonald restaurants into a private bed room, private living room for gatherings, game room or entertaining room for group games, discussion room for group projects, students' study room for homework and tutorship, and some even treat it as the common room or dinning room where people resolve their children's behavior problems or baby-sitting their children. These activities are actually in the opposite of McDonaldization because these McRefugees, McGamers, or even McStudents are no longer standardized and predictable customers. They do not confirm with McDonald's assumption that they should eat fast and leave immediately after dinning. Other commercial appropriation of space has even transformed McDonald into some kind of mobile office. Such appropriation is especially against McDonald and McDonaldization because these activities are generating profits out of the space and service provided by McDonald. They are actually some irrational consequences to their around-the-clock policy. Under McDonaldization, it should be McDonald who always maximizes their profits by turning the customers into unpaid workers, such as making them to put the leftovers into the trash after dinning.

In fact, space, as in our example, has become a commodity as well. In such process of spatial appropriation, space becomes transformable as well as renegotiable, even though it happens temporarily. All kinds of space appropriations actually are transforming McDonald's identity from the "illusion of fun" into some newly re-constructed "fun", "efficient", as well as "safe and comfortable" as discussed above. Private space has been transformed into semi-private space where people transformed the place into different functions temporarily and transitorily at different times. To conclude, they are making McDonald their temporary "Home" in a certain sense.

The emergence of the "McRefugees" and "McGamers" phenomenon actually illustrate to us a new spectacle in Hong Kong, which was promoted by the commercial world. As a symbol for globalization in economy, the golden arches of McDonald now become the mediator in reflecting such social phenomenon and social problem of poverty, the severe disparity between the rich and the poor, youth problem, as well as many other family problems. It also represents the fundamental changes in the social structure and consumer behavior. Such social phenomenon is actually an evidence of the overall hasty life in Hong Kong nowadays, including the long working hours, the social problem of homelessness, the high inflation rate, the inadequacy in transportation service in some district, the high rise rents, more contract and part-time jobs, irregular resting time, over-crowded living conditions, and most important to all, the vast gap between the rich and the poor.

(9) Scope of the Project

This project mainly combines of field visits & research on McDonalds located in the Hong Kong Island, Kowloon, the New Territories, as well as some of the outlying islands in Hong Kong. Although several field visits has been made in 2007 (see *Appendix C*), those data are just for the analysis part in this report. The data on the actual website comes from more field visits in 2008. During the period of time from 22 Jan 2008 to 20 March 2008, soundscape recording has been done for 21 different McDonald restaurants (see *Appendix A*) and more than 30 visits have been made with a total number of 44 final selected soundclip data being linked onto the website.

The following table shows the exact date and the name of the McDonald Restaurants that have been visited and studied for the purpose of soundscape data collection:

SUN	MON	TUE	WED	THR	FRI	SAT
(Jan) 20	**21**	**22**	**23**	**24**	**25**	**26**
		Un Chau				

SUN	MON	TUE	WED	THR	FRI	SAT
(Feb) 17	**18**	**19**	**20**	**21**	**22**	**23**
						Sai Yeung Choi / Sing Shing
24	**25**	**26**	**27**	**28**	**29**	**(Mar)1**
Sing Shing / Central / Connaught	Metropolis Plaza / Tin Ping / Uptown Plaza	Un Chau				
2	**3**	**4**	**5**	**6**	**7**	**8**
Mui Woo / Cheung Chau / Connaught	Un Chau / Uptown Plaza / Tai Po Central / Tai Wo	Un Chau	Un Chau	Bonham Road / Hill / Causeway Bay Plaza II / Hennessy	Jordan / Un Chau	Sai Yeung Choi
9	**10**	**11**	**12**	**13**	**14**	**15**
	Queen Road Central		Sun Chui / Shatin Racecourse / Un Chau			
16	**17**	**18**	**19**	**20**	**21**	**22**
				KCR Hung Hom Station		

Table 2.0, Visits and soundscape data collections have been done on the above date at different branches of the McDonald Restaurants in 2008. For a full list of these visited McDonald Restaurants and addresses, please refer to *Appendix A*.

(10) Format of the Project

The format of the final outcome of this research is an interactive website showing the identity of McDonald's space in Hong Kong through mainly soundscape data files plus the mixed materials of some others such as informative texts, tables, maps as well as some thumbnail photos. (URL: http://www.mcsoundscape.com).

All the findings of this research project are stored and displayed in the form of a website built basically by HTML with some additional techniques of database, xml and actionscripts. The front-end is composed of graphics built by using Adobe Flash and the goal is to create an interactive interface for users to control and browse among the data in a manner which allows multiple ways of accessing the same piece of data, which is the soundscape data file.

Multi-accessing of Information and Data

In the interactive website, there are several different ways to access the same piece of information and soundscape data file. The same data could be accessed through different tags as follows: (The details are visualized with sample screenshots in the next section called: "Project Outcome" below.)

10.1) Date and time using the **timeline navigation** on the **main** (timeline) screen;

10.2) Locations on the Hong Kong **map** screen (showing different districts in Hong Kong);

10.3) ***Categorization based on the **nature and the type of activities and displayed on the Hong Kong **map** screen; (i.e., the seven categories of "McStudents' Study Room & Tutorial Room", "McGamers' Arcade Centre", "Community Center/Playground", "Business and Finance", "McRefugees", "Family Gatherings", and "Other activities" respectively)

10.4) Categorizations based on the **nature and the type of activities** and displayed on the **weekly calendar** screen.

Color code (for the dots on website)	**Categorizations**	**Descriptions**
	Study Room & Tutorial Room	For Primary School students' Language class, Secondary School students' Mathematic class, Old-aged woman's English class, Primary School students under supervision of Father & Filipino Maid, etc.
	McGamers' Arcade Centre	For handheld network games such as PSP and NDS.
	Community Center / Playground	For Comics fans gatherings, Youth, Filipino Maid, Small Children, Middle-aged, Old-aged, Housewives, etc.
	Business & Finance	For Insurance Salesperson selling service to clients, McDonald's official promotional activities, Property Sales negotiating with clients, employers discussing business issues, Stock information sharing between old-aged women, etc.
	McRefugees	For those who sleep at McDonalds or others who hang around at McDonalds for the whole night.
	Family Gatherings	Parents & Children dinning while chatting, Old-aged couple discussing about financial situations, or other types of family member gatherings, etc.
	Other activities	As travelers' resting room to wait for the trains/ship schedule, Horse-racing fans' gathering place, tourists' rest place, coffee shops for off-hour gathering, etc.

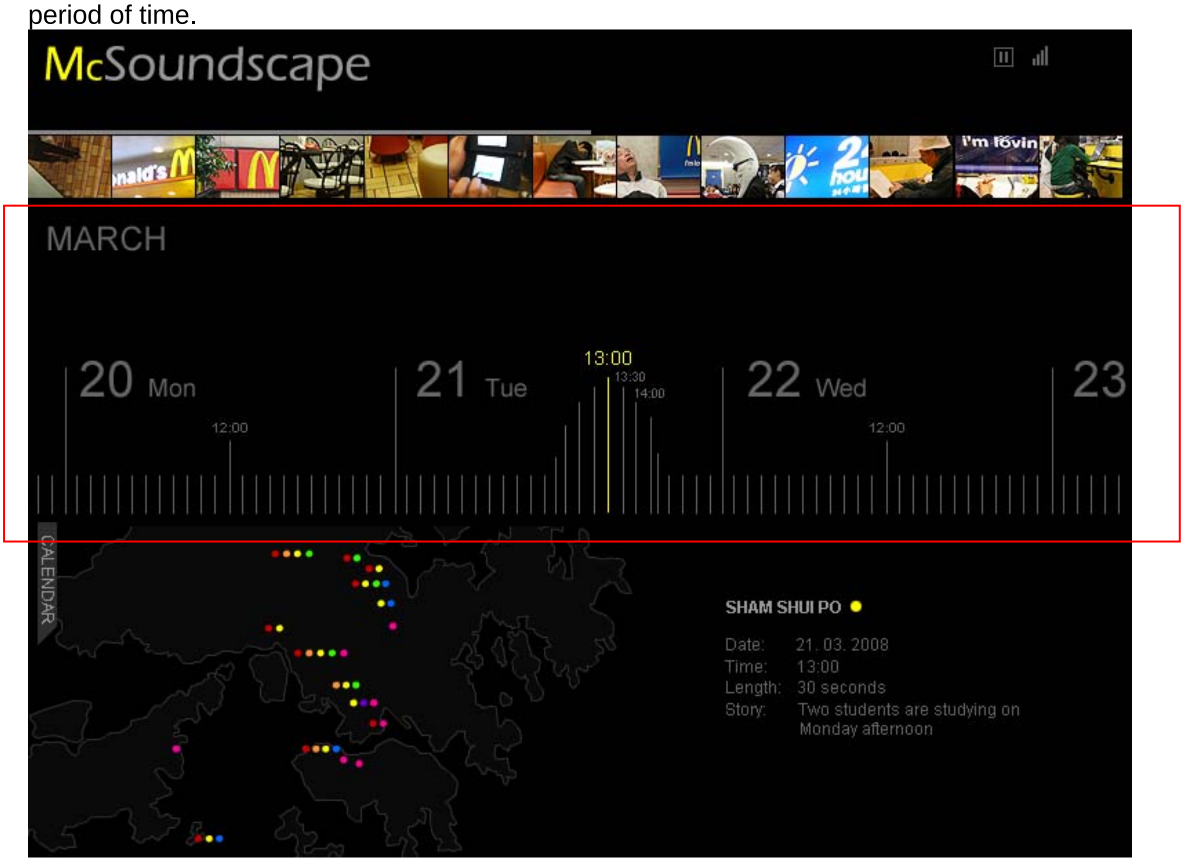
Table 3.0, ***** Categorizations of the major types of users and their activities.

(11) Project Outcome

The followings are some screenshot samples showing a few major navigation steps in the final website.

11.1) Main screen > timeline navigation

Screenshot sample 1:
Users are welcome to drag and click on a specific time to call up a particular Soundscape file recorded at different McDonald restaurants in Hong Kong. Some detail information about the sound file will be shown on the lower right hand corner as it corresponds to the selection of the different period of time.

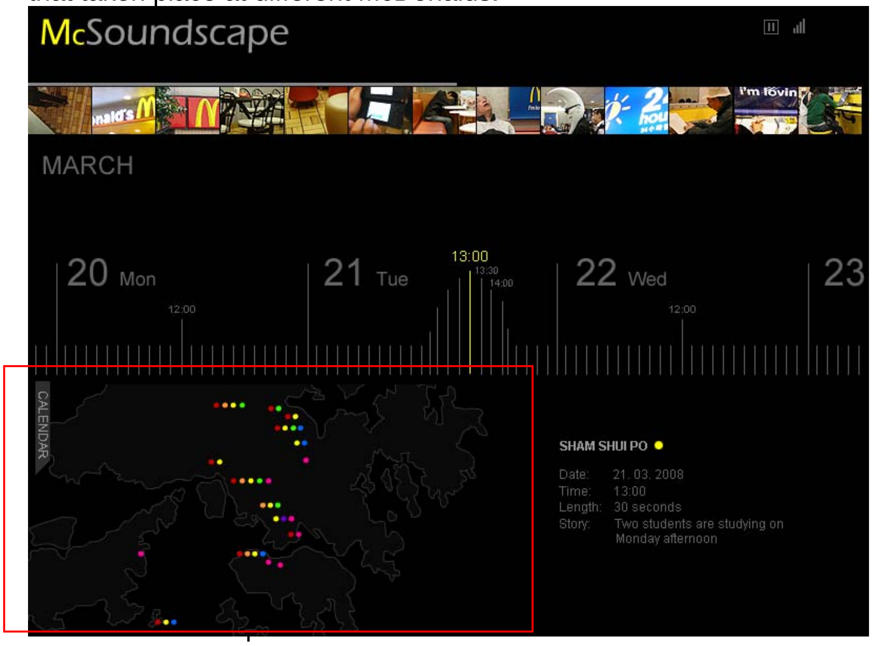


Screenshot sample 1

11.2) Main screen > map navigation

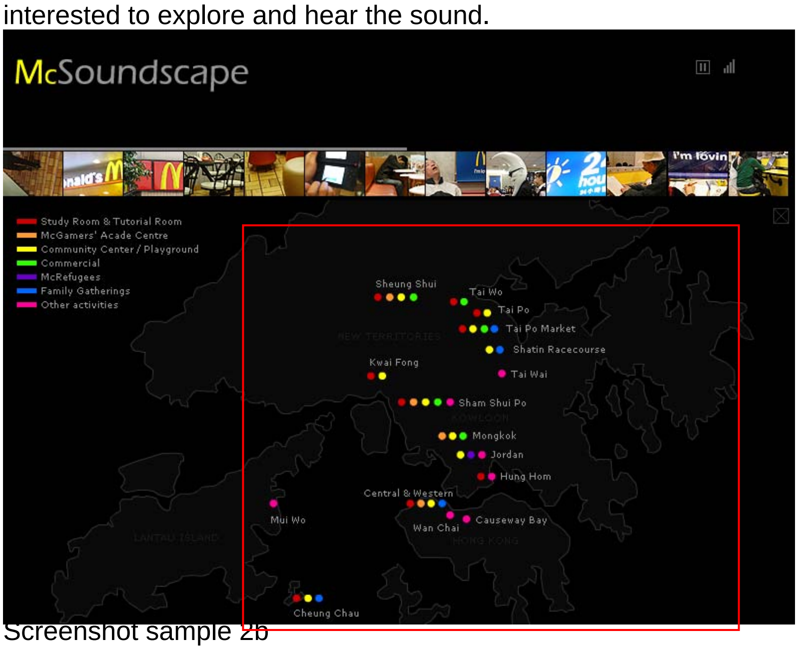
Screenshot sample 2a:

Users are able to access Soundscape (sound recording data files in the format of MP3) by clicking the dots on the map nearby where they live. Each color dot represents different categorization of activity that taken place at different McDonalds.



Screenshot sample 2b:

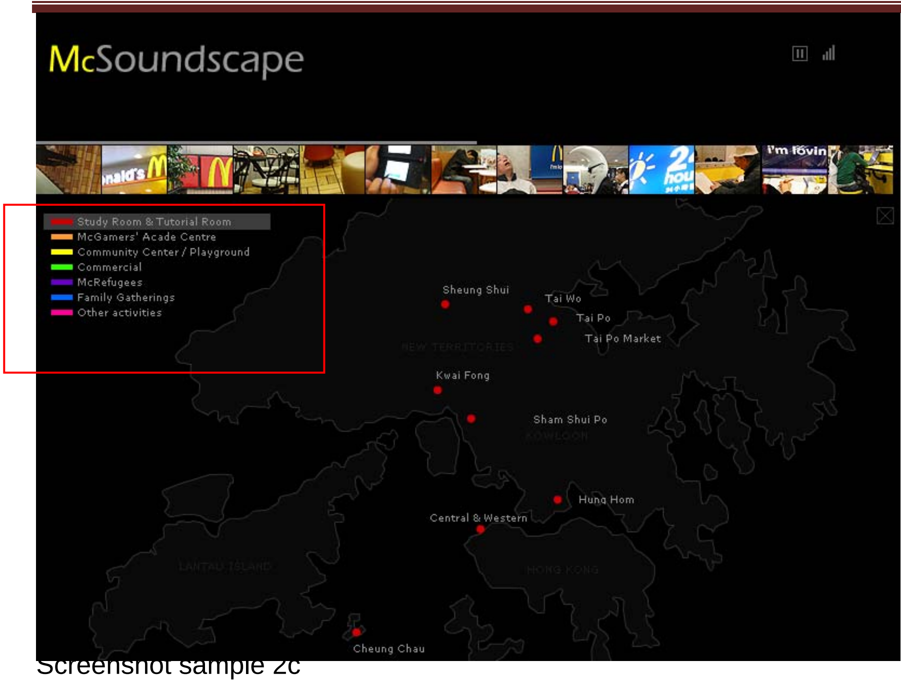
Once users click on the thumbnail of map which is showed on the previous screen, it brings users to the scaled-up version. Users can click on each colored dot in any specific locations where they are interested to explore and hear the sound.



Screenshot sample 2b

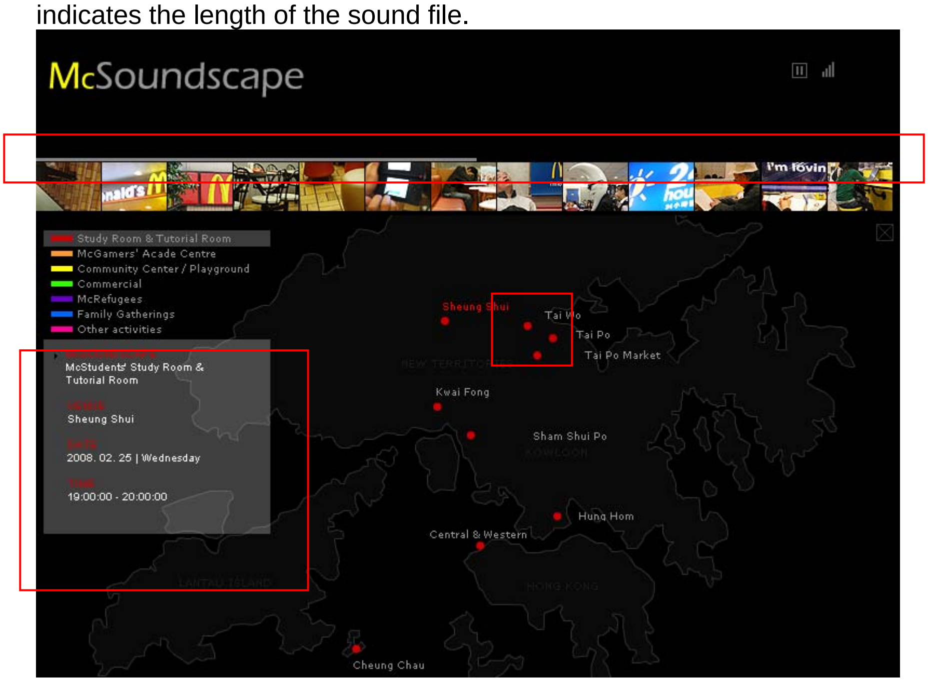
Screenshot sample 2c:

Users are able to show fewer dots to indicate a particular category (e.g., only the red colored dots below) on the map by clicking on them from the left-hand side column



Screenshot sample 2c

Screenshot sample 2d:
When the cursor comes over the dot, more detail information is being shown on the far left column, and Soundscape will be played automatically after pressed. The gray "sound-playing bar" on top indicates the length of the sound file.

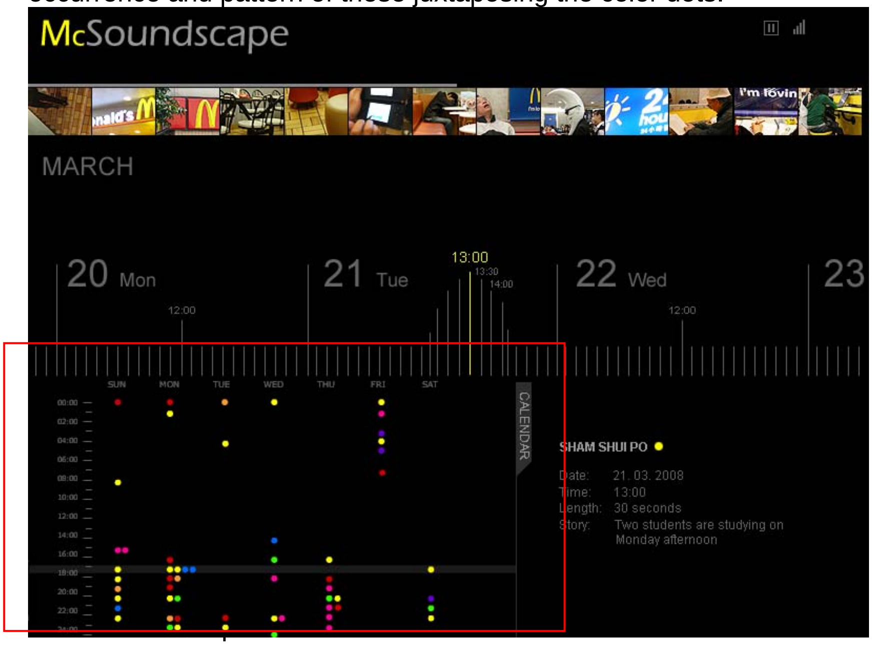


Screenshot sample 2d

11.3) Main screen > calendar navigation

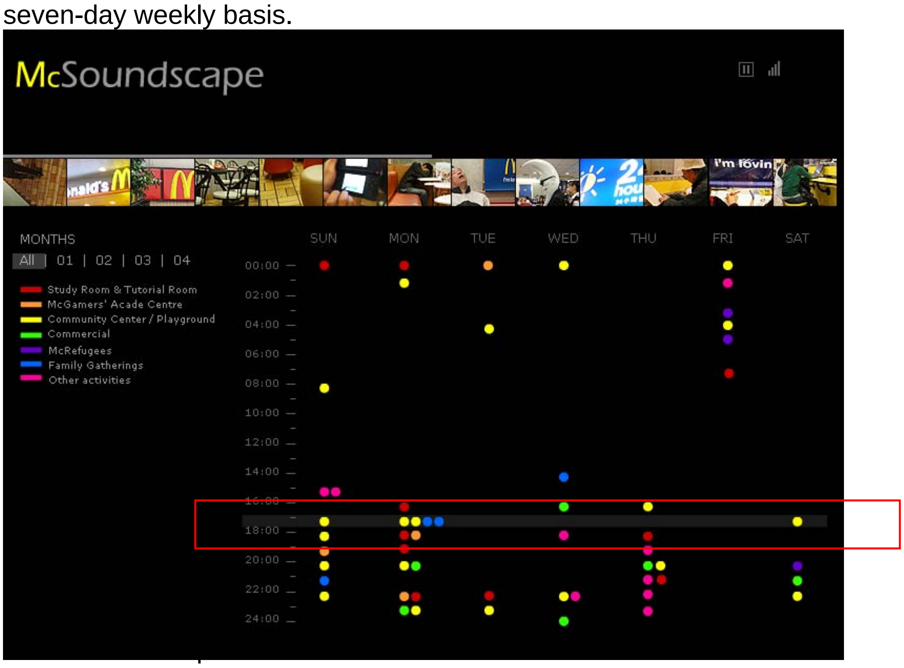
Screenshot sample 3a:

Soundscape is also organized and displayed within the weekly calendar. It helps to illustrate the Soundscape pattern visually and users can easily discover the frequent events by observing the occurrence and pattern of these juxtaposing the color dots.



Screenshot sample 3b:

Once users click on the thumbnail calendar shown in the previous screenshot, it brings users to the scaled-up version. Users can examine carefully each of the colored dots for a particular time on a seven-day weekly basis.



(12) Examples of Sound data

(For detailed information of all the Soundscape data, please refer to *Appendix F*)

Soundclip data sample 1:

District: Kwai Chung (by clicking on the map)
Date: 24 Feb 2008 (Sunday)
Time: 00:05
Sound Length: 2:38
Address: G/F, Sing Shing Building, 90 - 114 Wo Yee Hop Rd, Kwai Chung, New Territories
Story: McDonald staff cleansing the furniture at midnight
Categorization: “Others”

Soundclip data sample 2:

District: Central (by clicking on the map)
Date: 24 Feb 2008 (Sunday)
Time: 17:50
Sound Length: 3:03
Address: Basement, Yu To Sang Building, 37 Queen's Road, Central, Hong Kong
Story: A slight dispute between customers (Philippines working in Hong Kong as maids) and the staffs while many Philippines maids are occupying almost the whole McDonald
Categorization: “Community Center”

Soundclip data sample 3:

District: Tai Po (by clicking on the map)
Date: 3 March 2008 (Monday)
Time: 17:30
Sound Length: 4:05
Address: Shop 57-66, G/F, 4 On Chee Road, Fortune Plaza, Tai Po, New Territories
Story: Mother and father were teaching and tutoring their primary school son on school work.
Categorization: “McStudents' Study Room & Tutorial Room”

(13) Conclusion

This research-based new media project of "McSoundscape" is both an informative and artistic research project. This project mainly deals with the research findings and analysis in the way that it demonstrates to us how the commonly practiced transformation and appropriation of space, as a visual spectacle of Hong Kong, could re-articulate our identities of the space and even further govern the changing spatial identities, characteristics and meanings of our city space.

In many McDonald restaurants in Hong Kong, the local people do not want to spend time in such "non-places" and have been resisting to such original design of space by re-constructing the spatial identity and giving new meanings to the space by practical and direct experience. Hong Kong people change the meaning and identity of the space by actively participate in space appropriations and do their own private things at McDonalds. The users of Hong Kong McDonalds have, in fact, performed their sense of locality through some creative strategies (or tactics) and the result is a new construction of spatial meaning at the McDonald restaurants. What the customers have been practicing is exactly the same meaning as what Lefebvre (1991) defined as "Lived Spaces" or "Representational Spaces".

Through some qualitative research methods such as field study, participatory observations, sound recording, research and interviews, the goal of this project is to provide us with a closer look at such a new cultural phenomenon. The final output is to express all these actual findings through the artform of Soundscape, which are being published as an informative webpage on the World Wide Web. The process of the research is also the new media artwork in itself. All the research data and findings collected from the McDonald restaurants have been classified and grouped under an interactive website, and they were being illustrated in the form of an information design which displays those everyday life activities via sound data. Data were further categorized and visualized according to the different layouts of the Hong Kong map, weekly calendar, scrollable timeline as well as different categorizations. It is a common practice for us to inspect our environment through video or photography. However, if the same cultural phenomenon is being displayed and visualized through a graphical interface and design, we could be sensitive enough to discover the details, status or the correlations between those elements, which could be neglected in other visual forms such as photography or video.

Moreover, re-presentation through the acoustic approach helps the reader and audience to explore for themselves and get a realization that is detached away from the routine life in reality, and hopefully such realization can help us to observe and understand more about the reasons behind such cultural phenomenon. It is believed that the final output of the "McSoundscape" website can help illustrating such cultural phenomenon of how Hong Kong people making use of McDonald restaurants as their "home" and participating in some daily activities that they would otherwise have done in other private areas of their own.

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Appendix A

Shop names (according to the McDonald's official web site) and addresses of all the McDonald restaurants that had been visited for this research project:

Shop Name	Address
Bonham Road	G/F & Lower G/F, Good View Court, No. 51 - 53 Bonham Road, Sai Ying Pun, Hong Kong
Causeway Bay Plaza II	Shop G04, G/F, Causeway Bay Plaza 2, 463-483 Lockhart Road, Causeway Bay, Hong Kong
Central	Basement, Yu To Sang Building, 37 Queen's Road, Central, Hong Kong
Cheung Chau	G/F, No. 101-103 San Hing Street, Cheung Chau
Connaught	Chuang's Tower, 30 - 32 Connaught Road, Central, Hong Kong
Hennessy	G/F, C.C. Wu Building, 302 - 308 Hennessy Road, Wan Chai, Hong Kong
Hill	G/F, 484 - 496 Queen's Road West, Sai Ying Pun, Hong Kong
Jordan	Basement, Pak Shing Building, No. 31 - 37 Jordan Road, Kowloon
KCR Hung Hom Station	Restaurant No.2, Mezzanine Level, KCR Hung Hom Station, Hung Hom, Kowloon
Metropolis Plaza	Shop No.106, Level 1, Metropolis Plaza, Lung Sum Road, Sheung Shui, New Territories
Mui Woo	G/F, Mui Wo Centre, No. 3 Ngan Wan Road, Mui Wo, Lantau Island
Queen Road Central	Shop 2A on G/F, Centre Mark, No. 287 - 299 Queen's Road Central, Sheung Wan, Hong Kong
Sai Yeung Choi	Shop B-1, Basement, Good Hope Building, 612 - 618 Nathan Road, Mongkok, Kowloon
Shatin Racecourse	Portion of 1st Mezzanine Floor, Grand Stand Two, Shatin Racecourse, Shatin, New Territories
Sing Shing	G/F, Sing Shing Building, 90 - 114 Wo Yee Hop Rd, Kwai Chung, New Territories
Sun Chui	Shop No. 1B, G/F Sun Chui Shopping Centre, Sun Chui Estate, Tai Wai, New Territories
Tai Po Central	Shop 57-66 , G/F, 4 On Chee Road, Fortune Plaza, Tai Po, New Territories
Tai Wo	Shop No. 102, Cooked Food Centre, Tai Wo Shopping Mall, Tai Wo Estate, Tai Po, New Territories
Tin Ping	Shop 122, Ground Floor, Tin Ping Shopping Centre, Tin Ping Estate, Sheung Shui, New Territories
Un Chau	Shop No. 9 - 19, Manor Centre, No. 213 Un Chau Street, Sham Shui Po, Kowloon
Uptown Plaza	Shop No. 009, Level One, Uptown Plaza, 9 Nam Wan Road, Tai Po, New Territories

Table 4.0, List of McDonald restaurants that had been visited for this research project:

Appendix B

More photos from the Apple Daily report (蘋果日報) published on 2007-04-30

Source:
http://appledaily.atnext.com/template/apple/art_main.cfm?iss_id=20070430&sec_id=4104&subsec_id=12731&art_id=7052150

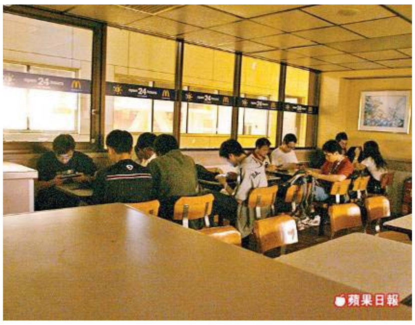
Original caption in Chinese: Kelvin 每周總有數晚到麥當勞打機直至深夜。
Caption translated: Kelvin said that he often comes to McDonald to play games until midnight, about a few days a week.

Original caption in Chinese: Iven 雖年逾三十歲，但經常到麥當勞以機會友，玩到凌晨兩、三時才回家。.
Caption translated: Although Iven is over 30 years old, he admits that he still comes down to McDonald and plays with other McGamers until 2 or 3 am before he goes home.

Original caption in Chinese: 這位不願透露姓名的女士聲稱，只因通宵沒車搭，才會滯留在麥當勞。.
Caption translated: This lady, who is not willing to tell her name, claims that the reason why she is stuck at McDonald is because there is no overnight transportation for her to go home.

Original caption in Chinese: 文叔（右）在銅鑼灣廣場麥當勞通宵讀報，而鄰座的女士已倒頭大睡，對記者的提問全無反應。
Caption translated: Uncle Man is reading newspaper overnight at a McDonald in Causeway Bay, while a lady sitting next to him was sleeping deeply and does not response to any question that we

ask her.



Original caption in Chinese: 凌晨兩點，觀塘裕民坊麥當勞分店已局部熄燈，但一班遊戲機玩家依然在大玩特玩。

Caption translated: At 2am in the morning, a gang of McGamers are having fun and concentrating on their connected games in the Kwun Tong McDonald Branch, even though most of the lightings have been switched off in some sections of the restaurant.

Appendix C

Blogger's comments:
(The followings are quoted from different bloggers' message on different blogs or web sites:)

> 24小時...不過佢都唔會趕人走既
(Translations:) >Its for 24 hours, but they won't expel people or ask them to leave the place (McDonald restaurants).

>不過我樓下果間D好煩, 一到9點度後半部份就要清潔, 就算一早坐係果度都要叫你坐返出面
(Translations:) >But the staffs of the McDonald in the neighborhood are not very nice, as they always clean up some sections after 9:30pm, even though you have been sitting there since earlier.

> 重有好多打機黨~ psp ndsl大戰機械獸
(Translations:) > There are even many McGamers who are killing Cyber Monster with their PSP and NDS handhelds.

> This happened b4 la!!! Aggress said McDonald tried 24hrs b4 and there were ppl sleeping over all the time!!
(Translations:) > This has always been happening before! Blogger "Aggress" said that ever since McDonald has opened for 24 hours, there have been many sleeping over all the time.

>覺得自己好幸福.
(Translations:) > I feel like I am very lucky by looking at the phenomena.

> 依家好多區都有"麥記賓館"
(Translations:) > Now there are many "McHotels" in many districts.

> 有能力又點會想咁先?
(Translations:) > Who is willing to do this if he or she has the ability to afford their livings?

> There are more and more ppl playing NDS in public area

> It happens everywhere these days.

Fantasy: > 露宿者之家
(Translations:) **Fantasy**: > The Home of the Street Sleeper

張雲: > 唔知係咪唔係首日通宵, 個收銀機冇用到, 要用計數機表示找幾多錢
多個地方俾係街通宵玩的小朋友, 打下機 好過俾人踢入會
(Translations:) **Chang Wan**: > Don't know whether it is because of the first night to run 24 hours, I have found that a lot of the staff have to use the calculators to do the changes for customers. It is a better place for the small kids to hang around overnight, instead of letting them exposed to the influence of the members from those triad societies.

Katherine Chan: > 日本d漢堡包平過hk 澳門1 蚊喎 一個漢堡包80 日圓（ 約5.3 港元）， 一杯咖啡 100 日圓（ 約6.6 港元）， 還可無限次添飲。
(Translations:) **KatherineChan**: > Those hamburgers in Japan are cheaper than the hamburgers selling in Hong Kong and Macau by HK$1 as they are selling at 80 yens (approximately HK$5.3); and a cup of coffee costs only 100 yens (approximately HK$6.6), and they can refill for unlimited times.

左少白: > 龍園m又為露宿者提供一個寄宿好地方, 近來天氣咁熱...岩晒~
(Translations:) Jor Siu Bak: >McDonalds at Lung Yuen is providing a very good accommodation for the street sleepers, especially the weather is so hot right now!

ky953123: 果度d冷氣好勁
(Translations:) **ky953123**: > The air conditions are too strong, making the place too cold to stay.

左少白: > 帶多件衫,有睡袋更佳~~~~~~~~~
(Translations:) Jor Siu Bak >Bringing more clothes will do, or it is better off to bring your own sleeping bags.

Fantasy: >帶埋psp, mp3, 乾電叉電機, 報紙, 雜誌, 毛巾, 牙刷, 衣服, 背包, 等等
(Translations:) **Fantasy**: > Should also bring with you the PSP handheld, MP3, electricity charger, newspaper, magazines, towels, tooth-brushes, clothing, backpack, etc.

pekheijnu: > 算啦,勸老麥唔好做到0甘絕,唔好趕人向入窮巷0甘趕佢地走啦
大企業要幫手承擔下d由政府施政失敗而引起0既社會義務同責任啦
反正夜晚開唔到賺得幾多, 0米比d人訓下law,唔好搞到其他客0米得law
(Translations:) **pekheijnu**: > McDonald should not expel them! The large corporations should sometimes share the social responsibility of taking care of the poor, which is due to the bad governmental policies. As long as the sleepers do not interrupted the other customers, McDonald should let them to stay there and they would not have a full house at night anyways.

> Hong Kong has once 無限次添飲 but now it is canceled. WTF.
(Translations:) > There was once unlimited refill service in Hong Kong, but now it has been canceled. WTF.

原梓畢 >「即係McRefugee,又叫做『麥記難民』呀! 傻婆」(近日在日本興起一個新字"McRefugees",意指那些辛勤工作,不肯攤大手掌領綜援,但工資太低,買不起樓,付不起租,索性將通宵營業的麥當勞當成超廉價宿舍,每晚進去買一杯咖啡宿一宵的人。原生想話振大綱,今鋪全靠麥當當 ...
(Translations:) Yuen Chee Butt: > McRefugee means people who are Refugees at McDonald, silly you! “McRefugee” is new word made in Japan, which means those people who work very hard and are not willing to take government subsidies; but at the same time they cannot afford to buy or rent a place as their extremely low wages. Thus, they would rather made use of 24 hours McDonald to become their cheap accommodations, as long as they buy a cup of coffee every night. Their intention is to gain some respect from the society, but they now turn out to become a dependent on McDonald...

> 香港除了麥難民還有機場難民啦..有空晚上去..
(Translations:) >Besides McRefugees, there are even Airport Refugees in Hong Kong… You better find some time to go there and have a look…

> 二十多人在店內呼呼入睡>>>好壯觀
(Translations:) >It is such a spectacular scene to look at when more than 20 people are making sweet dream inside the same restaurant!!

Appendix D

Observations and findings from the field visits in 2007:

1st Visit: (11-12 Nov 2007)
Date: 11 Nov 2007
Time:11:25 pm
Branch: Un Chau
Address: Shop No. 9 – 10, Manor Centre, No. 213 Un Chau Street, Sham Shui Po, Kowloon
Observation: The branch was filled with customers of different age groups. Some of them are dining but many of the rest were utilizing the place for other functions, such as reading newspaper, playing NDS, doing homework, watching movie on laptop, or even baby-sitting. One lady was actually watching the TV screen installed at McDonald, which providing information such as time, date, weather, HangSeng Index, address of 24 hours McDonald branches, local news update in the form of running text at the bottom, commercials, as well as entertainment (mainly as some sponsored MTV or infotainment about soccer games).
> *1 male (age of 40-50) – reading newspaper
> *1 male (age under 18) – playing NDS
> *4 youngsters, 2 female & 2 male (age around 18) – chatting, no food on the table
> 2 elderly, 1 female & 1 male (age over 50) – chatting, have bought drinks
> *2 Secondary school students, 1 female & 1 male (age under 18) – doing homework
> *2 lady (age around 20) – hang around and one of them talking on the phone
> 2 male (age of 30 & 40) – dining
> *1 male (age around 40) – working on laptop
> *1 man brought with 1 baby (age of 3) – playing around, chatting with staff, baby-sitting
> 1 male & 1 female (both age around 30) – dining
> *1 female (age around 40) – sitting and staring at the LCD screen at McDonald
> *1 male (age over 40) – reading newspaper while falling asleep
> 4 male (age under 20) – chatting, with drinks in hand
> 4 male (age over 20) – dining & chatting
Space Appropriation Percentage: 14/29 = **48%**
*(Notes: * means space appropriation)*
Interview: None
Photo:

Date: 12 Nov 2007
Time: 1:05am

Branch: Star Branch
Address: G/F & B/F Star House, 3 Salisbury Road, Tsim Sha Tsui
Observation: This huge branch of McDonald & McCafe is situated right next to the Tsim Sha Tsui Pier and it is supposed to be filled with lots of McRefugee in the past. However, since they have closed most of the area during 00:00 to 06:00, we even can hardly find customers there after midnight. Since all the lights were still turned on as other normal hours, it is very likely that such "temporary" closure is merely a tactic to deal with appropriation of space after midnight.
Interview: None
Photo:


2nd Visit: (12-13 Nov 2007)
Date: 12 Nov 2007
Time: 10:00pm
Branch: Prince (not for 24 hours)
Address: G/F, 416 Prince Edward Rd, Kowloon
Observation: Even though this McDonald is not opening for 24 hours, at least two groups of college or university students were doing group projects and discussion there, while a few others were reading newspaper. A couple of the gangs were playing PSP networked games together.
Interview: None
Photo:



Date: 12 Nov 2007
Time: 10:25pm
Branch: Sai Yeung Choi
Address: Shop B-1, Basement, Good Hope Building, 612-618 Nathan Road
Observation: As this branch is situated in the heart of a shopping district, there is always full house as the night of the visit. Although newcomers can hardly find spare seats, space was still being appropriated by some customers, such as working on projects, playing PSP/ NDS games, etc. However, a very different example was one large group of females (mainly university students) having a birthday party there. Instead of joining one of the McDonald's Fun-Packed Birthday Party, the group was holding a birthday party themselves as they bought their own birthday cake and occupied a large table with some spacious area. Although they had actually purchased some drinks at McDonald, however, they did not pay for the minimum service charge of HK$150, which would allow a birthday party to be

conducted at McDonald for only one and a half hours.
Interview: 1 *(refer to Appendix E)*
Photo:





Date: 12 Nov 2007
Time: 11:15pm
Branch: Full Win
Address: Shop B, G/F, Full Win Commercial Centre, No. 573 Nathan Road, Yaumatei
Observation: This branch is a small one, and there are only a couple of people dinning there. One teenage girl was enjoying her own chocolate while playing her NDS handheld. Her friend was sitting behind her and playing his own PSP at the same time. They are waiting for some other friends to meet at here before they head to another destination.
Interview: 2 *(refer to Appendix E)*
Photo:

Date: 12 Nov 2007
Time: 11:40pm
Branch: Langham Place (not for 24 hours)
Address: Shop Nos. 32-37, Level 2, Langham Place, 8 Argyle Street, Mongkok
Observation: Since it is situated inside a plaza, the closing time is around midnight. During the visit, there were still some shoppers dining at McCafe only. None of them are using the place for functions other than eating or chatting.
Interview: None
Photo:

Date: 13 Nov 2007
Time: 12:15 am
Branch: Argyle
Address: G/F, 105 Argyle Street, Mongkok
Observation: The first floor upstairs was closed during midnight, and very little space appropriation was found because the remaining seats are just a few and they are all facing the cashiers' counter directly. Not a single McRefugee was found, but many people were discussing their group project even though other customers cannot find their seats. Another guy also brought his own laptop to work with.
> 12 people – dining & chatting
> * 1 person– reading newspaper
> * 6 people – holding a group discussion on their projects
> * 1 person – working on laptop
Space Appropriation Percentage: 8/20 = **40%**
*(Notes: * means space appropriation)*
Interview: None
Photo:

Date: 13 Nov 2007
Time: 1:00am
Branch: Cameron Road
Address: Basement & G/F, L&D House, 2-4A Cameron Road, Tsim Sha Tsui
Observation: The "sleeping area" for McRefugee (as in the photo taken by Apple Daily) was closed during every midnight.
> 7 people – dining & chatting
> * 2 person– reading newspaper
Space Appropriation Percentage: 2/9 = **22%**
*(Notes: * means space appropriation)*
Interview: None
Photo:


Date: 13 Nov 2007
Time: 1:10 am
Branch: Hillwood
Address: G/F – 1/F Pacific Mansion, 172-174 Nathan Road, Tsim Sha Tsui
Observation: This is another branch with plenty of seats, including the McCafe upstairs. However, since McCafe is closed during midnight, not too many McRefugees and McGamers were found in this location, since there were not much secret corners which the McDonald staff cannot put an eye on immediately. However, there were a couple of McRefugees sleeping in front of the staff, and some others were reading magazines and books while waiting for the time to pass. It was even strange to notice that McCafe didn't expel a group of four who was discussion their own projects upstairs and occupied a table at a very far corner, even though the whole floor was supposed to be all closed at that time.
> 2 people – dining
> * 2 people – sleeping
> * 1 person – reading magazines
> * 4 people – holding a group discussion on their projects
Space Appropriation Percentage: 7/9 = **78%**
*(Notes: * means space appropriation)*
Interview: 3 *(refer to Appendix E)*
Photo:




Date: 13 Nov 2007
Time: 1:45 am
Branch: Jordan Road
Address: Basement, Pak Shing Building, No. 31-37 Jordan Road
Observation: Since every corner is opening for business in the branch, there are some

"comfortable" dark corners for our McRefugees to have a nice dream here. At the McCafe, I found 3 men sleeping there, with no food on their table. At the other section with easy concealment (they have fewer disturbances from staff because it was not an area where the staff at the cashier place can have a direct sight to look over it), there were a couple few more sleepers who were also middle-aged male. However, generally speaking, the staffs here were far more active in interrupting the sleepers or even customers by coming to sweep the floor twice, made some noise by moving chairs and tables, frequently check my table to see if the food was finished. Within an hour, two different staffs (normal staff as well as Manager) came to wake up all sleepers twice (at 1:45 am and 2:35 am respectively). The Manager actually woke them up by hitting their tables while complaining to them, "Don't sleep here! You guys are really doing too far! You have made the whole section looking like a sleeping section almost! How dare you!"

> 8 people – dining
> * 6 people – sleeping
> * 2 people – reading magazines & chatting

Space Appropriation Percentage: 8/16 = **50%**
*(Notes: * means space appropriation)*
Interview: 4 *(refer to Appendix E)*
Photo:






Date: 13 Nov 2007
Time: 4:10 am
Branch: Un Chau Branch
Address: Shop No. 9 – 10, Manor Centre, No. 213 Un Chau Street, Sham Shui Po, Kowloon
Observation: During 4am in the morning, McDonald has already been providing breakfast to customers. There a couple of McRefugees sleeping, reading newspaper, etc. Most of them are in their middle age and some elderly were attracted to come here for social gathering as well.

> *1 male (age 30-40) – sleeping, without purchasing any food.
> 3 females (age 40-60) – dining & chatting
> *1 male (age about 50) – reading newspaper
> 1 male and 1 female (age about 30-40) – dining
> *1 male (age over 35) – reading newspaper
> 2 males (age from 20-40) – dining

> *1 male (age around 45) – reading newspaper while falling asleep
Space Appropriation Percentage: 4/10 = **40%**
*(Notes: * means space appropriation)*
Interview: 5 & 6 *(refer to Appendix E)*
Photo: *(refer to the interview on Appendix E)*

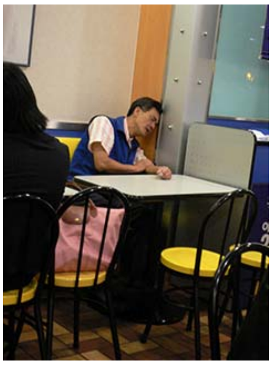
3rd Visit: (14 Nov 2007)
Date: 14 Nov 2007
Time: 09:40 pm
Branch: Un Chau Branch
Address: Shop No. 9 – 10, Manor Centre, No. 213 Un Chau Street, Sham Shui Po, Kowloon
Observation: This could be regarded as the golden time for many McGamers to meet here as there are at least 3 tables of gamers playing online games with their handhelds. It is also another peak period for study groups.
> 9 people – dining
> * 2 people – reading newspaper
> * 10 people – playing PSP connected games together
> * 7 people – working hard on homework
> * 4 people – chatting without any food on the table
Space Appropriation Percentage: 23/32 = **72%**
*(Notes: * means space appropriation)*
Interview: None
Photo:

4th Visit: (16-17 Nov 2007)
Date: 16 Nov 2007
Time: 11:55 am

Branch: Sai Yeung Choi
Address: Shop B-1, Basement, Good Hope Building, 612-618 Nathan Road
Observation: One special phenomenon from this visit is that a lot of commercial appropriation has been discovered in this branch. More than twenty broadband service promotional workers (mainly from PCCW, and most of them were wearing the black and orange color uniform) occupied more than 6 tables at the same time. From observation, they look like working hard on their client's contracts and they were doing mainly paper work. Some of the PCCW staff even keep coming down from the booth just around the corner and delivered a few more paper works immediately to their colleagues in McDonald. McDonald is like another extension of their mobile office which originally situated on the street. Some other officers of insurance company were also negotiating with their potential clients here. Although any kind of gambling games are prohibited in McDonald, another guy was playing poker game himself at another corner, needless to mention the large group of McGamers in this branch.
> * 21 people – promotional staff of PCCW working
> * 3 people – Insurance staff & clients discussing about their own business
> * 1 person – playing card games
> * 3 people – reading newspaper or magazines
> * 13 people – playing PSP or NDS handheld games (either separately or connected together)
> * 3 people – working hard on homework
> * 3 people – discussing on projects
> * 4 people – chatting without any food on the table
> * 2 people – sleeping
> 82 people – dining
Space Appropriation Percentage: 53/ 135 = **39%**
*(Notes: * means space appropriation)*
Interview: 7 *(refer to Appendix E)*
Photo:






Date: 17 Nov 2007
Time: 2:00 am
Branch: Sing Shing
Address: G/F, Sing Shing Building, 90-114 Wo Yee Hop Rd, Kwai Chung
Observation: Since most of the gloomy corners were closed for "cleaning", this McDonald was quite an empty one. However, one guy was sleeping inside the closed section and the staff did not expel him, even though they passed by his table.
> * 1 person – sleeping
> 3 people – dining & chatting
Space Appropriation Percentage: 1/ 4 = **25%**
*(Notes: * means space appropriation)*
Interview: None
Photo:


<u>5th Visit: (17 Nov 2007)</u>
Date: 17 Nov 2007
Time: 3:30 pm
Branch: Sai Yeung Choi
Address: Shop B-1, Basement, Good Hope Building, 612-618 Nathan Road
Observation: Again, this McDonald was filled with McGamers and McStudents during the tea time in the afternoon. Most of them were young people or shoppers who were either taking a rest or dining at the restaurant.
> * 3 people – playing PSP or NDS handheld games (either separately or connected together)
> * 10 people – working hard on homework
> * 4 people – discussing on projects
> * 4 people – chatting without any food on the table
> 64 people – dining
Space Appropriation Percentage: 21/ 85 = **25%**
*(Notes: * means space appropriation)*
Interview: None

Photo:


Date: 17 Nov 2007
Time: 4:45pm
Branch: Un Chau Branch
Address: Shop No. 9 – 10, Manor Centre, No. 213 Un Chau Street, Sham Shui Po, Kowloon
Observation: This was another peak hour for McStudents, as I could find more than 4 tables of customers working hard on their school assignments. Some of them were even parents giving tutorial to their own children in this public area.
> * 2 people – a mum giving private tutorials to her daughter
> * 9 people – working hard on homework
> 6 people – dining
Space Appropriation Percentage: 11/ 17 = **65%**
*(Notes: * means space appropriation)*
Interview: None
Photo:


6th Visit: (20 Nov 2007)
Date: 20 Nov 2007
Time: 10:05 pm
Branch: Un Chau Branch
Address: Shop No. 9 – 10, Manor Centre, No. 213 Un Chau Street, Sham Shui Po, Kowloon
Observation: McDonald always attracts many young people for all kind of social gatherings in the evening. This night was not an exception as many McGamers and McReaders were found. A couple of families were also dinning here while baby sitting their own children.
> * 10 people – reading books together
> * 3 people – playing PSP or NDS handheld games (either separately or connected together)
> * 10 people – working hard on homework
> * 4 people – discussing on projects
> * 4 people – chatting without any food on the table
> 64 people – dining
Space Appropriation Percentage: 21/ 85 = **25%**
*(Notes: * means space appropriation)*
Interview: None

Photo:

Appendix E

Details of the personal interviews:

Interview 1

> One of the University student (female, age around 20-23), enjoying the birthday party organized by themselves (the one in blue shirt as in the picture)
Q: Have you guys bought any food from McDonald? If yes, what have you bought?
A: Yes. 3 or 4 cups of McFlurry.
Q: How long would you guys stay here for?
A: about 2 hours
Q: Have you bought your cake from McCafe?
A: No, we have brought it to here.
Q: Why do you choose to hold your own birthday party at McDonald but not elsewhere?
A: It is more convenient for all of us to meet and come here. Also, this place makes people feeling lots of fun and freedom.
Q: Why don't you join McDonald's Fun-Packed Birthday Party?
A: Those are for small kids and we do not need those arrangements. We feel more relax by doing it our own ways.
Q: When do you usually come to McDonald?
A: It depends.
Q: Will you come to McDonald after midnight?
A: No.
Q: Do you love playing handheld games such as PSP or NDS?
A: No.
Q: Have you notice that there are many people playing these games at McDonald recently?
A: Yes. They actually play in many other places too.
Q: Do you think that they will be disturbing you if they do so at McDonald?
A: No. not at all.

Interview 2

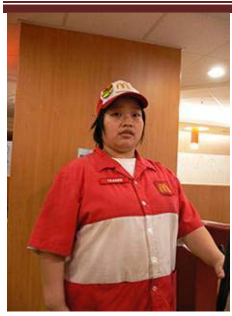
> Female (at the age of 18), playing NDS handheld game
Q: What are you doing here?
A: We are waiting for some friends to come over.
Q: Are you gonna to eat dinner here together?
A: No. We just gather here and then will go to some other places together.
Q: How long would you stay here for?
A: Don't know.
Q: Have you bought any food or drinks at McDonald while you wait here?
A: No. I am having my own chocolate bar.
Q: Why do you guys like to gather together at McDonald?
A: Because it does not cost me any money here.

Q: Any other reasons?
A: No.
Q: If McDonalds do not open for 24 hours, where would you go instead tonight?
A: We could be waiting on the street or at the entrance of some malls, etc.
Q: Have you ever play connected games with friends at McDonald?
A: No. I only play my own games on NDS, just like what I am doing now. He (the guy sitting behind her) is playing his own PSP.
Q: Have you ever seen people doing that at McDonald?
A: Yes.
Q: Do you think that they will be disturbing you if they do so at McDonald?
A: No. not at all.

Interview 3

> Female (age over 40), reading magazines
Q: What are you doing here?
A: We are waiting for my brother to come over.
Q: Are you gonna to eat dinner here together?
A: No. We just gather here and then will go to some other local cafes together. Originally I was waiting at the Cameron Road branch, but their air conditioning system just broke down, so I walk to here.
Q: How long would you stay here for?
A: I will leave very soon, as long as my brother calls me while he arrives.
Q: Have you bought any food or drinks at McDonald while you wait here?
A: No. Because I won't stay here for long.
Q: Why do you guys like to gather together at McDonald?
A: Since I work until very late, it is quite convenient to find the 24 hours McDonalds everywhere in Tsim Sha Tsui.
Q: Any other reasons?
A: Because it is a very bright and safe place to stay, and it does not cost me any money.
Q: If McDonalds do not open for 24 hours, where would you go instead tonight?
A: I may go to places such as Internet Café or local café in Mongkok and wait for my brother then.
Q: Have you ever seen any customers doing personal thing at McDonald, such as sleeping, playing connected games, etc?
A: Yes. Of course. Nowadays many people sleep at McDonald, just like the guy next to us. Many kids are playing handheld games too.
Q: Have you ever do those things at McDonald?
A: No.
Q: Do you think that they will be disturbing you if they do so at McDonald?
A: Not really. In face, McDonald usually woke them people up at 4 or 5 am so as to get ready for the business at the breakfast time.

Interview 4



> Staff at McDonald (age around 30), working
Q: Do you usually see customers sleeping at McDonald?
A: Yes! A lot of them sleep here every night, even though people eating next to them.
Q: What is the maximum number of sleepers you have ever seen at one night here?
A: Can't remember… something like more than 10.
Q: Is it allowed to sleep at McDonalds?
A: No! Never! But there is nothing we can do because we cannot expel them. So, we would rather tolerate it.
Q: What would you do to stop this phenomenon?
A: Our Manager would ask us to wake them up occasionally.
Q: Do you think the sleepers are interfering with other customers?
A: Yeah! That makes it looking bad!
Q: How about people playing games together here? Have you seen those?
A: Sometimes.
Q: Do you think that is disturbing kind of behavior too?
A: Hmm… not really. As long as they buy food here.

Interview 5

> Female (age 60), dining and chatting with friends
Q: What are you doing here so early in the morning?
A: I woke up early, and so I dated my friends to come over and have a chat.
Q: You have had your breakfast here?
A: Yes. We have just eaten.
Q: How long would you stay here for?
A: At least 2 hours usually.
Q: Why do you guys like to gather together at McDonald?
A: Because it is convenient place to meet my friends, since we all living nearby.
Q: Any other reasons?
A: We know the Manager very well here. In fact, she is also working at another McDonald in Sham Shui Po.
Q: If McDonalds do not open for 24 hours, where would you go instead tonight?
A: We may go to some other local cafes nearby.
Q: Have you ever seen people sleeping at McDonald?
A: Yes. There is one here now. Look!
Q: Do you think that they will be disturbing you if they do so at McDonald?
A: I think when there is full house, it is no good to sleep here. But during other times like right now, I think it does not matter to me. But still, it is not good to look at the place with so many

people sleeping and not eating or chatting here.
Q: Have you ever seen people playing handheld games together at McDonald?
A: Yes. There are many of them, especially during the summer time. But now you do not see them during midnight anymore. Because they have to go to school the other day.
Q: Do you think that they will be disturbing you if they do so at McDonald?
A: No. not at all.

Interview_6

> Male (age around 50), reading newspaper while falling asleep
Q: What are you doing here?
A: I am reading the newspaper while waiting for the train to my other home, Shenzhen.
Q: Have you eaten any McDonald's food here?
A: No.
Q: How long would you stay here for?
A: I will wait for a couple more hours, once the train is in service, I will leave immediately. That won't take long.
Q: So, you mean you do not have a home here in Hong Kong?
A: I am Hong Kong citizen, but my family is in Shenzhen. I work here now and then go back home in Shenzhen.
Q: Why do you like to stay here and wait for trains?
A: Well, I do not have to spend any money here.
Q: Any other reasons?
A: It is quite safe here.
Q: If McDonalds do not open for 24 hours, where would you go instead tonight?
A: I may go to other places instead. May be I will go to some local cafes nearby.
Q: That will cost you some money, won't it?
A: Yes. But everywhere costs some money except McDonalds.
Q: Do you do anything else here while you wait for trains?
A: I watch the news headline on the TV screen here, and sometimes I will write something quietly here.
Q: Have you ever seen people sleeping at McDonald?
A: Sometimes… People do not do that on purpose. They just fall asleep accidentally.
Q: Do you think that they will be disturbing you if they do so at McDonald?
A: No.
Q: Have you ever seen McDonalds' staff do something against sleepers here?
A: Yes, sometimes, they warn them not to sleep here.
Q: Have you ever seen people playing handheld games together at McDonald?
A: Yes.
Q: Do you think that they will be disturbing you if they do so at McDonald?
A: Yes, as all the youngsters are not self-disciplinary, they sometimes disturb me as they are too noisy.

Interview_7
> Mr Chan, Manager at McDonald (age around 45), working while being interviewed
Q: I want to know if you have noticed that there are any sleepers at your restaurants during the night time.
A: Yes, sometimes.

Q: Are there many of them?
A: Well, I would say these people only appear after midnight. There are quite a few of them.
Q: What would you do if they sleep at McDonald?
A: I will go to interrupt and wake them up.
Q: Is there any rules posted or published anywhere in the restaurants saying that it is not allowed to sleep at McDonald?
A: No.
Q: If not, what is the excuse that you use to wake these sleepers (McRefugee) up?
A: Well, we are afraid that there is any accident happened to them. You know, the sleepers may have some kind of emergency illness or something. We have to make sure they are feeling alright.
Q: Have you noticed that there are many PSP or NDS gamers playing at lots of McDonald restaurants day and night?
A: Yes, I aware of that.
Q: Are there many of them at your restaurants?
A: Yes, there are always a lot of them all the time.
Q: Would you interrupt them if they are playing games and not eating at your McDonald?
A: No. They are free to do that at here.
Q: Is it allowed to play pokers at your restaurant?
A: No.
Q: What if only a single person playing it himself?
A: Still not allowed.
Q: How about holding a private birthday party here by bringing in our own cake and stuff. Is it allowed?
A: You must join our “Fun-packed Birthday Party” instead. Nobody should hold their own birthday party on their own at McDonalds. You can take a look at our flyers here.
Q: Would you advice them to go somewhere else if you see that happening?
A: Yes, if I see them doing that here.

Ecolutive Systems

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Abstract
This document investigates about the hypothesis to create non-closed transformational processes which I call "Ecolutive", not confined inside the device and the language that has generated them.
Starting from some personal experiences, I analyse the peculiarities of this type-making process; I compare it with that systems which have the ability to "respond" to signals and values with metamorphic properties, have the ability to grow, adapt themselves and develop, but are born and limit themselves to "live" in the restricted area of the device or of the context for which they have been thought and implement themselves through the specific of the languages from which they originated, in specific realities where the rules are revealed and are generally accepted and shared.
I take into consideration examples of relashionship between operator, environment and final-user with operative and conceptual esthetic, where the variables are broadened to the environment universe; and also where the rules of the game may be not shared and known.
In other words I analyse procedures which influence is extended and with evolutional property. I evaluate the aspect of the conscience not as a pure reaction of astonishment in relation to the mimetic-simulative aspect, but as a part of the experience. I also estimate the graphic interface as an non impartial date of an experiment, a strong indication of field.
KEYWORDS :
Evolutive, non circumscribed , conscience, systems, environment, mimetic-simulative, influence.
Videoinstallation:
Signals for animals. A broadened system of relations in dynamic man-animal / animal-man context.

"La mentalità cinese antica contempla l'universo in una maniera paragonabile a quella del fisico moderno, il quale non può negare che il suo modello dell'universo è una struttura decisamente psicofisica. L'evento microfisico include l'osservatore proprio altrettanto quanto la realtà che forma il sostrato dell'I King comprende delle condizioni soggettive, ovverosia psichiche, nella totalità della situazione momentanea. Come la causalità spiega la sequenza degli eventi, nella mentalità cinese la sincronicità spiega la loro coincidenza"

J.C.Jung, I Ching -Il Libro dei Mutamenti (Book of Changes) (1995). A c. di R. Wilhelm e C.G. Jung. Milano: Adelphi.

In the early Eighties, in various projects and works, I was trying out things that I later discovered were of interest to many fields, although my approach was to do these things in a transversal way.

PREAMBLE

Authorship

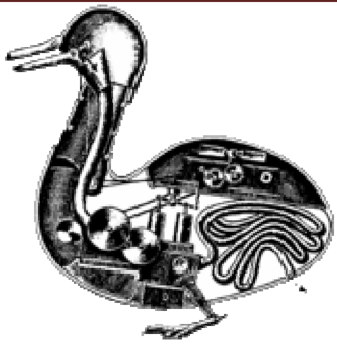
It seems that very little time has passed since Leonardo da Vinci argued with Botticelli about whether liquid paint thrown at a canvas would have been able to suggest countrysides, woods, crowds or the like. When the idea of authorship comes into doubt, it seems clear that this will be followed by a reaction of rejection. It is well known that Leonardo invented games for the imagination by interpreting stains as various forms. In Zen painting and the more recent Action Painting or in the wider *L' Arte e Vita* movement, we can see a constant struggle between intention and occasion, *chance and necessity*. A ceaseless bargaining between a closed operational approach, opposed to the open conception of certain methods, that are some of the diverse ways of accepting chance, divination, choosing between freedom within the project and controlled intention. Generative art has its origins in kinetic-Stochastic nature that can be seen in conceptual, cultural and material objects that are very different to each other. This clarification is necessary because this analysis tries to cross the boundaries of a purely perceptional reading of kinetic phenomena, as it is a development that mutates. This is because we can identify them in operations that extend their actions into reality. It should be clear that here reality is considered to possess the qualities that belong to cyberspace, even when it leaks out of the areas that can be more precisely considered 'virtual'. For us, 'material' is not simply 'non-virtual' and virtual' something other than 'non-material'. This is helpful, not so much as to study the fully-recognised historical roots and the importance of the phenomena of kinetic art, but rather to find links between the physical world and the simulated one.

Un organismo, o un automa, composto di solo hardware può esistere e conservare il proprio metabolismo, e vivere una vita indipendente, finché troverà nutrimento, ovvero numeri da macinare. Al contrario l'automa tutto software e niente hardware sarà per forza un parassita: funzionerà soltanto in un mondo che contenga altri automi, da cui prendere in prestito l'hardware, e replicherà se stesso solo se riuscirà a trovare un automa ospite cooperativo, come fa il batteriofago quando riesce a trovare un batterio disposto a collaborare…..

Freeman Dyson, origini della vita, bollati Boringhieri, Torino 1987

Artificial lives

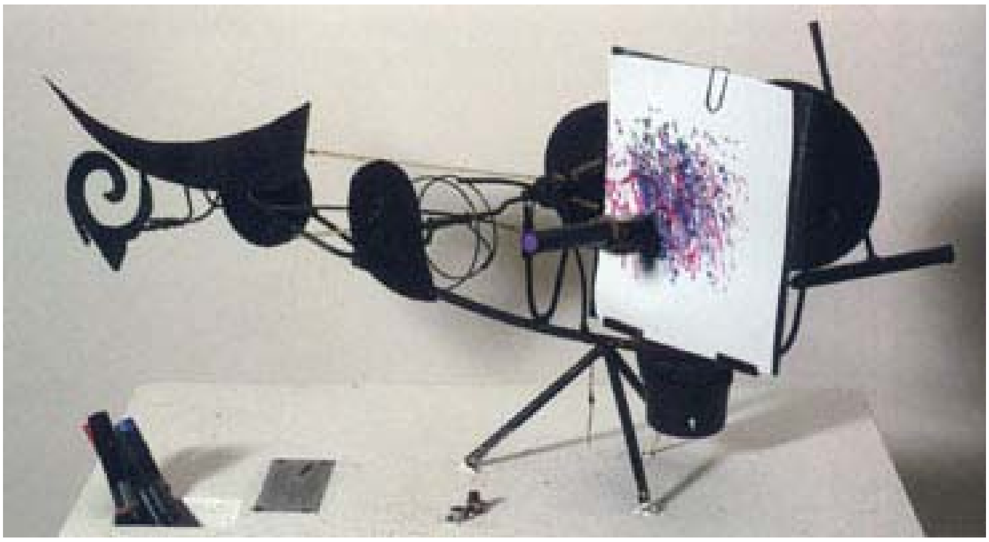
Certain questions regarding the body, nature, artifice and language derive in particular from the coordinate system theory of Descartes, who tries to find the physical location of the conscience (then identified in the pineal body). This theory is fundamental for conceptions that deal with life. We should remember the anatomical theatres, fashionable for a period for their shows during which animals were dissected. There was a common tendency at the time to create often-surprising automatons, clearly inspired by that train of thought. These origins have cast many long shadows, representing in some respects an act of re-birth, but also a strongly distinctive mark for a long time. When talking about simulation, we seem to move over a single plane of related indissoluble impressions such as: it doesn't seem to contain any life, it isn't conscious, or : it seems alive and intelligent. These projections have been present in different historical periods and with diverse weight.



The automaton-duck by the French inventor and mechanic Jacques de Vaucanson (1709 – 1782).

During the last century, artists like Marcel Duchamp, Lazlo Moholy Naghy, movements like Futurism, Kinetic or *macchinica* art, and Bruno Munari, added a new horizon to art, with aspects that almost seemed to hide the importance of the author. Multiform and vital, they flirt with existence.
E' la stessa esperienza di Cage quando suona il suo pianoforte "preparato". L'aritmia meccanica rende le macchine più "viventi", più interessanti, più piacevoli. Meno stupide e monotone.
Dall'intervista a Bruno Munari di Luca Zaffarano,1987

In music, Iannis Xenakis is one of the first to use information technology and calculators to compose music. In the Sixties, Kinetic or programmed art considers these questions, even though Bruno Munari had already written a 'Manifesto of mechanism' in 1952. The movement conceives of the project as detached from the subjectivity of the artist who now becomes a *visual operator*.



Meta-matic, Jean Tinguely, 1959

Jean Tinguelly creates machines that self-destruct, that disobey and do not respond to commands, such as the work Meta-matic, through which he creates interaction with the operator. It is a slot-machine that paints pictures automatically. In this context, Informatics is soon involved and the operation is controlled by a computational system. This work was a journey between the dimensions of reality and virtual reality, between automatism and the resolved, between open and closed systems, between art and life.

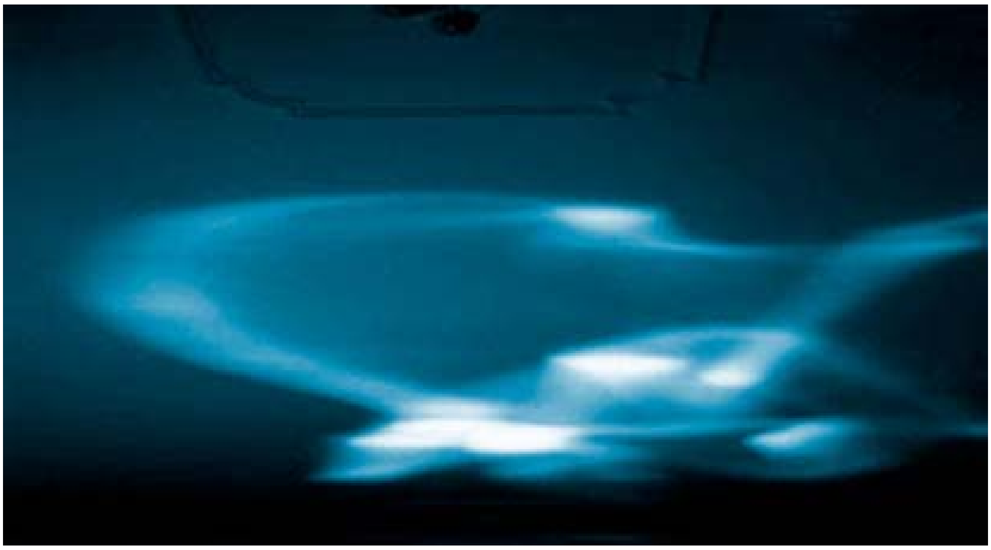
Trails that lead to the concept of *ecolutive:*

Noi dobbiamo considerare il tempo come ciò che conduce all'uomo e non l'uomo come il creatore del tempo.

Ilyia Prigogine, La nascita del tempo. Theoria Ed. Roma - Napoli 1991

Teoria and Periodo

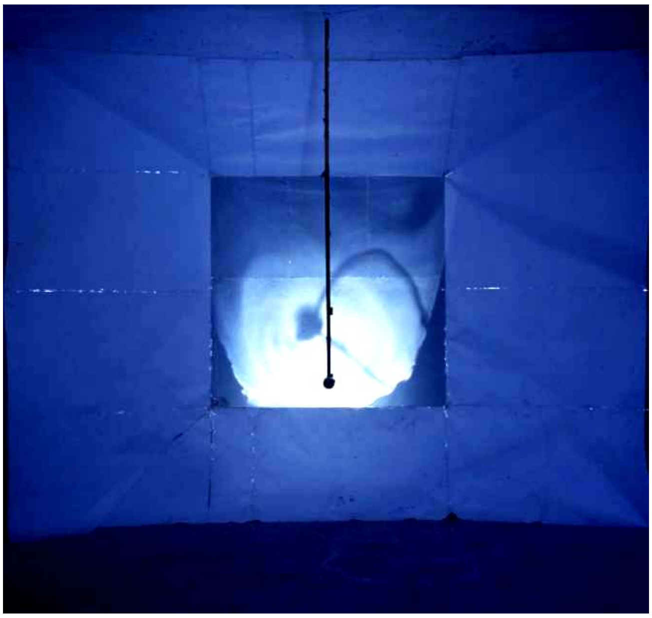
In 'Periodo' and 'Teoria' of 1983-89 and 1987-90, we already find the insertion of uncontrolled elements that are intrinsically 'interactive'; there is time and conscience insofar as there is the possibility of a relation between the 'operator' and the 'receiver'. There are elements that owe much to physics as they are liquid perturbations that relate to non-Euclidean geometry and are in rapport with the 'Roller' series, three-dimensional grid-drawings obtained by a non-manual process.



Teoria, 1987/90, Variable measurements. Electronic device and robotic system. From the catalogue of the Civic Museum of Gibellina "O generata" 1991.

These systems include the element of the complexity of forms that are never constant or equal, and that in addition include the quality of indeterminable. They have been created using a device with a small robotic, controlled by an electronic system. The idea was born during observation of natural and chaotic elements that produce casual structures to which the observer through various readings, can gradually tune in. the evolutional range depends on the observer: these perturbations take on the value of the future in his conscience. Time is evolutional because it bears the traces of the conscience of the user.

Periodo, 1983/87, electronic device and robotic system, screen. Variable measurements. From the catalogue of the Civic Museum of Gibellina "O generata", 1991.



TEST, 1998, electronic device, robotic system, electronic sounds. 500 x 300 cm. Salsomaggiore, International Prize 'Scritture D'Acqua' (literature, arts and science) 1998.

The clear and incontrovertible data of subjective and objective disappear if one doesn't accept as the initial certainty the existence of work and artist, user and work….
Extract from the press release of the exhibition of the International prize "Scritture d'acqua", Salsomaggiore, October 1998.

EXIT, 1997, Environmental measurements (particurlar) Hackmeeting 2002, TPO Bologna

In 'EXIT' we have a suspension that can be perceived through a tear in space-time (stopping the drops in mid-air). The gap that is created in this sensorial emptiness, where the perceptive fact is radically reduced to its fundamental, primary data, is violent and ecstatic. As in other occasions, there is an interest in the 'fusionality' of the autistic world… (from the press release)

Also These, conceptions of space and liquid time, are also fluctuations. These approaches do contain special 'generative' qualities. In the computerised simulations, the dichotomy between nature and artifice could sometimes end up being emphasised, even though the initial premise is exactly the opposite: *Look at the nice natural artifice that I have created*. The emulating of forms of nature can emphasise this component (objectivity, distance) of the creator, so it can then be projected. Often there is the tendency to consider *tout court* as generative only technological phenomena, and to think that only these can share these principles. But also the stasis of a real object becomes generative by repeating itself. Its "sameness" in time is a probable characteristic of its appearance, if this refers to the totality of the plane and universal time. A generative process is frozen at the moment in which we stop looking at it. It feeds itself and is implemented by our conscience. When I go back and observe it, it is true that it will be different but it will also be another phenomenon. An input of the evolutional conception that leans towards introspection may be more fitting. The participation, the nature and the distance of the author/user, are strongly related to the profound quality of perception that is not distinguished from action: the act of doing and perception are simultaneous and inseparable, the quantity and quality of perceiving.

Ad esempio, il grande contributo scientifico alla fisica teoretica venuto dal Giappone dopo l'ultima guerra può essere un un indice dell'esistenza d'una certa relazione tra le idee filosofiche dell'estremo oriente e la sostanza filosofica della teoria dei quanta. Può essere più facile adattarsi al concetto di realtà della teoretica quantica quando

non si è passati attraverso l'ingenuo modo materialistico di pensare che prevaleva ancora in Europa nei primo decenni del secolo.
Werner Heisemberg, Fisica e Filosofia, il Saggiatore, 1994

I am working on the idea of the death of the public (not physical, not violent, not provoked), the extinction of the species insofar as complementary polarity. Art cannot be called art without considering the aspect of the experience. As this experience is conditioned by data relating to shared space-time relationships with the user, the 'necessary conditions' are by no means taken for granted, and in fact become the decisive factor. The establishing of a relationship with any perceptive fact becomes an act of conscience, so it is necessary to accept the plane on which we act, or even better, the shared planes of the states that have been culturally imposed on perception. 'Conscience' thus becomes for me a place of work…
"Arte per corpi", 1993. Extract from the participation at the Neon Gallery, Bologna,
Mal di testa, 2003

From mutation within the system to circular action (ecolutive)

Mappe Immaginarie - Solarium

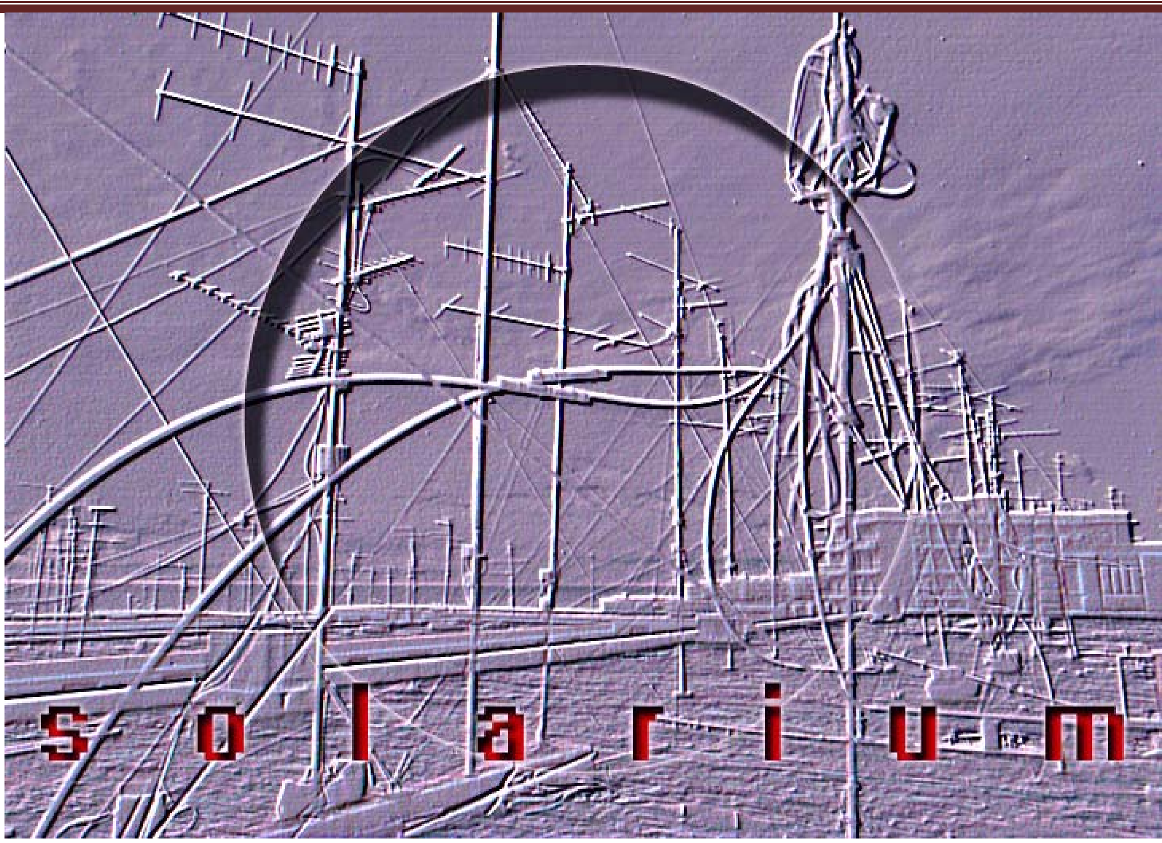
The series of *Imaginary Maps* begun in 1983 with geographical maps as satellite readings, and the intervention-installation *Solarium* of 1984 on terraces and among antennae, are fundamental stages for the origins of the idea of *Signs for Animals* of 1986, and for the consequent meditation on the concept of '*ecolutive'*. These moments were introduced by an interest in satellite surveys and the notion of transmission of energy-information via ether.

Solarium

1983, Poster for the event using an imaginary map

Solarium, 1984. Intervention, grouping, observatory, Environmental dimensions.

Solarium



Solarium, 1984- 2002

The highest point of a building is the extreme extension towards the sky, towards space, a place populated with antennae and delegated to reception and transmission. It is fundamentally from here that the many signals leave and arrive, signals that influence our daily perception, with information that is not just visual, but that determine the mapping of our planet, even influencing the less predictable politics of the geography of daily living that expands across the ether. Like an eye that has imposed itself on all, on the possibility of seeing, not just objectively, and it has created reflections, including the hypothesis of an external extension, the satellite…

Extract from the Presentation-poster for FreaknetMediaLab Catania 2002, and Warm Up, at Neon Gallery, Bologna 02-2003

Ecolutive systems : a definition

By *ecolutive*, we mean systems that produce effects in macroscopic areas that are not limited to material and immaterial devices of physical origin and substance. They are systems capable of generating tangible effects on the environment, on man, on living organisms interconnected by these processes, modifying behaviour, language, genetic structure, in the sense of adapting-evolving it.

Comparisons with other typologies

The term *ecolutive* makes sense if compared to other systems that foresee a certain degree of self-adaptation or interaction, but whose action doesn't produce tangible effects beyond that system. It must be made clear that evolution is obviously always taking place in nature, but the specific nature of the *ecolutive* device consists in the capacity in which it can contribute specifically to evolution, insofar as it is a programme that works by inserting a finalised novelty into the ecosystem. In the project *Signs for animals*, for example, the organism that perceives the signal as danger and adapts, has more possibilities of survival by transmitting, could be triggered as a selective action

Si può a priori sostenere che tutte le percezioni e tutte le risposte, tutti i comportamenti e tutte le classi di comportamenti, tutto l'apprendimento e tutta la genetica, tutta la neurofisiologia e l'endocrinologia, tutta l'organizzazione e tutta l'evoluzione, insomma tutto un vasto campo dev'essere considerato come avente natura di comunicazione. Ed è pertanto soggetto alle grandi generalizzazioni o "leggi" che valgono per i fenomeni di comunicazioni.

Gregory Bateson, Verso un'ecologia della mente. 1976 Adelphi Edizioni, Milano

There are many projects in which a device interacts with man and man with it, stimulating behaviour, reactions, considerations, gradations and different shades of these options. These devices do not have the aim and to capacity to act on a deeper level. They are limited to sensorial, behavioural or conceptual levels. They interact with reality but at an immediate level. The *ecolutive* system, when compared to these others, tends to provoke a profound and selective modification of the organisms on which it has effect. For devices with immediate interaction, the action ceases when the effects of the direct contact with the device are interrupted.

Ma che cosa dire in relazione al compito successivo di comprendere la vita psichica animale, di portarla a un'esperienza progressivamente sempre più perfetta, di procurarsi anche solo un'intuizione delle sue possibilità vitali e un'intuizione del mondo in quanto tale per la vita animale , o ancora intuizione dei suoi interessi vitali, dei suoi scopi e obiettivi, e così via? Se falliamo in questo compito il nostro mondo non ha dunque, e in definitiva in modo essenziale, un orizzonte di indeterminatezza?

Edmund Husserl, Metodo fenomenologico statico e genetico. Il Saggiatore, Milano 2003

Signs for animals, 1986. man/animal/animal/man

Born in 1986, this work is intrinsically linked to my Solarium project of 1984,as it takes up the problem of topography and telematics; here however, the urban and extra-urban spaces are imagined as an extension of language, no longer directed from man to man, but from man to animal and animal to man. Art changes its reference point, no longer thought of as communication between humans. Communicating devices, using satellite tracking systems shift the possibility of immediate interaction between man and animal onto the road-network, where the experimental project becomes the inverted extension of language that is no longer restricted to galleries and between men. Devices with sensorial and acoustic actions, visual and electronic impulses, are installed in the urban and extra-urban road-network, in air and sea communication via satellite, between the normal road-signs and tracks and inserted into vehicles in order to avoid the accidents caused by the 'inevitable' collisions with animals in the relative contextual environments. But it is also and above all an urban and spacial possibility, where the project is extended to possible relationships between man and other species. A broader interaction, obtained not only through technological devices, sensors and the like, but also a study of the links of perception and communication-language between man and animal, technology and vehicles.

Estract presented at the FreakNetMediaLab, Catania 2002, at the Civic gallery Montevergini, Siracuse 2006.

The starting point is the idea that it shouldn't be taken for granted that animals should be left dead along the roadsides. The problem has never been adequately considered. So the hypothesis was to create an art of extended systems, a process of change that shifts the interest to contextual environments imagined with a greater complexity of relations between environment, man, maps, language and space.

Diverse levels of action

This level of the project is still basically linked to the devices. It doesn't affect the deeper quality that makes up the *ecolutive* principle. This plane is affected when we go beyond the strictly material characteristics and the direct sphere of influence of the device. This still concerns the immediate action that it has on the organisms which are reached by the signals and the short term effects; that is, the presence of signals as 'warning'. This could still be confused with simple conditioning. The moment strictly defined as *ecolutive* is concerned with behaviour, communication, language, learning, transmission, mutation and space. Here, the animals affected by the device, due to a reasoned choice per area, according to the species present and exposed to the context involved, receive specific signals that have been studied with the collaboration of etiologists. On the same level, a man in his car using a GPS system, is reached by a signal that corresponds to the position of the animal. This 'short circuit' contains a very important element: both subjects involved are simultaneously aware of the others presence.

Telematics, maps, GPS

The distinction between model and reality made by Alfred Korzybski in his book 'Science and sanity' of 1993 is well-known. Our mental representations, our descriptions are not reality and the map is not the territory. There are representations of maps of cyberspace, of the development of projects for 3D visualisation and maps of the analysis of Internet use in real time. Apart from military use, there are various approaches that use the surveying of territory and its mapping using GIS satellite systems. Moreover, a sociological reading has been done with an analysis of cross-referenced data, that aimed to study migration routes, environmental factors such as de-forestation, pollution, social behaviour, settlements etc using diagrams, statistic flow-charts applied to maps.

Solarium/4, 2005. Video-installation 3d, video frame. Environmental dimensions. Montevergini Civic Gallery, Hypogeum of piazza Duomo, Syracuse. Seconda giornata del contemporaneo, 2006.

In systems of road navigation and in a different way, naval navigation, virtual visualisations are created, the map is modified by the software and the data is updated periodically to give information about navigation on the screen. They are therefore basically ‘virtual’ maps that are more precise, up-dated and diverse, without going far from the usual criteria of application, even though the satellite system controls the movement in real time. Studies for meteorological use as we see them are like *video frames* and are up-dated much more frequently, so the evolution is a continual succession of diverse images of the weather situation in various moments. The projections or forecast for the future developments are obtained through instruments for calculation.

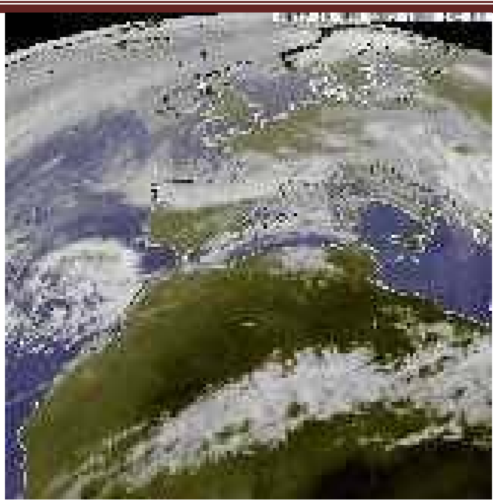


Image of a meteorological system at a given time

This presentation doesn't presume to be a complete and circumstantiated analysis of the technology applied to the project, but a short preamble to the application of a diverse philosophy of approach to the reading of the territory and behaviour at the level of language and communication between species, behaviour which is today surprisingly fortuitous. What the project does is to associate telematics to a typology of design-sign articulated with a dynamic-plastic and linguistic quality.

Animals:
The language level:
This point would require a very careful analysis, but would open discussions too vast for consideration her.
It seems that we will be able to understand what animals are thinking within fifty years. According to a projection by the 'New Scientist', an instrument capable of gathering, amplifying and transmitting the emotions and thoughts of animals will be created.

Scheme of circular relations
In effetti, vi sono importanti differenze tra il mondo della logica e il mondo dei fenomeni, e queste differenze devono essere tenute presenti ogni volta che basiamo le nostre argomentazioni sulla parziale ma importante analogia esistente tra i due mondi……Proprio nel campo della comunicazione tra animali e tra macchine deve valere qualcosa di simile alla teoria dei tipi
Gregory Bateson, Verso un'ecologia della mente. 1976 Adelphi Edizioni, Milano

The origins

The considerations that such a project stimulated at the beginning, above all because it was conceived of as an art project, were quite representative; ranging from the Franciscan idea to an animalist ecology, to a Disney-style projection into the world. Or it was seen to be the intention to equip oneself with a simple safety device designed to improve driving standards, like the many that exist today to protect against the dangers of mist, obstacles, traffic-jams, to simplify the hunt for streets or addresses. As if the communication interface between different species was less significant than imagining cars with a conscience. Seeing that the evolutionary state of the species is a quality that is polarised by the thought of the other, tied to the relative weight between entities that are part of a communal habitat, this cannot but proceed simultaneously.

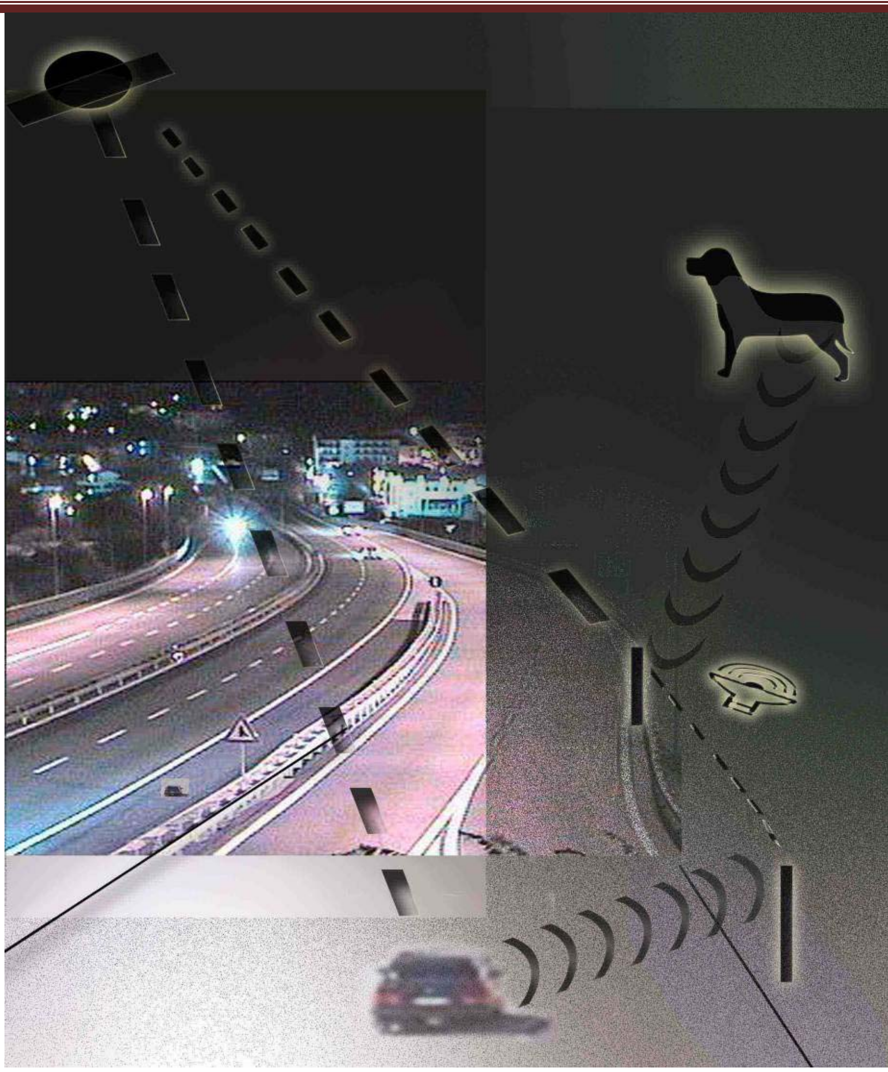
È sorprendente cosa possa fare il principio di selezione ad opera dell'uomo, cioè scegliere individui con una qualsiasi qualità desiderata, farli riprodurre e poi di nuovo operare una scelta. Gli stessi allevatori si sono meravigliati dei loro risultati……La selezione è stata metodicamente esercitata in Europa solo nell'ultima metà del secolo ma era stata praticata occasionalmente, e in certo grado, anche metodicamente nelle ere più antiche……L'uomo, per mezzo di questa facoltà di accumulare variazioni, adatta gli esseri viventi alle sue esigenze - si può dire che faccia in modo che la lana di una pecora sia adatta per i suoi tappeti, quella di un'altra per i vestiti e così via.

Charles Darwin, L'evoluzione. 1994, Newton Copton editore, Roma

One could object that these evolutionary leaps should have taken place already: one or more cars make noise, they have a strong visual impact and above all they kill. Probably there has already been an evolution, but vehicles are also a problem for man, who is their inventor. The change has been too complex, advanced and rapid for man too. Man's perceptive system has not managed to evolve the capacity of evaluation to respond adequately to certain stimuli. Road-signs are designed to fill this gap, but only for man.

Non vi è dubbio che nel corso di milioni di generazioni siano casualmente nati individui con qualche lieve variazione, utile a qualche settore della loro economia. Questi individui avranno una migliore probabilità di sopravvivere e di riprodurre la loro struttura nuova e leggermente diversa; la modificazione potrebbe venire lentamente accresciuta dall'azione complessiva di una selezione naturale in un certo grado utile.

Charles Darwin, L'evoluzione. 1994, Newton Copton editore, Roma



Scheme for circular action of device for Segnaletica per animali

The vehicle is tracked by sensors at the road-side; the signal is transmitted further ahead, depending on the speed of the car. If the presence of an animal has been noted in the area, then a (specific) alarm signal goes off to warn the animal of imminent danger. At the same time, a signal is transmitted from that spot to the satellite system, which then transmits it to the driver on his car's navigation system.
As concerns the survey systems for tracking animals, the most suitable device is a system of artificial vision with an interface with neural network software, capable of tracking situations at the limit of normal conditions in a given area. A notable series of system behavioural parameters can be identified.
Per It is a circular relationship, an interaction between various levels and factors. The *seganletica per animali* system has a technological level made up of sensors, transducers, transmitters, programmed software, with flexible qualities that can respond in different ways according to the behaviour of man and animal. It begins with a device programmed with algorithms, which reaches the environment, reacts strongly, send back signals to the device and regulates itself with the feedback.
To conclude, this sort of action can be considered to be a communicative quality that adapts, modifies and evolves, with characteristics that can be defined as *generative*. The levels of the generative aspect are established to begin with by the operator with a totally arbitrary act; it is the knowledge, history and culture that define the object,

entity, dimensions and quality of the observation. All in all, science and art do nothing other than always and only define various levels of ‘generative’ openings of action and thought; what a week ago was mere coincidence is intention today. This is determined by the catalogue of past operations that have become literature.

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Towards an Automatic Layout Transforming Game Using Shape Grammars Approach

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Abstract

In the design process, game designers maybe only have a few unique concepts about game stages. Through the layout of game stages, designers can imply some messages for players, such as that guide the how to operate of the game, or express designer's creative idea to interact with players. Game designers want to design rich and various game stages to satisfy with players continued playing, however, a huge number of game stages on the design of the game designer are heavy burden. And the fixed setting and ending of game is boring for game players. Hence, the research focuses on catch the designers' main concept that guide game player to do unconscious behaviour in game stages. If designers take the main concept transform the element of generation, game would keep designers' concept and generate more various by the analysis of players' behaviour.

In this research, we will take "Snow Bros" that 1991 CAPCOM USA developed it, as an example of the game layout of game stages, steps: (1) to find the main concept that is designer's main expression in the stages design, (2) to define the shape rules, (3) to generate the new layout of game stages by shape grammar.

The purpose of this research is to catch the designers' concept and transform them into a procedural description. It not only lets designers to see analysis of rules generated from the use of new design, but also initiates the unexpected game. And game players are able to experience the virtual world of immersion.

Keyword: Shape Grammar, Generative Game Design, Concept Generation

1 Introduction

1.1Background

Game usually is developed by game team. They plan the rules of the game, process, screen, and all kinds of feedback to present their creative ideas and thinking. Then, the game makes players (game players) enter the world that is built by game designers. Therefore, all setting of game is fixed by game designers while the game is released. But, the games have changed in order to provide the situation in the recent years. For example, a game has multi-story or multi-ending. It even becomes a social activity. The player interacts with the other players, such as network game and online game. This way will have unexpected ending or no ending.

"Generative Design" is a Computer-aid Design. Designers cannot remember the exact huge, and it is difficult to deal with high-repetitive things, but the computer can. The designers will be limited by culture and thinking, but the computer will not. However, the computer cannot identify human emotion and cognition, but the designer could be. As a result, both through mutual assistance, the computer can accurately generate the thousands of combinations, so the designer has a selection of beauty. Even trigger an unprecedented combination of new designers' creative ideas.

However, the other good way is the game generates the different results with player's behaviours by generative design in real time, rather than set up by game designers. Game designers just make the direction of the game, retaining the fundamental elements of the game. It's not only increas the possibility of the game, but also the huge generative results spring designer's creative idea.

1.2 Design Problem

In my view, the rules not change in the game, the change of layout of game stage can let player continue to involve in. Designers used layout of game stage to hint player how to play. While players played game, they maybe failure or obtain some feedback. They tried to solve some situation over again and again, and then regarded the process of play as an experience. I think that is designers would like to tell them the message.

There are interaction between game designer and player and hides in layout of game stage. Whenever the players encounter similar shape layout in the stage, they will remind that successful experience and try the way to deal with. The ways gradually become a set of players used to play, and it's just for every player himself or herself. This behavior is unconsciousness for players.

Therefore, this study analyzes the relationship between player's strategy and layout of game stage, and then generates the layout of game stage based on players used to attack the monster. The layout of game stage can be changed the arrangement in accordance with player's habit. The players are more involve into the game.

The paper has five parts: (1) Introduction: a brief description of this article; (2) Reviews: the overall game and shape grammar of literature review; (3) Methodology: A description of research methods and processes; (4) Implementation analysis Snow Bros, define shape and rules; (5) Generative Results: to display the results of generation; (6) Conclusion & Future work: sum up this study and conclusion.

2 Reviews

2.1 Game -- Snow Bros

"Snow Bros" is developed by CAPCOM U.S.A. and released by Nintendo of U.S. companies in 1991(Figure 1). It's similar to the other game named Bubble Bobble. The story of game is very simple and classic. A pair of brothers, Nick and Tom , by the devil's curse into a snowman, the Princess was taken away by devil. Consequently, the goal is "Defeat the devil, rescue the princess, and remove a curse."

Figure 1 *the Tile of Snow Bros*

This game emphasizes the collaboration of two players. The player has to clear all monsters for going to the next stage. Every ten stages have a Boss. And, the game totally has 50 stages. With the number of stage increase, stage is relatively difficult to rise. The player throws snow at each monster until completely become a snow ball. When the snow ball covered, player can roll it. Every monster would die out if the rolling snowball touches them. Then, they turn into additional bonus for player. If one rolling snowball can eliminate all monsters of one stage, the money will fall down. Besides, the player also goes ahead, go back, and jump to close or far away the monsters (*Figure 2*).[8]

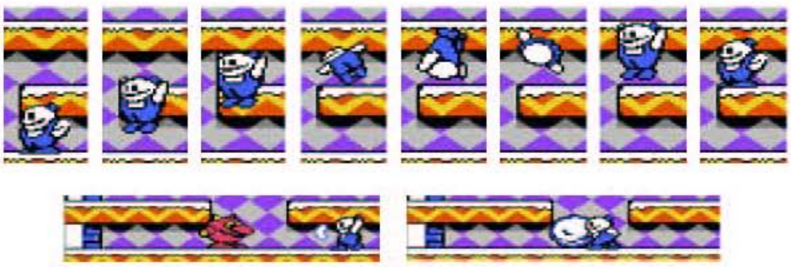

Figure 2 the process that player jumped and eliminated monster

Each stage is divided into three Layers: Background Layer, Tiled Layer, and Sprite Layer (*Figure 3*). Firstly, Background Layer is the base of the stage, and not obstructs characters (the leading character and monsters). Secondly, Tiled Layer is a foreground of stage, which is differently arranged in every stage (in this study to explore the part). Compared to the Background Layer, Tiled Layer is a scene of blocks. In the production of Tile Layer, designer used few single graphics to be repeated collage in order to save memory consumption (*Figure 3*). Lastly, Sprite Layer is where characters are placed.

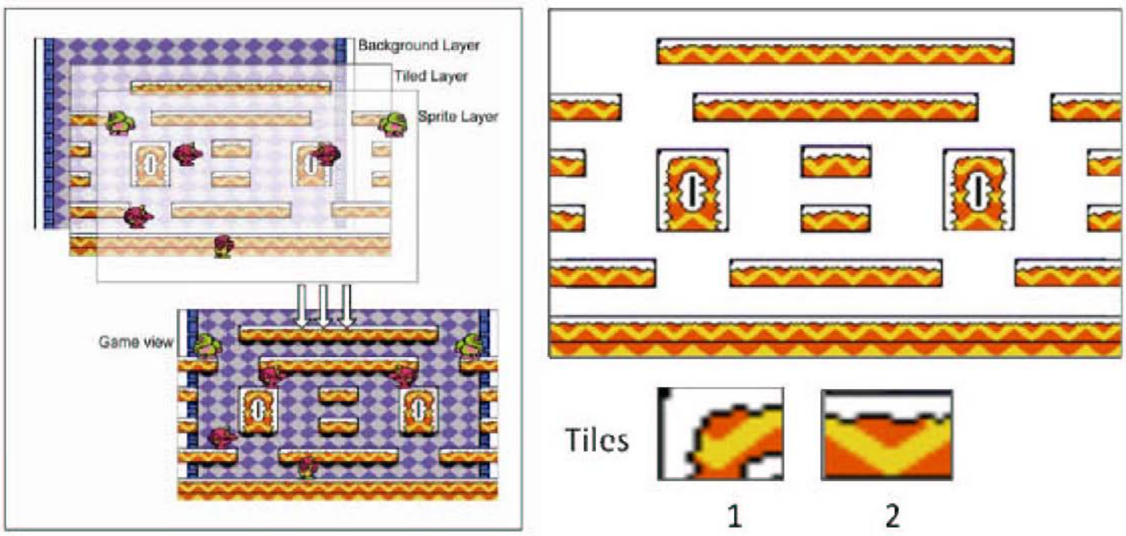

Figure 3 three layers of single stage (Left), the Tile1and Tile 2 of Tiled Layer (Right)

2.2 Shape Grammar

Shape Grammar concept is indicated by the G Stiny, and apply to representation and generation. For instance, represent the Chinese ice-ray lattices[4], Palladian's villas[7], Frank Lloyd Wright's prairie houses[3], Queen Anne houses[2], Froebel's building gifts[6], and so on.

It tries to transform some parts of design into procedural description. That's not easy. At first, it needs to establish the shape grammar formalism in two- and three-dimensional spatial design. All the base of shape grammar is to follow G Stiny proposed shape of the definition in 1980. "A shape is a limited arrangement of straight lines defined in a Cartesian coordinate system with real axes and an associated Euclidean metric."**錯誤! 找不到參照來源。** and then the definition of line, shape. Shape includes sub shape, Boolean operation for shapes, and transformations of shape. And then to the grammar, the four essential elements SLRI,

"S is a finite set of shape; L is a finite set of symbols; R is a finite set of shape rules of the from $\alpha \rightarrow \beta$, where α is a labeled shape in (S, L) +, and β is a labeled shape in (S, L) *; I is a labeled shape in (S, L) + called the initial shape." **錯誤! 找不到參照來源。**

In addition, under the framework that G Stiny defined shape grammar, concept of the structure was found C Carlson and R Woodbury. Rewriting rule is divided into precedent and consequent. Precedent consists of inclusive and exclusive. As a result, a rewriting rule r has inclusive α of precedent, exclusive δ of precedent, and consequent β is defined as r: $(\alpha, \delta) \rightarrow \beta$. As the exclusive part is empty $\varnothing$,write $\alpha \rightarrow \beta$. γ is applied by a shape rule $\alpha \rightarrow \beta$. Every element of $f(\alpha)$ is subset of γ, and intersection of $f(\delta)$ and γ is empty $\varnothing$.(1) They also imply this theory in stylized sports figures of 1972 Olympic Games.[1]

$$f(\alpha) \subseteq \gamma, \text{ and } f(\delta) \cap \gamma = \varnothing \tag{1}$$

Hence, this study applies the concept and theories of shape grammar to explore generate more layout of game stage of Snow Bros.

3 Implementation

3.1Analysis

The layout of game stagess from the first stage to ninth stages are discussed in this study. For the purpose of analysis, I take layout of game stages become the monochrome style. (*Figure 4*) Black sections symbolize tiles of stage and white ones symbolize the space. The arrangement of nine stages divided into symmetry and asymmetry.

A layout of game stage composed 13 lines. A line has 16 tiles. For the main character can walk and jump on tiles, the odd numbered lines were almost white sections and even numbered lines were black. Besides, 1st line must be the all-white, and then 12th Line and 13th line is all-black.

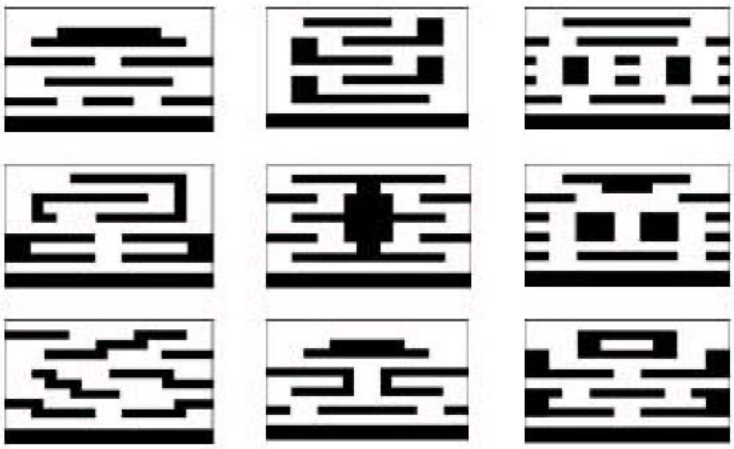

Figure 4 the monochrome style of nine Stages

Players have own strategies during playing in the game. Players gain experience from the process of playing. Every time they see the new stage, they plan to some strategy in their mind according to some familiar symbols or arrangement. As they start to attack, the strategies maybe change with the process. As a consequent, I analyzed player's strategies and put it in the generation of layout of game stage. Those strategies were collected from main character's behavior and walking path.

After observation of the main character behavior, I found a key-point of those strategies is "Crossfire Junction". Crossfire junction refers to the area where the main character met the monster. When players died or pass the stage, they will remain the situation. The images turned into player's experience. I believe crossfire junction is designers want to hint some message to players.

So, I define seven crossfire junction shapes that are hided in nine stages (*Figure 5*). In addition of them, one situation is the main character and monster stand on the same line. But I didn't define the crossfire junction shape result from the player usually provide the failure. It's not easy cause a threat for players.

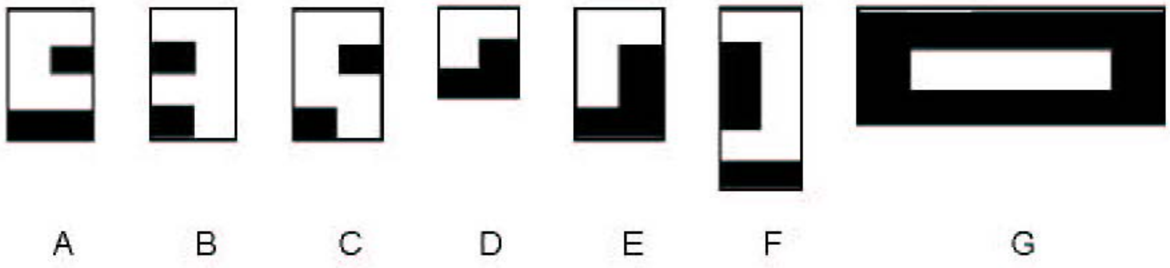

Figure 5 the seven crossfire junction shapes were defined by analysis

3.2 Rules

By the above, I defined several shape rules. The rules are divided into two stages. One hand is the shape rules of the basic arrangement, from rule1 to rule 10(Figure 6); the other hand is the arrangement of the crossfire junction shapes. Rules are defined symmetrical style. Although there are layout of game stages of symmetry and asymmetry, the generation of layout of game stage is symmetry arrangement. So, rule need to establish a symmetry axis. The shapes for both sides of the symmetry axis change at the same time.

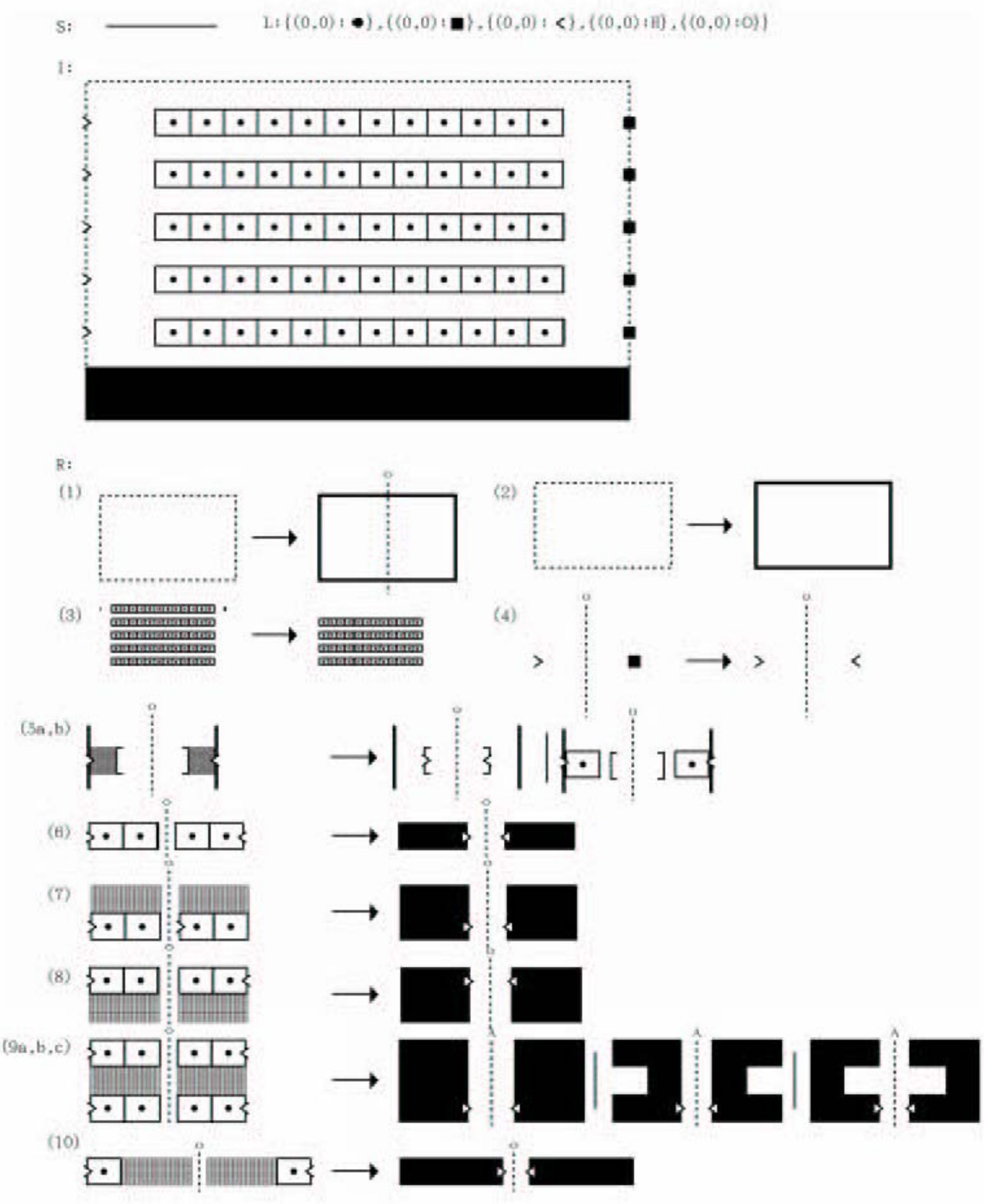

Figure 6 the shape rules of the basic arrangement

This stage is the crossfire junction shape for an alternative. Each crossfire junction shape is 2 tiles × n tiles. Any shape through transformation matches with α will replace the crossfire junction.

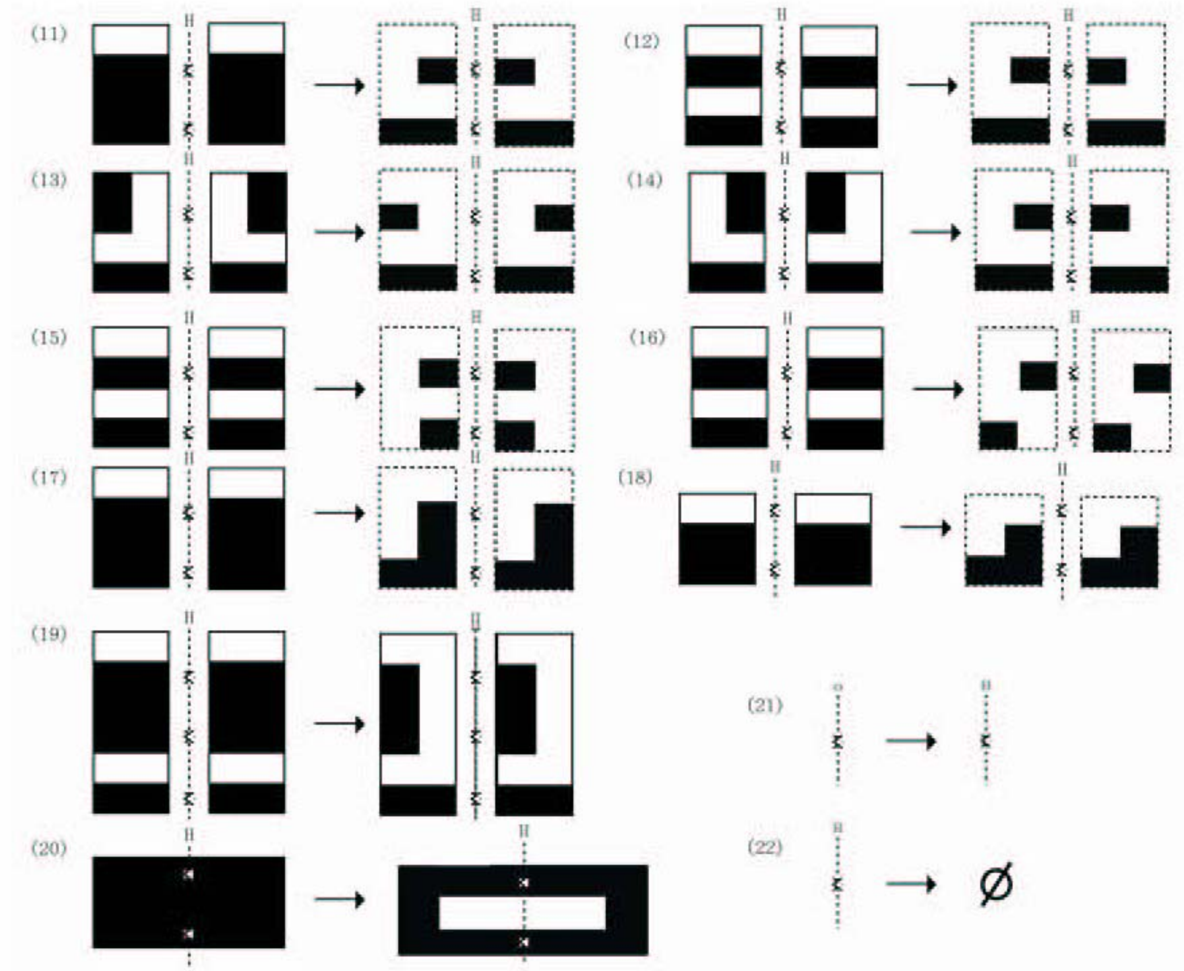

Figure 7 the rules that crossfire junction shapes and terminal rules

4 Generative Results

Generate a layout of game stage and figure out the process of generation step by step.By the initial shape to start the generation. First of all, rule1 is establish the axis of symmetry O. Rule3 reduce an upper line. Because of symmetry layout, Label■ are replaced by <(rule4). Label < begins to be move and produce black sections: rule5a to be moved from the edge, rule7 upward to increase in black section. To assign rule7 three times finish the first line. Then, the second line is applied two rules: rule5b and rule6. Rule5b means to increase in a label shape ⊡ at the inner side of the edge. Rule6 makes the label shapes ⊡ become black sections four times. The third line are applied 5a one time and rule6 three times.

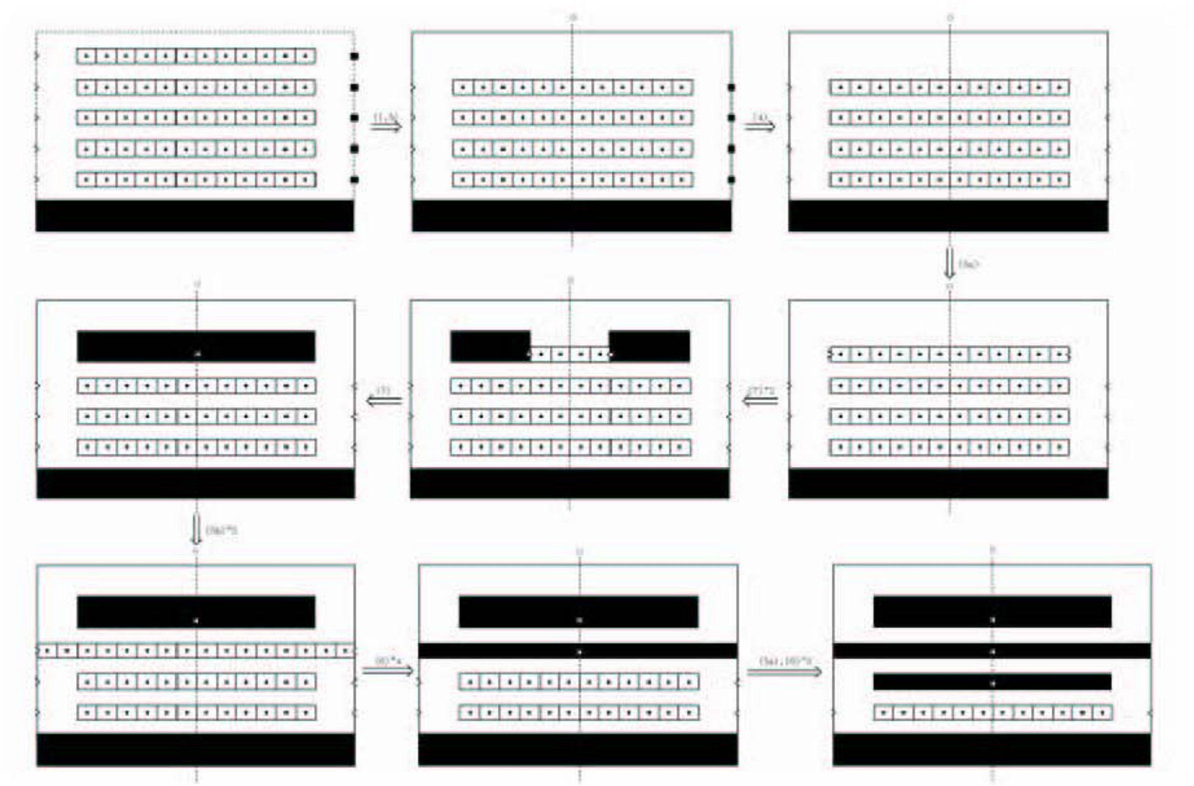

Figure 8 the generative process of layout of game stage

The steps that built last line and second line are the same. Thus, that is the first phase of the pattern. Before the next stage, the axis of symmetry O exchange H (rule21).

According to the pattern will rule11 ~ rule20 to replace two crossfire junction shapes A and D (*Figure 9*). I chose five crossfire junction shape A, and one crossfire junction shape D. therefore, only the use of rule11 ~ 14 to replace crossfire junction shapes A

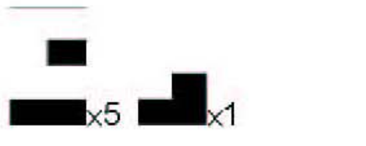

Figure 9 two kinds of crossfire junction shapes and the use of rule18 join the crossfire junction shapes D. Rule22 is a terminal rule in order to stop generating.

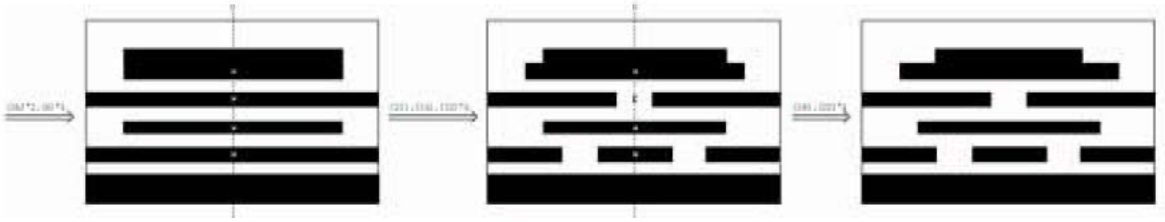

Figure 10 (cont.)

5 Conclusion & Future work

The findings of this study represent the layout of game stage of Snow Bros through shape grammar and to generate more layout of game stage with crossfire junction that is metaphor of designer's idea. Put the different position of crossfire junction shapes in a basic pattern, it can produce many new layout of game stages. But many new layout of game stages maybe change the player's strategy. It can record the player's behaviour in new stage. Then, it will generate the results via analyze the new data. For this reason, player will more immerses in the game.

Surely, Game designers can restrict the kinds of crossfire junction shapes in every stage. And the blank section is taken the place of the different material of a tile. The other games, designers also can use this way to catch their concept and generate more results out of imagine.

This paper is only the performance of this concept of layout of game stage rule; many details are not yet design completely. For instance, a case is like the basic pattern has been covered by crossfire junction shapes. And a case is not defined limit rule of placement of the crossfire junction. Another case is how to choose the one from plenty of generations. Those situations are requiring further examination.

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New Rhythms of Pattern: Generating textile print patterns through motion-sensing technology

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Abstract

In search of creating new visual imagery for printed textiles and finding an exploratory method of creating interesting print patterns, my interest in pattern formation in natural sciences has been a great stimulus. Previous studies investigating the use of digital technology in Textile Design by Bunce (1993), Briggs-Goode(1997), Treadaway(2006), Townsend(2003), Carlyle(2005) indicate that it is able to support the creative process at the generative stage of idea development through to the production of the final artifact. In the context of such "hybrid practice" in printed textile design this poster explores motion-sensing technology, to develop print patterns from hand movements used in conversation.

The focus of the study concerns how body movements such as; gestures in Non-verbal Communication (NVC) can be captured and expressed visually as print patterns. What kind of patterns can be generated out of these body movements? Can the patterns be transformed as printed textile patterns?

1. Introduction

1.1Context of Motion Capture in Art & Design

This investigation reviews motion-capture in the period before and after the invention of computers – the Pre and Post Computational period[9] – and applies the ideas involved within those techniques. The history of movement capture can be traced back to the late 1800's when Etienne Jules Marey[10] and Eadweard J. Muybridge[11] first performed motion studies of various animals and humans. Inspired by Marey's study of movement, Marcel Duchamp[13] and Giacomo Balla[14] produced their futurist[24] work, which depicted motion as painted on to a single frame. Dr Harold Edgerton[11], in the late 50's recorded movement that the unaided eye could not see with his development of the electronic stroboscope, Edgerton set into motion a course of innovation centered on a single idea making the invisible visible.

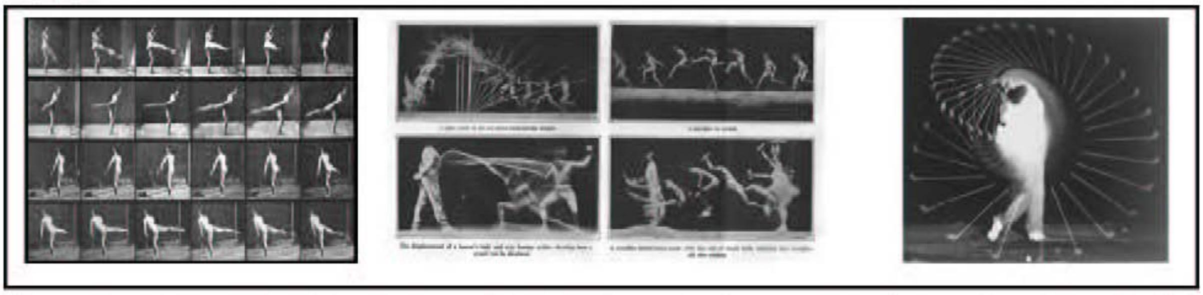

Fig 1: (a) Eadweard Muybridge "Animal Locomotion. Plate 99. First Ballet Action. [M.370] Copyright, 1887. (b) Etienne Jules Marey, Chronophotographs from "The Human Body in Action," Published in Scientific American, 1914. (c) Dr Harold Edgerton, Densmore Shute Bends the Shaft, 1938

The "Post-Computational period" captured movement as data using computer technology. The use of sensors added a new dimension to the process. Data could be captured from invisible sources and transformed to a visible and tactile form almost instantly.

For instance Karim Rashid's "Mutablob"[15],Marcel Wander's[16] and FRONT Design's[17] products are a result of capturing invisible movement and its translation into a three dimensional tactile form which is later produced by rapid prototyping methods[26].

Then there are some recent notable commercial applications of movement technology, the Nintendo Wii and Apple's iphone. By employing gesture-sensing controls they have changed the way we operated mobile phone and played video games.

In the field of Fashion & Textiles, Hamish Morrow's S/S 2004[18] catwalk show and the 'telematic dress' by Johannes Birringer and Michele Danjoux[19] embrace these new movement capture technologies and explored them to represent their new ideas. While Morrow captured digital light reflections from a model's body movements and projected them on to garments as virtual prints, the 'telematic dress' captured body movements of a performer to interact with another in far away location. Similarly 1 of 1 design studio creates one-of-a-kind, made to order apparel, "The Tissue Collection", designer Cait Reas worked together with C.E.B. Reas to generate the Tissue images by defining algorithm and translating them into images with code and software which was later printed digitally to fabrics. The outcomes of all these projects are interlinked by the context of body movement capture and application in Fashion & Textiles.

These studies show that a range of types of movement can be captured and transformed with digital technology into various two-dimensional and three-dimensional forms expanded into their applications i.e. Phones, games etc. As Gen Doy says in the context of Interdisciplinary Research:

"Should the outcomes (product) be functional…they would start 'conversations' for sure …isn't it a new function."[20].

The above context creates a space for a futuristic textile print development by digitally translating invisible body movement data into a visible form. It also lays foundation for a "real-time print process" where a performance could be translated and printed simultaneously although they are based in different geographical locations.

1.2 Generative Textile Print Design System

The proposed print design system uses computer vision to capture body movements in a conversation as binary data and translates it into a vector path. By using available assorted brushes such as line, dot, etc. in a vector software (Adobe Illustrator) the vector path could then be transformed to a continuous pattern.

The system introduces movement capture and transformation of hand movements as a generative [21] method of drawing print pattern. This system allows a "self" to interact with a computer through their body movements to create spontaneous print patterns.

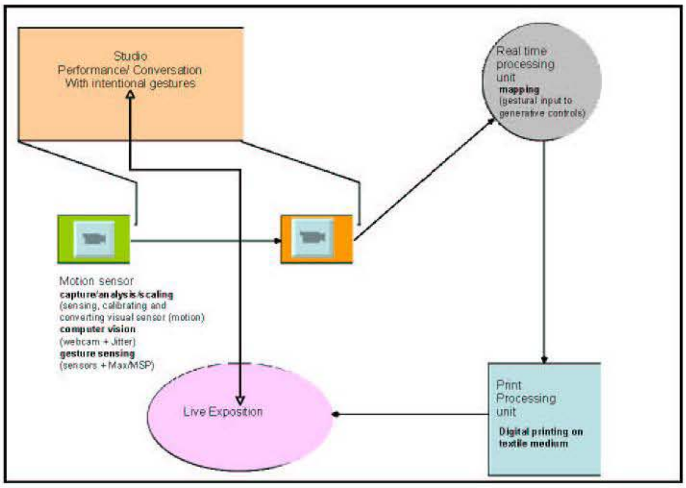

Fig 2: Diagram representing Generative Textile Print Design System as an exposition

The above diagram proposes to a stage of performance where the performer uses his body movements to create a textile print pattern. Even if the performance were repeated again it would not produce same identical set of patterns. Digitally produced textile prints were always associated with mass-produced and precisely identical products but by using the above generative process we can produce "one-off" textile prints that are never repeated.

In his seminal work "The Work of Art in the Age of Mechanical Reproduction" [22], Walter Benjamin made an assumption that the very nature of art is defined by (among other things) the way in which it has been produced and materialized. By revisiting Benjamin's notion, the project establishes that "digital craft" is manifested in this work as a design method, which promotes the creation of print patterns through processes of digital data capture and its transformation to a visual form.

2. Design Process

2.1 Capturing hand movements used in British Sign Language

The design process initiates with the translation of a poem in British Sign Language (BSL). Etymologically, "translation" means, "carrying across" or "bringing across." In this experiment the poem is 'carried' from one convention (English literature) to another (BSL) to then be further 'carried' to a machine language to make a print pattern. The final outcome of this translation is non-representational form (abstract) in itself. The form (Fig 4) does not convey the meaningful expression used either in the poem or in the BSL interpretation but creates an expression, which stands for itself. It represents a possibility that a poem could be translated to a visual form. If so does the form represent continuity in communication like the poem and the sign language intended to do. What does it communicate? Is it legible? Visually the form is a composition of fine curvaceous lines and it can be perceived as a silhouette in motion only in relation to the video film that represents BSL recitation. The BSL recitation can be understood in relation to the poem and the poem can only be understood in relation to its literature context. This relation puts forward an ontological enquiry if the form actually means or relates to something. Within the formal boundary of Textile Design "communication is not the explicit intention and that the decision is made purely upon aesthetic pleasure derived from them" (Briggs-Goode, Pg192) [2]. But in this project the patterns are a result of a continued communication and in order to make sense it should also continue communicating the translation.

2.2 Visual Capture, Transformation and Analysis of the pattern

The experiment used a HDD camcorder attached to the computer (computer vision) to capture the entire sign interpretation of the poem as a film, which is simultaneously divided into frames at the rate of 29F/ sec.1 (Fig 5). The generated frames are then saved individually in TIFF (Tagged Image File Format) in a single folder location so that they can be processed to trace finger movements as a vector path. The LiveTrace tool in Adobe Illustrator was found competitive to convert these TIFF images into editable vector paths.

Fig 5: (a) Video film (b) Video movement tracking (c) Tracking movement

The above figure illustrates the process of tracking movement in a film. The set of tracked finger movements, which were generated as scattered lines, were then blended seamlessly by vector blending tool to generate an un-repeated pattern (Fig. 7). This particular pattern represents the first verse of the poem…

"Tyger! Tyger! Burning bright,

In the forests of the night,

What immortal hand or eye

Could frame thy fearful symmetry?"

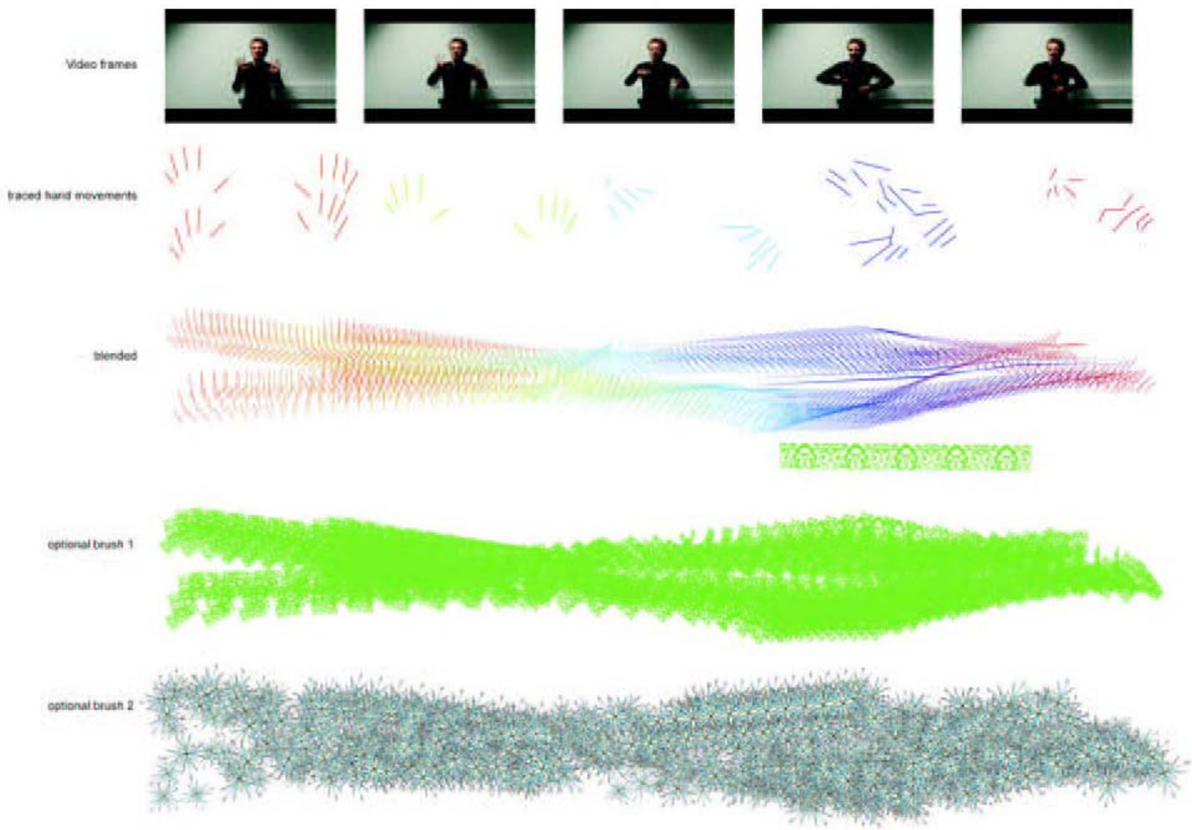

Figure 7: Pattern generated by Hand Movement Tracking

2.2.2 Visual Analysis of the pattern

Visual analysis (Semiotics is the study of sign processes (semiosis), or signification and communication, signs and symbols, both individually and grouped into sign systems. It includes the study of how meaning is constructed and understood.) by eminent semioticians such as Ferdinand de Saussure, Charles Sanders Pierce, Roland Barthes and Charles Morris, have explored images/ text, into categories, which relate to language, image and meaning. This project uses Pierce's triadic method of index, icon, symbol to enable the analysis of the printed pattern, for any semiotic significance they would have, to evaluate their communicative ability.

(a) Icon: As an Icon(… a sign that denotes its object by virtue of a quality which is shared by them but which the icon has irrespectively of the object) the form resembles closely to Boccioni's Fist (post modern futuristic sculpture) produced by Balla in 1914 (Fig:8). In this context the generated pattern represents a dynamic, energetic and ferocious subject (The Tiger) in digital media notation. It also signifies that digital translation can lead to visually unpredictable form.



Figure 8: (a) Boccioni's Fist produced by Balla in 1914 (b) Dr. Desmond Paul Henry, Picture by Drawing Machine 2 (c) Mu, Emptiness in Japanese

(b) Index: As an Index (…a sign that denotes its object by virtue of an actual connection involving them, one that he also calls a real relation in virtue of its being irrespective of interpretation) the pattern represents digital expression. If compared to (Fig 8 bPaul Henry's Picture by Drawing Machine 2) the linear form resonates that the pattern is drawn by a compter. It communicates the poem in BSL interpretation as Art, whose meaning resides in the process of translation.

(c) Symbol: As a Symbol (… is a sign that denotes its object solely by virtue of the fact that it will be interpreted to do so.) Its close resemblance to Japanese script (Fig 8 c: Mu, meaning emptiness) explains that although the pattern is abstract in nature, it can possibly have a literal meaning that could represent "The Tiger" in a new visual sign language (digital media).

This analysis finds the generated pattern as an art form that signifies digital translation can lead to visually unpredictable form, whose meaning resides in the process of translation and it can have a literal meaning that could represent the subject in a new visual sign language (digital media).

3. Conclusions & Future Research Directions

The unique design process explored within this poster supports the statement that digital medium allows the creative process from the generative stage to the final artifact. The generative stage in this case is the translation of the poem in BSL and its video film capture. The computer and its peripherals including the software's used in the process dictate the print pattern outcome. In the process the final form does not retain the meaningful expression used in the poem and its BSL interpretation but it establishes that Digital translation can produce unpredictable forms, beyond our imagination. The project creates a base for playful human & computer interaction in producing textile prints.

The central contribution of this poster is it insights into a new sort of creative process, a discussion about useful theoretical frameworks through which to understand this process. It lays foundation for future research direction, which is textile print design in “real time process”. It will look into the possibility of creating prints in future to translate Non-verbal Communication (NVC)[8] visually as print patterns as a method of exploring “digital craft”.

Acknowledgements

The research work is dedicated to my belated father Dr. S.C. Paramanik, and wishes to seek his eternal blessings. I am highly grateful of my Gurus, Dr Amanda Briggs-Goode, Dr Tom Fisher and Dr Katherine Townsend for their professional advice and guidance. I would also like to thank Elvira Roberts for her professional assistance in translating "The Tiger" in British Sign Language.

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[13] Duchamp's first controversial work, Nude Descending a Staircase, No. 2 (Nu descendant un escalier n° 2) (1912), depicts the motion of the mechanistic nude with superimposed facets, similar to motion pictures. The painting shows elements of both the fragmentation and synthesis of the Cubists, and the movement and dynamism of the Futurists.

[14] Giacomo Balla, Dynamism of a Dog on a Leash, oil on canvas, 1912

[24] The Futurist Manifesto, written by the Italian poet Filippo Tommaso Marinetti, was published in French in Le Figaro on 20 February 1909. It launched an art movement, Futurism, that rejected the past; celebrated speed, machinery, and industry; and sought the modernisation and cultural rejuvenation of Italy. Influenced by it Giacommo Balla adopted a style creating pictorial depiction of light, movement and speed.

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[26] Rapid prototyping is the automatic construction of physical objects using solid freeform fabrication. The first techniques for rapid prototyping became available in the late 1980s and were used to produce models and prototype parts. Today, they are used for a much wider range of applications and are even used to manufacture production quality parts in relatively small numbers. Some sculptors use the technology to produce complex shapes for fine arts exhibitions.

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Generating Architectural Envelope through Mathematica

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Abstract

After millennium, the making of building form raises and concerns sustainable terms. The architecture with an emphasis on sustainability is often devoted to a greater division of exterior and interior space by adding artificial devices on building envelope; such as the solar panel, wind turbine, and new architectural envelope material (GPR). Can this kind of building devices designed for environmental modulation satisfy the needs of sustainability? D'Arcy Wentworth Thompson ever comments in ***On Growth and Form*** that the morphology of living form has a dynamic aspect, under which the living forms are able to construct and dynamically maintain themselves to adapt the environmental change [1].

In the past, mathematics is often employed by engineers and architects to simulate and translate the form of 'nature' into geometric shapes. Now, architects are confronted by a more complicated challenge from 'nature': climatic change. There is an increasing interest in the new way of generating architectural envelope or surface. It encourages and inspires research on the investigation of the morphogenetic process between forms and dynamic forces through an algorithmic program – 'Mathematica.' It also suggests that the architectural design incorporating the issues of 'nature' (e.g. Airflow, Light, and Heat) in the generative manner may result in a more responsive form to nature. In order to examine the feasibility of the above propositions, the proposed paper takes airflow as subject to explore how 'Mathematica' can generate architectural envelope via environmental issue. The paper draws parameters from airflow to frame a time sector of vector field, which constitutes a basis for the production of a generative line. Following that, the time sectors are laminated together, and the generative lines are used to compose the envelope to represent the consequence of environmental variations.

This paper doesn't aim at proving how accurately the algorithmic approach to the challenges from environmental issues. Instead, it attempts to argue and evoke that the value of envelope lies in the interplay between environmental challenges and architectural design process. Through the interplay, an architectural form would embody functions or activities associated with envelope to create a new relation with 'nature'.

1. A mound of termite

A mound of Macrotermes michaelseni termite in Nambia has shown some potential to establish the relations between envelope and comfortable living form through the dynamic force of environment. While the termite mound have been investigated for over a century, the form of nest is proven to relate to the function of ventilation generated by the pressure fluctuation resulting from the changes of wind direction and speed in the dynamic environment outside [2]. Moreover, even though many studies indicate that there are absolutely interactive relations between form and environment, the morphogenesis still remains as a field for exploration.

The mound is organized by the bifurcate conduits to integrate the external wind pressure and internal buoyancy. This formal prototype is helpful to insulate the dry air from outside and maintain the temperature inside. Certainly, the bifurcate conduit becomes the most important functional pattern to determine the morphology of termitic living form. Does this mean that the termite mound transfers its architectural form to functional envelope via operating the energy in environment? In order to study the relations between environmental energy and morphology, research tries to use logistic map popularized by the biologist Robert May and written down as an equation by the mathematician Pierre François Verhulst to simulate and interpret the meaning of form of termite mound. Originally, the form of termite mound is determined by bifurcations occurred in different energy gradations to disperse overly concentrated energy and keep system stable. Michael Weinstock also argued in ***Matabolism and Morphology*** that fluid energy transportation in particular is an essential determinant of body plan and overall morphology [3]. In order to depict the relations between energy and morphology of termite mound; Figure1 is rendered by mathematica through logistic map given by equation (1) to show how the form forked and generated.

$$x_{n+1} = \lambda x_n(1-x_n) \qquad (1)$$

In equation (1), n denotes a generation, x_n denotes environmental variation in generation "n", and λ denotes an environmental parameter of energy in generation "n". By the calculation of logistic map, two different bifurcation diagrams are derived shown as Figure[1&2]. The first diagram calculates the parameter λ in region [2.5, 4], the second one does the parameter λ in region [3.4, 3.6]. Comparing with these two diagrams, it is noted that different regional energy makes the first bifurcation occurred at different energy gradation (λ= 3 and λ= 3.45) and influences the whole morphological structure. All of these forms could be as a model of adaptation to the energy. Through the adaptation of energy, an optimal morphology is generated to respond to the environmental variations, and it can be shown as a set of generative lines. The morphology of logistic map is similar to the structure of termite mound's envelope. The bifurcations divide the mound into several energy regions in height and orientation to derive different air density, which is the main factor to drive inner convention [4].

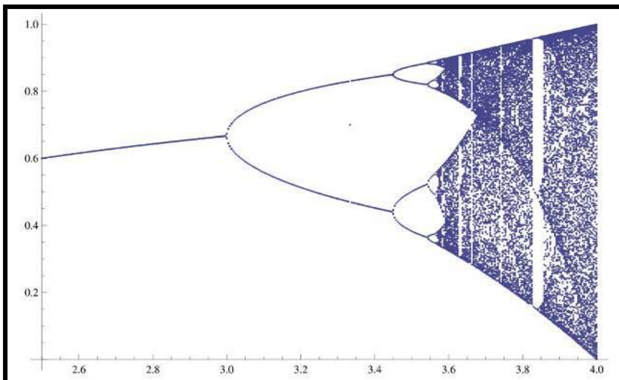

Figure1: f[x]:=λ*x(1-x); λ = [2.5, 4]

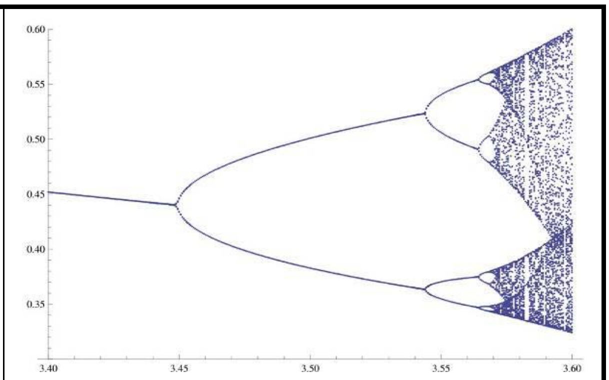

Figure2: f[x]:=λ*x(1-x); λ = [3.4, 3.6]

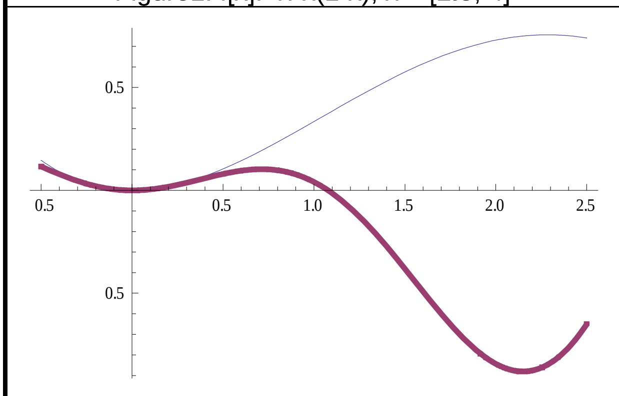

Figure3: f[x]=x*Cos(2x)-y

Figure4: Termitic mound in Nambia

In order to figure out the restrictions of equation (1) in explaining the relation between environmental energy and morphology, the study attempt to modify and rewrite it as follow:

$$f[x]=x*Cos(2x)-y \qquad (2)$$

Equation(2) is rendered by「Picard Iteration Method (PIM)」and shown in Figure3. Through the comparison if with Figure1 and Figure2, it is found that the bifurcation form could be rendered from different equations. It means that logistic map is one of the basic equations to represent the morphology of termite mound. Although it can not be used to explain the morphology in particular place or environment, it shows that the morphology of termite mound hold strong relation to the fluctuant energy in environment. According to the observation above, this study attempts to frame some key points below to establish a method for transferring natural environment to energy environment. It also associates with morphological study of architectural envelope in response to place. To sum up, the assumptions about this study are listed below:

1. The architecture could be regarded as a monolithic organization directed or manipulated by environmental energy.
2. The interactions between generative line and energy are a prototype to explore feasibility about a morphologic study of architectural envelope.
3. The environment could be represented and simulated by mathematics.

2. Generative Line

Through the morphological analysis of termite mound, the question is not only to indicate whether the environmental issues generate the form, but also to show the generative line could be a basis to help designer to contour the other field to study architectural morphology. In order to understand the process how environmental energy originate generative lines, the study tries to plot generative line and energy flow about equation (2) in two-dimensional transformation and give a process consists in calculation before piecing together a three-dimensional object out of them.

Firstly, the study tries to plot a map to visualize the flow of environmental energy about equation (2); consequently, equation (2) is formulated as a differential equation (3) to get vectors described by roots (x_0, y_0).

$$dy/dx = x*Cos(2x)-y \qquad (3)$$

Conceptually, if the roots could be gotten from equation (2), then, the roots could be generated as a "Direction Field" (Figure5) to show dynamic streams of environmental energy. On Figure5, all roots designate a tendency shown as curves traced by the arrows on "Direction Field". However, all of these curves are symbolized as approximate solutions. But, there is still an optimal curve existed in "Direction Field", How to diagnose it?

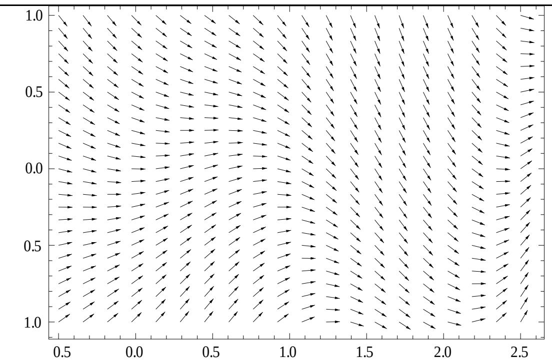

Figure5 : Direction Field of equation (III)

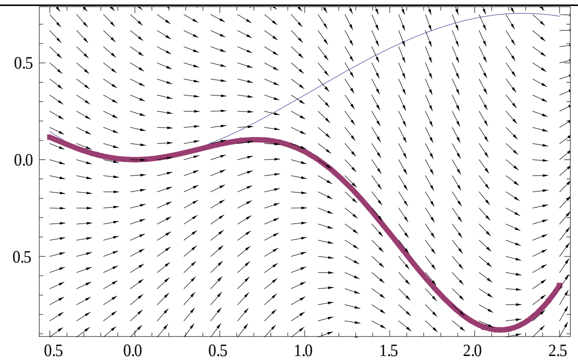

Figure6: generative line for equation (II)

Research uses「Picard Iteration Method (PIM)」 to get a optimal curve about equation (2). By algorithm of PIM, equation (2) could be extended into several generations until the optimal morphology generated to fit in "Direction Field". By the alternation of six generations, equation (2) could be solved and generated as differential equation (4).

$$dy/dx = 1/960\,(-135+x\,(135+2\,x\,(-15+x\,(5+(-5+x)\,x)))+15\,(9+13\,x)\,\mathrm{Cos}[2\,x]+15\,(-11+26\,x)\,\mathrm{Sin}[2\,x]) \quad (4)$$

When differential equation (3) and differential equation (4) are plotted by PIM, the blue curve and purple one is generated respectively for them in Figure6. Comparing with two curves, the purple curve is fitted in "Direction Field"; it means that curve is generated as an adaptable morphology after six generations. Learning from PIM, the algorithm could help study to generate an optimal morphology in energy environment, 「Equation」,「Direction Field」, and「PIM」have become a investigative tool kit to associate a morphological study with energy environment. Before starting with this tool kit, the most important thing to do is try to define an equation based on the data of local environment.

3. Environmental Equation

This Paragraph is aimed at transferring natural environment to energy environment; in natural environment, wind speed, pressure and wind direction are the critical factors to generate particle movement as a streamline in Bernoulli's Equation.

Time	Pressure (hPa)	Wind Speed (m/s)	P(Avg.) -P	Wind Direction
06:00	989.0	5.1	-5.75	π/8
07:00	988.6	5.3	-5.35	π/8
08:00	988.1	4.5	-4.85	π/8
09:00	986.9	4.3	-3.65	π/8
10:00	985.7	4.5	-2.45	π/8
11:00	984.1	5.2	-0.85	π/8
12:00	981.0	5.8	2.24	π/8
13:00	980.1	8.4	3.14	π/8
14:00	978.9	6.1	4.34	π/8
15:00	976.9	7.9	6.34	2π
16:00	976.4	7.1	6.84	2π
Avg.	983.245	5.836		

Table1: 28/09/2008 P-V Data

Bernoulli discovered that the dot product of pressure and wind speed is a "mechanical work", which is an environmental energy transferred by forces. It means that natural environment could be represented as an energy environment. The mechanical work could be formulated as a product by Pressure (P) and Wind Speed (S), which is given by:

$$W = P*S*\mathrm{Cos}\,\theta$$

From the inspiration of Bernoulli's Equation and mechanical work, the environmental equation could be conducted by wind speed and pressure. But, how to formulate these two factors to define an equation? The study uses the data on Table1, which is derived from "Central Weather Bureau" and associated with wind speed and pressure in "Taichung Harbour" in Taiwan. In mathematica, the data of 「P(Avg.)-P」to「Wind Speed」could be plotted as a chart (Figure7). Due to the rule of mechanical work, if there is an equation (x) existed to connect all dots in Figure7,「P(Avg.)-P」and「Wind Speed」would be explained as the roots of equation (x), then, equation (x) is defined as a environment equation for this energy environment to help study to plot a "Direction Field" and generate a optimal morphology. In mathematica, function「Fit」could help research to define an equation to approach the analysis of data.「P(Avg.)-P」and「Wind Speed」is calculated as a product, which is symbolized by parameter「x」in polynomials given by equation (6) and equation (7). Both equations are approximate solutions for Figure7, in order to diagnose which is the optimal solution for energy environment; both equations are plotted as curves on Figure8.

$$f[x] = 4.86632 - 0.844849x - 0.368324x^{2} + 0.314711x^{3} + 0.134932x^{4} - 0.0198913x^{5} - 0.0114207x^{6} + 0.000327375x^{7} + 0.000352525x^{8} + 5.95609\times10^{-6}x^{9} - 3.6747\times10^{-8}x^{10} \quad (6)$$

$$f[x] = 5.38681 + 0.468156x + 0.0283144x^{2} - 0.00818202x^{3} \quad (7)$$

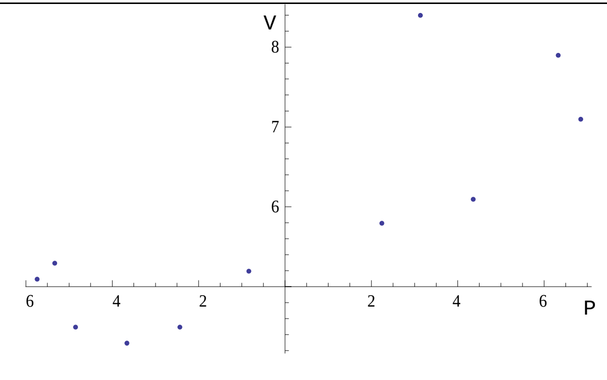	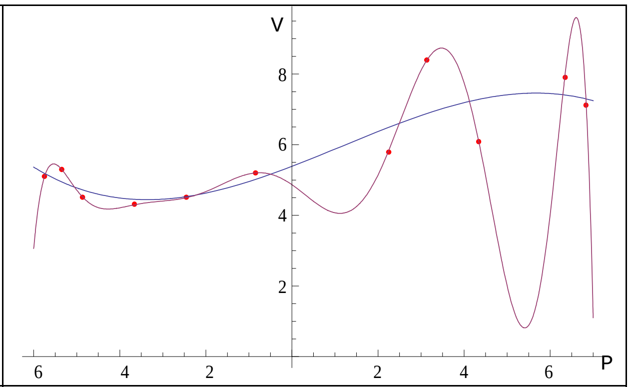
Figure7 : P-V Chart	Figure8: curves about “mechanical work”

In Figure8, equation (6) is plotted as purple curve, and equation (7) is plotted as blue curve. Comparing with two curves, the purple one is penetrated through all dots. It means that equation (6) is the optimal solution used to define as an environmental equation. The curve on Figur8 is a reference for study to sift the optimal environmental equation from multiple feasibilities, it doesn’t relate to the morphology. From the experiment in chapter “Generative Line”, the morphology should be derived from environmental equation in differential.

4. Generative Envelope

Actually, Figure8 could be plotted into three-dimension (Figure9) to modify equation (6) to equation (8). In this paragraph, the parameters of pressure, wind speed and wind direction is denoted as a value of [x, y, z]. Equation (8) is given by:

f[x]=-2.56+0.64y+0.31x*Cos[2x] (8)

In Figure9, the red dots show the relation of pressure, wind speed and wind direction, and the curved surface is a reference to help study to diagnose how closely that equation (8) approaches to exact solution about environment equation. From the exploration of last paragraph, equation (8) could present a solution of energy environment. At this step, equation (8) could be assisted with PIM to originate a generative process to visualize the inner structure between morphology and fluidity of energy environment. In Figure10, blue and purple curve presents an algorithm of morphology in different generation. Especially, blue curve approaches the optimal morphology. The curves are like the bifurcate prototype of termite mound’s envelope or the mold of Gothic. By the alternation of generations, the morphology of termite mound is aggregated by numerous bifurcation prototypes. Consequently, Figure10

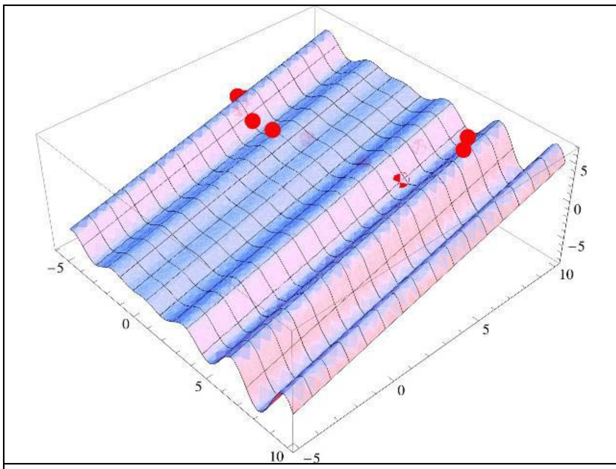	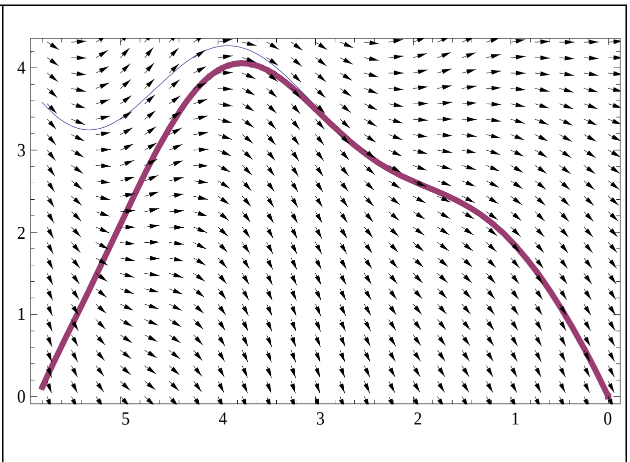
Figure9 : Plane about “mechanical work”	Figure10 : PIM Solution – Optimal Morphology

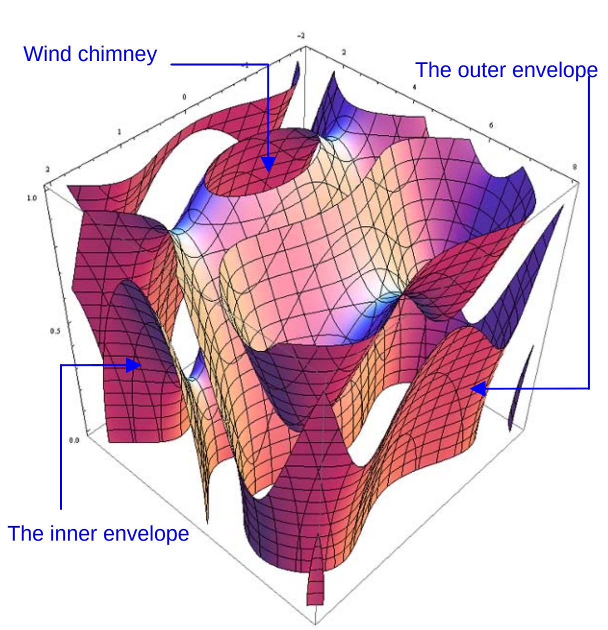

Figure12 :
the generative architectural envelope

doesn't show the result of whole, it just a partial mold of architectural envelope. In order to examine how the curves aggregated to generate an architectural envelope, the study derives more optimal curves as architectural molds from the data of "Central Weather Bureau" on August to October in 2008. The study takes a daily optimal curve as a mold of architectural envelope. By the aggregation of optimal curves, the architectural envelope is generated and shown on Figure12. The algorithm of envelope reveals the features of double skins and wind chimney. The basic knowledge of the experiment of wind tunnel explains when temperature of outer envelope is warmer than inner one; the different temperature on skins will engender the wind to flow through the interval between two envelopes; the wind chimney would accelerate an efficiency of ventilation. It seems that the generative architectural envelope originated in parametric algorithm is meaningful, but how to present the rationality of this meaning?

Moreover, even though the study does not aim at explaining how this morphological research really deals with a specific time and place, but, the study attempts to frame a field to explore the method how the morphology of architectural envelope could be generated and modulated by energy environment. By the aggregation of generations, the morphology of architectural envelope will continue to be generated.

5. Conclusion

After millennium, the most important global issues are focused on sustainability, seeking through the environmental issues, sustainability attempts to search a new architectural prototype to respond the questions in this green age. The ideas embedded in sustainability are often summarized under the terms generative, self-organized, responsive and circulative. These four issues form more complex behavior and depict that a number of simple prototypes could be operated and emerged from an environment. Like the envelope of termite mound, it not only a form but also a function to respond environment. From this complex sustainable issues, ***Klaus Bollinger*** agrees that Architectural design needs to incorporate complex organizational and functional requirements, and therefore constitutes a recurrent negotiation of analyzing existing and requisite conditions as well as generating and evaluating possible responses with environment [6]. Including "Water cube", "National Stadium – Bird Nest", and "Swiss re London Headquarters", there are more and more architectural projects challenge how the environmental issues associate with the multiple meanings of modern architecture.

In order to examine the feasibility of modern architecture in sustainability, the digital analytic software in three-dimension (such as Maya, Catia, and Rhino) is applied into architectural projects. Through the manipulation of morphologic algorithm of those software, architects or designers could design and clone a 「Functional Pattern」 at will, which is dealt with environmental issues nowadays. The idea of functional pattern is introduced on the book edited by Farshid Moussavi and Michel Kubo, *The Function of Ornament*. The new meaning of modern architecture is defined as a pattern design. Robert Levit also presents that the works such as LTW's Beijing, Water Cube, and Federation Square can be regarded as a product of varied cellular pattern produce a teeming articulation rather than a definite figure [7]. Although, it seems that algorithm, aggregation, pattern, and environmental issues become the most important features for those modern architects to concern, but, what is the question left behind? Robert Levit deemed that these forms appeal on a variety of symbolic level and offer an image of individuation [7]. Unlike the aboriginal architectures introduced on the book edited by Dora P.Crouch and June G, Johnson, *Traditions in Architecture,* Stilt House in Indonesia is elevated on posts and on all sides for optimal ventilation, the roof overhang provides shade [8]. Formerly, People learn the knowledge from environment; they construct the form of architectural envelope to coexist with nature. On the contrary, the form of modern architecture's envelope presents an idea of brand or the icon of architects rather than the respect for local environment? Consequently, the study looks backward to seek a method which could modulate the requirements between environment and human's life under the theme of algorithm, aggregation, pattern, and environmental issues.

In the book, *traditions in architecture,* Dora P.Crouch and June G, Johnson clarify that the architectural morphology generated from environment is depended on the environmental condition, material, structure, and certainly, the ornament. Equally, Robert Levit interpret that the role in the constitution of architecture is a Pattern, which is one of ornament's chief incarnations. Obviously, if the study tries to approach the field of architectural morphology in environmental issues, the material, structure, and ornament would be the next themes to explore.

6. Reference

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Kinematograph

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Abstract

Kinematograph is an artistic research project that raises fundamental questions about the nature and direction of computational and algorithmic art. Instead of approaching information technologies as mere tools, this project regards them as conceptual structures that can be critically examined as such. The essential methodology is to begin with a well-established algorithm, in this case the Huffman compression scheme, which is not customarily considered as an artistic medium. Instead of treating this algorithm as an efficient tool for lossless data compression, however the *Kinematograph* deploys it as the basis for an aesthetics of dispersal and defamiliarization. This aesthetic venture refuses to endorse the ideology of power and control endorsed by many contemporary theories of interactivity. The search for power is to be replaced with a problematical and experimental questioning of technology in the most radical possible way.

1. Problematical questioning

Kinematograph is an ongoing artistic and theoretical project in computational art. In its critical engagement with information technologies, it keeps faith with philosopher Gilles Deleuze's suggestion that the future of cinema depends on "its internal struggle with informatics" [1]. This statement can be extended, perhaps, to all of contemporary art.

In *Kinematograph*, the struggle takes the form of a question: "How does one do informational art?" This question does not call for a definite response. Its aim is not to arrive at some absolute answer that will dispose of the question once and for all. Rather, the aim is to render the question itself problematical [2]. To tackle the question is to learn how to pose the question anew. This process can be described as "experimental", but the term can be misleading. An experiment is sometimes understood as a technical setup oriented towards a predefined range of possible answers. But the questioning involved in *Kinematograph* does not aim to select the right answer out of a pre-given set of possibilities. Just what might count as a possible answer is itself part of the problem. Heidegger famously noted that thinking "is a way", but not in the sense of a well-worn route between two points. It is not a path that pre-exists the wayfarer's journey. Thought exists only in the very act of raising the question, only so far as we remain "underway" [2]. To advance along the way is to engage in an ongoing practice of problematical questioning. *Kinematograph* is experimental in this radical sense.

The media artist begins the journey by acquiring a certain facility in the use of informational technologies. Know-how is essential to the computational artist. But here, at the very outset, the question itself already becomes problematical. What does it mean, to learn information technologies? Many artists choose to learn a higher-level programming language. Some also attempt assembly language or electronics. Others study the mathematical theory of communication, as well as cybernetics, information systems, or computer graphics. The fundamental definition of the domain is not given in advance. There are multiple entry points. We do not know what information art consists of before embarking on the journey. And yet we must make decisions about what to do, which apparently require at least a preliminary understanding of the subject matter. To begin is to make an initial choice.

It would be a mistake, however, to describe the subsequent journey as a progressive elaboration of some initial definition or plan. The way is neither continuous nor linear. It proceeds by delays, detours, regressions, doubts, and radical revisions. We may even come to discover that we never knew what information was, and so must reconsider our fundamental assumptions from scratch. The best visual metaphor for this process is the well-known image, proposed by Paul Klee in his educational notebooks, of “taking a line for a walk”. The journey resembles a line that meanders without a fixed direction, lingering and folding back upon itself.

2. The Outside

I started this project by selecting a well-established technique that is not customarily viewed as an artistic method. The technique chosen was the Huffman compression algorithm. The journey begins, quite simply, by learning how to implement this algorithm (in this case, using the Java programming language). The reason to select this particular technique is that Huffman encoding was first published in the early 1950s, when the foundations of the mathematical theory of communication had only recently been laid out. The design of the Huffman algorithm directly exhibits many of the assumptions at the heart of this then emerging field of research. More crucially, artists do not normally consider Huffman compression as an arena of creative exploration. Thus the starting point of the journey already involves a confrontation with an “outside”.

This alien quality is an important feature of the way of working being proposed here. The process starts out by stepping outside of art, in the sense that the object of exploration belongs to scientific or engineering fields that have traditionally been excluded from artistic education and discourse. This is not an arbitrary decision, but rather a core aspect of the subject at hand. The artist who chooses to learn computer programming thereby enters a domain customarily regarded as “technical” and so foreign to art. This estrangement is an important stage in the way of the information artist, and the *Kinematograph* project embraces it head on.

This decision runs counter to dominant tendencies in media art education, where students are encouraged to learn digital tools by developing graphical or sound applications that are obviously “artistic”. An animator might, for instance, start out with a definite visual outcome, such as drawing a perfect sphere or a realistic image of water, and then develop computational applications to realize this outcome. The relevance of technology to artistic applications is accepted from the outset. But I would suggest that any effort to smooth over the tension between art and technology tends to fall back on standard ways of using digital computers as artistic tools. Alternative possibilities are seldom explored.

Instead, the *Kinematograph* project commenced without any definite outcome in mind. It was not clear in the beginning whether its final output would be a graphical image, a sonic installation, an interactive application, etc. I regarded that act of learning the Huffman algorithm as an end in itself. This way of commencing the journey already implies huge risks, since it was not at all clear whether the process would eventually result in anything that could even remotely be classified as art. The *Kinematograph* project thus embraces thinking as an open adventure. It treats the field of “art and technology” as the site of an ongoing uncertainty.

3. The black box

This way of working is unusual, because technology is often regarded as a tool, and a tool is defined as a means to realize some predefined end. Considered as a tool in this sense, technology takes the form of a black box. Vilém Flusser’s study of photography suggests that the concept of the black box constitutes a core aspect of media art [3]. Every digital technology essentially appears as a black box. A black box contains input and output terminals. To know how to use the black box is to know how to select the inputs that will reliably produce certain expected outputs. The user need not, and often cannot, know the internal mechanism that connects inputs and outputs. This opaqueness defines the black box.

The concept of the black box implies a dialectic of mastery and exclusion. The user learns to “master” the tool, and yet this mastery does not lead to understanding. The tool remains opaque. This dialectic manifests itself, for instance, in interface design.

To design an interface is to establish a context of relevance for the “user”. According to this ideology, the task of good design is to shape the user’s mental model of the device by supplying clear analogies or metaphors. Such metaphors should be obvious to everyone; they should also express clearly and unambiguously the core functionality of the device. The aim is to communicate the intended function of a device in its external design, which should be based on cultural analogies and natural models that are immediately understood. But the face presented by the machine to the user typically has no visible connection to the formal implementation. The interface, according to many designers, should have no relationship to the underlying structure of the device. The user’s ignorance of the internal structure of the device is thus taken as a premise of the design methodology.[1]

The problem lies in the assumption that the device must present a friendly "face", which must accommodate the user's prior knowledge and experience. Interface design, as normally conceived, is regressive. Instead of reinforcing natural analogies and immediately comprehensible metaphors, the *Kinematograph* proceeds by inventing new ways of thinking and acting. I propose that we view informational arts as an experimental process of interrogating technologies. In the process, artists might discover new interfaces that illuminate and problematize the relationship of the user to the black box.

4. Technology as a way of thinking

To problematize technology means, first of all, to treat it as a style of thinking. What does this mean? It is common to view information theory as an "engineering" paradigm. There is obviously a great deal of truth in this assumption. The concept of information was meant to facilitate practical tasks pertaining to data storage and transmission. The Huffman algorithm, in particular, was designed to supply an optimal method of data compression. Its underlying motivation was essentially pragmatic. The *Kinematograph* project does not, however, consider information theory exclusively as a tool designed to solve pre-existing engineering problems.

Information theory is first and foremost a conceptual construction. The theory supplied an innovative vocabulary that has transformed our thinking about the tasks to which it is applied. Terms like "source", "addressee", "message", "communication", and "channel" acquire new technical meanings in the context of the theory. These meanings have essentially modified the basic terms of the engineering problems that the theory was designed to tackle. Instead of considering technology instrumentally, as a means to some end, the *Kinematograph* project aims to characterize technology as a frame of mind, a style of thinking. The basic move, in other words, is to isolate the theory from its intended application domain (its engineering context) by taking it as a conceptual edifice that can be explored as such.

This conceptual construction is hidden from the user of the black box. To use the black box is to ignore the ways of thinking that made possible the fabrication of the black box. My approach therefore outlines one way of subverting the black box concept. By treating technology as a style of thinking, moreover, I propose a way of relating to the digital that avoids two bad alternatives: uncompromising refusal and blind acceptance. The former fails to explore the novel ways of thinking and acting that can potentially arise from human-computer interaction. The latter normally celebrates the role of the user, capable of deploying digital tools without understanding their internal mechanisms. There is another choice, which proceeds

[1] "Software design is the act of determining the user's experience with a piece of software. It has nothing to do with how the code works inside, or how big or small the code is." Terry Winograd, Bringing Design to Software, Addison Wesley, 1996, chapter 2. http://hci.stanford.edu/bds/2-liddle.html

by critically examining the fundamental concepts of information technology. This is the choice adopted in the present project.

The guiding question is: how does information theory, and the Huffman algorithm in particular, define the conditions of its field of problems?

5. Formalism

Information technology is (broadly speaking) formalist. It concerns itself exclusively with the topic of symbol manipulation. Questions of truth and meaning ("semantics") are outside its domain. Information theory defines its object in formalistic terms. The entire theory depends on this fundamental exclusion of content. Its focus pertains to the tasks involved in sending symbols over some channel, such as for instance telegraph or telephone lines, *regardless of what those symbols happen to mean*.

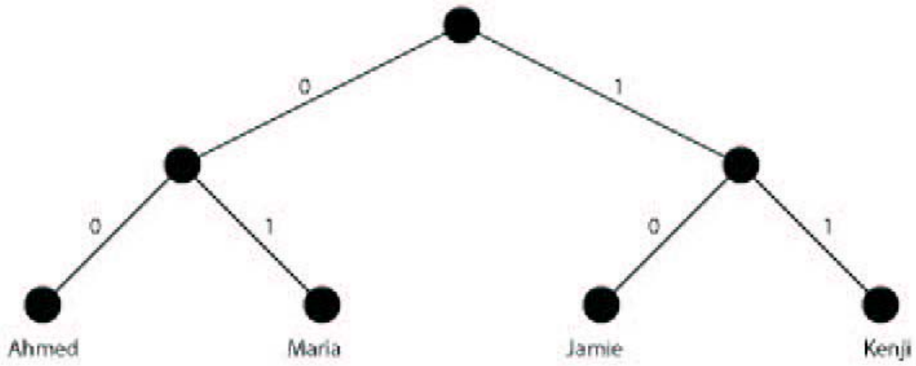
The *Kinematograph* project embraces the formalist problematic and disregards all questions of semantic content, thus situating itself firmly within the conceptual field of information theory. This formalist orientation manifests itself in the underlying concepts of the theory, such as "source" and "message". An information "source" is an agency that makes a selection out of an ensemble of possibilities, such as for instance a team leader who picks a team member to perform a task or a novelist who selects a letter to write down on paper. All of these actions involve a choice from some set of possibilities. The source need not be an intentional agent; it can be a natural process or an artificial machine. From an informational standpoint, the meanings attached to the choices made by this source are irrelevant. What matters is that somehow a selection is made, and this selection reduces the number of possibilities to one.

Information theory always regards every "message" (choice) in relation to an ensemble of possible messages. This raises the important question of the criterion for the identity of messages. In other words, what counts as the "same" message? Suppose that one source chooses one out of four possible letters (for instance, A, B, C, and D), whereas another source chooses one letter out of the entire Roman alphabet. Even if both sources happen to choose the "same" symbol, for instance "A", they do not thereby produce the same message. The reason is that the second source has more possibilities to choose from. Two messages are from this standpoint different, *even if they are perceptually indiscernible*, because they have been selected from a different set. The statement that one symbol has been selected is only informative relative to a set of possible choices.

6. The Dictionary and the Trace

The idea of an ensemble of possible choices can be formalized in the following way. Suppose that a team leader needs to select a team member to go on a difficult mission. She can make her selection using the following method: first divide her entire team into two disjoint groups, then throw a coin to select one group, and iterate the procedure until the chosen group has only one member. This technique comprises a sequence of binary (yes/no) decisions. If the team has only four members, the leader need only make two binary decisions to reduce the possibilities to one [4]. Every decision can then be assigned a binary digit (0 or 1). The resulting binary code can be understood as the static representation of a temporal process: the progressive reduction of the set of possible choices by means of a sequence of yes/no decisions.

For instance, suppose that the members of a team are called Ahmed, Maria, Jamie, and Kenji. The tree in *Figure 1* represents every possible sequence of binary decisions.



[*Figure 1*]

Given a finite ensemble of possible messages, it is always possible to represent the entire network of binary choices available to a source by means of such a binary tree. Every possible message is a terminal node. Every non-terminal node represents a binary decision. I propose to use the term "dictionary" to describe such a binary tree, which characterizes the entire network of binary choices for some ensemble.

The dictionary illustrated here can be used to identify every team member uniquely. To determine the binary code for a particular person, simply proceed downwards from the root towards the person in question, adding a 0 to the code when choosing a left node or a 1 when choosing a right node. Thus the codes for Ahmed, Maria, Jamie, and Keni are 00, 01, 10, and 11 respectively. Another well-known dictionary is the ASCII system of character encoding. Every symbol is encoded as a sequence of seven bits, which means that seven binary choices are needed to reduce all possibilities to one. The binary code for the symbol "A", for instance, is 1000001.

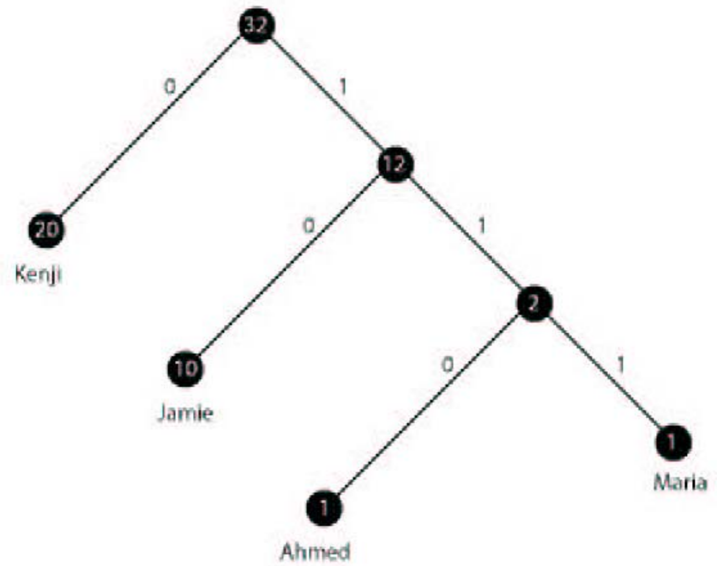
From this viewpoint, then, a binary code is the static expression of a temporal process. I propose to use the expression "binary trace" to describe the representation of a dynamical process as a binary choice sequence. This brings me to an important methodological rule: always understand every static digital representation as the residue of a (real or hypothetical) dynamic process. I call this precept the "temporalization rule", because it suggests that the basic information theoretic concepts are essentially time-based. A binary sequence is of course a static object, but I propose to view it as the frozen picture of a dynamical process, the progressive reduction of an ensemble of possibilities by a sequence of binary choices. The temporalization rule suggests a tentative connection between information theory and the "time-image" that Deleuze identified as essential to cinematic and perhaps also media art [1].

7. Ordering

The method of successive binary decisions is of course only a fiction. Actual sources seldom actually proceed by successively partitioning the possible messages into two disjoint groups. This fiction, however, highlights an important conceptual point. To *transmit* the information that (for instance) *one out of four* elements has been chosen, the source only needs to write down a sequence of 2 binary digits, since every element is uniquely identified by one such sequence. For instance, if the team leader wants to notify another team that Maria has been chosen for some mission, the leader can transmit the code 01 via some communication line. The team on the receiving end can then use the appropriate dictionary to decode the information received.

This example shows the extent to which the practical problems of data transmission constitute the horizon of information theory. The theory was intended to facilitate the task of relaying messages encoded in binary symbols. The engineering aspects of information theory are evident, above all, in its concern with issues of fidelity and economy: How can messages be transmitted without losing information (fidelity) and with the shortest possible average code length (efficiency)?

In 1952, David Huffman invented an algorithm for the construction of a dictionary that generates a maximally efficient encoding [5]. The dictionary is organized by associating a frequency or probability with each of its elements. It is straightforward to discover the frequency of every message by recording the actual choices made by some concrete source over an arbitrarily long span of time. Suppose that, over the course of two months, the team leader selects Kenji 20 times and Jamie 10 times. Each of the remaining two members, Ahmed and Maria, is only chosen once. It is convenient to represent the behaviour of such a biased source as a binary tree, where the more frequent messages are placed closer to the root. In other words, the proximity of a terminal node to the root depends on the probability that the source will select the team member represented by this node. The hierarchical organization of the tree thus manifests the "preferences" or "biases" of the source. Every node now has a number associated with it, the frequency with which the team member represented by that node has been selected. The dictionary of *Figure 2* captures this idea.



[*Figure 2*]

The outcome of the Huffman algorithm is that every message now has a variable (rather than fixed) length encoding. As illustrated in *Figure 2*, the codes for Kenji, Jamie, Ahmed, and Maria are now 0, 10, 110, and 111 respectively. The number of binary digits that encodes a message depends on the probability that the source will select that message: the greater the probability of a message being chosen, the shorter its binary encoding.[2]

Suppose that our team leader has to transmit her selections over some communication channel. Her choices are: Kenji, Kenji, Kenji, Jamie, Jamie, Kenji, Ahmed, Maria. The code for this sequence of messages, based on the scheme shown in *Figure 1*, should be 1111111010110001. The new scheme, in contrast, yields the shorter binary string 00010100110111. The reason for this compression is that the codes of the more frequent messages are shorter than those of the more infrequent messages. If every message occurs with equal probability, the Huffman method does not offer any advantage over the fixed length encoding illustrated in *Figure 1*. But if the source displays some bias, the codes can be considerably reduced. A binary code is "compressible" or "redundant" if an algorithm exists that can reduce its length (measured in bits).

The efficacy of this algorithm is well known. I propose, however, to bracket the engineering aspects of Huffman's technique, and to concentrate instead on the style of thinking that underpins it. Although it is not necessary here to give a detailed description of the algorithm, it is worth noting that the procedure builds the tree by first arranging every possible message into a queue. The Huffman algorithm essentially depends on the assumption that all possible messages can be queued in

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[2] Moreover, the code for every possible message is not the prefix (the first part) of any other code. This property ensures that messages can be decoded at the receiving end without any ambiguity. For example, 0 is the code for Kenji, and this is not the beginning of the code of any other team member.

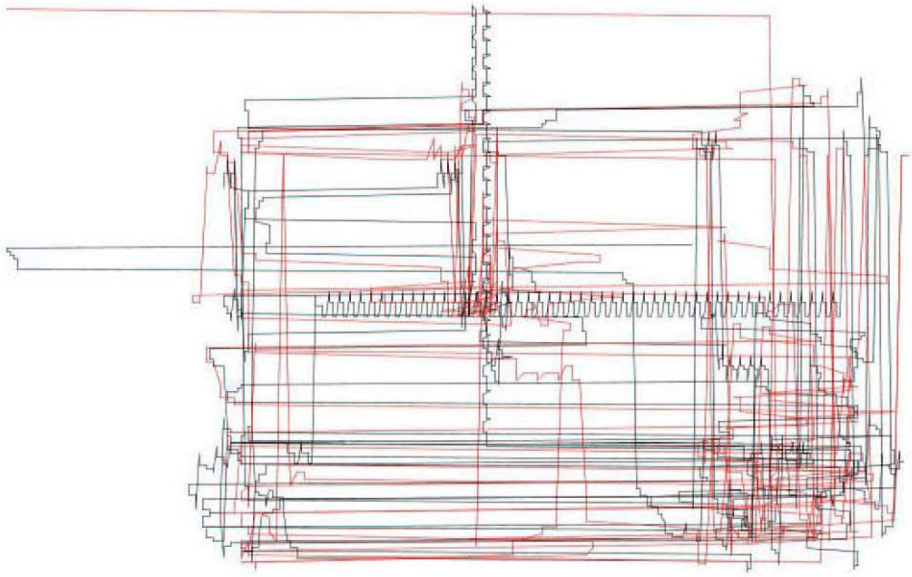
order of frequency (or probability). This presupposition, which underpins the construction of the binary tree, highlights an important feature of every information system: It consists of a dictionary whose elements can be arranged into some definite order. In this case, the ordering is based on the frequency or probability associated with every possible message. The essential function of frequencies within an information system is to render messages quantitatively comparable, so that they can be arranged in order. Describing the origin of modern technology, Heidegger aptly notes: "nature reports itself in some way or other that is identifiable through calculation and that it remains orderable as a system of information." [6]

Certain additional features of Huffman encoding play a key role in the current version of the *Kinematograph* project. The Huffman dictionary can be altered dynamically. A sequence of new choices made by a source whose behaviour changes over time will alter the frequencies associated with every message, and so modify the configuration of the Huffman tree. Suppose that our team leader begins to choose Ahmed far more frequently than before. This element will have to be brought closer to the root of the tree, and so the entire structure will have to be recalculated. Whereas a scheme such as ASCII assigns an unchanging code to every character, a Huffman dictionary is not necessarily fixed once and for all. For this reason, whoever receives the coded message must have the Huffman dictionary in order to restore the original message. Without access to the Huffman tree that was used to encode the message in the first place, it cannot be appropriately decoded. This point is important in this context, because the current version of the *Kinematograph* deliberately hides the underlying dictionary from the users of the work.

8. Installation description

The current version of the *Kinematograph* is an interactive installation that addresses the various aspects of information technologies mentioned here. The core application was originally developed in Java and subsequently extended in Processing. The basic setup consists of a five-screen projection system controlled by five networked computers. The interface to the entire system is a single keyboard. Exhibition visitors interact with the system by typing. The computer stores frequency data (i.e., the number of times that visitors choose to press a given key) in the form of a Huffman dictionary. The dictionary is continually updated in response to every new key pressed by the visitor. The five screens visualize the changing dictionary. Thus the visitor is both the source and the addressee of the messages. But, instead of displaying the messages that were typed, the five displays foreground the operation of the underlying algorithm. The installation thus ignores the main practical motivation for Huffman encoding: the faithful reproduction of information. Instead, it develops a cognitive laboratory.

The first screen visualizes the dynamical construction of the Huffman tree in response to the characters typed by the visitor. The visualization is based primarily on Paul Klee's famous description, in his teaching notebooks, of taking a line for a walk. The display consists of two lines, one red and one black, each moving in a stepwise manner (*Figure 3*).



[*Figure 3*]

The black line displays every binary digit in the standard ASCII code for the key typed by the visitor; if the bit is a 0, the line moves horizontally; otherwise it moves vertically. When reaching one of the edges of the screen, the line continues moving in the opposite direction. When the last bit of the code for this particular key is reached, the system computes the following mapping:

```
int x = map( (int) key, 0, 122, 0, width );
int y = map( (int) key, 0, 122, 0, height );
```

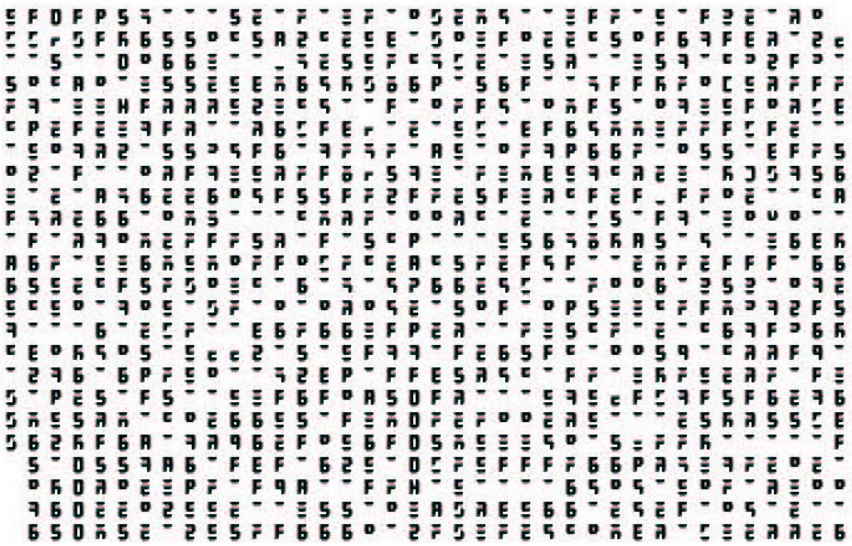
The line moves to the point with coordinates (x,y) on the screen, and continues its motion as soon as the user types a new character. The aesthetic effect is of a line that meanders all over the two-dimensional screen. Its rapid motion visually expresses the underlying idea that a binary code is the trace of a dynamical, essentially temporal process.

The red line uses a similar rule to visualize the Huffman encoding of the character typed by the visitor. Its motion will be somewhat slower and less complex, particularly for characters which are very frequently typed, since the average length of the Huffman code tends to be shorter than that of the ASCII code. The graphical movement of the two lines thus visualizes the essential properties of the underlying algorithm. Visitors often experiment with the system by, for example, typing the same key over and over to observe the effects of their inputs on the visual representation. Any subsequent change in the visitor's behaviour, for instance, a modification in the frequencies with which certain characters are typed, causes a sort of "perturbation" of the system. This alteration forces the software to reconfigure its underlying dictionary, which in turn affects the movement of the line. The kinetic "style" of the line thus responds to the changing behaviour of the visitor.

The second screen displays the ASCII code of every key pressed by the visitor, but the display relies on a special typography created specially for this project. Each symbol consists of up to seven vertical and horizontal strokes. Every stroke visualizes a single bit in the ASCII representation of the key pressed by the visitor. Thus for instance, the binary encoding of the small "a" is 1100001. In the graphical representation of this letter, only three of the seven possible strokes are shown. The binary encoding of the capital "A", in contrast, is 1000001, and its visualization in my alphabet accordingly has only two strokes (*Figure 4*):

[*Figure 4*]

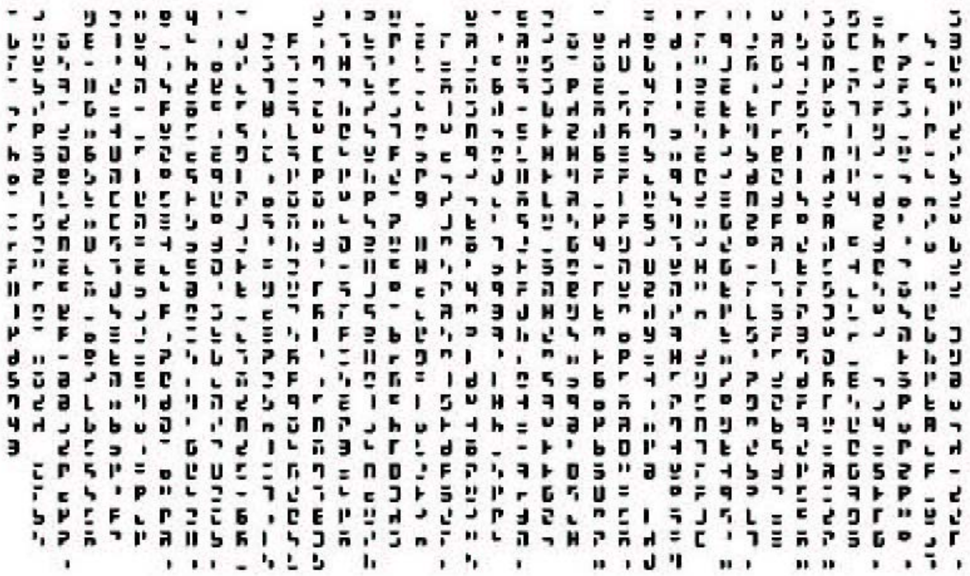
The characters are displayed in the fashion of classical Chinese writing, from top to bottom and from right to left. This graphical arrangement is arbitrary, but it expresses how the structure of Chinese writing, where every symbol can be decomposed into basic elements, loosely inspired the design of this alphabet (*Figure 5*).



[*Figure 5*]

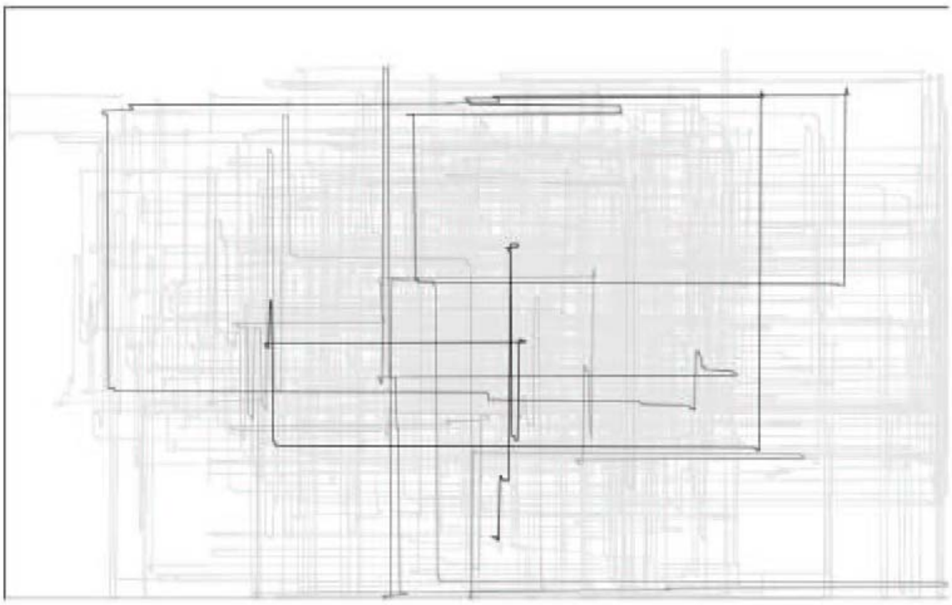
The resulting alphabet is of course opaque to first-time users. Its strangeness dramatizes the condition of the user of a technological black box, for whom the internal operation of the device is essentially obscure. It is nonetheless theoretically possible for the visitor to "learn" this encoding, since every key is consistently displayed as a clearly recognizable symbol. By typing the same key over and over and observing the visual outcome, for instance, she can convince herself that there is a one-to-one mapping of characters to graphical symbols. This system thus functions as a medium of experimental learning for the visitor. This project demonstrates an alternative way of designing user experience which (a) does not aim to foster among users an impression of mastery and knowledge, and (b) refuses to drive a wedge between the visual design and the underlying implementation. The graphical properties of the alphabet express the ASCII encoding of the characters, and so reveal the way in which the computer represents symbols.

The contents of the third screen, illustrated in *Figure 6*, closely resemble those of the second display, but with an important difference. The typographical symbols are constructed on the basis of Huffman codes, not ASCII codes. Since every symbol in this alphabet has seven possible strokes, and since the Huffman scheme reduces the length of the codes relative to the standard seven-bit ASCII scheme, every symbol typically encodes more than one character. As well, the code for one single character may be represented across two symbols (for instance, it may comprise the last stroke in the first symbol and the first three strokes of the second symbol). The mapping of characters to symbols is not one-to-one. Since the Huffman codes are continuously modified in response to every new key pressed, it is difficult for visitors to learn the current encoding scheme. The dictionary cannot be inferred from the visual feedback, because the dictionary is in a state of flux. The same graphical symbols often express very different codes. Since characters lack a fixed-length encoding, and since the visitor has no access to the underlying Huffman dictionary, it is impossible for her to know precisely how many strokes represent one single character. There is no way for visitors to map the characters they have typed to the symbols on the screen.

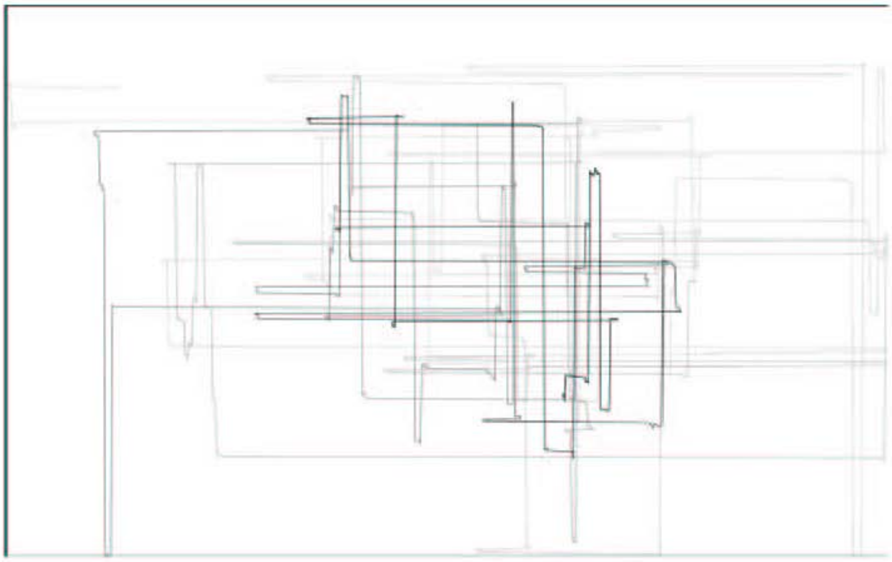


[*Figure 6*]

The content of the fourth screen differs strongly from the previous two (*Figures 7* and *8*).



[*Figure 7*]



[*Figure 8*]

My objective in this section of *Kinematograph* is to generate random characters whose probabilities reflect the frequencies with which those characters have been typed during the exhibition. The frequency data is of course stored in the Huffman dictionary. Throughout the exhibition period, the system continuously generates characters by making a sequence of yes/no decisions based on the probabilities associated with the nodes of the Huffman dictionary.[3] The characters generated are

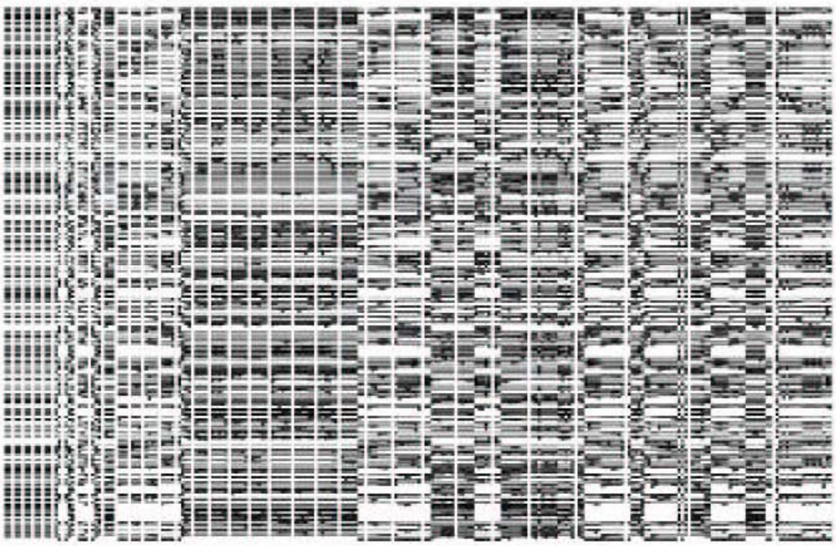
[3] A short technical explanation is required to understand this display. Most programming environments have a random number generator. In this installation, I use the random() function built into Processing language, which produces random floating point numbers with a uniform probability distribution. I assume that the software represents every node in the Huffman tree as an integer. The variable j is first initialized with the value of the root node. I use an algorithm that, first of all, uses the standard random() function to generate a floating point number uniformly on the interval [0,1]. I now use this number to select a character (one of the terminal nodes of the Huffman dictionary). The procedure that accomplishes this is as follows:

```
int j = root;
float ran = random( 0, 1 );
while (j  > max_value) {
     if (ran < probability(j) )
        j = left[ j ];
     else
        j = right[ j ];
}
return (char) j ;
```

In this program, max_value denotes an integer constant that stores the maximum possible ASCII code (i.e., 127). I assume that the Huffman dictionary has been constructed so that non-terminal nodes are assigned numbers greater than max_value, so that the while loop therefore continues until a terminal node is reached and the character associated with this node is then returned. I also presuppose the existence of some function probability(), which takes one parameter representing a node in the Huffman dictionary and returns the appropriate cumulative probability. If this cumulative probability is greater than the random number, the left child of the current node is selected; otherwise the right node is selected. (Here, left and right denote integer arrays that store the left and right children of every not, however, displayed to the user. Instead, the system visualizes the operation of the generative algorithm as an animated line: a horizontal stroke represents the selection of a left node in the Huffman tree, and a vertical stroke represents the selection of a right node.

Although this section of the system does not directly respond to user inputs, the user nonetheless has an indirect impact on the animation. Since the algorithm relies on the current Huffman dictionary, which is constantly being updated in response to keyboard inputs from the visitors, the visualization depends on the accumulated choices made by visitors over the course of the exhibition. They can affect the visualization indirectly, by typing some characters more frequently than others.

The fifth screen demonstrates another way of thinking about the generative algorithm just described. Every iteration in the generative process that produces the fourth display involves a progressive elimination of possibilities. The algorithm traverses the Huffman tree. At every node, a binary decision is made: whether to go left or right. If the right node is selected at any given step, then all characters reachable from the left node are thereby ruled out, and vice versa. This procedure is repeated until a character is selected. Now, the fifth computer receives data from the fourth computer and uses this data to visualize the gradual reduction of possibilities that takes place during the generative algorithm. Every time the generative process begins anew, the system draws a row of horizontal line segments running across the full length of the screen. There are as many segments as possible characters (i.e., 128). The first segment from the left represents the first possible character; the second segment corresponds to the second character; and so on. As the system calculates further iterations, new rows of segments are rapidly drawn below the first row, but the segments corresponding to characters eliminated in each iteration are *not* drawn (*Figure 9*). Like the fourth display, this process continues without interruption, even in the absence of visitors.



node).

[*Figure 9*]

Taken together, the fourth and fifth displays show two different aspects of the generative algorithm: (a) the algorithm consists of a sequence of binary decisions, such that (b) every decision eliminates a set of possible choices.

Conclusions

The installation never displays the characters typed by the visitor in their standard alphabetical form. Moreover, the various displays are updated even when the visitor types a key that does not represent any printable character, such as for instance the BACKSPACE. *Kinematograph* thus embraces the elimination of meaning that lies at the heart of information theory, and explores alternative ways of organizing thought and experience in this informational ecology. It raises the question of what it means to think, what it means to read and to write, with computational technologies that have no built-in semantics.

At the heart of this project is a fundamental reconfiguration of the problematic of information art. The concepts of “interactivity” and “interface” have often been presented as essential features of new media art. Interactivity is normally understood to require clear and immediate feedback to user inputs. Interfaces are often designed in line with principles of direct user manipulation. Systems are designed to be responsive and unobtrusive. Computation is thus conceptualized as a tool that augments our capacity to act. From this standpoint, the telos of informational technology is mastery. While *Kinematograph* continually responds to user inputs by updating the various visual displays, its principal aim is not user empowerment. Since there are no tasks for users to accomplish, its organization cannot be understood in instrumental terms.

The installation thus brings into being a way of relating oneself to technology that is not based on the desire for mastery. Technology is not essentially a means to an end. Instead, the system presents a situation of strangeness that facilitates a space for questioning. This strangeness primarily arises because it reveals certain technical features of information technologies, mainly the Huffman encoding algorithm, normally hidden from the user. The installation uses this technique to emphasize the dispersion of writing into multiple forms, and to resist all efforts to achieve purposeful mastery.

The relationship between inputs (the characters typed by the visitors on the keyboard), visual outputs (the five graphical displays), and the underlying algorithm at once invites exploration yet remains obstinately obscure. The installation invites visitors to participate while affirming its own self-autonomy and integrity. First of all, because those displays that respond immediately to user inputs subvert any expectation of clarity and control. The relevance of the system’s feedback to the user’s actions is not immediately evident. Secondly, because some of the displays (the fourth and fifth) continue to do their own thing even in the absence of any visitors. People cannot personalize and appropriate the system, which confronts them as an alien object.

Whereas the standard ideology of interface design reinforces the role of the user who chooses certain inputs to produce expected outputs, the *Kinematograph* presents an alternative design model. This model affords an experience of engagement and estrangement, interactivity and alienation. The system promises to interact with the visitor but its feedback is not transformed into immediately comprehensible metaphors. This twofold experience dramatizes the fundamental alienation of the person confronting technologies that have become detached from normal human contexts, and which follow a purely formalistic logic.

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A robotic system for interpreting images into painted artwork

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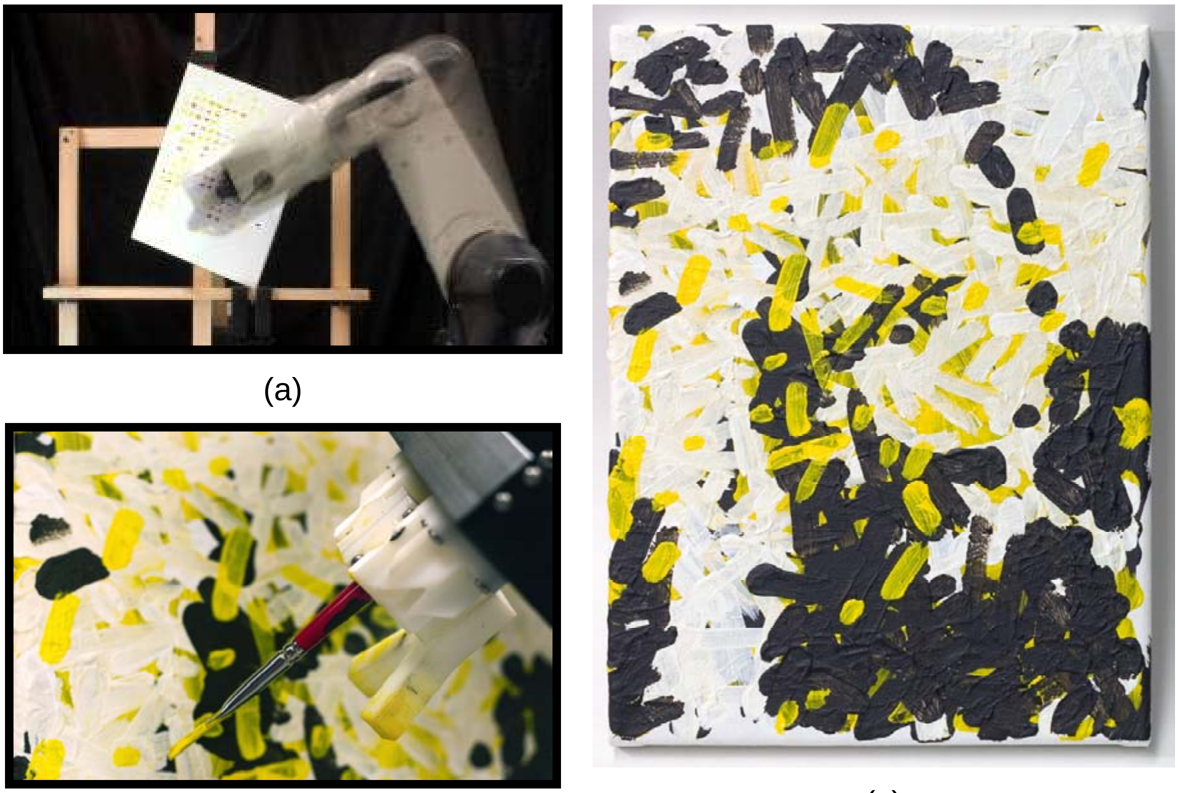
Abstract

We report on a robotic system that can physically produce paintings with a wide range of artistic media such as acrylic paint on canvas. The system is composed of an articulated painting arm and a machine-learning algorithm aimed at determining a series of brushstrokes that will transfer a given electronic image onto canvas. An artist controlling the system is able to influence the resulting art piece through choice of various parameters, such as the palette, brush types and brushstroke parameters. Alternatively, an artist is able to influence the outcome through varying the algorithmic parameters and feedback of the learning algorithm itself. In these results, a genetic algorithm used a painting simulation to optimize similarity between the target and the source images.



(a)

(b)

(c)

Fig. 1. The robotic painting system: (a) An articulated 6DOF arm holding a paintbrush to a 23 x 30cm canvas; (b) A close-up view of the brush holder; (c) sample painting of a portrait

1. Introduction

1.1 Paint and its significance

Even the technological advancements of the post-modern age cannot replace the simplicity or cultural significance of paint and other traditional media. Artists have created representational art from suspended pigment for tens of thousands of years. From cave paintings through the Renaissance to the modern and contemporary eras, paint has never ceased to have a significant role in art. Traditional mediums will always have a power associated with the history of art: every new painted artwork refers implicitly to the history of painted art.

We have developed a robotic system which allows a computer to generate a physical painting from a source image with the aid of the *technartist*'s artistic interpretation. Given an input image and environmental parameters, such as brush sizes, the combined computer-artist system is able to interpret the image and the robot then executes the image onto a canvas using paint.

The robotic system is comprised of three main components: a digital paint simulation, a genetic algorithm and an industrial robotic arm. The paint simulation gives the ability to predict how a paint stroke would look if it were painted on canvas. The genetic algorithm utilizes this paint simulation as feedback in order to try to choose a set of brush strokes that will match the input image. Finally the robotic arm automatically executes these strokes onto a physical canvas by manipulating brushes and acrylic paint.

Computer scientists have attempted to transfer the power of paint to the digital era: a whole field of computer graphics is devoted to generating digital images that resemble paintings. Computer scientists have also developed algorithms to simulate the physical behaviour of paint on a computer. Artists have taken advantage of these paint simulations to make original digital paintings.

New media artists have also taken advantage of the artistic significance of paint by developing machines able to produce painted artwork autonomously. Several robotic painting systems will be outlined later in this paper.

1.2 An intelligent robotic artist

One goal of this research is to create a robotic system with a self-model based on paint simulation algorithms. This allows the robot to intelligently predict its own behaviour. We present the first machine system able to intelligently interpret an image into an original style of physical artwork.

Genetic algorithms are stochastic algorithms able to solve some open-ended problems in creative and ingenious ways. These algorithms are especially useful when a solution of a problem can be accurately modelled and easily evaluated. GA's can often free a computer from human imposed limitations on a problem and can achieve unexpected results. For these reasons artists have found GA's powerful when trying to create generative art.

Computers have become an integral part of every facet of our lives and art is no exception. Producing or manipulating digital images has become a part of many artists' process. To reach the full effect of an artwork, however it must be taken out of the digital realm and rendered physically, whether displayed on a screen or printed using a printer.

Artists only have a handful of ways to physically produce digital images. Conventional printers and display technologies represent digital images using pixel primitives. A primitive is the most basic unit of any image; they are the atomic elements of an image. Pixels arise as a natural way for a computer to produce a digital image, not because they are appropriate for displaying images in an interesting or artistic way.

Our software implements a standard way in which a computer can represent an image in terms of an abstract primitive; in this case the primitive is a paint stroke. This abstract primitive allows the system to treat the primitive physically, taking advantage of the physical characteristics of a paint stroke.

1.3 Implications

People are integral in the artistic process surrounding this robotic painter. The system is not intended to make high level decisions – it relies on human input for these decisions, such as subject matter and palette. This means that a person that might lack the manual dexterity to paint is still able to explore paint as a medium. This research opens the door to a new level of human-machine artistic collaboration. An artist is able to understand how the algorithm tries to interpret an image, but the algorithm will ultimately add some unrepeatable and unpredictable interpretation of its own.

In this paper we present a brief survey of robotic meta-art, explain the painting simulation and genetic algorithm used to implement our robotic system and finally show some simulated and painted results from the robotic painter.

2. Problem Statement

Our goal is to take a digital image and have a computer analyze it and produce a physical representation of this image in an original style. This problem is fundamentally different than the problem of painterly rendering in computer graphics. In computer graphics, arbitrary paint behaviours, paint colors and stroke types can be used to achieve whatever type of affect the user or the algorithm requires. Our research however addresses a physical problem: what instructions can I give a robot to produce a painting? Real paint phenomena must be recreated and predicted in a computer and the result of the algorithm is a set of robotic instructions, not a digital image.

Our work is also materially different than other software based art that can be outputted using a printer. While many software systems can claim original styles of art, these styles are fundamentally digital and can only be transcribed to reality using digital processes which utilize the same digital primitives that a computer uses. One of our central claims is the ability of our system to use the physics of the resulting art in its creative process.

3. Background

A number of robotic systems have been developed which produce works of art without the use of complex robotic behaviour such as Sabrina Raaf's *Translator II: Grower* [1]. In *Grower,* a robot slowly traverses a wall and plots in green ink the CO_2 content of the room.

Grower contains an interactive element not present in our work and in the rest of the robotic systems discussed in this section. As viewers enter the room they are able to see their affect on the growth of the simulated grass. *Grower* however represents a robotic system whose behaviour is pre-programmed. The most important similarity between Grower and our system is that the mechanism for synthesizing the art piece has been automated. The process of painting then becomes an important context for the viewer. The action of painting becomes a significant, and often times publicly displayed portion of the art piece.

Another class of robotic art systems produce artwork with agent robots programmed with individual behaviours. The most compelling example of this class is the work of Leonel Moura. In one of his projects, *ArtSBot* [1] Moura uses a swarm of independent autonomous robots which travel across a canvas depositing ink. The robotic system has no global goals, but each agent has a series of programmed behaviours that depend on the sensor information from its environment: namely the color of the canvas below it and obstacles in its way. The artwork becomes a performance of these simple machines and the resulting drawing is an artefact of the complex dynamics that arise from each agent's simple programmed behaviour.

Our work belongs to a final class of robotic painter that is able to produce representational images. Harold Cohen's *AARON [3]* is probably one of the earliest and most advanced robotic action painters able to produce physical, representational artwork. AARON uses a representational model for synthesizing a series of objects: people, rocks, tables and plants. AARON is entirely autonomous, choosing its subjects, composition and palette entirely without the input of humans.

While AARON produces paintings with an element of randomness, the style and aesthetics of the paintings have been designed and programmed by humans. This work takes the opposite approach to representational art. We do not attempt to automate high level decisions such as subject matter. Our system tries to choose strokes to take advantage of the physical media by predicting the results of the executed painting.

Other robotic representational art includes Robotlab's *Autoportrait* [4], Calin *et al.*'s *A robot Painting a Portrait* [5], Adrian Bower's robotic painter [6] and Jessica Bank *et al.*'s *Fotron 2000* [7]. The media is different in each of these systems: the first two systems use markers, Adrian Bower's system uses paint and the Fotron 2000 uses light emitting diodes that paint light onto Polaroid film.

All of these systems use image processing techniques to decompose an image. Autoportrait features edge finding as well as face recognition algorithms. The Fotron 2000 also uses an edge finding algorithm but is also able to represent some colors with different lights. Adrian Bower's paint robot uses algorithms to decompose an image into several regions of solid color which the robot then attempts to fill in on the canvas. These systems are different from the system presented in this paper in that they attempt to reverse engineer an image in order to represent it. The result is a human programmed style of representation. Our system, unlike any system before it, does not have any specific instruction on how to paint, just knowledge of how it can affect its environment.

4. Materials and Methods

4.1 Approach

This project exploits the strength of evolutionary algorithms in solving complex problems with well-defined objectives. In this case, the objective is simply to attempt to reduce color error between our input image and the painted image.

This software takes a bottom up approach to generative art, using the ingenuity of its genetic algorithm to solve for stroke-level style. While other algorithms are better suited for finding solutions for a specific painting goal with a given set of parameters, no other algorithm provides the same flexibility of a GA. For example, the algorithm could make line drawings simply by changing the fitness function and types of strokes used in the algorithm.

In the following sections we will outline a previous version of our robotic painter that did not include a self-model. We then outline the simulation algorithm and genetic algorithm used for the intelligent version of our system.

4.2 Brief overview of previous methods

The first version of our robotic painter used the well defined Cyan Magenta Yellow and Key (or black) primaries (CMYK) in order to attempt to paint an image onto canvas. The algorithm calculated the density of each of the channels CMYK using an approximate conversion from the RGB values.

Several iterations of this algorithm were developed. The final version of the algorithm painted first with larger brushes and covered large areas, and covered smaller details with smaller brushes. For the smallest brush, the algorithm would simply paint at the gradients of the channels.

4.3 Paint Simulation for feedback painting system

4.3.1 Kubelka-Munk

The Kubelka-Munk theory of pigment reflectance [8] is used to simulate paint mixing in a computer paint simulation as was first proposed by Haase *et al* [9]. Kubelka-Munk gives an approximation of the reflectance of light as a function of the ratio of absorption (K) and scattering (S). For an infinitely thick paint sample, the result is Equation 1.

$$R_8 = 1 + \frac{K}{S} - \sqrt{\left(\frac{K}{S}\right) + 2\frac{K}{S}} \tag{1}$$

For a homogenous mixture of several pigments, the total absorption and scattering coefficients are simply weighted by the relative concentrations of each paint in the mixture. We can then find the effective ratio of absorption to scattering as in Equation 2, where c is a concentration between 0 and 1.

$$\left(\frac{K}{S}\right)_{Mix} = \frac{\sum_1^n c_i K_i}{\sum_1^n c_i S_i} \tag{2}$$

To display the colors on a monitor the reflectance values must be converted to the 1931 CIE color space. The set of discreet reflectance values from (1) represent an approximation for the spectral reflectance curve of the paint mixture. This discretized reflectance curve can be linearly transformed into the tristimulus XYZ primaries as in

Hunt's *Measuring Color* [10]. The tristimulus primaries are then transformed into RGB space using Bruce Lindbloom's *RGB/XYZ Matrices* [11].

Absorption and scattering coefficients are used for twelve paints derived from the physical paint data collected by Jeff Budsberg [12],[13].

4.3.2 Paint Simulation Algorithm

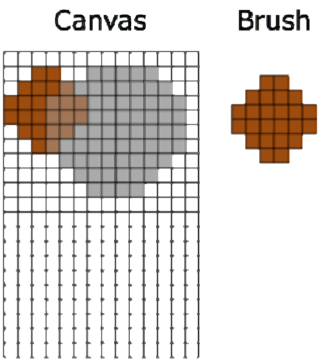


Fig. 2. Example of a simulated paintbrush-canvas interaction

A cell based algorithm similar to Baxter's Impasto **Errore. L'origine riferimento non è stata trovata.** is implemented to produce the paint simulation algorithm. The algorithm is able to simulate paint mixing at up to eight wavelengths. Two digital images are used to represent the canvas and the brush in the simulation. Each pixel represents a cell and the channels of the image keep track of the scattering and absorption coefficients. There is also a channel that keeps track of the amount of paint at each cell. This means that each image can have up to 17 channels.

To simulate the interaction of the brush on the canvas we register the brush image to a desired location on the canvas image and perform a cell transfer operation on corresponding cells in each image as in Figure 2. We can then recalculate the absorption and scattering coefficients using (1) and (2).

To model paint layering, a simple mechanism is introduced in the cell transfer operator that allows for different opacities when depositing simulated paint.

To produce an entire stroke, the brush transfer is performed once at each pixel along the path. The results of varying the layer opacity are shown below in Figure 3.

(a) (b) (c)

Fig. 3. Simulated paintings using three different layer opacities: (a)0.1, (b)0.5 and (c)1.0.

4.3.3 Physical Implementation

The purpose of the paint simulation is to accurately model a dynamic physical system. The approach of a genetic algorithm is effective only if our simulation corresponds closely with the physical system. For this reason the physical system is initially chosen to be as simple as possible.

Acrylic paint is used at a slow deposition rate to insure consistent dimensions and quality of paint strokes. This also allows for strokes to dry before the next layer is deposited. After this simplified painting setup has been developed more complicated and dynamic paint behaviours can be simulated and utilized.

Although this simplified system allows for accurate simulation, it limits the behaviour of a single brush stroke, which in turn makes it much more difficult to use this brush stroke to evolve paintings.

4.4 Genetic Algorithm

4.4.1 Introduction to Genetic Algorithms

Genetic algorithms use mechanisms inspired by biological evolution in order to find an a solution to a problem. The first step is encoding the problem's solution into a series of numbers or bits that the computer can manipulate; this encoding represents the genotype of the solution. The algorithm then creates a random population of solutions: in our case, this population consists of randomly encoded paintings. Most of these random paintings will not correlate at all with the input image, however some will undoubtedly be better than others. The population is then modified using recombination and mutation operators and a new generation of paintings is born. Each generation the best paintings of the new generation replace the least fit paintings according to some fitness criteria and a selection method.

It is noted that this is not the first attempt to use evolutionary algorithms to evolve paintings. John Collomosse and Chakraborty *et al*[15] both report on code able to evolve a set of brush strokes to an input image. Both of these evolutions, however are entirely non-physical. In the evolution they allow the algorithm to layer an arbitrarily large number of strokes with an arbitrary opacity and arbitrary RGB color. The result is a digital image with a painterly quality, but differs greatly from the physical problem we attempt to solve.

4.4.2 Representation and Population Initialization

A painting is represented as a list of brush strokes. Each brush stroke consists of five parameters: an index representing the paint color, an index representing the brush size, a length, an angle and a position. To convert the brushstroke list into a painting, the list is first sorted by brush width and then paint color.

A population of strokes is initialized by producing random strokes of a user-defined maximum stroke length along a grid that is also defined by the user.

4.4.3 Fitness

The HSV color error between the input image and the simulated painting are used as the fitness criteria:

$$E_{HSV} = \sqrt{(v_1 - v_2)^2 + (s_1 * \cos(h_1) - s_2 * \cos(h_2))^2 + (s_1 * \sin(h_1) - s_2 * \sin(h_2))^2} \qquad (3)$$

The HSV color error is defined as the vector distance between two colors when represented in the conical HSV color space. The error of the simulation versus input image is then summed over all of the pixels.

4.4.4 Selection

Deterministic crowding is used for selection. Every generation each painting is paired with a randomly selected painting for crossover. After crossover and mutation, each offspring is then paired with the parent that contributed the most strokes to it. The offspring then competes with the paired parent to see which will get inserted into the population. The parent is replaced if the its color error is larger than that of the child.

4.4.5 Crossover

A box region crossover is used to produce two offspring paintings from two parent paintings. Each child will take all the strokes in a random boxed region from one parent, and will take all of the strokes outside of this region from the second parent.

Figure 4 demonstrates the crossover operator.

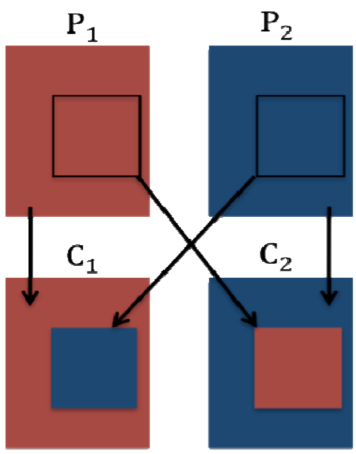


Fig. 4. Example crossover operation.

4.4.6 Mutation

The mutation operator modifies a single stroke in a painting. The mutation operator modifies one of the following parameters with equal probability.

Position – the position is moved a distance D and by an angle A. A is chosen random to be between 0- 2π. D is chosen randomly to be between zero and the grid size used to initialize the population.

Stroke color – either adds one or subtracts one to the paint color index.

Brush width – either adds one or subtracts one to the brush index.

Angle – change the angle by a, where a is chosen to be a random number between - π and + π.

Stroke length – scale the brush length by a random number between 0.5 and 1.5

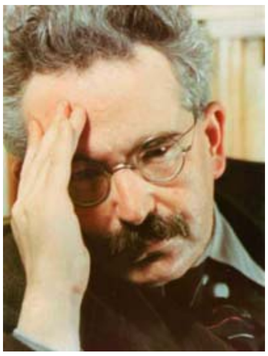
5. Results

5.1 Results from Human Designed paint algorithm

An early version of the robotic painter was a semi-deterministic painter that used described in section 4.2. In this version of our system there was no feedback of any sort, so simulated results are not available. Several results from several versions of the human designed painting algorithm are shown in Figure 5.

(a) **(b)**

(c) **(d)**



(d) **(e)**

Fig. 5. Robotic paintings from human-designed painting algorithm: (a) Dan Whoarly's 'Jimi' [17]; (b) 10 x 16.5 cm robotic painted acrylic on canvas; (c) flower image by André Karwath [18]; (d) robotic painted 15 x 20 cm acrylic on canvas; (e) Picture of Walter Benjamin [19] (f) 28 x 31.5 cm robotic painted acrylic on canvas

5.2 Evolved Simulation Results

Each result of an evolution is unique and cannot be replicated. However, the evolution has several mechanisms by which the user can affect the result. The initial population size, the mutation ratio and the crossover ratio will affect the performance and efficiency of the algorithm. Most importantly the number of strokes, the stroke maximum length and the paint colors affect potential styles of the resulting painting. We first look at a simple input image given in Figure 6.

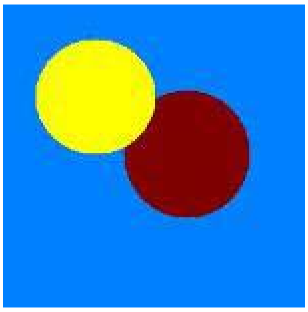


Fig. 6. Two circles input image

This case is a simple test to demonstrate the functionality of the evolutionary algorithm. The circles are chosen because there is nothing in the primitive (a straight stroke) that implies it should be able to represent a circle trivially. A non-physical paint palette is used, shown in Figure 7. The paint colors were invented to somewhat correlate with the input image, but do not trivially match the input image's colors. The layer opacity is set to .25 to allow for paint mixing and the initialization grid is set tightly so that the evolution can take advantage of paint mixing. Six hundred brush strokes is chosen to demonstrate that the algorithm is able to converge a large number of parameters, and also to ensure that there are enough strokes to represent the input image.

Fig. 7. An artificial palette used for painting evolution

Each generation of the evolution (generations 1-56) are shown in Figure 8. The evolutionary algorithm can successfully map the three colors in the input image in under 60 generations.

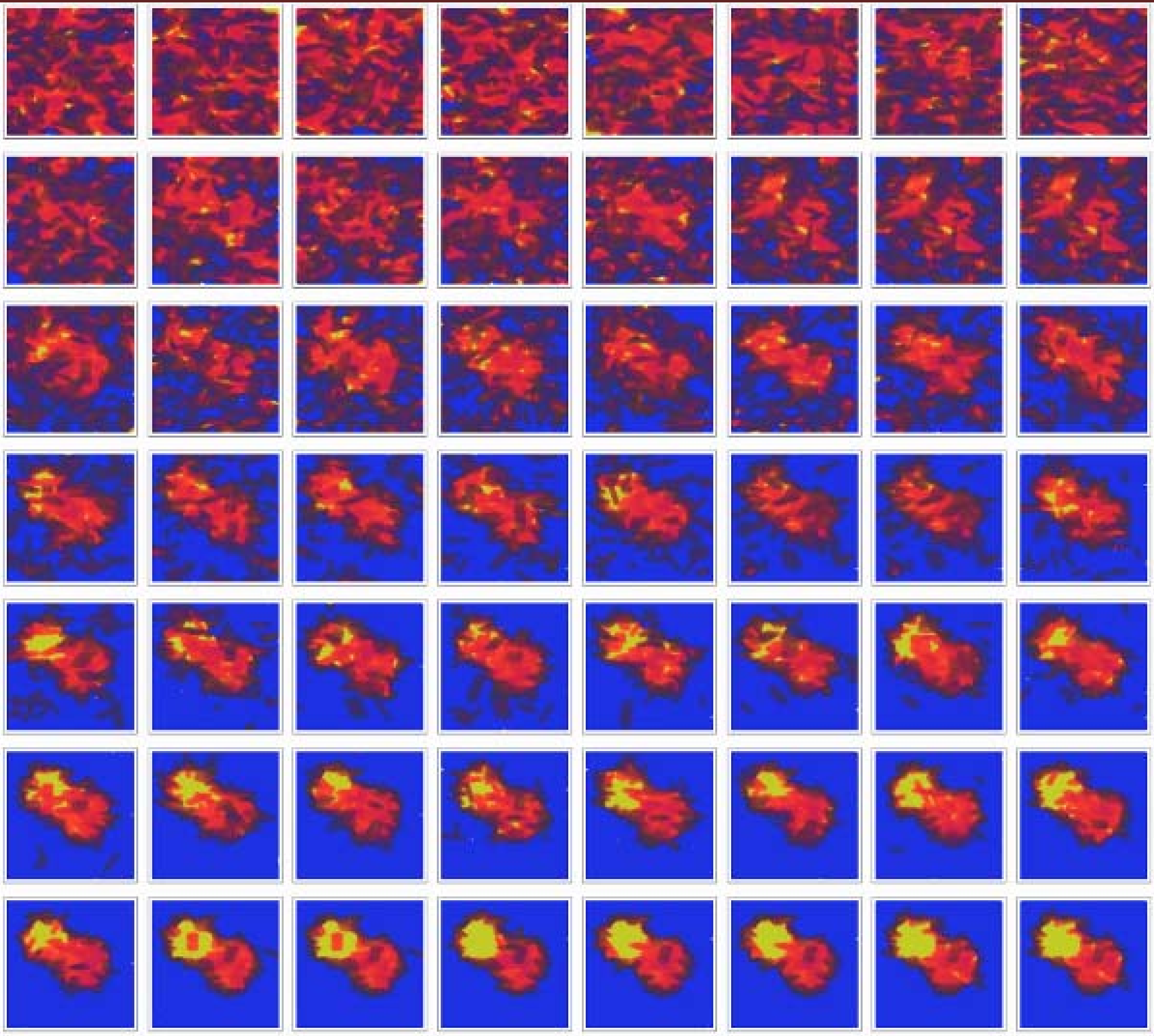
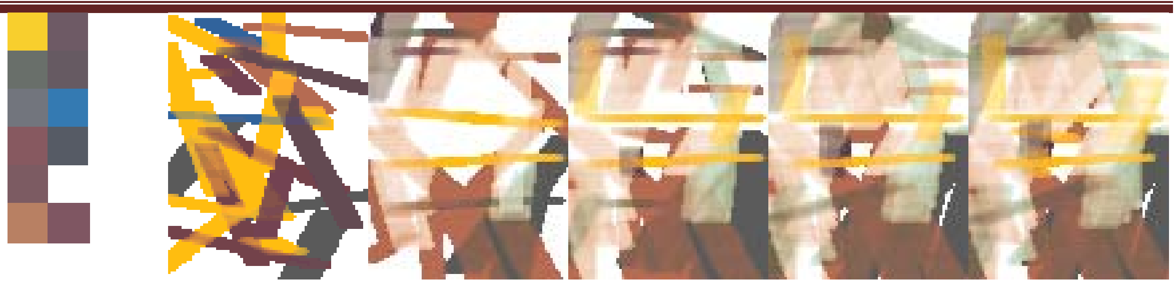


Fig. 8. 56 generations of an evolution

For the next case, a more complicated image is chosen. The first simulations using Budsberg's physical paint data are performed on a picture of German philosopher Walter Benjamin, shown above in Figure 5. Walter Benjamin is chosen for his influential essay relevant to the field of representational art and the study of artistic media: *The Work of Art in the Age of Mechanical Reproduction* [20].

The first evolutions use just twenty brush strokes to attempt to represent the input image. Two different palettes: one which we thought would be appropriate for the picture, the second palette simply contained all of the colors for which there was physical data.



(a) (b)

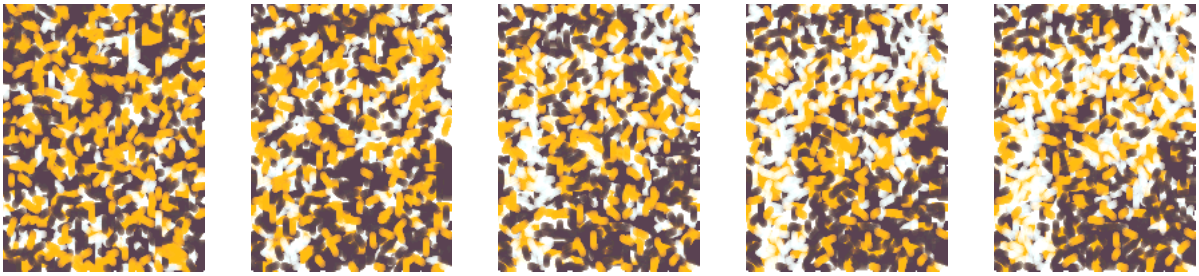
Fig. 9. Abstract painting of Walter Benjamin with layer opacity of .1: (a) The palette used; (b) the best simulated painting after 0, 50, 100,200 and 300 generations.

Additionally different amounts of paint mixing are allowed in the simulations. A layer opacity of 0.1 corresponds with a system where more paint mixes in the canvas or where the paint layers are thin and translucent. A layer opacity of .5 on the other hand does not allow for a significant amount of paint mixing. The progressions of one such evolution are given in Figure 9. The final result of the abstract painting evolutions are shown again in Table 1.

Layer Opacity / **Palette**	**0.5**	**0.1**
		
		

Table. 1. Sumarized results from abstract evolutionary paintings.

Finally the algorithm is tested on a much more difficult problem with the same input image of Walter Benjamin. For this evolution a simulation corresponding to the physical system described in section 4.3.3 is used. Here virtually no paint mixing is allowed, using a layer opacity of .5. Also the dimensions of the strokes is reduced and the density of strokes is greatly increased. A total of 1223 strokes are used in the simulation. The results are shown in the figure below.



(0) (25) (50) (100) (125)

(150) (300) (600) (1200) (1530)

Fig. 10. Progression of an evolution of Walter Benjamin. The generation number is given in parentheses.

5.3 Evolved Paintings Physical Results

A painting was physically executed of an evolution similar to Figure 10. The input image, the simulated result and the physical result are shown in Figure 11.

(a) (b) (c)

Fig. 11. A physically painted evolved painting. (a) shows the input image, (b) shows the simulated evolved painting and (c) physical painting 23 x 30cm robotic painted acrylic on canvas.

6. Discussion

The simulation results demonstrate the diverse styles and aesthetics our robotic painter is able to conceive. The first painting executed from a simulated evolution (Figure 11) is a good test of the flexibility of the genetic algorithm. Since minimal paint mixing is allowed in this particular evolution, determining a painting to match the input image becomes difficult. The result however is still clearly a unique interpretation of the input image.

The effect of the primitive in determining the result and style of a painting is demonstrated in the abstract evolved paintings in Table 1. In these short evolutions we see that given a more flexible primitive, the evolution is able to achieve more accurate representation consistently. Specifically if paint mixing is allowed then we are able to obtain images that more closely resemble the source image.

The ability of the algorithm to find a good representation depends greatly on the palette. For example if we only use two similar colors that are not represented in the source image the algorithm will not be able to represent the input image well.

The dependence of representational ability on palette stems from the fitness function. A broader palette and an ability to mix the colors in this palette together allows the algorithm to better match the colors to the input image.

Alternative fitness functions based on shape and frequency could address this limitation. Using the Fourier Transforms of an image has been considered as a fitness that would allow a wider variety of palettes to represent a given image.

It is important to note that while the goal given to the algorithm is to produce the most accurate reproduction of an input image, this is not necessarily the final goal of the controlling artist. The most interesting facet of these results is not how well we can reproduce a given image, but how fundamental parameters and human choices affect the way the algorithm chooses to interpret the image. Collaboration between the artist and the machine becomes necessary because their goals are at odds with each other.

While a significant amount of time was spent improving the algorithm to be able to evolve more precise representations, the most compelling results might be the abstract representations in Figure 9, although this evolution only took 1% of the time to evolve when compared to the more precise painting in Figure 10. The abstract results were also more unpredictable. While the small stroke, high precision problem often times resulted in paintings that looked very similar, the abstract evolutions often produced unexpected and varied results.

The face has proven a powerful tool for abstraction. While the image of Walter Benjamin is a complicated image with large gradients, and small details, human ability to recognize and interpret faces allows us to recognize the image even with the high levels of abstraction.

7. Future Work

The simulated image still deviates from the painted result in Figure 11. Moving forward, the greatest improvement that can be made to our work is to improve the paint simulation. This will have the resulting painting match the simulation more closely. More importantly it is desirable to expand to expand the simulation in order to predict a wider variety of paint behaviours as well as curved strokes. As we teach the computer to model more complicated shapes and behaviours of paint strokes, the system will be able to develop a wider variety of unique styles.

8. Conclusion

Our painting robot is the first machine to intelligently reproduce an image in an original artistic style. From the results we have seen that the program has determined several original styles in which to paint in simulation.

Harold Cohen's 1974 essay *On Purpose* predicted: "[W]ithin the next two or three decades… the computer will have come to be regarded as a fundamental tool by almost every conceivable profession. The artists may be among them. That will be the case, obviously, only if it shows itself to have something of a non-trivial nature to offer to the artist; if it can forward his purposes in some significant way" [21].

This project attempts to forward the artist's purpose significantly by adding intelligent machine collaboration. We have avoided the viewing of robotic art as an entirely stand-alone agent of art production. Our system is not designed to act entirely on its own. Our system does not produce the subject matter because a computer cannot choose an input image with any understanding of its significance. Therefore giving it this ability seems trivial and does not further the artist's purpose.

This project formulates art in a way which computers can powerfully contribute: as an optimization problem. Optimization is similar to some low level human artistic processes: how can one best represent a certain form, possibly using only a certain type of basic element? Or how could one represent a certain value or color using a limited palette? These questions are not completely analogous to computer optimization because the human optimization is inevitably interwoven with many higher-level processes such as emotional intelligence.

For example, Georges Seurat's technical thought process approached the problem of representing color by trying to maximize the averaging effects of his pixel-like primitives. Similarly, Picasso thought technically about the most basic shapes that might be able to represent a scene in many of his abstract paintings.

While a computer cannot produce the original artistic styles or creative breakthroughs of Seurat or Picasso, the described low level technical thought process is achievable in computers.

Acknowledgement

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A Generative Remixing of Music Tracks based on an Interactive Swarm

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Premise

"Identity SA" is an interactive and generative installation that combines a swarm-based simulation with real time camera based interaction that we presented at GA conference 2007. We extended it by embedding two methods to generate sounds and music from pre-recorded sampled sounds. One is to let agent trigger sounds at intervals that are synchronized to a particular musical rhythm. The other one is to generate sounds whose transposition and timing is purely related to the agent's properties. The probability that an agent triggers a sound is proportional to the square of its angular velocity for both cases. By mixture of these two methods, it generates a rich variety of attractive sounds that react with the visitor's motion.

1. Introduction

Swarm simulation is one of the algorithms that automatically produce complex dynamic patterns. It was originally inspired from collective behaviour of a variety of animals, such as school of fish and flock of birds, and imitates such behaviour by simple mathematical model of local interaction. That means each agent, a member of swarm, determines its own movement according to the information gathered from the local environment. This is useful for scientific research for emergent properties of animal behaviour, but also for artistic creation in the context of generative art. Some artists employed this type of method for their artworks on both visuals and sounds such as [1-3]. The authors' former work named "Flocking Orchestra" [4] used visually interactive swarm that flocks in a three dimensional virtual space and composes a music by selecting timing and note following the virtual physical state of each agent. Each sound element is generated as a MIDI note managed by the computer. This is one of the methods to generate music. Another type of generative music generation presented here is reorganization of a set of pre-recorded musical sounds.

"Identity SA" [5] is an authors' work that employed more than two thousands of agents flocking in not 3D but 2D virtual space to cover whole of screen. It draws an abstract painting that dynamically changes according to the position and orientation of the agents. It also reacts to a visitor's motion through a motion-detection mechanism utilising a live camera. The original implementation included only one method to generate reactive sounds. In our first experimental exhibition, most of the visitors gave us positive comments that they enjoyed it, but at the same time, some of them told us that the sound was scary. This comment is not so bad from our artistic point of view, but we considered it would also be nice if it could have more variety of sounds acceptable for as many persons as possible. Then we added two new methods as described in the following sections.

2. Sound generation

Three types of sound effects were implemented, synthesized sound, modified sampled sound, and remixed music. Sound synthesis for all of these types also depends on the movement of agents and visitors. Only a subset of all agents is involved in the generation of sound. The probability that an agent creates a sound is proportional to the square of its angular velocity so as to make it easy for the visitor to recognize the reaction. Our current sound synthesis implementation doesn't rely on any synthesis libraries but is based on relatively simple routines that calculate samples at a fixed frame rate of 44.1 kHz. Agents that are allowed to generate sounds are organized in a queue of fixed length. In the current implementation, the queue can hold 12 agents. If a new agent is selected for sound synthesis and the queue is already full, the new agent replaces the agent that has been in the queue for the longest time.

In each case, the length of the sound is scaled so that it is proportional to $1-\sqrt{F}$ within the range of 0.01 to 1, where F represents the agent's force of attraction towards detected motion. Accordingly, strongly attracted agents tend to produce short sounds whereas agents that don't respond to interaction create long sounds. Therefore, many different types of short sounds are generated in short time when the camera detects any type of very active motions.

Finally, white noise is mixed together with the audible output. The volume of the noise is proportional to the amount of motion captured by the camera. The stereo panning of the noise is controlled by the position of the centre of gravity of the detected motion. This noise is very effective for the visitors to become aware of the reaction of the system to their motion.

The following part of this section describes the generation of sampled sound and remixed music. The creation of synthesized sound has already been described elsewhere [5].

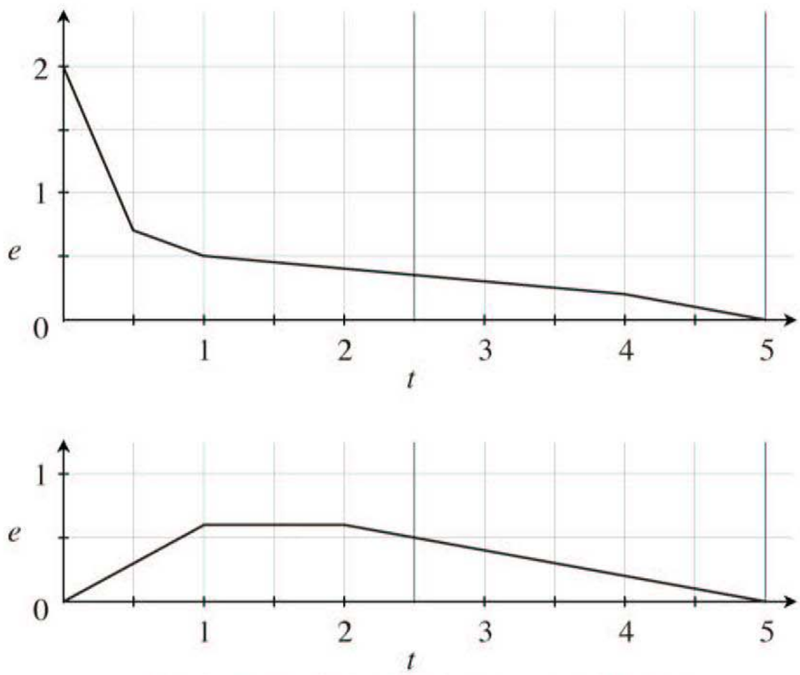


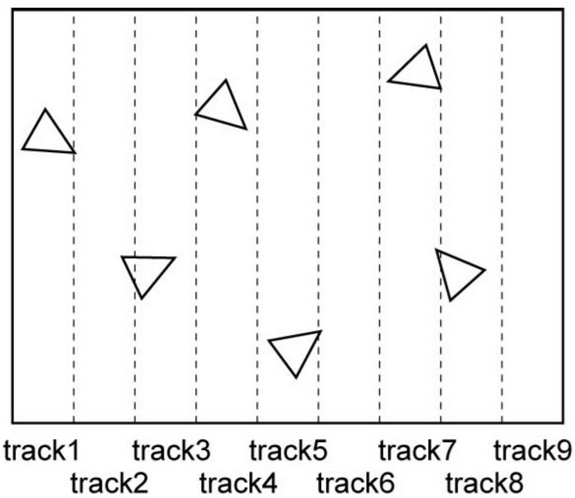
Figure 1. Two predefined envelope shapes.
The upper envelope possesses a strong and fast attack, the lower one starts slowly.

2.1 Modulated Sampled Sound

This method employs pre-recorded sounds that are imported from audio files stored in an assignable folder. The audio data can be stored in any format that is supported by the Audio Toolbox of Macintosh OS X, such as AIFF, MP3, and AAC. Each agent plays back its own allocated audio file. As in the case of synthesized sound, audio panning is controlled by an agent's horizontal position and playback speed depends on its vertical position. The Horizontal position is mapped to the balance of loudness between left and right channels as it is heard in natural, and the vertical position is mapped so that the higher position makes higher pitch and shorter duration. According to this playback speed, an amplitude envelope is generated and this envelope is applied in the same way as for the synthesized sound. Basic shapes of the envelopes were designed in two types, strong attack and slow starter, as shown in Figure 1. A sound track is created by repeating the sampled audio data as many times as is needed to reach the required playback duration.

2.2 Remixed Music

This method remixes pre-recorded sounds according to a uniform rhythm and loop interval. Usually, these tracks correspond to recordings of individual musical instruments such as a drum set, bass, piano and so on. Unlike the modulated sampled sound version, the playback of the selected tracks is synchronized to a global clock. In case the selected tracks differ in length, shorter tracks are iterated in order to match the length of the longest track. Accordingly, all tracks restart at exactly the same time. We tried two types of different methods to allocate tracks for agents. The first one is as same as the case of modulated sampled sound described in previous sub-section, that is, each agent has its own track. The other one is to place tracks in a grid on the space. In the current implementation, the screen space is evenly divided into consecutive vertical regions and each track is assigned to one of these regions. Tracks are selected for playback depending on the agent's horizontal position at the time the agent starts singing. For this method, the agents' vertical position is not taken into account. A playback sounds of a track come from any positions depending on the agents horizontal position in the former method, but the same track is always from the same position in the later method. Therefore, it is possible for the visitors to control the track selection a little by moving left and right.



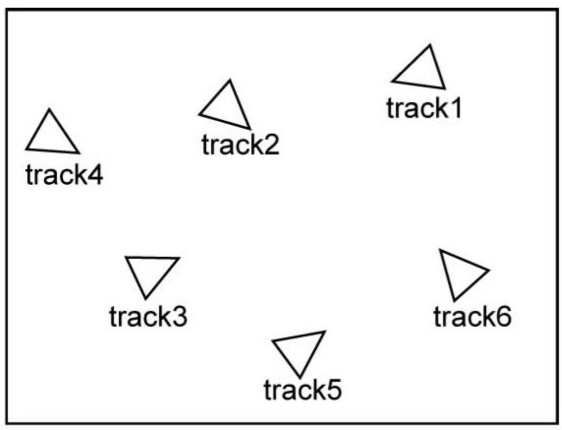


Figure 2. Two methods for track assignment.

2.3 Method selection

The swarm of Identity SA is consists of two species of agents. By changing the relation among the species in terms of physical interaction in collective behaviour, it produces a rich variety of dynamic motion pattern. For each species, one of the methods of sound generation described above can be assigned, but only a single set of sampled files is loadable at any moment, in the current implementation, that is, the same set of sound samples are used to generate each sound even if one species uses modulated sampled sound and another one uses remixed music. However, this style of combination produces effective sounds enough to entertain the visitors.

3. Experimental exhibition

We organized an experimental exhibition at Soka University's campus festival in October 2008. It could receive more positive feedback from the visitors than previous occasion in aspects of both visuals and sounds. For this exhibition, we prepared three sets of sound samples each of which includes a number of sampled files in same rhythm, same tempo, and same keynote. First one is house music of 135 beats per minute, second one is rock music of 120 beats per minute, and third one is hip-hop of 80 beats per minute. These tracks were picked up from a set of free samples accompanied to Apple's music sequence software "GarageBand". Some visitors were dancing at the front of the screen since all of them are danceable.

Concerning the difference between two methods of track assignment, it did not seem effective because it is difficult for the visitors to recognize the positioning of the sound without an explanation by a staff.

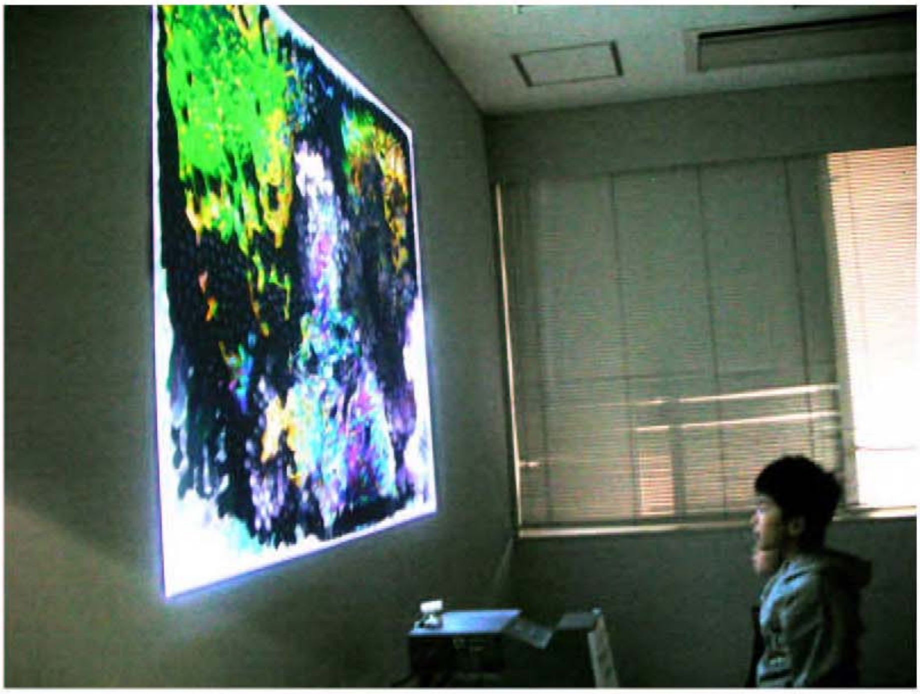


Figure 3. Photograph at experimental exhibition in the campus festival, October 2008.

4. Concluding remarks

A generative remixing of music tracks embedded in Identity SA was effective to engage people in wide range of ages and preferences in the experimental exhibition. Further possible extension includes assignment of more than one set of sample files for different method of sound generation, and introduction of generative music composition by the same method as “Flocking Orchestra” does.

“Identity SA 1.6” is a freeware downloadable from the following URL:

http://www.intlab.soka.ac.jp/~unemi/1/DT4/

We hope as many persons as possible will enjoy it.

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Across time and space: how the networked environment saved the screensaver

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Abstract:

Having come to represent an idle computer, the widespread adoption of broadband network systems and the 'always online' computer has helped reinvent the screensaver and the way it functions. This paper looks at two types of networked screensaver projects – the distributed computing network screensaver, and the more recent widget-style screensaver—and discusses the way that they use data flows to reshape the way that the applications behave and visualise themselves. *Seti@home* and Scott Draves' *Electric Sheep* are compared with That Ltd.'s *Drop Clock* and *Kaze to Desktop*, looking at the different ways that they engage with data flows and notions of computer downtime.

1. Introduction:

The screensaver was a programme initially developed to protect computer displays from screen burn when they weren't being used. Over the last 25 years though they come to represent a type of inactivity, populating office and home computers that have been left dormant: a visualisation of idleness in a world obsessed with productivity. At a time when it was becoming increasingly obsolete due to improvements in computer display technology, the screensaver's embrace of data networks has given it a new sense of purpose and possibility. Computer downtime has now become an opportunity for screensavers to quietly interact with data feeds: dynamically generating forms that respond to the flow of information, or in the case of the Berkeley Open Infrastructure for Network Computing (BOINC), putting millions of PCs to work collectively searching for extraterrestrial life or a cure for cancer.

Drop Clock, released by Tha Ltd. In 2008, is a mesmerising screensaver to watch, partly because of the way it visually brings together two different modes of time: actual time mixing with a highly detailed slow-motion sequence. When the programme is activated it transforms the computer monitor into a clock-face, drawing upon the computer's settings to display the current time of day. The numbers of the clock-face are represented by slow-motion footage of numerals falling into water—an effect not-unlike watching sand trickle through an hour glass, apart from the unique splash and pattern that each falling number creates. The time on the clock ticks over minute by minute, but despite the predictability of each sequence of numbers, the seductive nature of the slow-motion footage keeps the viewer mesmerised. It feels like a good thing to waste time with. Behind the clock-face of *Drop Clock* is a third passage of time that is crucial to any screensaver programme—the period of time since anyone last used the computer—a space that David Reinfurt refers as 'negative time' in his aesthetic genealogy of the screensaver [1]. Throughout this period of inactivity *Drop Clock* re-employs an idle computer monitor as a time-piece, shifting the function of the monitor so it still has the potential for usefulness when it's not being used as a workstation.

2. A brief history of the screensaver

The function and form of screensavers have changed since their arrival on the home PC in the early 1980s. Computer monitors at this time were susceptible to permanent marks left by phosphor burn-in if the same image was displayed on screen for a prolonged period of time: The first screensavers were programmes designed specifically to avoid this ‘screen-burn’. Early versions simply blanked the screen after a few minutes of inactivity, or cycled through screens of randomly-generated colours. As the PC grew more sophisticated in its graphic capabilities, so did the screensaver: the blank screen was soon replaced by animations, slide-shows or pieces of generative art made using Beziers or Lissajous curves. The screensaver had begun to develop new potentials, but was almost rendered obsolete by changes in computer-display technology— particularly the move away from CRT monitors towards LCD screens—which eliminated the risk of screen-burn, and therefore made the screensaver redundant, leaving it as more of a visual gimmick than a practical tool.

3. Screensavers and Distributed Computing

The *SETI@home* project helped reinvent the screensaver when it was launched in 1999, turning the screensaver into a front-piece for distributed computing. As networked PCs became more commonplace with the uptake of broadband in the late 1990s, distributed computing was recognized as a viable way of making the most of a PC’s downtime: a program is split into small parts and farmed out to available computers on a worldwide network, using their combined processing power to collectively work through mountains of data. Developed by the University of California, Berkeley, *SETI@home* allows over a million participants and their computers to contribute to the search for extra-terrestrial intelligence, with the idle PCs processing data gathered from the Arecibo telescope in Puerto Rico, analysing the radio signals for signs that might indicate life out there in the universe. *SETI@home* is the biggest example of this type of distributed computing, but the Berkeley Open Infrastructure for Network Computing (BOINC) has given rise to many similar applications, using screensaver-activated grid computing to process data relating to a diverse range of issues such as cancer, climate predictions, Sudoku and the search for megaprimes.

SETI@home inspired Scott Draves to create *Electric Sheep*[2]—a screensaver released the same year—that taps into a distributed computing network that creates and renders high quality fractal animations. The title for Draves’ project refers to Philip K Dick’s novel *Do Androids Dream of Electric Sheep?,* with this screensaver employing sleeping computers to create what Drave refers to as ‘sheep’: a flock of generated life-forms that are bred and evolve depending on the size and power of the distributed network, and how active a role the screensaver’s users choose to take in selecting animations. Where the BOINC screensavers generally use grid computing to process vast amounts of data in the name of scientific research, and tend not to focus so much on the display itself, *Electric Sheep*—being primarily focused on the creation of generative images—returns the screensaver to the graphical playground of earlier times. Besides the sophisticated evolution algorithms and high-quality render farm, where it does suggest new possibilities for the future of the screensaver is in its fostering of a networked community. With a touch of the cursor keys on their keyboard, users of *Electric Sheep* are able to vote for or against the animations that they see, with the data being fed back into the evolutionary algorithm. Like *SETI@home,* contributors and participants feature on the website[3], whilst *Electric Sheep* makes a significant contribution towards community-building by making its code open source, encouraging others to build and develop from *Electric Sheep*’s start point.

4. Smaller data flows

Distributed computing is not the only possibility that a networked environment has brought to the screensaver’s occupation of idle computers however. Smaller sets of data can offer as much to the generative nature of the screensaver, providing a flow of inputs that trigger and shape the programme’s responses onscreen. Where *Drop Clock*’s use of the computer’s time settings was a fixed input, Tha Ltd’s 2007 release, *Kaze to Desktop* takes wind speed and directional data from local weather reports. When the screensaver activates it redraws the desktop as if the wind had somehow gotten inside the monitor: windows, icons and tool-bars tumble across the screen with varying degrees of velocity, depending upon the weather conditions. The items left onscreen mid-job become raw material for the animation, while the weather data controls their behaviour. On a quiet day the items might tumble delicately, whilst stormy weather naturally brings a more frenetic energy to the movements. A worker who has gone out for fresh air might return to the screen to find the weather conditions mirrored inside, while the worker who is too busy to leave the room can still get a taste for what is happening directly outside. Where *SETI@home* is looking intently out into the distant parts of the universe, the charm of *Kaze to Desktop* is that it is so localised—what's being experienced directly outside is also being experienced inside the computer. Where *Electric Sheep* alludes to Dick's android dreams, perhaps some of *Kaze to Desktop* and *SETI@home*'s simple beauty comes from the fact that they more directly refer to the passing of time and our inactivity; creating tumbleweeds determined by how much is or isn't happening inside and outside.

5. Summary

The screensavers from Tha Ltd. have both been developed at a time when widget applications are becoming more prevalent—selecting from a vast number of available data feeds, internal as well as online, to dynamically visualise and respond to information. *SETI@home* has helped redefine the screensaver as a networked application, finding a new purpose through the collective processing of data. *Electric Sheep* took this model and shifted it towards the creation and sharing of new data and new images. The Tha Ltd. projects suggest that, even in small ways, the screensaver can continue to find new uses by responding this constant flow of data that move across the networked world. An idle computer monitor needn't stare blankly when there's so much activity happening right outside the window and out across the universe.

6. References

[1] *Screen.saver*, David Reinfurt, 'Art Lies' magazine, issue 55, Fall 2007 <www.artlies.org>
[2] *The Electric Sheep Screen-Saver: A Case Study in Aesthetic Evolution*, Scott Draves, EvoMUSART 2005, Lausanne, Switzerland
[3] <www.electricsheep.org> and < setiathome.ssl.berkeley.edu>

The bases of generative Tomb in Islamic Architecture

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1-Abstract

It possible to know the buildings and architectural designs through the planned structure and elevation with relations or characteristics between their schemes, which contain relations can be analyzed by geometric type, these relationships or characteristics evident in some plans may not be clear and easily recognized, only after geometric and graphic analyses. Therefore, it is not possible to distinguish between types of buildings in most Islamic buildings especially in Islamic tomb plans were unclear because the most buildings are found non-specific identification by experts, especially when found ground floor of the building , From here emerged the importance of this research paper to create a base for generating plan shape and form of buildings which can be relied upon in the analysis and diagnosis of schemes of buildings and the possibility distinguishing from several types of patterns and sorting through some of the analytical study of the scheme of horizontal buildings and engineering study of its relations and types .Some of important relationships that can be analyzed in the scheme are(repetition – symmetry - measure - Adjacency – size –overlap- pattern shape). Where we can analyze each scheme and found the code of each scheme according to the use and the type of relations in the scheme .After founding the code of each scheme , we can compare between the codes of each architectural style, it was found that there code Legacy between tombs plan in Islamic architecture in spite of the differences in style and type of planned job .It can also compare between different architecture styles and find there codes Legacy., as codes can be converted to information and databases put in the determinants and restrictions incorporated into the program of artificial intelligence , the most important thing in this study is to find or generate codes that are specific to each type in Islamic architecture, especially tomb and arranging them as DNA tape private to Islamic tombs, this DNA tape can used as a matrix for generate and create the plan shape not in the Islamic

architecture only but it can used to create shape in other architecture style , so the arrangement of the geometric relationships In the schemes are the basis for generating the shape plane and give schemes the styles in Islamic architecture and other architecture styles.

2-Introduction in Islamic architecture

Islamic architecture, or architecture used by Muslims, consists of models including certain formal bases and vocabularies to generate the form of the horizontal plan. They interrelated to form a specific generation code for each formal and functional type or pattern in Islamic architecture. As this relation among the items of each code is changing, the form of the plan is also changing, thus changing the pattern of using plan. Among the architectural models with various forms plans that could be analyzed are Tombs. Tombs are buildings that immortalize the memory of the significant men and indicate the relation between life and death and the memory of the dead [7].

the power and glory of Muslim rulers was given public expression in series of magnificent tomb, out living death ,these tomb are characteristic of virtually all Islamic dynasties [1] .

Tombs are among the building patterns that are not complex where there are no many spaces due to the functional pattern of the Tombs. A Tomb could be a tomb for one of the righteous Muslims, a monument or a witness for one of the previous Muslim leaders. This is why Tomb pattern is selected as a model to be analyzed in order to explore elements of generation[3].

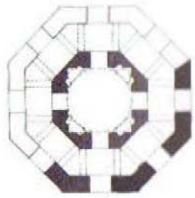
3-The types and composition tomb

There are types of Tombs according to plans formation. Some are mono–central and others have many axis that are either perpendicular or diverged in a certain angle[9].

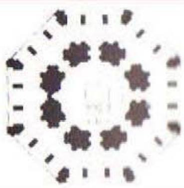
So much for the origins of the Islamic tomb , the terminology used to describe it , and more to the point its religious and secular associations , it may be helpful to comment in general terms on types of forms which found favor over the centuries and inquire into the reasons for their popularity [6]. The tomb was a type reproduced , sometimes with remarkable accuracy of detail, the monumental tent of the Turkey peoples still further east , in the Mughal dominions of northern India , the type of building which culminated in Taj Mahal served its patrons as a pleasure pavilion in their life times and as atomb after their death .[1]

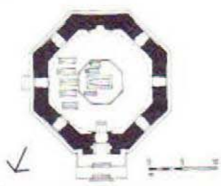
Tombs usually consists of high walls with one central dome or more. The dome is in the middle of an elevated platform and some Tombs consist of many layers. These layers generate the internal walls of the Tomb and they are ring like where formal relations and properties distribute. This is like any of the Islamic buildings where their forms are generated from basic elements and relations. Our study focus on important elements related to the formation of Tombs. The basic properties of the Islamic architecture are axiallty, proportion, symmetry, repetition, rhythm, size and adjacency in addition to other elements taking part in the production of forms in Islamic architecture. Each of the Tombs will be graphically and geometrically analyzed using 3dMAX–ACAD to create horizontal plan form generation matrix for the Tomb through the selected models of Tombs in Islamic architecture. These are characterized by their plans forms and various locations in ancient Islamic world.

4-Selected models of the Tomb

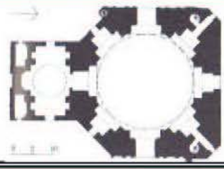
Sample No.1				
Sample Name	City	Time	Reference	Figure
Qubbat as-Sulaybiyya	Iraq	896-862	Robert Hillenbrand	

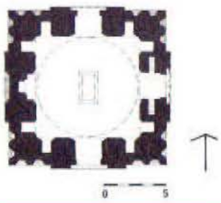
Sample No.2				
Sample Name	City	Time	Reference	Figure
Shah Zada	Afghanistan	1200-1000	Robert Hillenbrand	

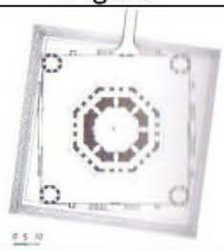
Sample No.3				
Sample Name	City	Time	Reference	Figure
Khan-I Jihan Tilangani	India	1369-1368	George Michell	

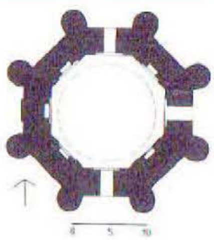
Sample No.4				
Sample Name	City	Time	Reference	Figure
Green Tomb	Turkey	1421	George Michell	

Sample No.5				
Sample Name	City	Time	Reference	Figure
Tughtabeg Khatun	Urgench	1370	George Michell	

Sample No.6				
Sample Name	City	Time	Reference	Figure
Oljeytu	Iran	14 Century	George Michell	

Sample No.7				
Sample Name	City	Time	Reference	Figure
Chotte Khan Ka Gunbad	India	15 Century	George Michell	

Sample No.8				
Sample Name	City	Time	Reference	Figure
Sher Shah Sur	India	1540	George Michell	

Sample No.9				
Sample Name	City	Time	Reference	Figure
Shah Rukn-I Alam	Pakistan	1320	George Michell	

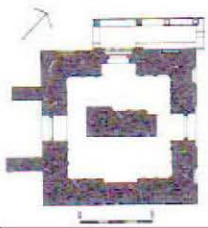
Sample No.10				
Sample Name	City	Time	Reference	Figure
Imam Yahya	Iraq	1229	George Michell	

Table -1- Selected models of the Tomb

5-Matrix of Tombs Elements Generation:

Tombs consist of many elements through which Tomb plan is generated. Focus will be laid on the main elements and properties generating such plans. Geometric relations among the analytical elements are rational systems of the architectural language characterized by abstractness depending on the regular and geometric form in addition to mathematical ratios in generative process of the formal models.

5-1. Axiallty:

Axiallty represents a symbolic trend, unifying some elements and regulating them sequentially and continuously giving a direction for the system. Axiallty is related with the formal balance of the plan.[8] The more there are axis the less the plan is balanced, in particular when there is equal intersection among axis[2]. This concept transform and generate forms as single and abstract elements to be unified in a new system, i.e. transforming the form pattern from a primary condition, simple and standard, to ultimate condition, complex derived from the origin [10]. Thus the first element of Tomb generation, axiallty, consisting of two variables: multiaxis and monoaxis, is determined. The mutliaxis variable is subdivided into two minor variables, balanced 90° and non–balanced more or less than 90°, indicating the form balance through axis deviation angle.

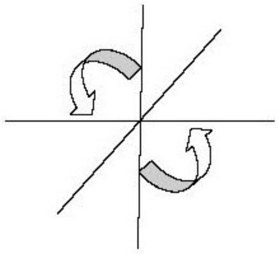


Figure (1) more than one axis – not balance

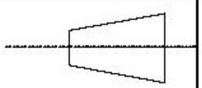
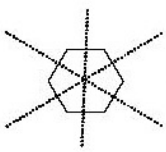
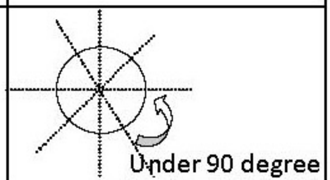
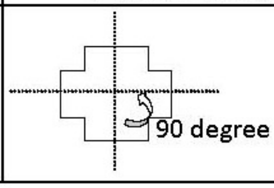
G1 axiallty	A-Single axis		Balanced	
	B-Multi-axis		B1-Unbalanced <90˚	
			B2-Balanced > 90˚	

Table -2-Cragheic and geometric Analysis Axiallty

5-2 Formal type

Plan formation is determined through its generation system. Tombs include various types of forms serving the building function [8]. The form could be central, as in cross dome Tomb, linear, radial or mixing all these formal patterns. Focusing on these patterns will be through using form centrality; all the plan elements are centre related or radial directed radialy outside the center. Form pattern could be simple linear and in some buildings there are a mixture of these patterns [2].

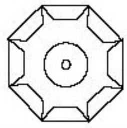
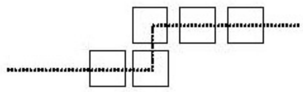
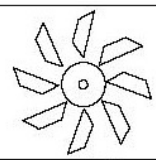
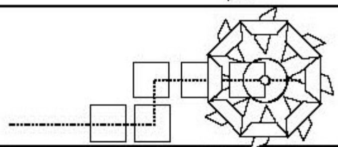
G2 Formal Type	A-Central	
	B- Linear	
	C-radiate	
	D-Mixed	

Table -3-Cragheic and geometric Analysis to find Formal Type

5-3 Organization Pattern Shape

It depends on how form is shaped through including layers of lines and spaces among these lines. The Tomb plan, due to its function, should be organized to be utilized in building function [7].

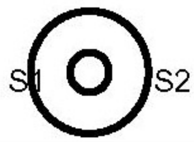
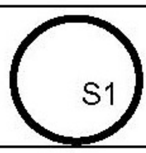
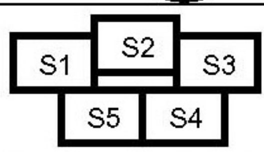
G3 Organization Pattern Shape	A- Multi-layer	
	B- single layer	
	C- units clustered	

Table -4-Cragheic and geometric Analysis for Organization Pattern Shape

5-4 Size

Size is the base of design unit where human body forms a part of the nature. This made the ancient people take their basic ideas for the building size. Measuring units were related and derived from human body and this is not only adopted in architecture but in other forms of art [2].

The measuring unit could be a number row or geometric in general. The designing theory of the Greeks had not been formed yet and the temple was generated from certain dimensions depending on rectangles within the golden ratio (1/1.618).

After finding the modalar, plan size is generated through repetitions of a fixed number of horizontal row to obtain the building length and width and then the height through a fixed number to achieve the third dimension of the building, thus determining the building size geometrically and patternly[11].

Hence, architectural plans could be analyzed through finding the modalar through determining the measurable quantified variables and measurement conditions of dimension system variables. In addition, type of the modala could be find, whether horizontal or vertical [5].

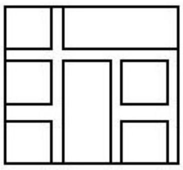
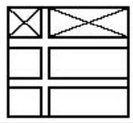
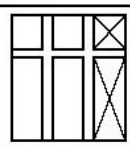
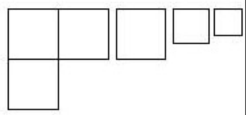
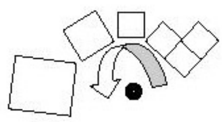
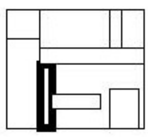
G4 Size	A-Dimensional Domination		A1- Size distribution	A1- horizontal	
				A2- Vertical	
			A2- Size Type	A1- linear	
				A2- Pivotal	
	B- No Domination				

Table -5-Cragheic and geometric Analysis for size element

5-5 Repetition

Repetition is of the important geometric properties that could be used to generate the form of the geometric plan. Repetition is not done unless the repeated element and repetition path are fixed. Kinds of repetitions vary according to the type of building to be designed. There various kinds of repetition, linear, for example, where the repeated line is linearly directed, or central – radial repetition.

In all the above types, adjacency in repetition exists. There is adjacency with contact, adjacency with intervention or divergent adjacency [2]

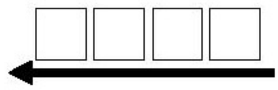
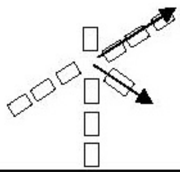
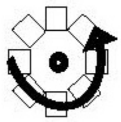
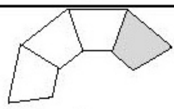
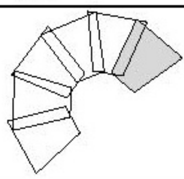
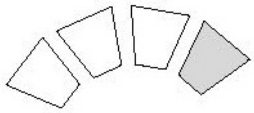
G5 Repetition	A- Repetition Type	A1-Linear	
		A2- radiate	
		A3- central	
	B-Adjacency Type	A1-Tangent	
		A2-overlap	
		A3 -Divergent	

Table -6-Cragheic and geometric Analysis for repetition element

6- Practical Study

We will analysis the selected tome as a Matrix of Tombs Elements Generation and we will presented one tome(Qubbat as-Sulaybiyya -model No.1) form selection tomes as following :

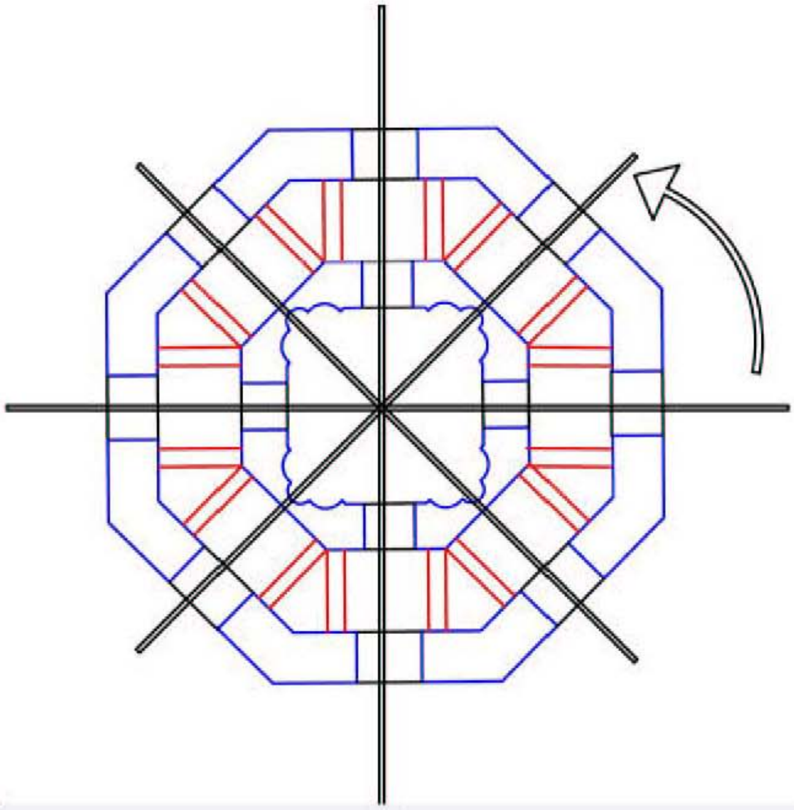
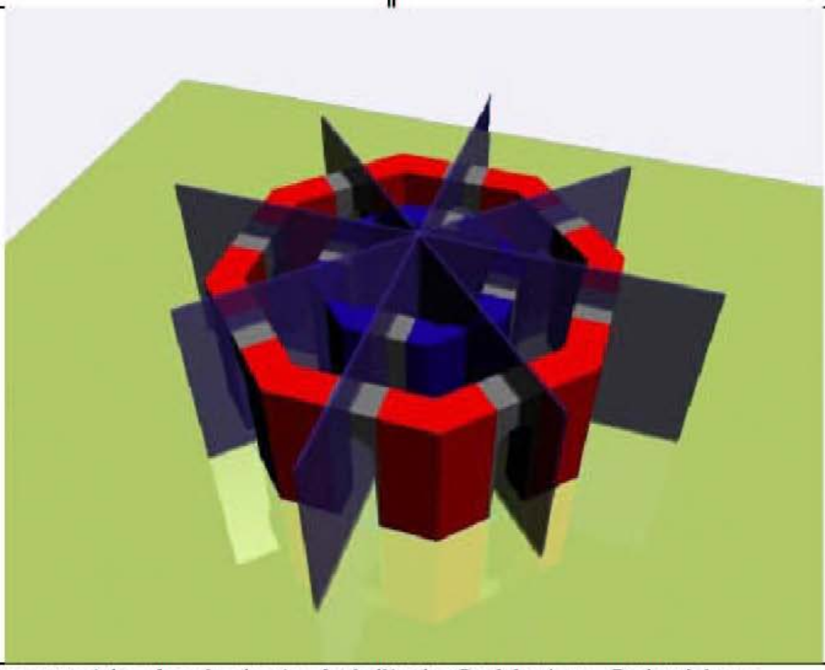
G1 axiallty	Unbalanced <90˚	 

Table -7-Cragheic and geometric Analysis to Axiallty in Qubbat as-Sulaybiyya

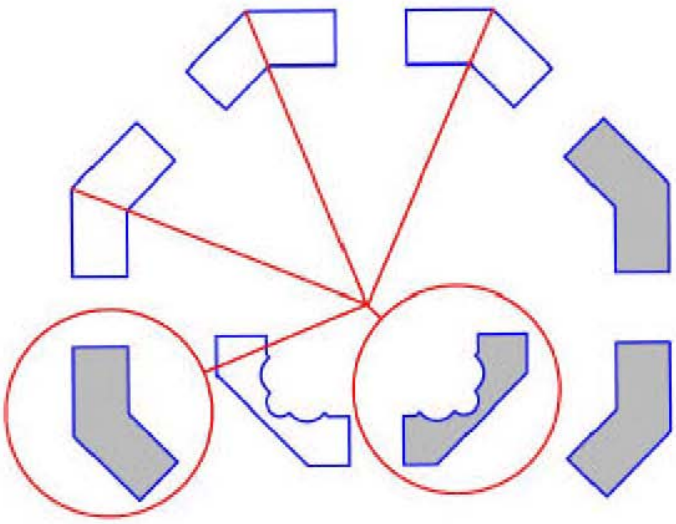
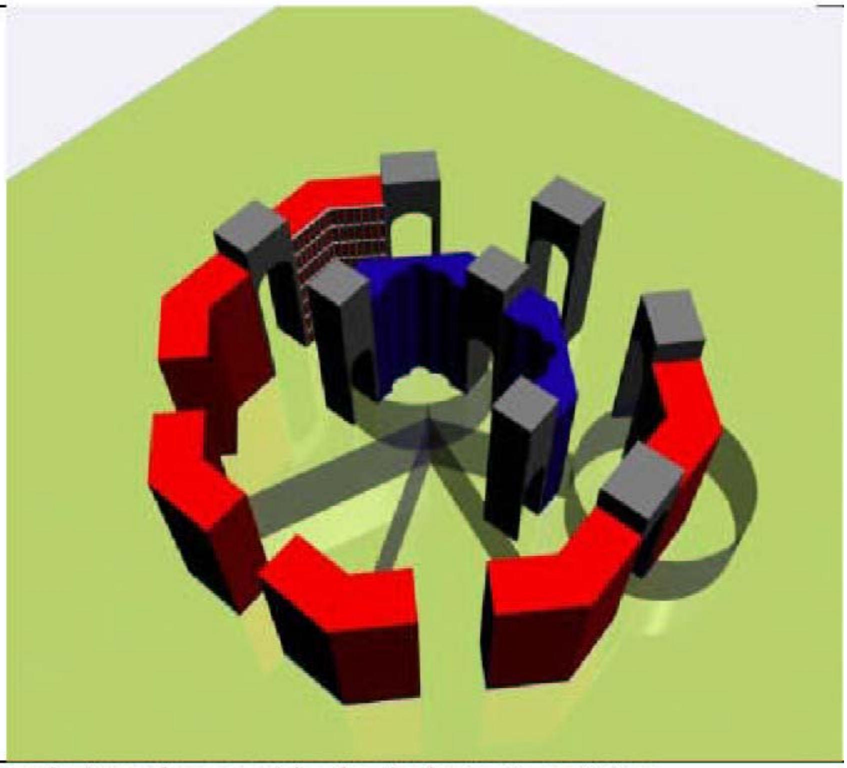
G2 Formal Type	Central	 

Table -8-Cragheic and geometric Analysis to Formal Type in Qubbat as-Sulaybiyya

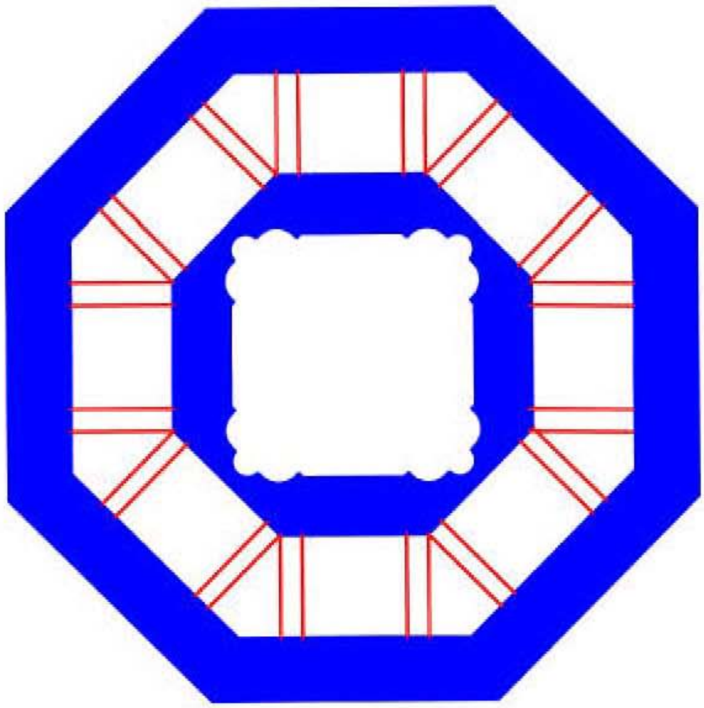
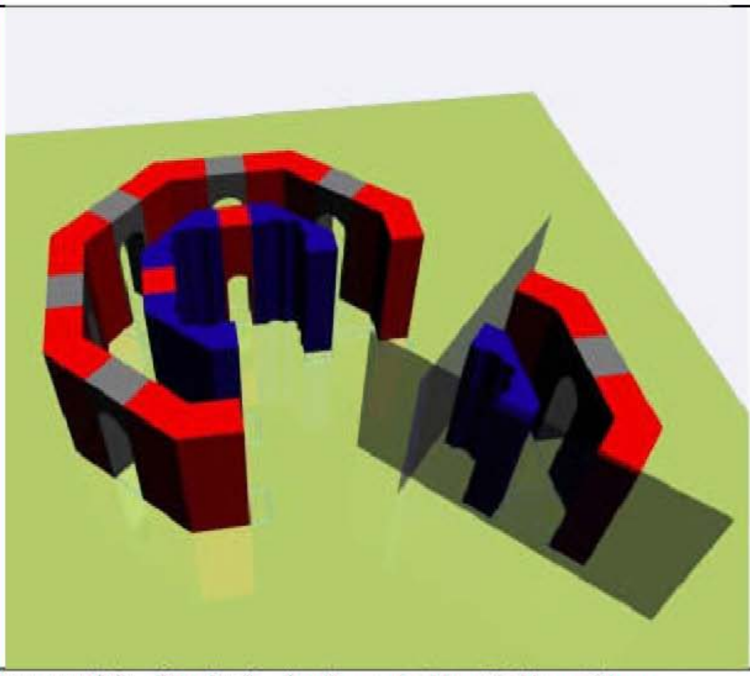
G3- Organizat-ion Pattern Shape	Multi-layer	 

Table -9-Cragheic and geometric Analysis to Organization Pattern Shape in Qubbat as-Sulaybiyya

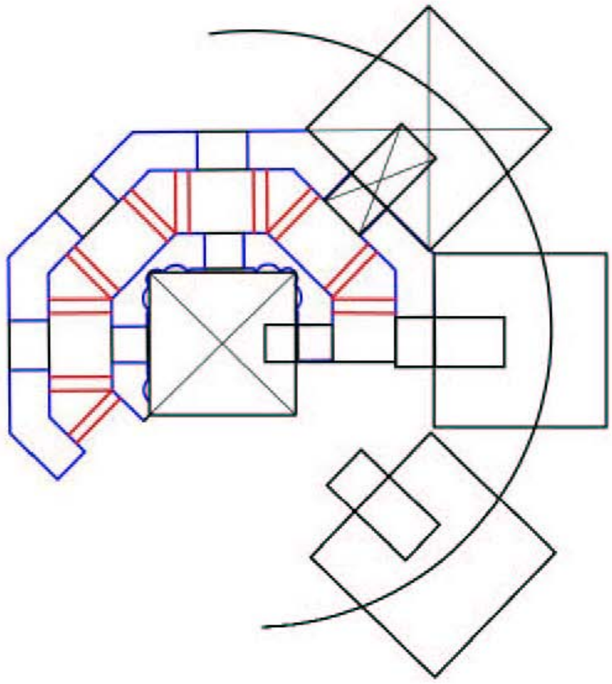
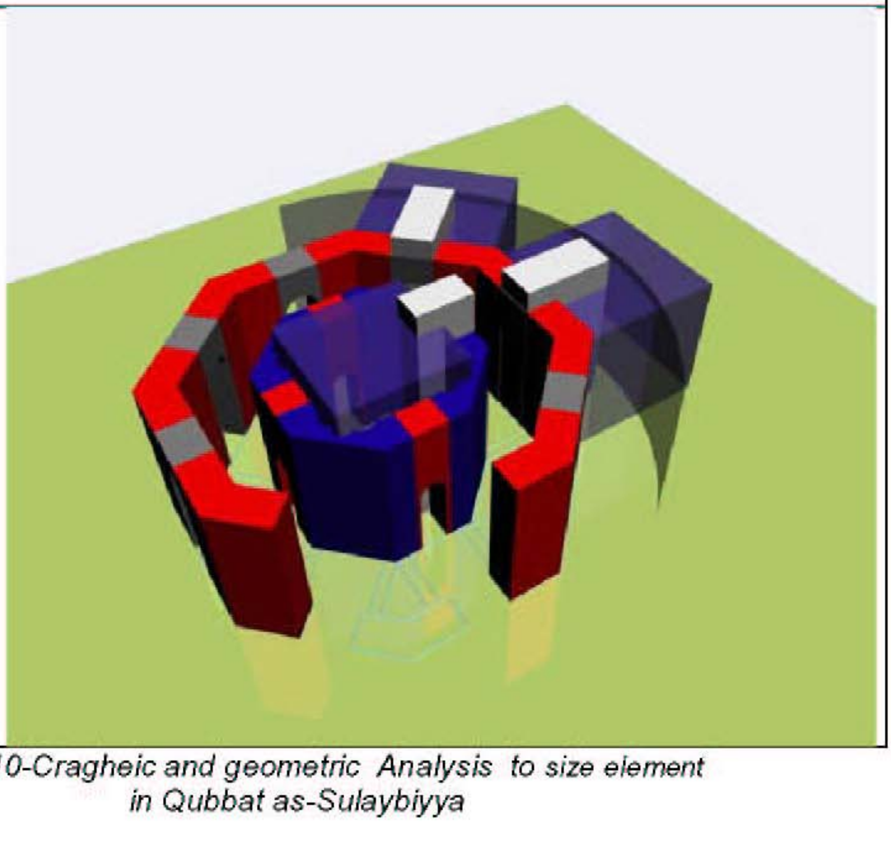
G4 Size	A- Dimensional Domination Size distribution Balanced - Size Type Pivotal	 

Table -10-Cragheic and geometric Analysis to size element in Qubbat as-Sulaybiyya

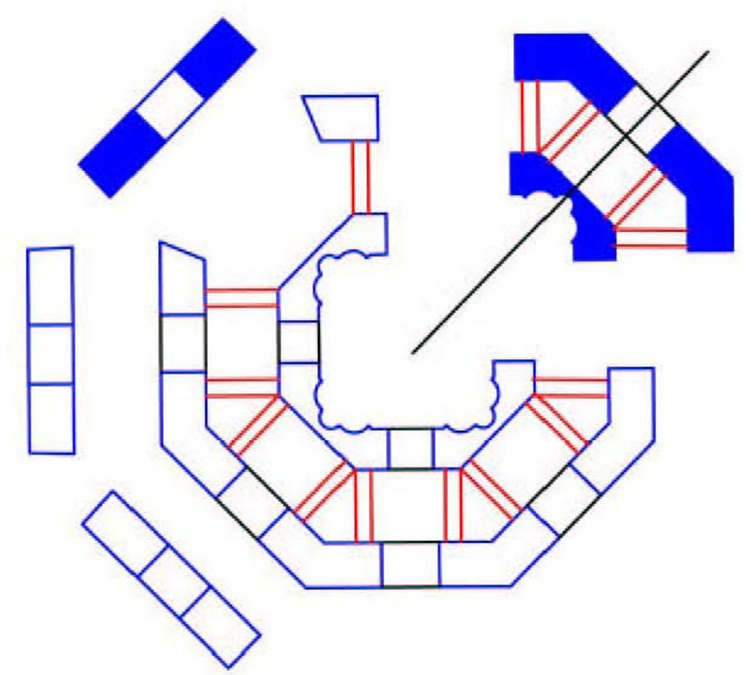
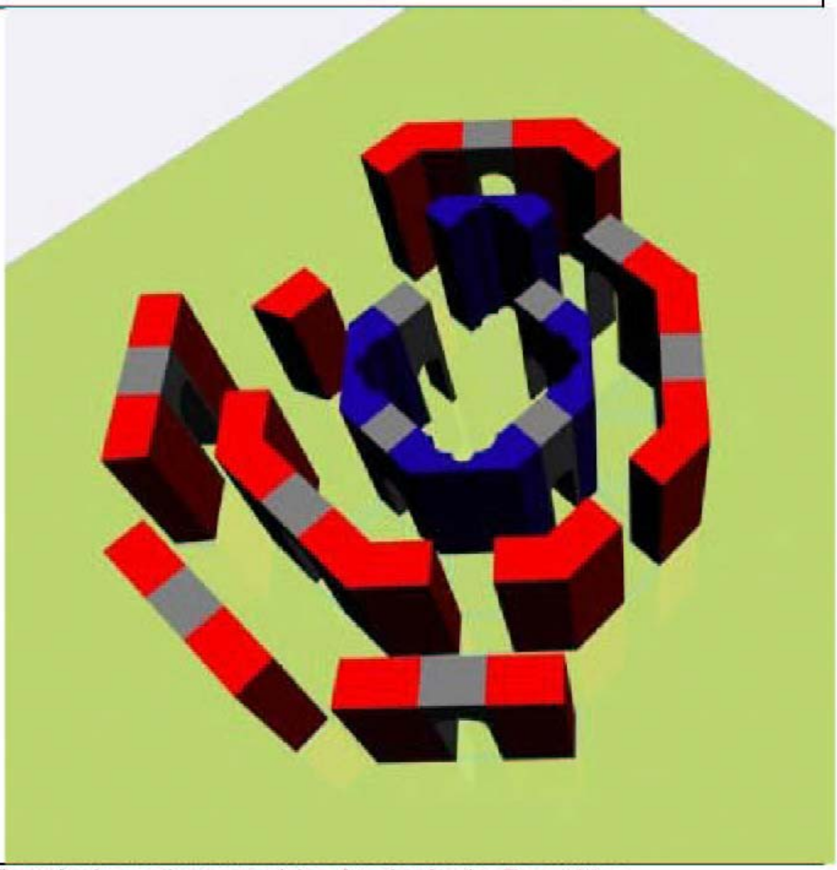
G5 Repetition	Repetition Type Central - Adjacency Type overlap	 

Table -11-Cragheic and geometric Analysis to Repetition in Qubbat as-Sulaybiyya

7- Results

1. **Axiallty:** Results of the variable G1 shows that Tombs in Islamic architecture generated through the multiaxes in general. They resulted from perpendicular axis 20% and non–perpendicular axis where the angle is less than 90° with 80% of the samples examined.
2. **Formal Type:** Results of the variable G2 shows that Tombs in Islamic architecture generated through a central pattern with 90% of the samples examined and 10% for the linear pattern.
3. **Organization Pattern Shape:** Results show that 40% of the Tombs in Islamic architecture consist of two layers or more and the remaining 60% consist of one layer.
4. **Size:** Practical study and graphical analyses show that 30% of the samples examined have one modalar unit predominant by horizontal direction. The remaining 70% have parallel measuring unit. As for the body generation, 10% of the samples have a linear vector and the other 90% have an axial generative vector.
5. **Repetition:** Results show that 20% of the repletion is linear and 80% is central. As for the nature of adjacency, 10% is for contacted adjacencies and 90% for interrelated adjacencies.

Table -12-Final results for Tomb that selected from Islamic Wordl

Matrix element for tomb generation					Selected models of the Tomb 1	2	3	4	5	6	7	8	9	10
G1	axiallty	A-Single axis	Balanced											
		B-Multi-axis	B1-Unbalanced <90˚		•	•	•	•	•	•		•	•	
			B2-Balanced > 90˚								•			•
G2	Formal Type	A-Central			•	•	•	•	•	•	•	•	•	
		B- Linear												•
		C-radiate												
		D-Mixed												
G3	Organization Pattern Shape	A- Multi-layer			•		•					•	•	
		B- single layer				•		•	•	•	•			•
		C- units clustered												
G4	Size	A- Dimensional Domination	A1- Size distribution	A1- horizontal										
				A2- Vertical					•	•				•
				A3- balanced	•	•	•	•			•	•	•	
			A2- Size Type	A1- linear								•		•
				A2- Pivotal	•	•	•	•	•	•	•		•	
		B- No Domination												

G5	Repetition	A- Repetition Type	A1-Linear							•			•
			A2- radiate										
			A3- central	•	•	•	•	•	•		•	•	
		B- Adjacency Type	B1-Tangent			•							
			B2-overlap	•	•		•	•	•	•	•	•	•
			B3 -Divergent										

8- General Conclusions:

Samples of Tombs from different parts in the Islamic world have been examined and analyzed. It is concluded that Tombs pattern generation in Islamic architecture followed a certain code for generation with some models that showed a jump in generating genetic plans forms. Pattern form totally depend on certain codes to generate them and they are the same that are used in analyzing the selected samples of the Tombs. The change of any code will lead to a change in building plan pattern where code change will lead to a change in the functional pattern of the bundling. Five codes, axiallty, formal type, organization pattern shape, size and repetition are used in addition to some other minor codes. Such codes generate the basic form and this is emphasized by Islamic architecture studies stating that there is a designing unit of the form.

The base for generating Tombs form is axiallty where form should be based on multiple axes. These are non–perpendicular and pass through the form center thus creating imbalance on the Tomb center where the tomb is located. This is to emphasize the importance of the buried person as in the cross dome. These axes forced the central pattern generation of the form and any addition of the shape or the development through a designing process will be generated on the bases of certain sizeable measures subjected to ratios or relations. The sizable measure take an axis direction where size increase depending on a formal center.

Formal repetition is of the other codes for generating Tombs. There is a repetition in the plan for a part or an element of the form. Repetition is based on centrality generated from axiallty and form in addition to interrelations.

We will named the element as a code Number to fined the code for each tome and after this we get the final code that used to generate the shape plan of tomb in Islamic Architecture as following

Table -13- Code for each element As serial Number

Code for each element				
G1	axially	A	A	
		B	B1	
			B2	
G2	Formal Type	A		
		B		
		C		
		D		
G3	Organization Pattern Shape	A		
		B		
		C		
G4	Size	A	A1	A1
				A2
				A3
			A2	A1
				A2
		B		
G5	Repetition	A		A1
				A2
				A3
		B		B1
				B2
				B3

Table -14- Code for each Tome shape As serial Number

No	Final Code For Each Tomb																
1	G1	B	B1	G2	A	G3	A	G4	A	A1	A3	A2	A2	G5	A	A3	B	B2
2	G1	B	B1	G2	A	G3	B	G4	A	A1	A3	A2	A2	G5	A	A3	B	B2
3	G1	B	B1	G2	A	G3	A	G4	A	A1	A3	A2	A2	G5	A	A3	B	B1
4	G1	B	B1	G2	A	G3	B	G4	A	A1	A3	A2	A2	G5	A	A3	B	B2
5	G1	B	B1	G2	A	G3	B	G4	A	A1	A2	A2	A2	G5	A	A3	B	B2
6	G1	B	B1	G2	A	G3	B	G4	A	A1	A2	A2	A2	G5	A	A3	B	B2
7	G1	B	B2	G2	A	G3	B	G4	A	A1	A3	A2	A2	G5	A	A1	B	B2
8	G1	B	B1	G2	A	G3	A	G4	A	A1	A3	A2	A1	G5	A	A3	B	B2
9	G1	B	B1	G2	A	G3	A	G4	A	A1	A3	A2	A2	G5	A	A3	B	B2
10	G1	B	B2	G2	B	G3	B	G4	A	A1	A2	A2	A1	G5	A	A1	B	B2

Table -15- Final code that used to generate tomb shape plan

Generative Code Tomb																	
G1	B	B1	G2	A	G3	B	G4	A	A1	A3	A2	A2	G5	A	A3	B	B2

9-Final Conclusions:

Tombs plans in Islamic architecture are generated from a unified code including five main elements which are the base of generating form in architecture. They are the base for generating Islamic architecture recently or in the future.

Matrix could be transformed into digital information and could be used in artificial intelligence programs to generate Tombs plans forms. These could be later used in computer software to produce Tombs models. Other Islamic buildings or functional patterns could be analyzed and examined using the resulting digital codes to find their primary elements.

This study has focused on five elements and other elements could be included in the code like symmetry, proportion, rhythm, centrality and predominance. It is not possible to deal with such codes in this study as they will increase the study range.

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Interactions between an artificial colony of musical ants and an impaired human composer: towards accessible generative arts.

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Abstract

Working on accessibility, art and computer science, we propose an accessible music creation tool to allow the largest possible number of person to access a new form of artistic expression. It consist in a simple virtual music instrument. To take interface issues into consideration, we use multimodal displays to offer various ways to access the application information, but also multimodal controllers to provide alternative solutions for controlling the application. This instrument should not require any specific knowledge, so we supplied it with musical rules to allow the user not to need to learn them. We also experiment the idea of an automatic accompaniment to enrich what the user plays. This is based on one of the many methods for automatic music production. It consist in an artificial ant colony algorithm based on the path finding behaviour in ants. Each ant lays down an chemical information behind her called pheromones, to indicate that she passed this way and every ant chooses randomly where to go giving a bigger chance to path with higher pheromone values. We propose two major adaptations to this mechanism. The goal of the first one is to generate notes efficiently. Our artificial ants are in fact wandering on different graphs getting information on each vertice they pass on to build musical notes. We use a graph of pitch values and a graph of duration. As they are following preferentially path with high pheromone rates, we notice the construction of cyclic patterns, corresponding to the cyclic ways taken by the ants in the graphs. This pattern creation and its repetition can be musically interesting. The other adaptation consist in making this ant algorithm interactive, not to have a autonomous music creation method but a system collaborating with the user. Therefore have we add two interaction's mechanisms. The first one is to make the user build dynamically the graphs on which the ants will move. But to keep the application simple, we take the notes played by the user and use them to transparently build the graphs and make them grown. The other idea is to consider the user as an ant leader. Thus is he or she also laying down pheromones on the graphs to influence the ants and help them not to stay in too frozen configurations.

1.Introduction: about art and accessibility

Starting from the idea that art seems to be an important activity for human beings, we explore the possibilities for computers to help people accessing art creation.

1.1.Accessibility issues

As members of the HaNT team (Handicap and New Technologies), we interest in accessibility issues. According to wikipedia [1]:

> *"Accessibility is a general term used to describe the degree to which a product (e.g., device, service, environment) is accessible by as many people as possible."*

Of course, it's about dealing with impairments, but not only, and in fact, it appears to be important not to segregate people facing handicap by developing applications for them only. So we are trying to address as many people as possible, with or without impairments. The three different kind of problems we face are problems accessing the information, controlling the applications and understanding the concepts and the functioning. To solve this, we follow specific guidelines for the design of our interfaces and application models. This design rules will be described in the following.

1.2.Accessible art

Considering art, computers show themselves as powerful tools to help artists in their creation tasks. But as we take a look at the existing softwares, we must face the facts that the huge majority of this tools are widely inaccessible. They use dense and complicated interfaces, propose the manipulation of sophisticated concepts and impose a long training to be successfully used. They are indeed designed for artists able to and agree with learning a complex software. Accessibility is obviously not an objective of their conception.

Base on this observations, it seems interesting to work on accessible computer art creation tools. In a prime approach, we choose music as the artistic domain to work in. We propose to offer a musical expression system which is accessible, interactive, and "intelligent".

2.A virtual instrument

One of our idea to explore the crossover of this three domains of art, accessibility and computer science is to provide an accessible tool to make real-time music.

2.1.The model

The goal of this application is to offer a music creation tool for most of the people, even if they don't know anything about music or suffer from disabilities. The proposed model has to be simple and not presume of any specific knowledge, but still has to offer artistic expression opportunities.

The application concept is a virtual music instrument. It associates user's actions with sounds and tries to ensure that the sounds he or she is playing are always appropriate. Even if the notion of good or bad notes is very subjective, we choose to begin with strict rules, we could always relax this rules in the future if the first results are satisfying. So to deal efficiently with this issue, in a first step, we offer only a single scale to play on (like the C Major scale, for example). So all the notes played are in a given harmonic pattern and won't be too dissonant.

The association of notes with the user's actions depends on the controlling device, and as we are offering several of them, there are various kind of associations. We won't describe them precisely because we are still testing to see which of them are suitable and which are not.

2.2.Interface considerations

Designing the application interface, we focus on two main axis : Information access and application control. So we adopt a solution to address the associated problems : multimodality. It consist in always offering several different ways to do a given action in order to offer the user the choice of using the most adapted to him.

To ensure the widest information access, we propose to by-pass sensory impairments, by giving alternatives to visual informations, like textual alternative to graphics and images, sound menu, or braille display (see [2] or [3] for examples in games). It does not constitute the major problem in our case because as it is a simple musical application, there should not be so much visual information.

Similarly, we want to propose several ways for controlling the application. For the moment, keyboard or mouse controllers are provided and were designed keeping in mind that they can be substituted with alternatives. For example, the keyboard can be a virtual one, or the mouse can be replaced by a motion capture device, tracking eye or head movements. This kind of substitution is not totally transparent and we cannot expect people suffering from hard motor handicaps to show the same behaviour with this devices as anyone with his or her mouse. Therefore we avoid using too complex or simultaneous actions like drag and drops or multiple key combinations and we provide a mouse only and a keyboard only controller.

So we have a simple virtual music instrument, with several controllers and ways of displaying information. Developing this controllers, we can emulate the functioning of a regular music instrument, like a piano keyboard, or even try to make something original. New ways of expression could emerge from new kind of interfaces.

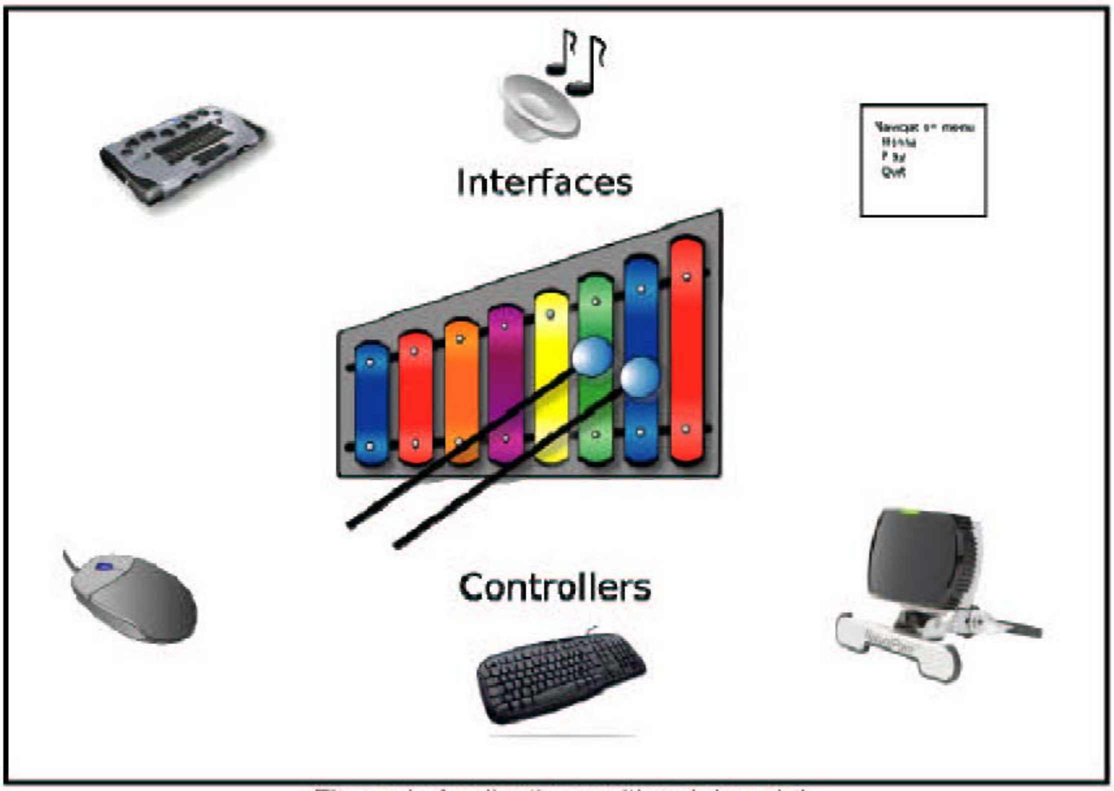

Figure 1: Application multimodal model

2.3.Automatic accompaniment

Going one step further, we also want our instrument to accompany automatically the user while he or she is playing. A great deal of methods are used to produce autonomously music. Markov chains [4], formal grammars [5], constraint programming [6], cellular automata [7], artificial neural networks [8], genetic algorithms [9], ant colony algorithms [10] probably others... We decided to use this last method because it seems promising and is still young and not so often used for this kind of problem.

The idea of automatic accompaniment is to adapt an autonomous music production algorithm so that it will work with the user, taking informations from him, like the music he or she plays, and use it as the basis for its art production method. We are here in the line of interactive evolutionary algorithm. Let's describe this human – computer interactions.

3.Ants playing music

3.1.The ants displacement behavior

Real ant colonies are fascinating because such simple and tiny creatures shows a global organisation at the colony level without having any central control. In fact, each ant is taking decisions having only local information of its direct neighbourhood and lay down chemical substances called pheromones to indicate about its activities. This communication based on the environment leads to an emergent behaviour, defined as collective intelligence.

From the entomology, mathematical models of this kind of phenomenon were made, like the Bonabeau's ones (see [11]). This models can be used as solving algorithms for computer science problems, like classification [12] or combinatorial optimization [13].

The model we use here is based on the ant displacement behaviour. It has already been successfully used to solve shortest path finding problems (see [14]). It consists in a whole colony of ants moving on a squared map. Ants are adding an amount of pheromones behind them on every case they pass on. At each step, each ant compare the amount of pheromone on all the cases around it and chooses randomly the case it'll go, giving a bigger chance to the case with higher pheromones values (see figure 2).

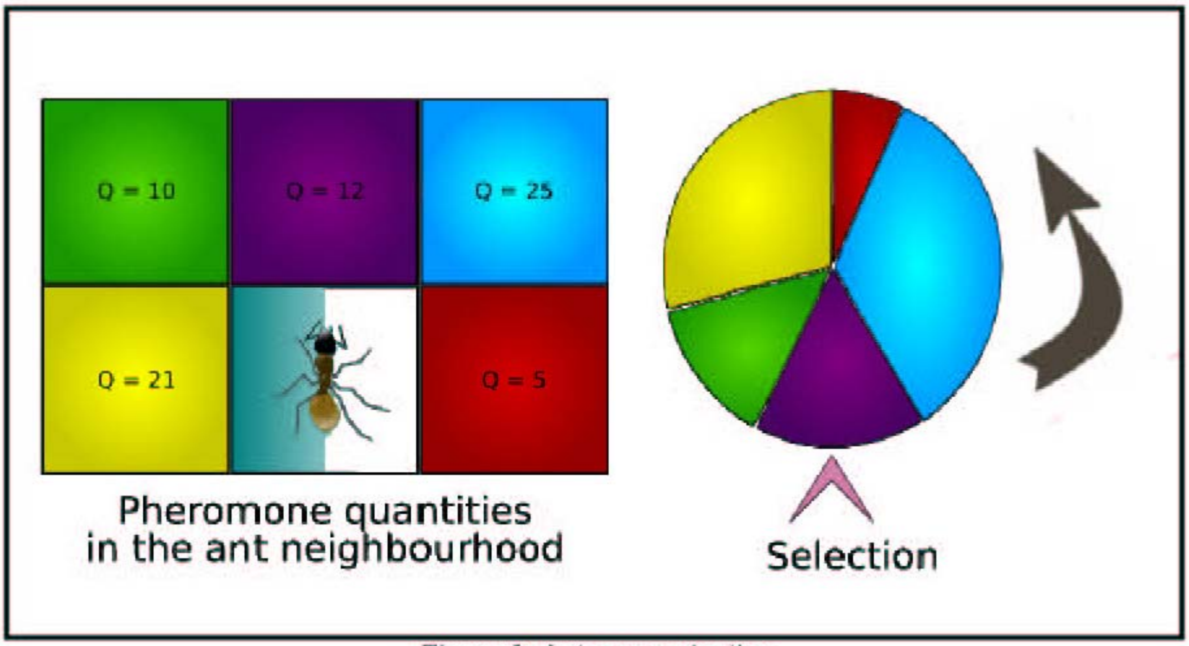

Figure 2: Ant case selection

An evaporation process is added to this pheromone's paths mechanism. Regularly, the pheromone quantity on each path is decreased, to simulate a natural evaporation. It's not simply to have a more realistic phenomenon, but it also improve the robustness of the system. Without this, the system may stuck in local optima, or don't tolerate perturbations. On-line dynamic adaptation is indeed one of the main advantages of ant colony algorithms and evaporation is a major mechanism behind this.

3.2.Notes and graphs

The notes we use to make music are based on the midi specifications, so each note is defined by three parameters :

1. A pitch.
2. A duration.
3. A volume.

The idea, to let ants choose which note to play, is to make them wander on a graph of notes. In the previous works: Antmusic [10], each vertice is a note, i.e. the combination of a pitch, a duration and a volume. So ants are evolving on a huge graph which edges contain a pheromone value. At each timestep, ants are choosing between the different edges the one they will take, of course according to the pheromone values on them. Then, following this chosen edge, it will arrive to a new vertice, and play the note associated with it.

In this project, we decide to make several graphs, a pitch graph and a duration graph (see figure 3). We are always playing notes at the same volume for now but we can easily add a third volume graph to the system. Each ant is on a vertice of each of the graphs simultaneously. It'll lead to much smaller graphs, so less need for memory and computing power. It also have a “creative” interest : we can have the same rhythmic patterns used with different harmonic schemes, and the contrary. Indeed, the global behaviour of this ant colony algorithm is to create cyclic path in the graphs. Most of the ants will take this preferred path so we observe the production of repetitive sequences that can be seen as musical patterns.

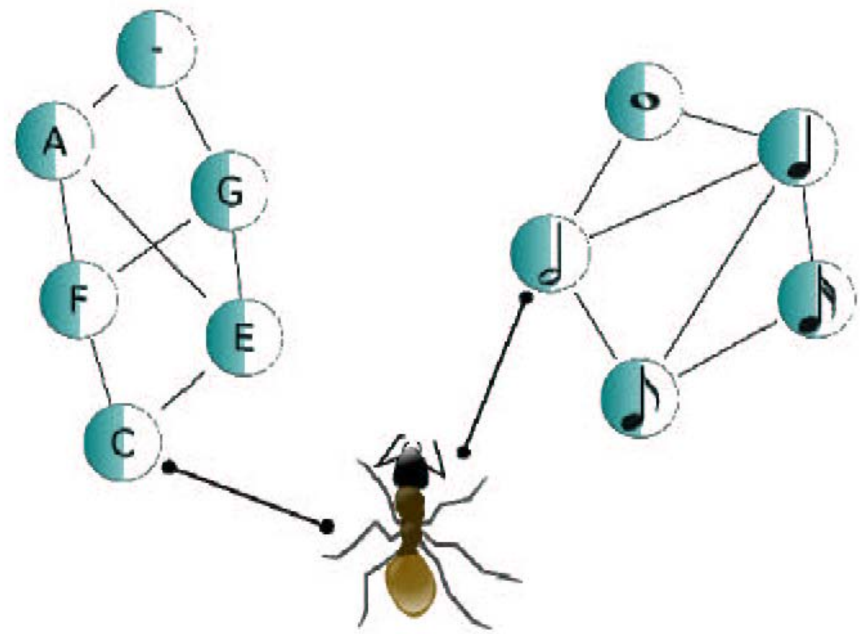

Figure 3: Ant evolving on multiple graphs

This ant colony based methods need at least several ants to have an emergent behaviour. But if we have a huge number of ants playing notes, we'll just obtain a big sound shambles. To have an audible music, we must limit the number of playing ants. The solution adopted to deal with this two contradictory problems is to have two kind of ants: a few number of playing ants (even only one), triggering notes as they move, and silent ants, more numerous, wandering on the same graphs, also depositing pheromones behind them, but without playing any sound.

It seems important to add the notion of silence besides notes. We have a special value in the pitch graph interpreted as a silence. Thus, associating it with a duration from the other graph, playing ants are also able to play musical silence.

4.A collaboration with the user

In our context, we do not plan to have an autonomous music production algorithm, but to enrich what the user plays. Therefore the automatic music production method should be guided by the user. We propose two way of interactions between our artificial ant colony and the user.

4.1.Building the graphs

The first idea is simply to use the notes the user plays to build the graphs. Each time a new note is played, we add its pitch to the pitch graph and its duration to the duration graph. To build the transitions, we also keep the user's position in both graphs, each new note is then linked to the previous note played by the user. Of course, if the note already exists, we only add new transitions.

So the ant method will only provide variations on the user's theme. It uses the same harmonic context and progressions and the same rhythmic patterns as the user, but can mix rhythms and harmonies in a different manner. In that way, the accompaniment has creative opportunities but only in a given user chosen canvas.

4.2.Dance with ants

There's another idea that allow the user to guide the ant colony. Using only the elements played by the user to build the graph, we ensure that the ants will only play in the same context, but as the ants are evolving on the graphs, they are building preferred cyclic paths and their production may become much too repetitive and not follow the user's changes.

As the user is already wandering on the same graphs as ants, we just add pheromones on his or her path, as for ants. So he also influence the ants displacement dynamically while he plays. The pheromone quantities laid down by the user have to be more important than the ants' ones, to give a bigger importance to its lead and not to have his or her influence totally drowned in the ants crowd.

5.First Results

The implementation of the method described above needs to set some parameters.

- The number of ants : the silent and the playing ones

- The pheromone values: Initial values on edges, amount laid down by ants and by the user.

The number of playing ants depends on the instrument we made them play. From an unique ant for monaural instruments, like flutes, to three or four for polyphonic ones, it depends on the maximum number of sound we want to have in one chord. The influence of the number of silent ants is more subtle. It affects the quickness of the apparition of cycles in the ants movements. But it also have an effect on the changes' opportunities in the colony's behaviour. Thus these influences are linked with the amount of pheromone deposited by ants it's hard to distinguish each of this parameters specific effects.

The pheromone initial values don't seems to be important, but if we want the user to really influence the ants behaviour, his or her pheromone trails must be more important than the ants' ones.

The musical pieces generated by the automatic accompaniment need to be linked to a tempo to be played. Now the tempo is still a fixed parameter, chosen by the user. It's not very satisfying because it introduce the concept of tempo and oblige the user to know it and choose the tempo he's going to play. A much better solution is having tempo detection system to guess automatically the tempo while analysing what the user plays. It's a difficult problem, but solution exists.

6.And the future ...

This proposition is only a first attempt, and a lot of obvious improvements can be made. We choose to have a very simple model to be sure the largest number of people can understand intuitively how it works, but it will be much better to have an auto-adaptive mechanism that allows the application's complexity to self adapt to the user's skill and propose more complex but also more powerful features to advanced users.

Other methods could be used to generate the automatic accompaniment. As genetic algorithms seems to be very efficient methods for automatic music generation [15], we planed to use an interactive version of those methods and compare the results with the ant colony ones.

This evolutionary algorithms could also worked on the notes' volume, and maybe other parameters of the notes' interpretation (vibratos, notes' attack ...). The more parameters we add the more complex the system will be, but we also hope the more diverse and expressive the musical results will be. The musical concept of pattern is interesting too. A system able to detect and extract them will allow artificial ants and probably other methods to work on it. It should lead to more structured automatic music productions.

Of course, a tempo detection system could be added to get the tempo directly from the user's playing. It's quite a difficult task to detect tempo in real time midi playing, but it seems possible, according to recent works (see [16] for an example).

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Sniffing space

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Abstract

This research looks into the problem of spatial arrangement, towards the well-trodden field of the automatic generation of architectural plans. Decomposing typical hierarchies of architectural space we look to the use of agents to generate architectonic form in a process of distributed representation. A component in a larger research project, the focus here is the problem of circulation and explicit spatial arrangement. The work presented looks to swarm intelligence and established computer methods based on the way finding means of social insects. Ant foraging algorithms are used generally for optimisation and tend to rely on a-priori knowledge of the environment. Outlined here is an investigation of emergent route formation and spatial connectivity based on simple agent and pheromone interaction. A stigmergic process which defines arrangements for which optimisation is not the key, but emergent connectivity through blind local communication.

Deconstructing rooms into their constituent parts identifies an array of activities, which will inherently own some measure of association with each other, but these associations may be asymmetric, have associations to activities typically located in other rooms, or relative to a specific routine of habitation (in relation to the problem of dwelling), have varied and ambiguous associations. The premise is that the dynamic association of these associational parameters may develop spatial topographies previously obstructed by the traditional hierarchical definition of rooms in plan arrangement.

The model incorporates two systems of agents working in parallel; the space-colonies (representing activities) and the space-agents. The space-colonies have associational parameters with each other, such as those within a brief between different rooms. Space-agents, whose birthplace is a particular space-colony, transmit information throughout the space-colony population, whilst defining an emergent communication network that defines circulation paths.

Key words: Space; agents; self-organisation; circulation; ants; pheromones; plans

1. Introduction

The premise of this paper is that the plan is embedded in the process of architectural production and that space is vicissitudinous; meaning that it is in constant flux. This is not the visible object space of the built environment, but the space of user movement, activity, habitation and interaction. This is a condition of constant change, a natural process of mutability. The Euclidean practice (commanding form; of mapping a perception from above) of organising space and defining architectonic form is therefore contrived and a perverted representational methodology to define the intrinsic substance of space; being the plastic qualities of the *thing* produced through the act of body movement and the behavioural practice of social interface. Buildings are systems of spatial relations, defined by the dynamic interactions of various autonomous spatially discrete entities [1]. The basis of any building is the relationship between solid and void, the void being the theatre of activities that take place in the building [2]. Activity is here considered the essence of architectonic form.

Although the plan is in contradiction to the vicissitudinous of space, the success of the plan is in abstracting the problem into two dimensions, defining the problem calculable to the user. To all intents and purposes the plan is the facility with which an understanding and arrangement of the utilitarian programme of a building is determined. Le Corbusier's well known statement "the plan is the generator" [3] emphasizes this, extending its value as a driver of form; exemplified in his own work quite literally. Many examples, paper and built, from architecture record illustrate this; indeed my own experience in practice illustrated the significance of the plan in generating form. That form is a derivative of the plan is indubitable, in that being the means of organising the utilitarian parameters of a building's programme it will undoubtedly have some generative significance but the plan is a two-dimensional linear organisational tool, and as such its significance is simplification, to interpret and define the utilitarian parameters of an architectural brief.

The parameters of the problem are spatial and as such are complex. Space itself is an undefined *entity*; the ephemeral (void) commonly defined by the tangible (solid). The object (solid) defines the western perception of space; it is bounded, constructed. The antithesis to this is the eastern perspective of the space in-between (void). Typified by the jug, Lao Tse postulated that a jug's significance is derived from its void; that the void defines its form and affords its ability to function as [4]. Heidegger, (possibly) taking precedence from Lao Tse, proposed that the void was the generator of the jug's form defining its capacity to function as a jug, and that the jug's utilitarian significance (embedded in human experience) defined it not as an object, which is abstract and detached from daily experience, but as a "thing" [5, 6].

The problem of organising the utilitarian parameters of an architectural brief is complex. As such space may be considered a complex adaptive system, in that space, in relation to utility (that utility is function defined by activity, which is three-dimensional defined by the act of body movement) has organising properties, which are dynamic. The intention of this research is towards development of a tool that bridges our understanding of space as a *thing*, and the practise of architectural production. Such a tool should provide the user with the means to visualise the inherent dynamic spatial parameters within an architectural brief. A model for interrogation and interpretation, the designer's enhanced visual understanding of the spatial dynamics to be expressed through the designer's skill.

The current aspect of this research is a project focused on the problem of organising the functional parameters of a building brief. The plan, being the traditional practice of this stage in design, is reconsidered here to an earlier stage lying between bubble diagrams and plan formation; termed, for clarity, the practise of generating space diagrams. This is a broad-brush approach that considers two aspects of spatial organisation, that of circulation and the arrangement of activity space.

The paper first reviews the precedents that have defined a basis for this work: in representation, the field of automatic plan generation and the problem of circulation. This is a computational approach, based in the principles of artificial life (bottom-up rules of self-organisation), and as such the approach differs significantly from precedents in this field. The (old) AI approach was an optimised process of spatial configuration, whereas emergent organisation is the motive here. The model is then introduced with the two elements of the model looked at separately. The problem of circulation is approached on the basis of the route finding methods of social insects. Adopting the approach of Panait and Luke two pheromone trails are used, one for either state; 'search' and 'return home' [7]. The problem of configuration is defined by the associational parameters of the individual activity spaces.

At this stage the model is an abstract theoretical framework for the modelling tool outlined. The current model is written in Netlogo version 4.0.2. Netlogo is a programmable modelling environment for simulating natural and social phenomena that is well suited for modelling complex systems [8]. The framework of this model is being translated into a more flexible object orientated platform, to facilitate integration of geometric features and to allow implementation of extended parameters.

2. Representation

The typical practice of plan generation is a Euclidean methodology (see above), which is an abstract representation of space, founded in the classical understanding of the world. Pickering proposed that the historical concept of the world, defined by classical science was representational, being the exercise of mapping the world to produce articulated knowledge of it. He proposed that such studies were epistemological and in contrast proposed an ontological approach; studies of causation and how things come to be [9]. The architect Frederick Kiesler opposed the deterministic approach, recognising the opposition between historical representation and the creation of architectonic form, writing *"If God had created a man from a plan, a monster all heels and toes would have emerged not man"* [10]. Given that the plan is embedded in architectural production the judgment is that the approach towards its manifestation be reconsidered. Thus, taking root from Pickering's favouring of an ontological approach the process of organising space is reconsidered.

2.1 topology

Steadman and March illustrated a syntactical approach to design, defining the ordering of spaces as the ordering of relations between people and the ordering of activities in relation to people's routine; i.e. people and activities can be linked by time, distance, and communication, defining an order, which can be developed into a graphical representation of space. Their use of graph theory to generate representations of building topologies illustrated the homogeneity of spatial layouts, viewed from a single perspective [2].

Hillier and Hanson reviewed this perspective, transporting themselves within the plan form to review the organisation of space from each room within a plan. They identified space as heterogeneous, illustrating space as a system that is defined by the dynamics of social habitation. Extending this to perceive spatial configurations from a representation of space as a configuration of discrete entities, the justified graph of Hillier & Hanson, illustrated how the perception of space changes when viewed specifically from the perspective of user location [1].

2.2 automatic plan generation

The application of graph theory to spatial organisation was extended by Steadman [11] and others; Grason [12], Steadman & Brown [13], Mitchell [14] towards the problem of architectural layout and planning. Combinatorial analysis illustrated that the number of potential plan solutions to a problem was considerably greater than that generally planned manually; although deterministic rules imposed by an architectural brief can be restrictive, so simplifying the problem [13]. Analysis of the configuration problem highlighted a number of issues, notably, that of the potential configurations automatically generated a vast number where not applicable; as they were either reflected, symmetrical, rotated or architecturally impractical [2, 11]. Automating this reduction to the potentially realistic solutions encouraged an exhaustive approach defining a catalogue of plan formations to a layout problem for investigation and interpretation. The focus was the adjacency requirements of individual spaces, their geometrical parameters and configurational relationships, approached from the perception of the boundary condition. Revisiting the problem Elezkurtaj [15], Rosenburg and Gero [16] adopted evolutionary and genetic algorithms, and Duarte used shape grammars [17]. Although adopting varied approaches computationally the perspective was object orientated. Representing the incidence relations of the line segments and faces of connected linear shapes (walls and the boundary constructions of space) defined the solid aspect of architectonic form.

The LOOS programme developed by Ulrich Flemming holds particular interest here. Flemming's approach was to focus on the spaces, and their arrangement primarily describing the crucial spatial relations; a stage of the design process which is prior to plan definition (on which the above focused). The LOOS programme generated diagrams of loosely packed arrangements of rectangles. This was a broad-brush approach which was generative and exhibited emergence [18].

2.3 Circulation

Although generalized I think it is quite fair to remark on 'circulation' as a neglected aspect of architectural design. It is a necessity, being that which sticks all the parts together. This is an indiscriminate judgement; there are of course many examples of architectural projects in which circulation is a significant aspect of the design, if not a generator for, but one will generally find that its significance in such projects is a particular element (such as a foyer, staircase, central core/atrium[1]). As part of an architectural brief, circulation is generally detailed as a percentage value of total floor area. Such a value is typically a standard value, defined by building type [19]. General architectural principles note consideration of path configuration, path-space relations and the form of circulation space; a building's circulation system as positive elements that affect our perception of the building's forms and space [20]. Such attention though is typically distracted from the start by the importance indicated in the architectural brief and its representation of circulation as servicing; being an area provision to link the parts. This promotes optimisation and the practise of trying to organise rooms in a plan in the most efficient arrangement so as to minimise circulation space, which hinders the potential articulation of circulation space. Perceiving circulation as little more than optimisation inherently defines space that is linear, juxtaposed and generally considered as little more than a connector between destinations, which equates to the manifestation of the corridor.

The field of automatic plan generation incorporated the problem of circulation; an obvious component since the rectilinear configuration of plan arrangements is defined by the problem of circulation. Tabor investigated plan arrangements, and the economy of different plan forms in relation to their communication structures; being the mean sum of travel distances between individual rooms/user locations [21]. Willoughby approached the problem as optimisation [22]. The combinatorial problem of configuring rectangular plan arrangements dictated optimisation prompting efficiency in circulation. The calculation of shortest paths connecting the individual rectangular arrangements had direct similarity with the combinatorial optimisation problem of wiring diagrams in engineering, being a well-defined problem for computer application. But, although the majority of our buildings are rectangular configurations navigated through a framework of corridors, optimised to fit within total floor area requirements the consideration here is that architecture is not merely optimisation. Market constraints on practice promote optimisation, and our manual capacity to surpass this is constrained. The capacity of the computer applied in a bottom-up approach of distributed representation may provide a facility to question the standard practical approach.

The emergent trail formations where people had formed routes across open spaces, Helbing realised, did not "efficiently" connect the actual destination points. Investigating this he developed his peploid model [23], later developed by Goldberg, determining that people's movement in such instances was defined by where people want to go and where others have gone [24]. Helbing's peploid model was an ontological approach in which the trails emerged as a result of many autonomous agents' behaviour. Although the global outcome of the agents' behaviour was the emergence of a trail network the behaviour of the agents was as discrete entities interacting with their immediate context. It was the feedback system between the individual elements that defined the trail network not the programming of behaviour to generate the trails. This stigmergic relation between agent and its environment is the basis for the *intelligent* behaviour of social insects that provides the

[1] For example; August Endell's staircase at Atelier Elvira, Munich, 1898. I.M. Pei, stair and entrance foyer, Louvre, Paris. 1989. Charles Garnier's grand staircase of the opera house, Paris, 1875. Future Systems, circulation atrium, Selfridges, Bullring, Birmingham, 2003. RRP, atrium Lloyds building, London, 1986 and façade escalators Georges Pompidou, Paris, 1977.

computational basis of this model.

3. Generating space diagrams

Social insects (specifically ants) are self-organising entities, which are decentralised. They exhibit global behaviour through interaction as a colony; which is the emergent outcome of simple agent interaction. A well-defined field of work on which to build illustrates four distinct advantages in 'swarm intelligent' systems. They are;

1. Flexible: the system can react to internal and external changes.
2. Robust: tasks are completed even if some individuals fail
3. Decentralized: there is no central control over the system
4. Self-Organized: paths to solutions are emergent rather than pre-defined which leads to better utilisation of resources and gives a dynamic character to the solution finding process.

An essential assumption of such work is that it is not the behaviour of dwelling or people performance between spaces being modelled, or that ants in any way represent the behaviour of human beings, but that the application of autonomous agents can be used to simulate natural systems[2] and systems modelling can help to understand and define an alternative approach to problems which are complex and dynamic.

3.1 Emergent trail network

Computational techniques in swarm intelligence vary predominantly in the way agents find their way back to the nest. A previous paper by the author detailing this and the basis of the approached used here, illustrates the differential results of various approaches [25]. The model here consists of agents and patches. The NetLogo world is a two dimensional grid of 'patches'. Patches are the individual squares in the grid, which are a type of agent; they can be assigned values and change state but do not move. The agents leave a trail dependent on which state they are in; leaving trail *'x'* in search mode (leaving the colony) and trail *'y'* when returning. The agent's environment consists of void, birthplace/home, other spaces and the trails left by other agents. The world is a grid of patches, in which values for the two trails exist. Agents sniff their immediate context, being the eight patches (neighbours) surrounding the patch, which an agent currently occupies (known as Moore's neighbourhood). See figure 1. An agent hill-climbs the scent value of the trail. In motion an agent 'wiggles' forward, therefore those patches in front are checked for any trail scent first. If none exists the two patches immediate left and right are checked, moving backwards until finally the patch lying immediately to the rear is checked. This ensures that the agent maintains a predominantly forward motion. If no scent is found to exist in any of the patches the agent moves forward in a random direction; in that it maintains a forward motion, but its angle of direction (plus or minus *'x'* degrees from straight ahead) will alter by a random amount at each step.

[2] For example, Craig Reynolds, Boids, 1986 and Marco Dorigo, Ant Colony Optimisation, 1992.

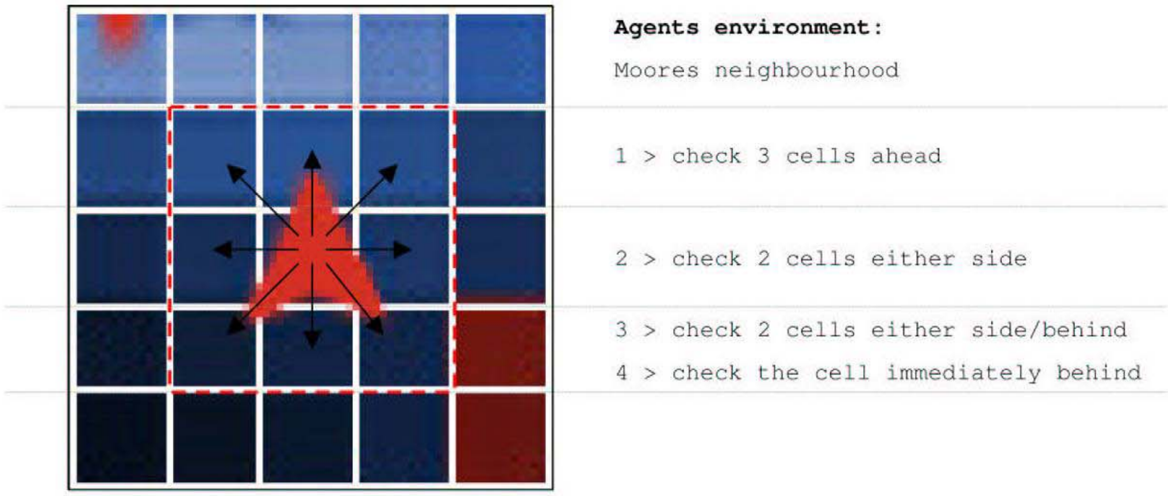

Figure 1: Agents environment

Each agent has a birthplace, being a particular activity space. Therefore an agent is described as a space-agent and the activity spaces as space-colonies. As each space-agent owns an identity which equates to the identity of its birthplace the patches need to maintain a list which holds the values for pheromone which is specific to each space-colony; so the space-agents are only following the pheromone deposited by other space-agents from the same space-colony. A space-agent leaves its space-colony with an amount of pheromone, described here as a 'smelly-bag', due to the fact that it is exchanged upon reaching a destination (a space-colony), and which 'bag' it carries depends on which state it is in. See figure 2.

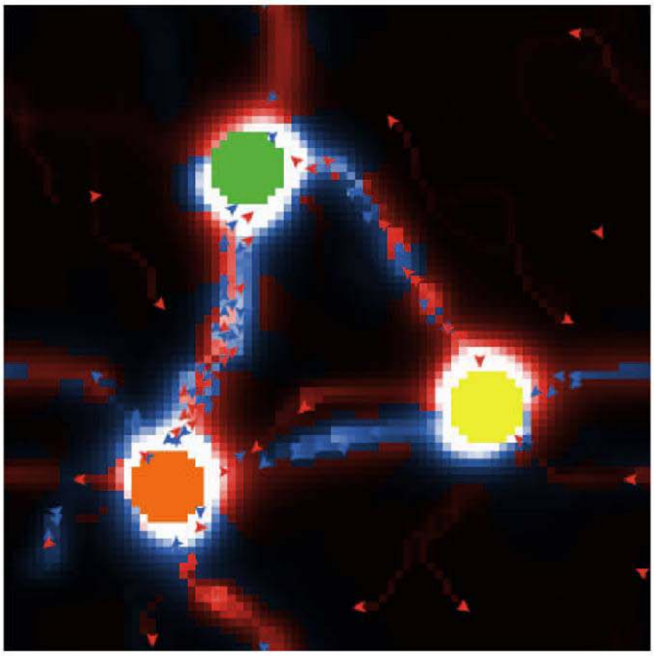

Figure 2: Trails emerging defined by the alternative trails laid by space-agents.

If a scent is picked up then the space-agent changes direction to face the direction of smell and moves forward, thereby following the trail. Upon finding 'other' space (another space-colony) the space-agent changes state, collects the alternative 'smelly bag', turns (a random amount) and moves forward leaving the alternative trail, sniffing the environment for a trail which may lead it home. The structure of the programme is a feedback relationship between pheromone, evaporation, diffusion and agents, resulting in an emergent network of trails. See figure 3.

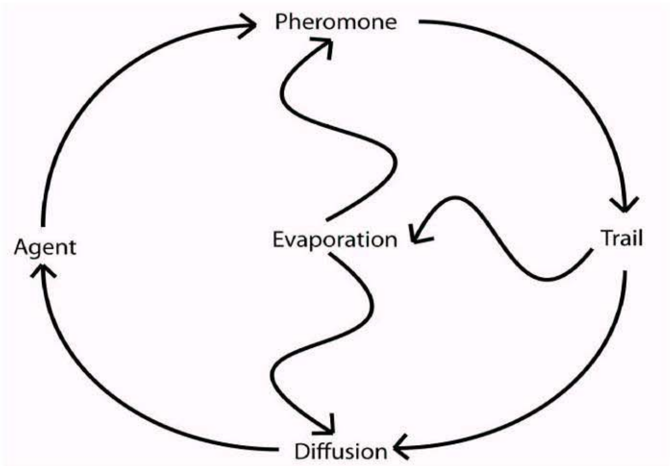

Figure 3: Model structure

The pheromone trails laid by a space-agent attract other space-agents, which in turn reinforce the trail. If a trail connects space-colonies, diffusion will attract further space-agents, defining an emergent network of trails linking each space-colony to others. See figure 4.

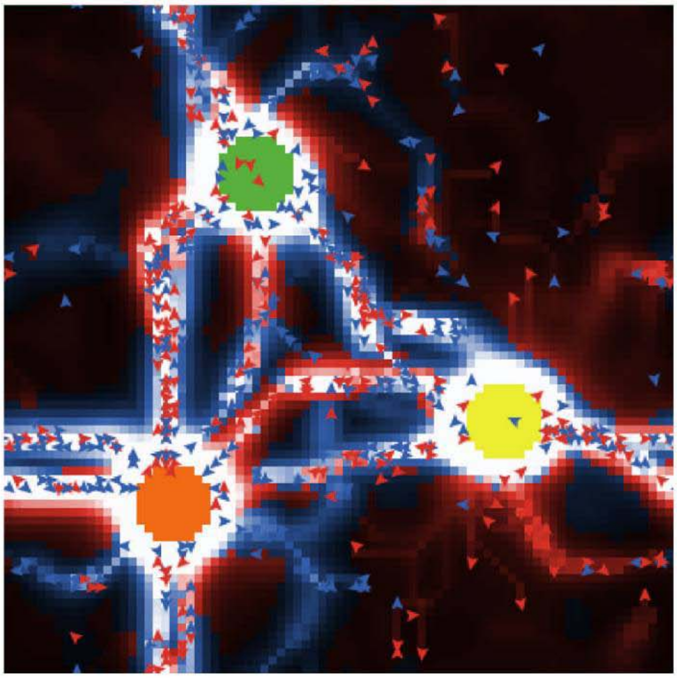

Figure 4: A network of trails emerging in a toroidal universe

The model incorporates an array of variables, which cause it to be very sensitive. It appears best when it is adjusted such that there is some interaction between user and code. The variables and consequence are;

- number of agents: *the population of each space-colony*
- diffusion rate: *the amount of pheromone a patch passes onto neighbouring patches*
- evaporation rate: *the amount of pheromone each patch loses at each time step*
- amount of pheromone dropped at destination: *the amount of pheromone dropped by an agent when it leaves a space-colony*
- amount of pheromone dropped in motion: *how much pheromone a space-agent leaves on a patch as it moves between space-colonies*
- pheromone capacity: *how much pheromone a patch may hold*
- smelly bag: *how much pheromone a space-agent carries*

The result of the two-trail approach is a dynamic model, which displays emergence based on simple agent interaction with the environment. The trials and network that emerge are similar to the behaviour of biological systems and are interesting from a systems perspective due to their emergent quality and fluctuating behaviour produced through the self-organising behaviour of the space-agents. From an architectural perspective the results illustrate a dynamic methodology towards generating circulation routes, and their non-linearity is attractive. Interrogation of space-agents along a trail show that some trails are group-specific, which suggests a level of organisation beyond anticipation, that could provide a basis for integrating specific features into the model such as route programming and schedules.

Additional features are required to develop the model towards a useful tool. Obstacles are a general aspect of circulation and ordinary navigation and have been incorporated as the first extension of the model to date. See figure 5.

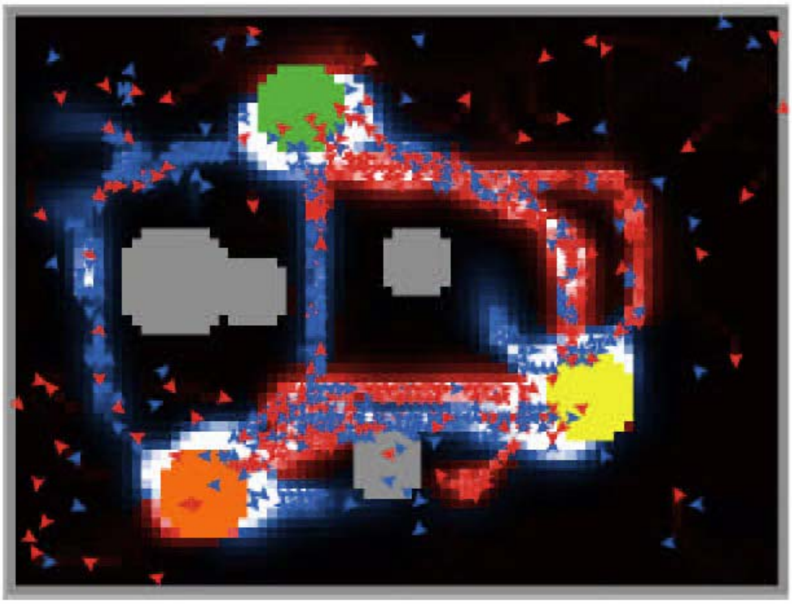

Figure 5: Space-agents avoiding obstacles

3.2 Constructing space

The associational parameters between activities are specific and dynamic, in that they are asymmetrical. Specification is relative to inhabitant and function, therefore the pattern of association can define architectures of alternative configurations of form. The nature of buildings is that they are shells to house a host of activities of which a variety of individuals will perform. Encountering, congregating, avoiding, interacting, dwelling, are not attributes of individuals, but patterns or configurations, formed by groups or collections of people. Hillier states the relation between space and the act of living lies in the relations between configurations of people and configurations of space [1]. Therefore the approach defines a spatial morphology in relation to configurations determined by the associations of an array of activities.

Each activity (space-colony) has associational parameters that define it. Deconstructing rooms into their constituent parts identifies an array of activities, which will inherently have some degree of association with each other, but these associations may be asymmetric, have associations to activities in other rooms our, relative to a specific routine of habitation (in relation to the problem of dwelling) have varied and ambiguous associations. See figure 6.

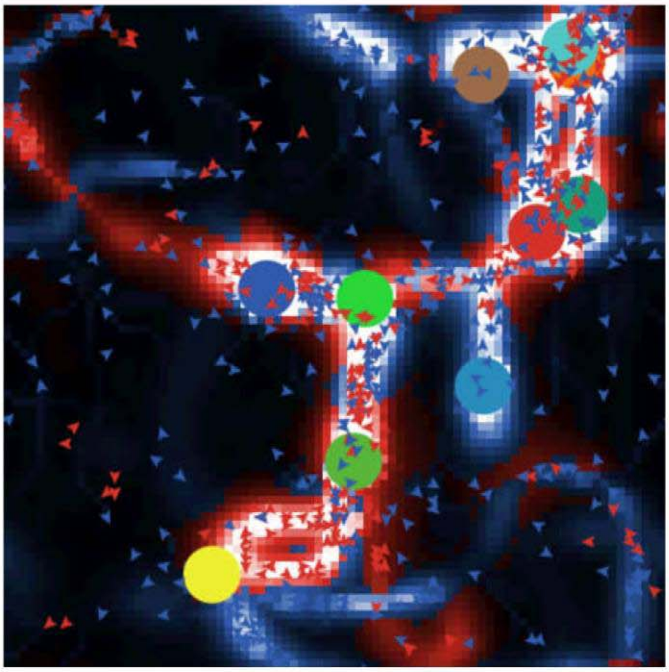

Figure 6: Space-colonies self-organising relative to association parameters

Communication between space-colonies is via space-agents. Each space-agent has a birthplace that defines its identity, which allows the space-colonies to identify space-agents and check whether they come from another space-colony with which they share an association. A space-colony will respond to those space-agents that belong to the space-colonies with which it shares an association. On identifying such an alliance a space-colony will follow the agent. But a space-colony's movement is restricted, as an agent may not necessarily return to its birthplace (any time soon). The behaviour of a space-agent is defined either by their attraction to the trail network (and explicitly to those trails specific to their space-colony) or in the case of detecting no pheromone, by the random wandering of its search mode, which may result in the space-colony moving in a negative direction. Therefore the 'step-size' of a space-colony is less than that of a space-agent, so that it does not follow aimlessly. The space-colony's behaviour is therefore defined by the degree of traffic between it and the other colonies, which is defined by the emergence of the trail network. The result is that the space-colonies configure themselves relative to their associational parameters, being patterns of space defined by an array of inter-related activities. The premise is that the dynamic association of associational parameters may develop spatial topographies previously obstructed by the traditional hierarchical definition of rooms in plan arrangement.

In order to prevent the space-colonies from responding to their closest neighbours with whom they have an association (as this only results in the rearrangement of space-colonies in response to other space-colonies in close proximity) the space-agents undertake a tour. This is an itinerary of those space-colonies with which their home space-colony has association. A space-agent therefore holds a list of its home space-colony associations, which upon discovering a space-colony listed will return home, checking its progress and continuing with its journey until each destination has been checked. This creates an association tree for each space-colony. Through each space-colony defining its own association tree a complete network is generated defining a closed network trail with traffic intensities illustrating the scale of association. See figure 7.

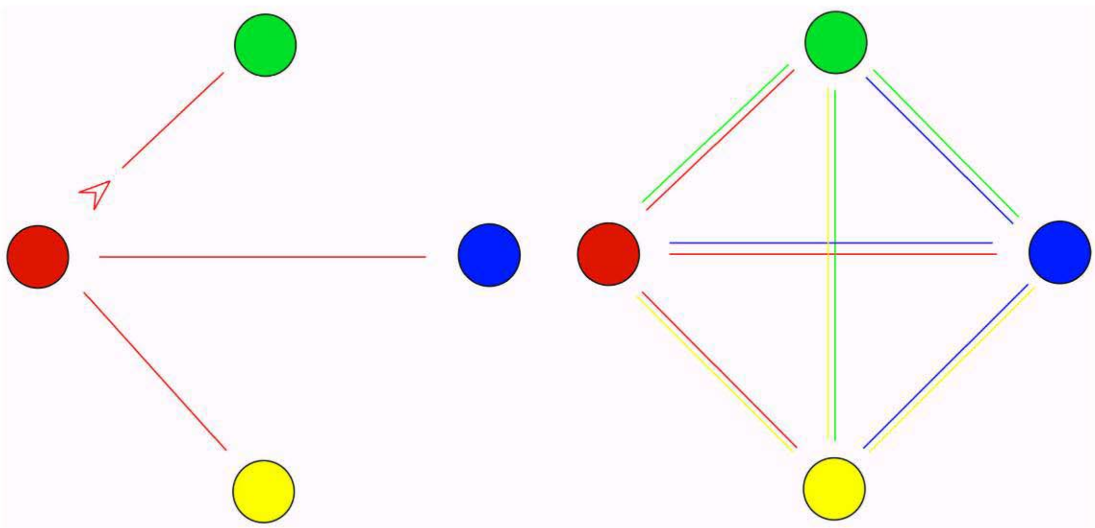

Figure 7: association structure of individual space-colony and global structure.

4. Conclusion

This is a summary of work in its early stages, an abstract model, which has the capacity to incorporate additional features that will advance its capacity as a tool; however this development will require a change of platform. The criterion to date has been to develop the model to test the dynamic structural properties, with a focus on the ontology of the system.

The notion of hidden parameters being exposed has yet to occur, but it is thought that this is a possible outcome given further development. Such a result is not realisable given the restricted agent form. The geometry of the model is an emergent property of the system, but the model needs extension to incorporate geometry representative of built-form to promote potential exposure of any hidden parameters. It is also a matter of architectural perspective as to how the relationship of entities is perceived in the definition of spatial organisation: a potentially moot detail. The model needs to incorporate architectural geometry in order to demonstrate the philosophical and methodological approach towards development of a tool for generating models of architectural space.

An interesting application for the model is towards those building types that are specifically defined by circulation parameters, such as airports, hospitals and schools. The organisation of such buildings is complex due to the connectivity problems of defining paths between particular destinations, which have potentially varied parameters. Another interesting application is towards the philosophical aspect of the work in relation to space and the perspective of the space-between. Designers such as Kiesler demonstrated a non-linear approach in his work, culminating in his model for the Endless house [10]. This cave-like form was a model to promote an alternative model of space, which its thought may be extended here - not literally for the production of building form but as a tool for an architect to use, to interpret and interrogate the spatial parameters of an architectural brief. Through deconstructing such parameters and the generation of dynamic models, Kiesler's cave-like forms may be developed to expose pothole-like fissures within the usual spatial compositions of space, illuminating hidden parameters to the user. Hillier proposed that buildings transmit information through their interior structures, both through general variations in the basic syntactical parameters and – perhaps primarily – through variations in these, which appear when a plan is looked at from the view of its various constituent parts. *"Buildings…map relations* between [different types of users] *through some parameterisation of the syntactic* dimension [and this suggests] *that as the forms of solidarity to be mapped into a building change and the relations between users change accordingly, consequent changes in the syntactic dimensions will construct a building of a certain type, and with certain individuality"* [1].

Development of the model towards purpose will require the integration of further features; such features may include obstacle types, variable tours, views, integration analysis, depth analysis, axial analysis, and behaviours.

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Can Virtual or Digital Creation be Considered as Art or Technique ?

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Abstract
The framework of art using software environment implies a reflection on today's aesthetics and its many creative means. In the following corpus we propose a number of steps to help analyse the state of digital art work including virtual art. Art is experiencing one of the biggest challenges: the pragmatic use of abstract information systems deprived of any primary and direct link with a reality, whatever it is. Because of the processing power of computers and the development of innovative man-machine interfaces, digital arts are facing a specific technique and cannot select only some features of it. As a matter of fact, virtual reality (VR) technology, developed in the field of art, allows converting virtual experimentation and/or experience into an operational and daily reality. Thus, art becomes totally technical and as Pierre Levy put it – technology is rather similar to the Art approach following the scheduled, ordered aspect of gestures. This is the context of our publication, we propose to study the following question: does virtual or digital art essentially belong to technology or mathematics and does it convey the right idea of what new art is?

1. Introduction

During the two last decades, the artistic production was radically influenced by the modern techno-scientific effect of artificial intelligence. New relations were created between art and aesthetics. This heavy Hegelian heritage which defines aesthetics as the rational discipline which studies the artistic beauty "free demonstration of the spirit, higher than nature" is seen challenged. The artistic thought as much as its products and its tools, see themselves trapped by the techno science. One attends a redefinition of art, of its systems and its practices. Thus, we are facing a indefinitely amplified process of rationalization. This inescapable development of algorithmic design of the artistic forms raises an aesthetic culture completely seized by mathematical theories of algorithmic models.

An "aesthetics of algorithmic" progressively imposes itself in contemporary artistic mentality, and we do not hesitate to recognize an authentically virtue. Everywhere, the innovation and the novelties are seeked. It is precisely what identifies the contemporary art : its degree of innovation, of unforeseen, of novelty, without prejudging so far as it is recognized and appreciated by us [1] .
Indeed, art is questioned in these most fundamental concepts. The new artistic practice indicates the general phenomenon of bursting of aesthetics out of the institutional limits that the tradition assigned to him. In this context, it is necessary to understand the changes with which the contemporary artistic creation is confronted.

The approach developed in this article involves three parts. In the first part, we draw three reference marks that will guide us towards a reflection on art at its virtual age. In the second part, we try to elucidate the relationship between art and science. In the last part, we evoke the relationship between art and technique. Then we conclude by evoking new perspectives concerning these three domains.

2. Art at its virtual age

2.1 The artist and the act of creation

At the end of intense ideological debates on aesthetic, the Sixties contribute to call in question concepts of artist and creation. The contemporary art reversed there prospect which binds representation and effect of realism in the traditional design of creation. The artist becomes an operator by the effect of immersion in virtual worlds.

What changes, are not only the formal procedures and the use of new technical means, like those related to computer science such as automatic generation of patterns or virtual reality techniques. It is the nature of the art work which differs from its concept, such as it is heard in the tradition of the visual arts, its materiality, its structure, its genesis, its mode of apprehension, its reproducibility without limits and its spontaneous possibilities of diffusion which escape any skirting.

These cues concerning art at its virtual age lets appear new forms of artistic expressions, in particular, those supported by interactivity, real-time simulation, user's immersion in 3D virtual worlds. This new aesthetic culture – that we will call "digital aesthetic"– raises a philosophical disagreement between partisans of "natural" art, fruit of the inspiration and the technical knowledge, and defenders of techno scientific art [2].

The detractors of digital aesthetic denounce that the algorithmic would empty the art work as well as its process of creation of their enigma and of their possibility of direction and values. They also fear a certain limitation of freedom and originality of the artist personal expression. Thus, the new techniques of creation constraint the expression of the creativity by their nature of meta-tool. This can be expressed by : "no aesthetics can be the base of a work without a sensitive nature: the sensitivity is not measured nor is calculated.

For the defenders of computerized creation, digital art offers the possibility of a broad field of new art works of which the nature is based of complex algorithmic equations. the simulation function, creative function by nature, assigns with these works the privilege to explore all the fields, all the tests, all the creative experiments.

In this way, numerical work is based on a changing materiality and does not limit itself to some constraints. It is disconnected of any physical support and does not rely on any pragmatic relation with a given matter. It is pure abstraction, *a" work without matter"* which leads to a redefinition of the modalities and methods of artistic creation.

2.2 : Art work without matter

If it is admitted that any image comes from a model, that draws its substance and its power from it, one notes that with numerical art, one attends the absence of model and the use the digitalisation.

How can one then circumscribe the matter of numerical work in the absence of it?
How digital images could be objectified without recourse to a presentation of matter ?

Different from the traditional representations (photographic or videographic images), synthesized images are not images, they are language. The rough reality of traditional materials the reality simulated or – virtualised of – the numerical one replaces.

One aspect of artistic synthetic images is abstraction. These images are sometimes expressed via mathematical models and computer programs, although they offer a visible material aspect. In this way, the mathematical representations produce visible results (images). Indeed, in the field of figurative thought and artistic creation, the digital world introduces a different way of designing and perceiving the world.
Moreover, a radical change appears in the quality of the materials used. These materials being strongly structured and inseparable of the computing processes which generate them.

The image ends, in this way, by becoming means of ubiquitous writing which must carefully be read, interpreted, compared with its text, as we have learned how to do it in the field of writing.

One has thus the right to fear an increased virtualisation of art, a loss of the body one, or an irrepressible reduction of scientific rationality, with the abstraction and the analytical deconstruction [3] .

With its new images, one calls upon the shade. No trace, no human print is given to follow and decipher.

2.3 Authenticity of art work

In its numerical spaces of creation, contemporary art reveals new ways of representation of the world. By its abstract character, it is anchored in reality without being fully real. It deploys on a purely new world, on virtual realities which threaten "its authenticity" and its value.

These new characteristics associated with the contribution of technology and computer science and more recently virtual reality technology, generated divergent meanings which led to the disappearance of the uniqueness of the art work. Technology undermined the identification of autonomy suitable for art. It also induces a delocalisation and the absence of temporal synchronisation which abolishes the membership of the image to a space and a given time, and allows not only new perspectives for the object but also the possibility of new existences [4].

New artistic practices indicate a general phenomenon of bursting of aesthetics out of the institutional limits that the tradition assigned to it. One attends the decline of the "aura" of the art work [5]. Dimensions which explain this event were largely interpreted by the art work of Rainer Rochlitz, entitled, *disenchantment of art* [6].

This devaluation of the authenticity of art work is primarily the effect of many transformations:

On the artistic level, technique introduces at the same time a transformation of our point of view and a change of our relationship to time. It substitutes eternity by topicality; at the duration, the moment, the fugacity, the accelerated rate that new technologies and more recently virtual reality technologies amplify. These new processes confer to art work a new actuality, which threatens its capacity of historical testimony and breaks it from its tradition.

On the anthropological level, the decline of the "aura" of art work returns to the rise of mass society and diffusion. This, corresponds today to what we call "a democratisation of art ". This value of exposure, which takes seat of the cultural value of work, generates a new process of significant perception: art escapes the field from appearance of the "beautiful" and gives up its properly aesthetic dimension.

Virtualisation, simulation, interactivity, temporalities, variability, memorisation of the volatile, provide new reference marks in the aesthetics of the digital image. The image at its virtual age, proposes sequences of reversible figures to us : it twists, it is stretched, turned over, etc.

The exploration of the image temporal plasticity related to its algorithmic dimension, also introduced a modified perception of space, as the illustrated material which makes it. From now, the algorithmic and temporal identities of numerical works constitute their aesthetic identity.

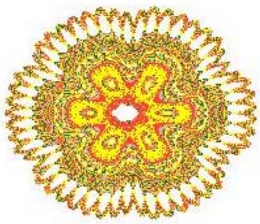
If art got rid of duration, if it integrated its transitory character by sympathy for the "volatile", it could not be that under the terms of a design of the truth which is not baited to regard this one as abstract, but becomes aware of its temporal aspect [7] .

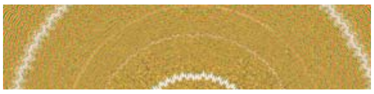
3. The art seized by mathematical modelling and computing

The use of mathematics in art is not new. Indeed, mathematics have always underlay artistic creation (research of the symmetry and the balance of the composition as in the Renaissance), in painting, *Vera Molnar, Jenner or the SPACE Group,* use graphical representation of algebraic structures. This step towards science finds one of its illustrations with the design of an abstract imagery based on the adaptation of the mathematical formulas *(*works *of Max Bill, Gérard Chamayou or Félix).*

"Mathematical art " is especially an idea, a thought, a knowledge converted into form. It is an act of theorems modelling external to it, suitable act of the scientific thought. Art came to Science [8]. As machines became the main source of inspiration, mathematical art returned into a new experimental phase. This marriage between mathematics and new technologies raises new artistic disciplines such as numerical art, generative art, fractal art, or virtual art. One of the common aspects of these new disciplines is that they reformulate in an understandable way abstract contents.

For example, fractals or other computer generated images, as a result of a complex mathematical modelling and simulation, reduced creative acts to their simplest expressions. Thus, giving a mathematical function or a functional system of equations with adequate parameters setting, a computer program is capable of generating complex aesthetic images. Such works put in scene complex and chaotic universes characterized by phenomena of proliferation, overload, saturation, or excess, a universe in permanent metamorphosis in witch nothing is stable, neither the image, neither the colour, nor the figure itself (Fig. 1). This lead to a culture of flow, where instability, abstraction, fugacity, and chaos are dominant values. Fragmentation, irregularity, bifurcation or junction points, bind order and chaos, random and determinism, finite and infinite [9].





4. The art seized by technique

Modern art stuck, all along its history, to release itself from any technical specificity. This resulted in the possibility of making art with any technique. Carried by the computing power and the development of innovative man-machine interfaces, digital or virtual art is today confronted with specific techniques which cannot take only positive aspects.

The introduction of virtual art creates suspicion and faintness persisting in the field of art. It is a polemic in the centre of which "contemporary" art sees itself, suddenly and brutally, questioned. We entered a new era, the era of the generalized connectivity which will transform, not only the supports of art, its diffusion, its know-how, but also its perception [10]. Indeed, the inescapable development of the functionalities and modalities of this new technology, at the software level as well as at the level of human-machine interface, allowed the emergence of the concept of virtual experimentation. This one consists to study various mathematical models and to solve its equations so as to follow the evolution of the various variables representative of a physical or non-physical phenomenon. Thus, it will be possible to act, via these models, even on virtual objects or to test non-physical conditions.

Released from their scientific and technological aspect, these tools offer to the artist new means of expression which can give life to fantastic universes. This raises to a new kind of art offering infinite potentialities resulting from both the continual increase of computing power and the creation of new software.

It is a system of which various functions (processing, interaction, visualisation, motion capture devices) may be delocalised but they appear to the user, belonging to the same logical entity. The effective use of new technologies such as virtual reality and the numerical results they produce lead to fabulous tool of discovery. The produced images generate unforeseen and unforeseeable patterns (although already present in the equations).

Such revolutionary tools modified academic references and tradition of the theory of creation. Should we announced an epistemological rupture? The artist holds anyway, power tools for creation which will also permit to question our senses, our relation to reality, space, and time (art work of Edmond Couchot and Michel Bret (Fig. 2) and those of Miguel Chevalier (Fig. 3, 4)).

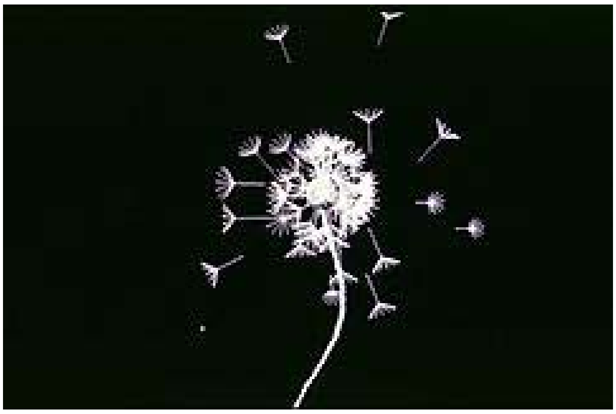


Figure 2 : "Le pissenlit" - Edmond Couchot et Michel Bret (1996).

Figure 3 : "Sur-natures" - Miguel Chevalier (1980).

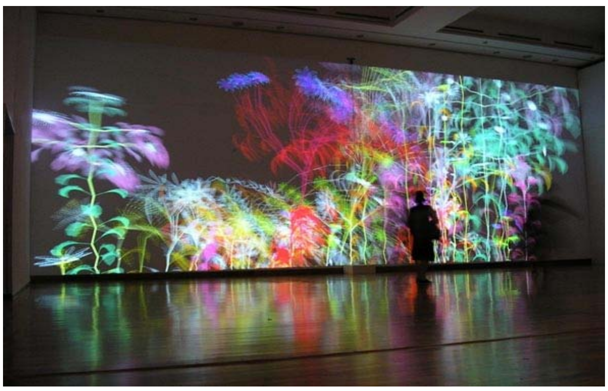


Figure 4 : "Digital Paradise" *- Miguel Chevalier (2005).*

5. Conclusion

In this article, we have presented two main tendencies of art : one assigns its scientific aspect and the other assigns its technicality. Indeed, the most projecting feature of the current state of art holds in the fact that technique and science take an increasing importance in art work. Evolution of art and techniques went hand in hand, maintaining a close relation. Facing this huge potential offered by computer-aided creation and virtual reality techniques, does art will be considered as being completely technical or mathematical ? The start of a reconciliation of art and techniques led to a sharp reflection : does "digital art" is a cut art ? Anyway, it is an art which falls under the continuity of artistic research and the prolongation of the history of art. Although it is very related to computer science, its evolution testifies to an artistic and aesthetic original history, which cannot be reduced to a simple application, as "advanced" as can be. Even if one reaches with digital art, an ultimate degree of use of techniques and mathematics, art and technique were never contradictory. Digital art does not break, but differently poses the relations of adjacency between technique and language, technique and art. It facilitates and automates the exchanges and communication modes between figurative and technical thought. So, potentialities offer by the technology enable any creator to redefine his subjectivity and to reconsider the respective relationship between reality, virtual reality, and imagination [11].

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Self-adaptation to High Density Based on Sunlight Analysis

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Abstract

The modernism architects began to improve the housing conditions by sunlight analysis in 1920s. Nowadays, generative design employs various analyses as criteria for form-generation. This research investigates the optimal organisation of cubic houses in 3-dimensional array for high density. A generative tool is developed based on the integration of iterated algorithm and sunlight analysis.

Both brute-force strategy and advantage search algorithms such as genetic algorithm are not available for this optimisation task. A "make it better" scheme based on iterated operation is applied to solve this problem to some extent. It is interesting the algorithm gets into the 3-dimentional matrix deeply to observe the interactions between the units of the matrix. In fact, these interactions are based on the dynamical sunlight which produces shades in the matrix. The iterated processes add or eliminate the units according to sunlight analysis, leading to local transitions in 3-dimentional array.

The local behaviours shape the light environment in the matrix and the changing environment drives local transformations during the iterated processes. The accumulation of local transformations leads to the self-adaptation of the whole system, towards extremely high density in 3-dimensional context.

The system articulates complex form of high density. It is always unpredictable or unexpected, however, it innovates upon the design process. The generative tool helps the architects manipulate the complexity by studying local behaviours and setting up the transition rules of dynamical system.

Keywords: self-adaptation, iterated process, sunlight analysis, high density

1. Form of High Density

More sunlight and fresh air are brought into buildings to improve living conditions by Modernism architects since 1920s. The raw strategy is inevitably responsible for the “simple” style of their early works. The awesome “Radiant City” of Le Corbusier came from the requirements of abundance of sunlight, air recirculation, traffic efficiency as well as green spaces, upon which the individual freedoms depend. Furthermore, Walter Gropius applied sunlight analysis on residence planning and proved that “ordered” array of housing is more competent than complicated traditional blocks in sunshine estimation.

In fact, it is just an accident that the efficiency leads to simplicity. If “efficiency” problems in architecture domain are interpreted as optimisation tasks based on mathematical models, we will not get into the “function-form” issue, but develop variations of techniques then appreciate what the algorithms themselves will bring to us. In addition, this is more interesting considering the notion of “Adaptation Builds Complexity” by *John Holland* who developed new optimization methods now known as genetic algorithms in 1970s. His achievements suggest a sophisticated relation between optimisation process and form generation. And it is natural that unexpected and complex articulations emerge from the execution of the computer program, through which the nature of the problem may be exposed.

2. 3-Dinmensional Matrix

Employing unique search techniques, this design research takes an investigation to the organisation of high density housing, taking sunshine duration as single criterion. Other architectural factors such as structure and function are not put into the main body of the generative design, while they will be reconsidered in the phase of further design below. First, we set up a model of 3-dimensional array of cubic houses. Each unit gets a state of “O” or “V” which presents a unit space occupied by house and a void (unoccupied) unit space respectively. There must be a unique or series of solutions getting a highest density in the 3-dimensional array in which all units satisfy sunshine duration, however, the right way to catch the solutions is not always available due to the complexity of the subject as can be seen below.

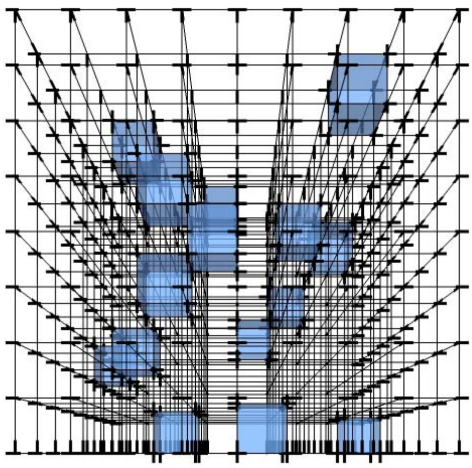


Figure 1. 3-dimensional array of cubic houses

Theoretically, the answer can be found by brute-force search strategy which checks the candidate layouts one by one. It seems that it is an $O(2^n)$ problem as the number of units grows, however, it is actually more complex for the sunlight analysis in each iteration becomes more complex as the 3-dimentional matrix gets larger. Once the matrix comes to 4×4×4, the sum of the subjects reaches to 2^{64}, or 1.844×10^{19}, making the search task an impossible mission. Genetic algorithms are born to conquer this kind of problem. Whereas, the genetic representation of the problem based on 3-dimenional array and sunlight estimation is so difficult. If the candidates are generated without any constraints, then most candidates are illegal (not all the units of them satisfy sunshine duration criterion). On the other hand, the candidates could be tested in initialisation. In spite of that, most percentages of new subjects produced by the crossover operations are illegal and subsequently the whole scheme fails. At last, we come back to analyse the mechanism of 3-dimensional array in sunlight context and try to develop a valid way to find a high density solution, not the highest.

3. Strategy and Algorithms for High Density

3.1 Sunlight Analysis

This research commences with tracing the path of sun. By conventions in architecture, it is presumed that:

1. The path of sun (relative to the earth) is a circle (not helix or ellipse) during a particular day.
2. The plane of sun path is constant relative to the earth during a particular day.

They are not true, however, it doesn't matter because the difference between computed value and true value is limited. Taking the time as parameter, the path of sun could be described by a formula which is acquired by geometry techniques (see Figure. 2) on the presumptions.

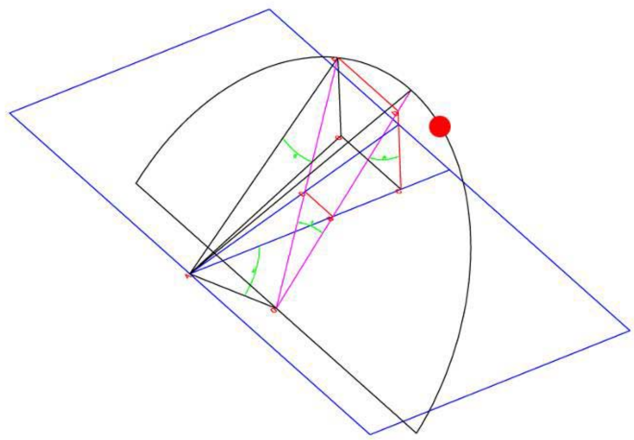


Figure 2. Geometry analysis of sun path

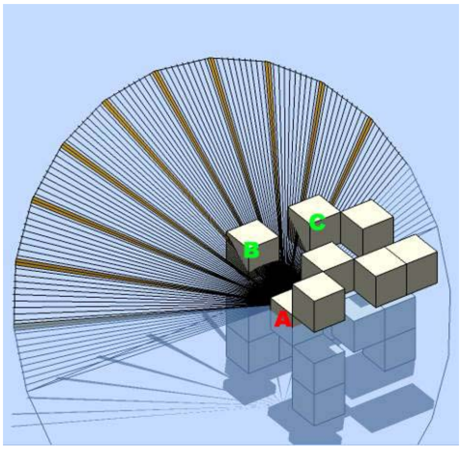


Figure 3. Shade analysis

It is clear that the sunshine is essential to houses. On the other hand, it is a real problem that how to evaluate the quality of sunshine to a particular room in a house. In areas where the low temperature is uncomfortable in winter, sunshine is important to warm the room. The architectural code of P. R. China makes a compromise between feasibility of the code and the accuracy of sunshine assessment. *Code of* *urban residential areas planning & design* orders that the sunshine duration of housing must be more than 2 hours on the day of "*Dahan*" (in big cities such as Nanjing). "*Dahan*" is around January 20th, defined as the coldest day in traditional lunar calendar established around 104 B.C. based on the climates and related farming activities. It is reasonable that "*Dahan*" is approximately a month later than "*Dongzhi*" on which the sunshine duration is shortest in daytime.

An algorithm to calculate the sunshine duration for any unit in the matrix is essential. A unit is likely to be shaded by several other units (see Figure 3). The algorithm searches all the units to check whether it produces shade on a target unit during the whole daytime. There is a set of shaded times because more than one units could project shades on a target. Superposing these data, the sunshine duration of the target comes out.

This method is not the most efficient way to calculate shades. In China, Commercial software has been developed for sunlight analysis whose aim task is checking whether the architectural layouts meet the code. Advance algorithms are employed in the *Sunshine 2.0* by CAAD lab of Tsinghua University which leaded by Wang Gu [4], a domestic pioneer who began to step into form-generation from analysis-oriented research. Actually, it is more powerful if advanced analysis software is embedded in the generative process, though this is not realized in our research yet.

3.2 Iterated Algorithm

The analysis does not only provide a way to calculate the finesses of subjects, but also reveals a clue for high density optimisation. It indicates that the amount of illegal units (whose sunshine duration under the criterion) in a 3-dimentional matrix is related to interactions between them. Here, the interactions are established by shades, or dynamical sunlight, which define a unit as shading one or shaded one. Available is the data describing a particular unit produces how much shades to others and who make how much shade to it. So, two special attributions are attached to each unit: "Shade" and Sunshine Duration. One's "Shade" is defined by the sum of all others' shading durations produced by it. Usually, there are both "killers" whose "Shade" is extreme high and "victims" whose Sunshine duration is very low in a matrix. So that's the key problem how to eliminate all killers and save as many victims as possible.

The "make it better" strategy is introduced to solve the complex problem. It aims to improve both the potential and current density of a subject gradually based on iterated operations. Generally, the algorithm acts like this in every iteration:

1. Find and delete (make it unoccupied) the one whose shade is greatest.
2. Delete an illegal one.
3. Create a new one (make it occupied) where sunshine duration is high enough.

The relations (shading and shaded) between the units in the matrix make up the dynamical environment which drives local transitions during the iterated processes described above. On the other hand, the local behaviour reshapes the environment built by units. These iterated processes outline the main idea of "make it better" scheme, though it causes too many bugs in execution. It is improved as below:

1. Get a set in which all elements:
   (1) Unoccupied (by house)
   (2) Legal (sunshine duration is higher than the criterion)
   (3) Shade of which are lower than a constant LIM1

   Then occupy the one whose Shade is lowest in the set.

2. Get a set in which all elements:
   (1) Occupied
   (2) Illegal

   Then eliminate (make it unoccupied) the one whose Shade is highest.

3. A copy of step 1

4. Get a set in which all elements:
   (1) Occupied
   (2) Shade of which are high than a constant LIM2

   Then eliminate the one whose shade is highest.

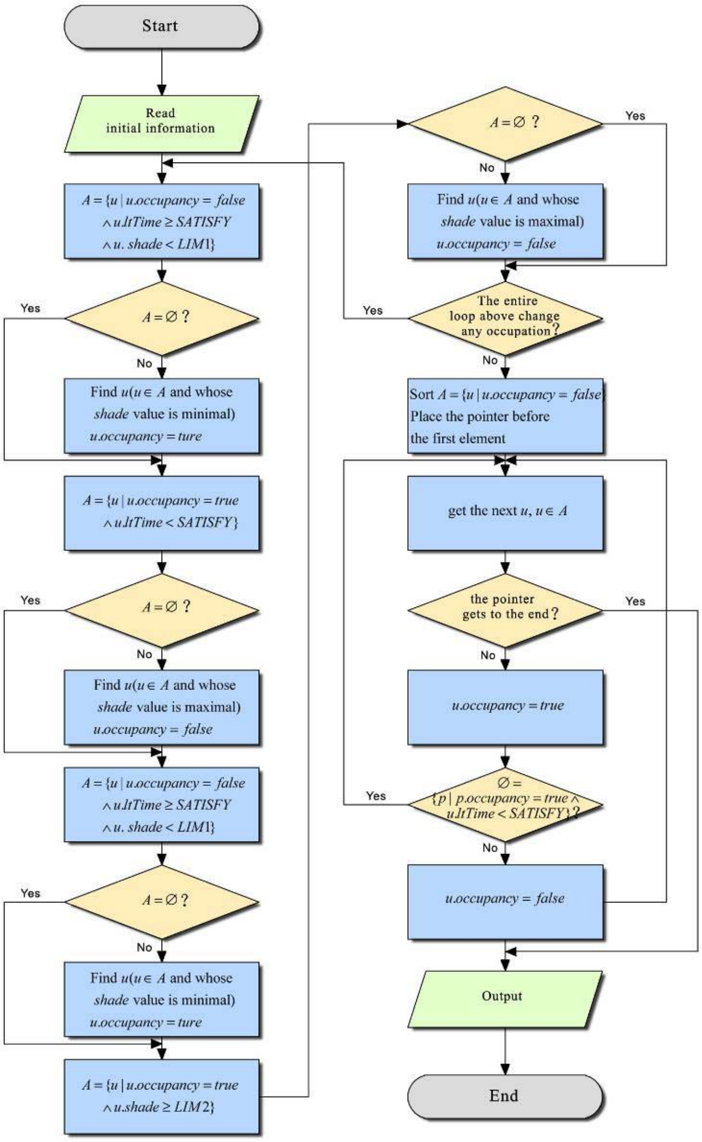


Figure 4. Flowchart

What is worth mentioning is that the algorithm consisting of the four steps is full of varieties both in framework and in details. Anyway, it avoids these situations:

1. The program gets its end without substantial improvement.
2. The program just involves a small number of units in the whole procedure.
3. The program is too difficult to get its end.

The program suggests this algorithm works well. It does make the matrix a more potential one and a higher density one during iterations. At least, it is capable of adding units to the initial array and making sure all the units are legal after execution. Paradoxically, the weakness of this algorithm is clear. First, it is very difficult to prove that this procedure will generate the highest one from randomly initialisation. In fact it has not this capacity according to our experiments. Then, the performance of the program is very sensitive to the constant of LIM1 and LIM2 which are very difficult to get optimal values. Additionally, the initialisation plays an important role, however, it is clueless which one is best considering the total number of initialisations grows at $O(2^n)$ (n denotes the sum of units in the matrix).

Besides these disadvantages, we found there are some unoccupied units in certain solutions are legal and they will not “kill” others if occupied. In other words, the algorithm fails to explore the full potential of the matrix. The first step of the iterated algorithm above is responsible for the failure explicitly. The four steps are designed to make a compromise between the robust of the program and the high fitness of the final state, it is better to design another algorithm for additional improvement than modify the framework of the exiting algorithm. Applied to the solution of main process, the new algorithm checks the legal unoccupied units one by one to see if they will make others illegal if be occupied. The two algorithms make up the framework of our final program.

The program drives the matrix to high density successfully. While, the matrix can also be regarded as an automated machine which modifies its state iteratively according to inner interactions. Self-adaptation is achieved by its iterated actions which aim to improve the micro-environment made up by its own units.

3.3 Performance of the Program

A user interface is developed to allow designers to set the parameters in algorithms and observe the performance of the program. It also helps the programmer to get a graphic understanding of the algorithms and make further improvements. The 3-dimensional array is presented by plans (Figure 5) rather than 3-d view, for algorithms dealing with 3-d view are complex and use too much proportion of CPU. Figure 5 shows a 6×6×6 matrix with six plans (the left top one presents the first floor). Users can set the initial density of the array before running the search program. This parameter is necessary for the initialisation based on random functions and will bring distinguishing performances with different values. The experiments indicate that extreme low/high values are not appropriate. The two important constants of LIM1 and LIM2 can also be modified if the users plan to try alternative values and see what will happen.

In our experiment, running the program on a 4×4×4 matrix for 20 times emerges four high density ones which contains 24, 24, 26 and 25 units (Figure 6). It is not clear that if there is a pattern in the high density ones for this matrix is too small. If the array grows into some extent like 20×20×20, the pattern will be easily recognised if it exits. Unfortunately, the program written in Actionscript 2.0 loses its capacity of manipulating a matrix large than 7×7×7 on an ordinary personal computer. Suppose high efficiency languages like C or Java run 10 times faster than Actionscript, a 15×15×15 matrix is be likely be solved by this program, for the complex of this algorithm is $O(n)$ (n denotes the sum of units in the matrix).

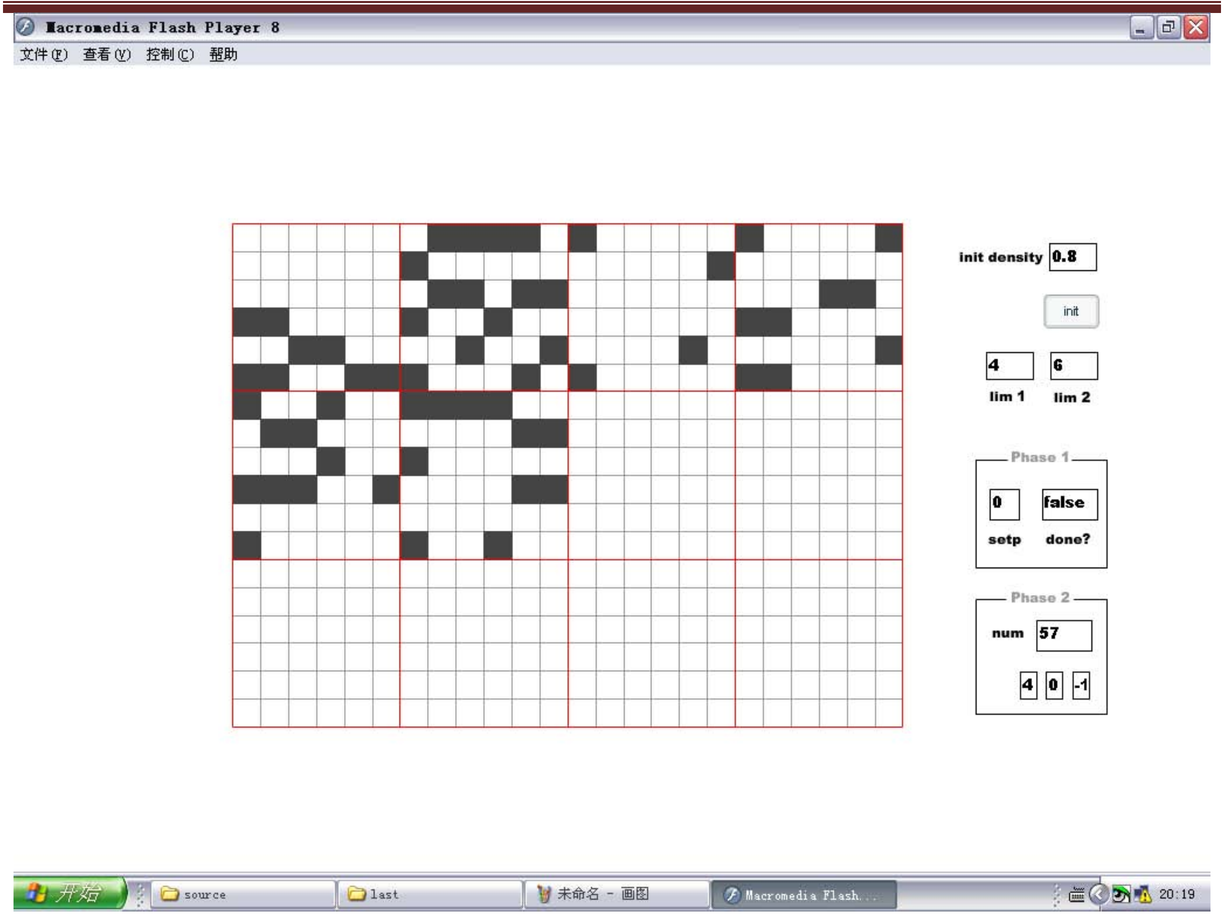
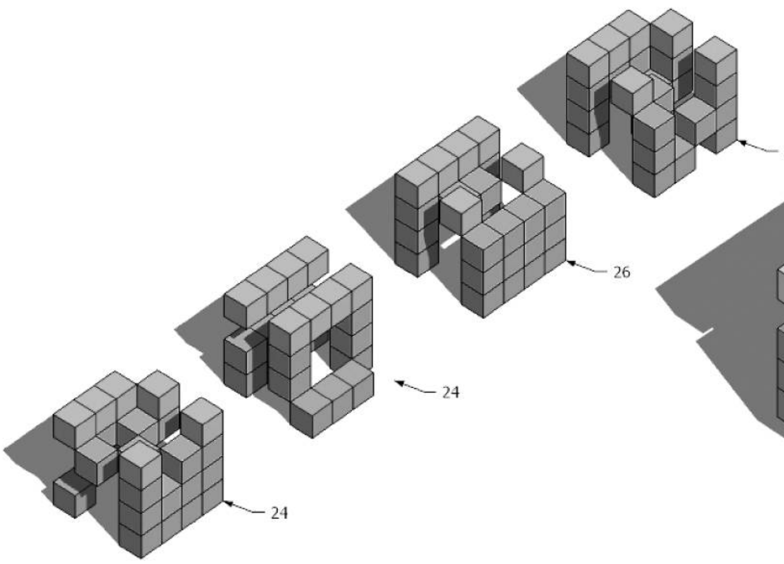


Figure 5. Interface of the program



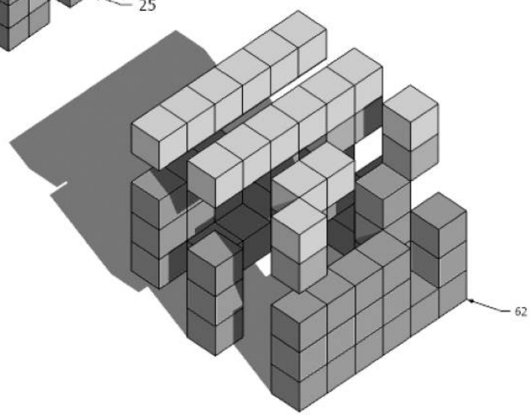


Figure 6. Solutions from 4×4×4 matrix *Figure 7. Solution from 6×6×6 matrix*

It is tried for a great number of times to get a high density one in a 6×6×6 matrix (Figure 7). The number of 42 seems to be the limit that allows 28.7% of the units occupied by houses. This solution is employed by our further design.

Further Design

The outline of layout is derived from the generative tool and it needs further design to become a true residential plan.

Initially, the dimension of the 3-dimentional array should be defined. In this project, the unit is set to be six metres in width, depth and height, and the whole matrix is as large as a cube of 36×36×36 metres. The height of six metres is inappropriate for small house, so most units are divided into two layers with three metres in height. And the whole unit could either be used by single family or provides two separate spaces for different inhabitants. Furthermore, adjacent units could be connected and make up a large space for big families or public facilities.

The transport inside of the matrix is anther substantial issue. Two cores with elevators and stairs are built into the matrix (Figure 8). The north one just occupies the exiting units and does not add new volumes. The south one adds several units but makes no shade to others. Aisles and bridges are also added to make horizontal connections.

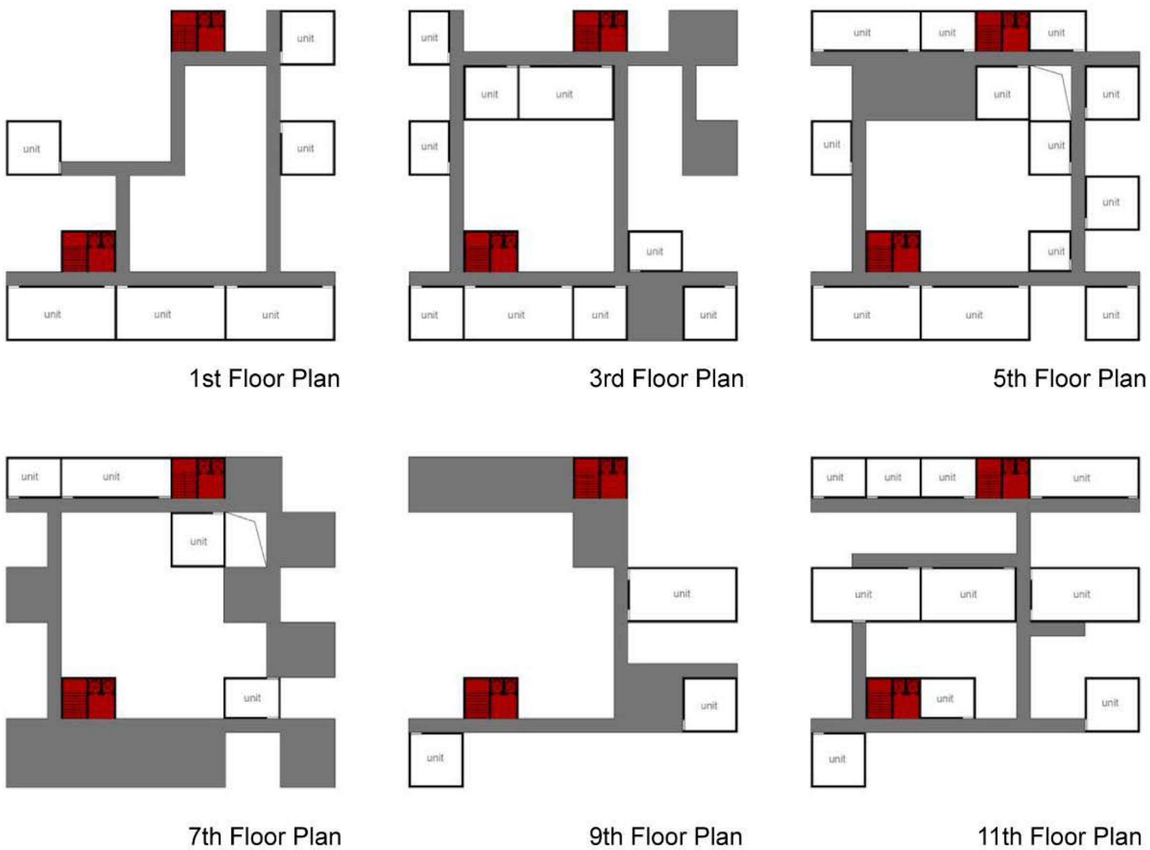


Figure 8. Plans

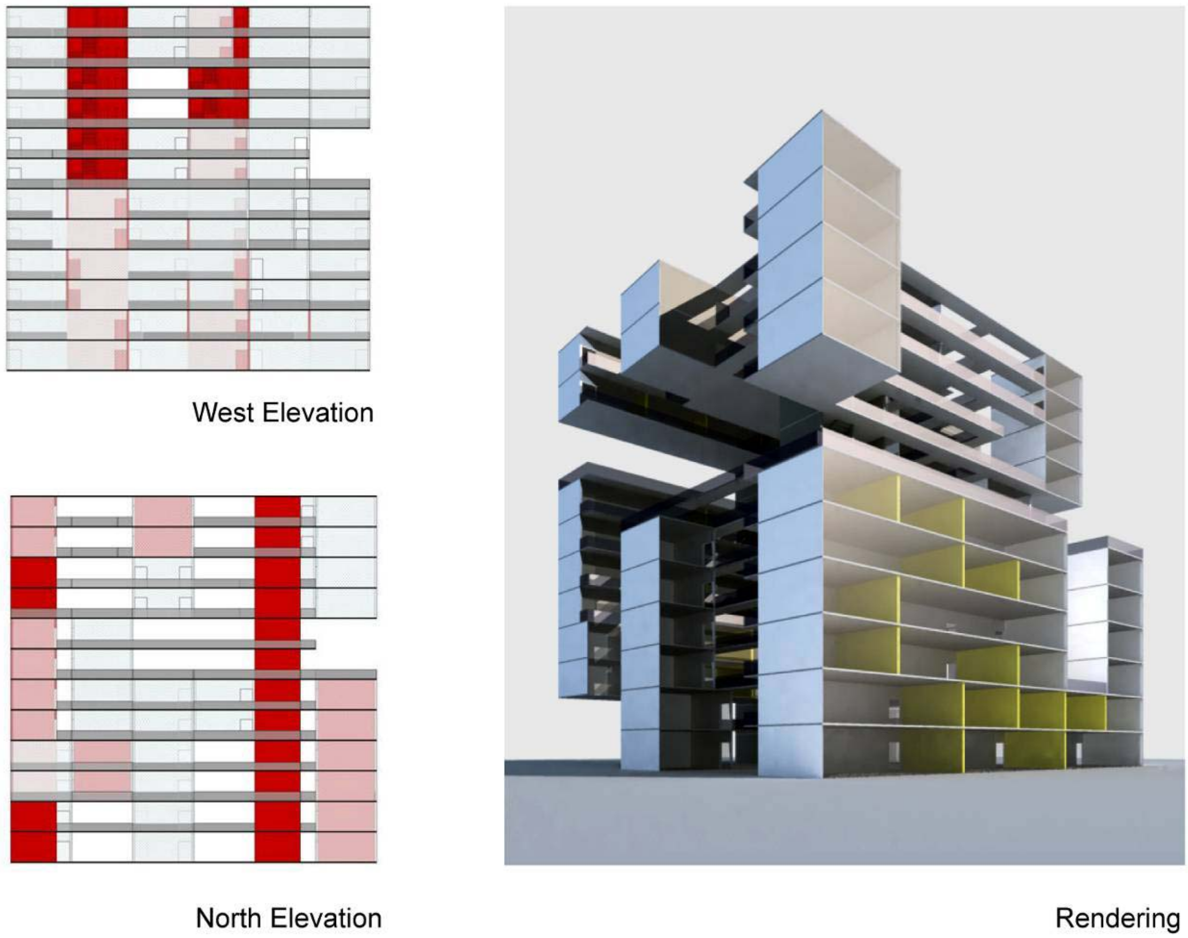


Figure 9. Elevations & rendering

The complex form is a precise solution for high density and sunlight criterion. In architectural viewpoint, the form makes each unit unique and build up various micro-environments. These features suggest that the optimisation of architecture may lead to innovative and diverse environments for inhabitants.

4. Conclusion

From the analysis of sunshine to architectural design, this research design tries to find an optimal form according to simple criterion. The core of the whole process is the automated iterated process which improves the matrix gradually. Though, the iterated function made up of four steps are not full-developed, it succeeds in generating complex and excellent prototypes for further design.

Analysis is always applied to make diagrams regarded as the sources of architectural design. As is shown above, design computation provides a new way how to employ analysis to drive design processes. In computer science, analysis on a special domain usually contributes to algorithms for fitness calculation but lose opportunities to develop innovative schemes dealing with the subjects' inner structures which determine its fitness. In this research, the integration of iterative process and sunlight analysis introduces a new method to improve the structure of the matrix for higher density and better sunshine quality. It seems that analysis processes are more powerful if it interacts with the volatile subject.

Great efforts were made for form-finding in architectural design and a variety of strategies with emphasis on different aspects have been developed since Modernism. Different from them, algorithm based form-generation is able to build strict connections between analysis and form. Simultaneously, these connections do not means simplicity, but are capable of creating unlimited structures and forms. Compared with the evolution mechanism of nature organisms, recent algorithms are too simply and stiff to generate complex systems with multiple hierarchies, however, they are stimulating the designers to step into systematic processes.

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Generative Tool for Courtyard Pattern

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Abstract

The generative tool presented in the paper explores the possibilities for developing potential approach of Chinese traditional spirit of vernacular dwellings yard. Chinese spatial qualities are rhythmic and crisscrossed. The ethic orders play a crucial role in the layout principles, and the rational topological relations facilitate the habitants' activities. Patterns of traditional Quadrangle Dwellings are investigated as a self-organisational system, from which constitutes the mathematical model of the generative tool.

Multi-agent system (MAS) is efficient to employ the self-organisational rules extracted from the courtyards. Each agent in the MAS presents a courtyard in the whole layout. The architectural constraints and the extracted rules set up the behaviour standards for the agents. The interactions between them make the system self-adaptive. Based on the system, a design tool was built and applied in the practical projects.

The complex patterns emerged from the system lead to new understandings of the traditional spirits. Innovative methodology and perspective is provided for architects to deal with Chinese courtyard.

1. Introduction

With the development of architecture globalization, inevitably, courtyard space as a Chinese traditional architecture characteristic has lost in the past several decades. Two main reasons should be responsible for this consequence: First, the scale of traditional courtyard can not meet the request of modern architecture for large-scale public space with the rigorous site limitation. In addition, the existing courtyard design method is incapable of dealing with the complexity of architecture, together with the cultural context. Therefore, how to design courtyard space in public architecture integrated with traditional pattern becomes an emergent task for Chinese architects.

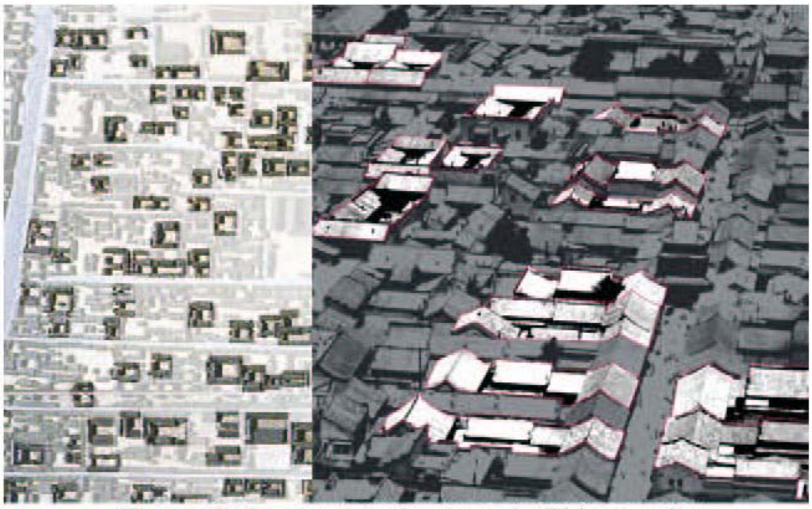

Figure 1: the courtyard pattern in Chinese city

On the other aspect, MAS（Multi-agent System）has been proved to have the ability to deal with complex organization problems in past several years. Compared to traditional design method, MAS is a top-down self-organized system defined by abstract regulations. This paper explores the potential of courtyard layout designed with this evolution tool.

The second part of this paper is to explain the characteristics of Chinese courtyard space. The study takes Chinese Quadrangle Dwellings as investigated objects, and analyzes traditional architectures from two dimensions, through which derives program organized regulation:

- Relation among courtyards. The function, ranking, and social character decide the location and scale of each unit.
- Shape of courtyard. Courtyard with different ranking corresponds to various space organization and topological pattern, interrelated with the active mode of space-user.

The third chapter focuses on the program process through mathematical algorithm, and the result of the program is also described in this part. In the program system, each agent represents a courtyard unit, and ranks, adjacent relations, courtyard area and building area are programmed through the regulation derived from former analysis. Based on MAS system, a generative design tool was built and applied in the practical projects.

At last, the limitation and disadvantages of this tool will be proposed for future exploring and developing.

2. Background

Chinese tradition in its most ancient roots conceives of the elementary units of reality as changes from yin to yang or vice versa. More particularly, an identifiable unit of reality is a harmony of yin-yang transformations. (Robert C.Neville) Some dialectic references in China, such as inside and outside, being and non-being, solid and void, may be comprehended and articulated through the terms *yin* and *yang*. Courtyard is also a system integrated with *yang*/solid and *yin*/void, which consists the internal organization logic. The organization of courtyard system, hence, may be comprehended as structured by two categories: the structure combining each unit with its social function, and the organization of *yin* and *yang*, being and non-being.

2.1 Courtyard organization order

The founder of Tao philosophy, Laozi, stated in his Daode jing that "Out of Tao, One is born; Out of One, Two; Out of Two, Three; Out of Three, the created universe", in which Laozi put forward the concept of one as the foundation of the spatial schema, starting from one to two, and moving from two to three. Based on this philosophy, the process of courtyard organization, generating its own motion by the interaction of forces, is fundamentally transformational. There is no final beginning or end in this process; rather, there is the identifiable rhythm, order, and cadence of transformation. (Roger T.Ames) There are three main measures of traditional design method: repeat in north-south direction, move parallelly in both widths and depths orientations, and scale-up or scale-down based on corresponded hierarchy.

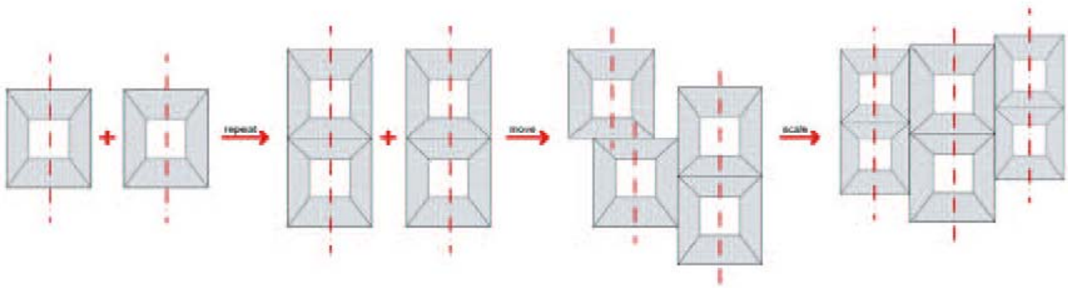

Figure 2: the sprawl order of courtyards

So many theories and diagrams in ancient China are contributing to the centrality thought. Bagua, is an Eight Trigrams, founded on the categorization of the eight directions of the world with the void in the centre. The strong correlation in numerology, structure and ethics, between man and Heaven marks man's esteemed status in the cosmos, and hence formed the centrality. Eight elements around the central void space correspond to rigorous hierarchy and the complementarities and restrictions among each unit build a harmony and consistent system. And according to the diagram, Nine Realms of Zhou, the degree of barbarism increases or the degree of culture deceases with the square of the distance from the centre. To this regard, the reality of traditional architecture emerges from the transformation of space to reflect social meanings.

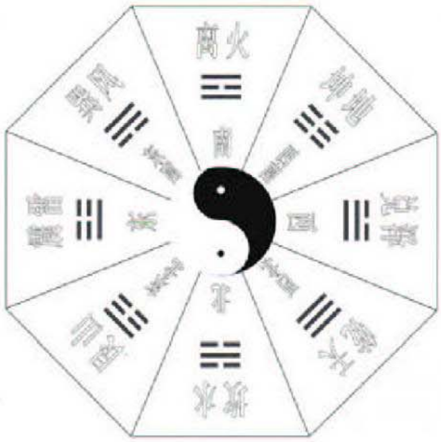

Figure 3: Bagua

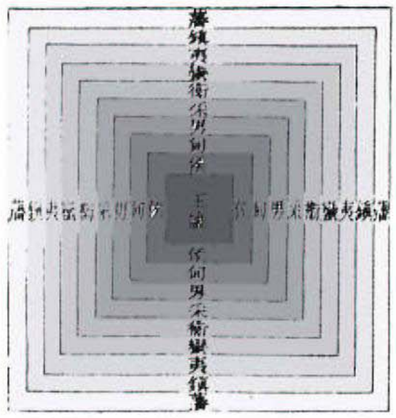

Figure 4: Nine Realms of Zhou

The active mode of ancient Chinese also decides the orientation and arrangement order of courtyard. From the records, based on the east-west orientation, in Chinese courtyard, the west architecture is usually reserved for sleeping and the east is for daily activities. However, in the ordering of external space, the north-south orientation occupied the principal place in Chinese culture. Thus, the spatial arrangement as well as settlements came to incline towards this orientation. The north is revered and esteemed on Earth, for example, the emperor faces the south and his subjects profess allegiance to the north. Therefore, architecture is sited with its back to the north, facing the south. Such layout idea may of course have had a rationale of Chinese temperate condition, which naturally favours the warm sunlight that comes through into the south-facing interior and has its back turned away from the harsh cold wind form the north.

Meanwhile, the Chinese concept of space was founded upon a spatial imagination that emerged and evolved over time. Indeed, Chinese enclosure space is appreciated as it relates to impending departures or arrivals, that is, in terms of movement from one space to another; it is dynamic. Take Prince Gong's Mansion (*Gong Wang Fu*) as an example. Prince Gong's Mansion is Beijing's largest and the best preserved Qing Dynasty (1644-1911) princely mansion. The mansion was constructed around the year 1777, and covers a total area of 60,000 square meters. The residential portion stands within three sets of courtyards occupying a central, eastern and western situation. The movement through the main, central section comprising the front door, the second door, the anterior hall, the major hall and an extended pavilion, composes the sacrifice routine. Each of the western and eastern sections contains three smaller courtyards for residential function, and based on the east-west orientation rules, the eastern section has higher hierarchy than the western section. In Figure 5, the most important courtyard is located in the centre of the mansion, surrounding by eight lower ranking courtyards. The orientation and the distance from the central courtyard decide the social function and hierarchy class of these eight units, and vice versa. The service courtyards and entrance courtyards are arranged at the outside of the complex, because of their assistant functions.

Figure 5: ranking analysis of Prince Gong's Mansion

2.2 Pattern of courtyard

Laozi claimed that the universe created carried the yin at its back and yang in front, and through the union of the pervading principles it reaches harmony (Daode jing), from which he expanding the planar schema into a three dimensional schema with the concept of yin and yang. That forms the elemental entity in Chinese traditional conception of space. In cases of Chinese space, the spatial imaginations are manifested as two rudimentary characteristics: enclosure and enclosing qi, being and non-being. Architecture space is defined by its enclosure/being and enclosing qi/non-being.

Differences between transformations consist in different patterns of yin and yang being exhibited. Thus there are patterns that can be ingredient in a harmony, and over time those patterns can be repeated or exchanged for other patterns.

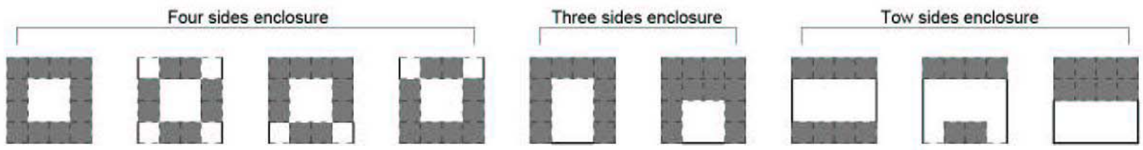

Figure 6: the shape of courtyard

3. Program description

The mathematical model of the experimental program takes the rank as the crucial trait of every courtyard. The ranks reflect the status of the inhabitants in traditional courtyards. The ranks could be derived from the different functions of the parts in modern architectures, such as museum and hotel with traditional space pattern. The model assumes that the units with higher rank would be located nearer the centroid than the others with lower ranks.

The topology is the basic trait of the courtyards in both traditional dwellings and today's architectures. Each courtyard has particular "neighbours" for the convenience of various activities or the ethic principles in the Chinese traditional architectures. The adjacent relations between the units are essential parameters for the architectural organization in practical designs. In the mathematical model, each pair of the courtyards is assigned to "make neighbours" based on the initial specification. Though the bubble diagram has been well developed in conventional design process, this program just take the simplest mode for descriptions of adjacency relationships.

ID	Rank	CAR	Building Area	Adjacency
0	3.0	100	28	
1	2.7	80	25	
2	2.5	50	25	
3	2.0	40	18	
4	2.0	50	20	
5	1.6	45	15	
6	1.2	150	10	
7	1.0	12	8	
8	0.6	10	10	
9	0.5	8	8	
...	...	...	...	

Figure 7: program structure

The Courtyard Area Reference (CAR) is a reference value of courtyard area. The true value in final articulation after execution is always smaller than the value calculated by CAR, for this system is still under test with some inevitable disadvantages. The value of building area controls the building area of each courtyard precisely. The building area could be equal to the CAR when the building covers the whole courtyard. In this condition, this model is not only for courtyards organization, but also ordinary organizations of unit spaces. A unit with higher rank usually has a higher value of CAR and building area, however, there are exceptions. For example, a unit presenting garden may have low rank, large CAR and very low building area.

The ranks, adjacent relations, courtyard area and building area are basic configurations of the mathematical model. The multi-agent system based on this model could test any space problems which can be described by these parameters, while the self-organization of the system will bring out interesting hints.

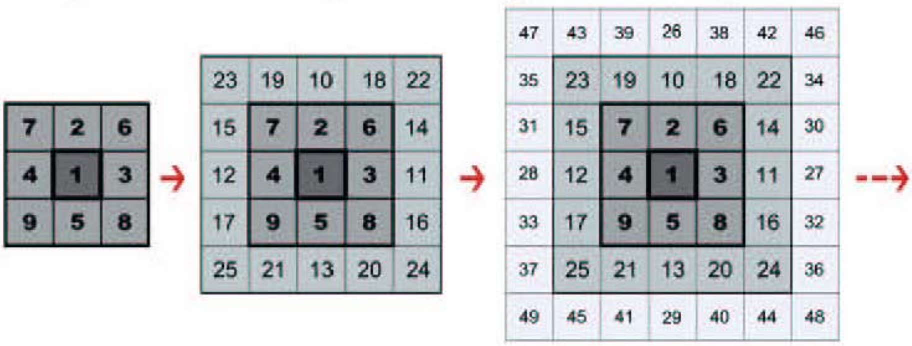

Figure 8: the ranking of courtyard

3.1 Employing rules by MAS

The configuration based on parameters could not lead to any forms or patterns without other composition rules. Architects are good at applying their rules to the existing configurations even though they may not notice this key process. The generative tool needs its own rules to produces forms. Multi-agent system (MAS) is efficient to employ the local-organization rules based on the configuration information. The initial state of the MAS is set up by random function and the self-organizations of the units generate population of forms during the whole life period of the system. One initialization leads to a unique but unpredictable process of running and a particular final form articulation. From a traditional viewpoint this situation turns counter to the notion of design by its indeterminacy and ambiguity, while it is a feasible way towards true analogy of nature evolution and it brings out abundance resources of forms for designers.

Every agent in this system presents a courtyard with the parameters of rank, neighbourhoods, CAR, building area and location. The locations of all agents are randomly initialized. The behaviours of the agents are put into five categories: pushing, making neighbours, exchanging locations, assembling and keeping in site. All behaviours are induced by virtual forces. The system's main character is that all the forces are "soft". This character creates new possibilities in the process of layout generation and brings some inherent disadvantages.

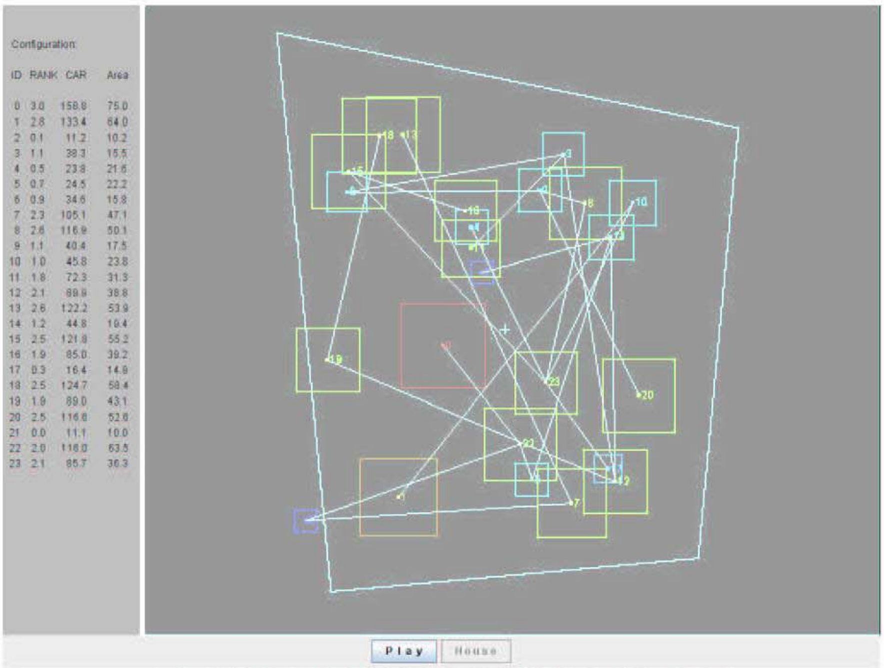

Figure 9: early layout of individualistic agents

The behaviour of pushing aims to avoid the overlapping of the courtyards. Because the force of pushing is soft (the magnitude is proportioned to the overlapping area), the agents are still likely to overlap under the pressure of other forces. That is why the CAR could not precisely control the courtyard area of the courtyard. Fortunately, it is not a vital problem for the deviation does not obstacle the generation process and does not reduce the building area. When two agents are overlapped during running time, they will exchange their locations if the one with higher rank is on the outer side. This mechanism keeps the high rank agents around the centre of the whole group. And it is capable of improving the robust of the system for this mechanism provides uncontinuous changes to the smooth evolutionary process, just as the role of the mutation in genetic algorithms.

Any pair of agents which are defined as neighbours move towards each other until they touch each other. The magnitude is proportioned to their distance. This type of behaviours could fulfil most adjacent requirements together with the special mechanism (exchanging locations) in the pushing behaviour. While some complicated topological configuration will induce premature convergence and result in ill layouts.

If any agent is not completely covered by the area of the site, there is a force push the agent into the site. In early period, the system is tested without any site boundary. The performance is better than the situation with boundaries, for there is more space for the agents to modulate their locations. Compared with the forces for pushing and making neighbours, this kind of force is very small so the restricts of site boundary will not be too strong to interrupt the running of the system. The additional force of assembling for each agent is constant and much smaller than other forces. In fact, there is not necessary for the assembling forces coming into play until the main topology structure is shaped.

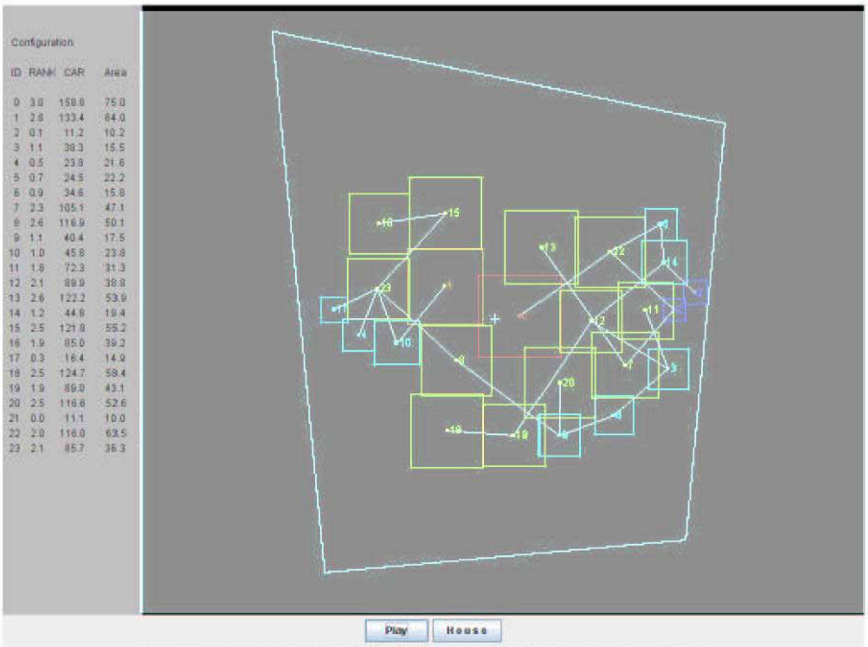

Figure 10: later layout of individualistic agents

As soon as the system reaches equilibrium, the framework of the courtyards layout is generated. The equilibrium does not always imply an optimal organization. There are many "neighbours" which are far away from each other in ill equilibriums. An easy way to solve this problem is to develop a user interface for the designers to change any courtyard's location. In spite of that, this strategy could not improve the capability of the multi-agent system.

In the other hand, the system is difficult to become stable in some situations. Usually, the behaviours of the system become periodic: it may reach some state near equilibrium, then rush into chaos and move towards another semi-stable state. The generative tool allowed the designers to freeze the semi-stable state and start building generation.

3.2 Building generation process

Several layout patterns in single courtyard have been extracted from traditional precedents. In the building generation process, every courtyard chooses a layout pattern for building generation, based on the true area of the courtyard and the predefined building area. This operation is an absolutely parametric, different from the self-organization scheme of the previous process. It's a direct way connecting the traditional patterns to the practical design tasks.

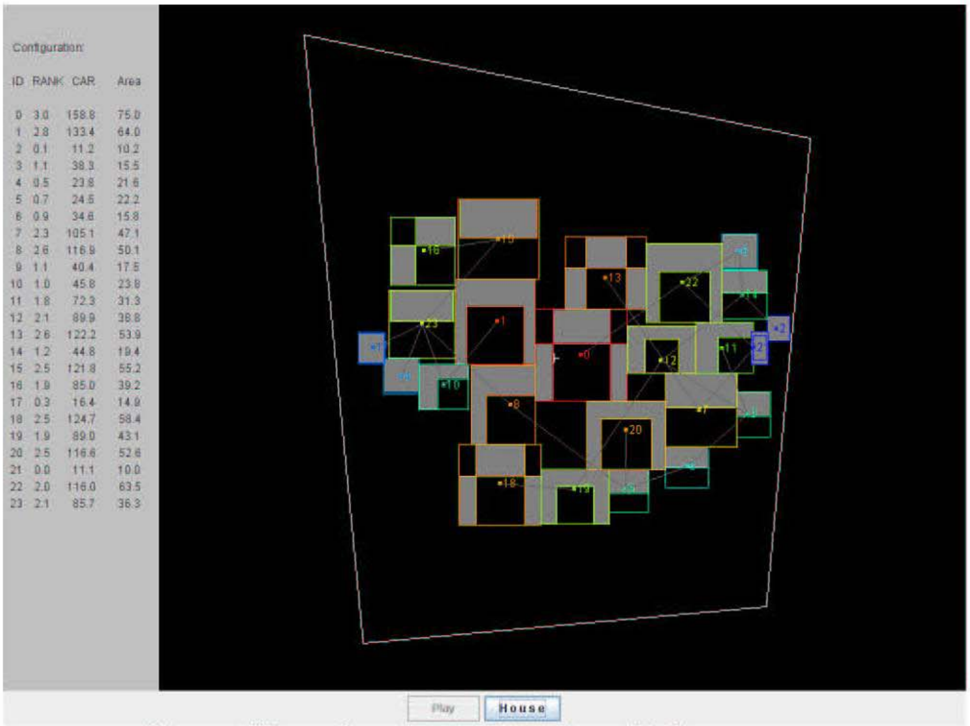

Figure 11: employ shape of courtyard in the program

4. Conclusion

Through the research of Chinese philosophy, the interrelated organized rules and layout pattern of courtyard has been derived. The centrality and yin-yang theory take the most crucial place in Chinese traditional architecture planning system, although some orders have changed over time. An evolutionary mathematical tool has been advanced to deal with the complexity of modern architecture, integrated with the traditional courtyard pattern. This method offers architects a flexible, dynamic and feasible measure to explore the possibility of Chinese courtyard pattern in practice.

However, as a primary experiment of a long-term research, there are some limitations and disadvantages of this program. Several architectural factors are not taken into account in the generative process. Feng Shui (traditional knowledge about geomantic omen) plays an important role in the layout of traditional buildings. But most part of this knowledge is far from scientific analysis and cannot be applied in the computation. The accessibility is essential to every courtyard. For example, the main access must be placed on the southeast side in most traditional courtyards. This program does not consider this factor for its complexity.

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Sheni: A Generative System for Decorative Pattern Design

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Abstract

Graphic designers always take both time and efforts when they are creating a decorative pattern with complicated curves and a great deal of motifs. Although there are many sourcebooks of decorative patterns, the satisfaction of the results couldn't accomplish with designers' requirements. Thus, graphic designers need a faster and easier system to create decorative patterns.
The purpose of this research is to build a decorative pattern generation system called "Sheni". This system analyzes decorative pattern of plants and formalizes classical styles into design representation by using stylistic analysis and shape grammar. This representation records in the system and will be Controlledled by graphic designers to create decorative patterns of one kind of or integrated style. The intention of this research is to produce the satisfied generating results for designer more efficient or make the results be the source material for follow-up design works.

1. Introduction

1.1 Background

Decorative patterns of craft have influenced the classification of classical style most. Especially there are so many decorative patterns of classical style used natural curve of plant and foliage motifs to present beauty of nature. These patterns have been widespreadly applied to artistic works, handicrafts and design form to the present.
So far, the manufactures of decorative patterns get into computational period. From making by hand to duplicate by printing, a computer program of today has been able to analysis and interpret how designer thinking and create patterns automatically. As a generative system integrated shape grammar applied to computer-aided-design, designers can set their concept and conditions of design to generate all the computing results which adapted to the rules they defined. Then designers can choose a satisfied one. Comparing with a traditional design process that designers merely rely on their intuitive and inspiration, this generation mechanism serves with an evaluative and selective way to solve time consuming in design processes.

1.2 Motivation

In order to solve the processing time of creating decorative pattern, graphic designers need a generative system which can creating decorative pattern of plant faster and easier.
A computational design way provides supports form computer system for designers to recognize the distinction of different style, and then they may select or develop one style they want.

1.3 Purpose

The intention of this research is to build a generative system for decorative pattern design of plant. We use a code, "Sheni", to be the name of the generative system. Graphic designers can operate Sheni to

create or modify decorative pattern to be the source material for follow-up design works.
This research also converts the stylistic factors of classical style to rules according to shape grammar and stores in Sheni. Graphic could use these picked out rules to create decorative patterns of one kind of or integrated style and arouse designers' inspiration when they are creating, and then produce a more satisfied works.

1.4 Design Problems

There are some situations at present when graphic designers in internal creating decorative patterns:
(1) There is no software to aid decorative patter design
(2) The existing source books of decorative patterns are usually unadoptable
(3) Creating decorative patterns is a time-consuming course.
(4) Designers are not familiar with classical style

According to the above reasons, this research defines the design problem as the lists below:
(1) How does Sheni make graphic designers create decorative patterns of plant faster and easier and facilitate them to do the modification and for follow-up design works
(2) How to use shape grammar to convert classical style to rules storing in Sheni, then make graphic designers get the support form Sheni when they are describing one style?

1.5 Research Scope

The points of this research merely discuss about decorative pattern of plant, and all kinds of decorative patterns and styles won't discuss in depth. Besides, the manufacturing process, material, and context of culture won't be concerned in this research either.

1.6 Overview

This research involves five chapters: Chapter 1 is an instruction, introduces the background, motivation, purpose, design problem and the scope of the research. Chapter 2 provides a comprehensive review of the literature. Chapter 3 describes research methods, including style describing system and label points, generation processes of shape grammar. Chapter 4 presents the implication of system according to the integration of analysis results and literature review. Finally, Chapter 5 is a research conclusion, providing the finding, contribution, and recommendation for future researchers.

2. Literature Review

In order to get enough analyzable information to construct shape grammar, the literature review aims at the classification and structure of classical decorative patterns of plant at beginning. But there is no suitable finding result able to construct shape grammar due to a limited time. The most classifications of style base on only the cultural context and background at the time, but not the form elements of stylistic factors with a systematic conclusion and summarization. For this reason, this research first focuses on the stylistic analysis theory and classification decorative pattern, and second surveys the relative research of shape grammar.

2.1 Decorative Pattern

The consists of pattern can be analyzed via some outward factors like shape, contour, facade, visible structure…and so on, or investigated according to the inward context like concept of creator, meaning of icon, cultural background...and so on.[12] For the instance of seeming form elements, these basic design elements may be mixed or matched in infinite variety. These are the designer's alphabet and he uses them to form his unique vocabulary to create essays in shape.[13]

The outline of form of one pattern may determine the use of decoration, these can mainly classify into these 5 categories [9]:

(1) Heraldry form:

Decorative patterns without limitations by outline of form.

Fig 3 A heraldry form pattern

(2) Suitable form

Decorative patterns within limitations by outline of form. The pattern must fill up the area in the boundary.

Fig 4 A suitable form pattern

(3) Partial form

Decorative patterns within limitations by outline of form. The pattern has not to completely fill up the area in the boundary.

Fig 5 A partial form pattern

(4) Corner form

Decorative patterns use for corners in one plane. It is usually with a right angle and triangle form.

Fig 6 A corner form pattern

(5) Fringe form

Decorative patterns surround the planes.

Fig 7 A fringe form pattern

The book "*Architectural Ironwork*" [13] provides many classical decorative ironworks, such as doors, signage, balustrade, and staircase with plant elements, and classifies them into systematic categories in terms of their composition and structure. There are mainly able to distribute into natural object and artificial object. Natural object involves floral decoration (like fleur-de-lis, rose, camellias…and so on that are popular in middle age), foliage (such as acanthus, palmette, and scroll used widely in Rome and Greece period), human face, seashell, fruit, animal, Imaginary creature…and so on. Here is the summarization list below:

(1) Curves
(2) Foliage and floral decoration
(3) Scroll
(4) Animal decoration
(5) Heraldry shapes
(6) Others

2.2 Stylistic Analysis

The definition of style from the aspect of fine art is the integration of peculiarity of creation, completeness of creation, and selfhood of creation. A style can be owned by one person, one group, one sect, or one period. The existing of style must be the result from comparing more than two categories of style.[7]

From the aspect of form, style is a clear and duplicable relationship of syntax in a collection of object.[16] A style can describe the characteristic feature of shape, structure, design. Every object has a form, and the style will be generated when this object has a characteristic feature. Moreover, the style needs a form to be the loader to present its visible externals.[2]

Chen has developed a system that can describe the feature of style called "Style Description Framework (SDF)."[2] This is a theory can represent a style by converting style into formal language, and it can record every factor composed the style completely. There are six main analyzable categories as the list below:

(1) Form elements
(2) Joining relationships
(3) Detail treatments
(4) Materials

(5) Color treatments
(6) Textures

The stylistic feature attributes can be converted to polar adjective pairs with a five-rank descriptive scale and use for describing each attribute. This is the most important contribution of this system for stylistic analysis. Every one polar adjective pair means one dimension in a style space. First using an estimated value (ev) to be a centric value, and confidence factor (cf) to adjust the range of the centric value. A style class with fewer salient attributes is likely to be at a higher level in the style hierarchy. On the other hand, a style with more boundaries becomes a specific one in the style space. A specific style is the subclass of a general one. There is a example in Fig7. A polar adjective pair is used to be an attribute respectively for “form elements”, “joining relationship”, and “detail treatments.” The estimated values of style Sy and Sx indicate the centric in a 0.0-1.0 hierarchy and the confidence factors define the range of each attribute in this style space. If Sy’s space contains the Sx’s, Sx is the subclass style of Sy.

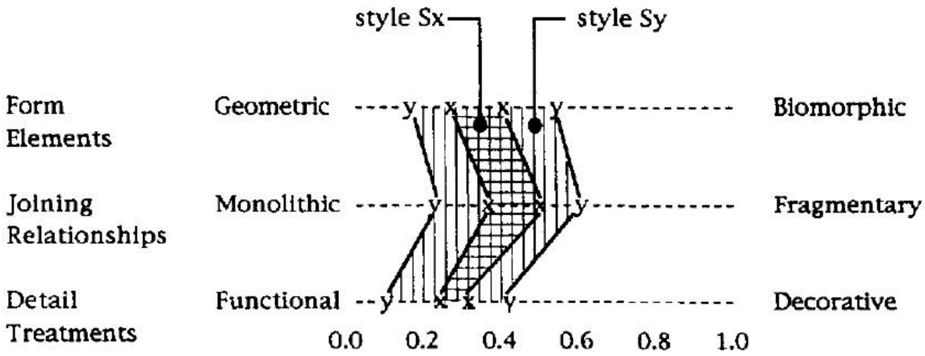


Fig 8 A SDF model with style Sx and Sy

Seven polar adjective pairs are included to describe the form elements representing distinguishable parts of an object:

(1) Harmonious-contrasting
(2) Homogeneous-heterogeneous
(3) Geometric-biomorphic
(4) Pure-impure
(5) Simple-complex
(6) Balanced-unstable
(7) Low cultural reference-high cultural reference

Polar adjective pairs are used here to describe the joining relationships among parts in three dimensions:

(1) Monolithic-fragmentary
(2) Self evident-hidden
(3) Static-dynamic

Four adjective pairs describe the detail treatments given an object:

(1) Uniform-multiform
(2) Angular-rounded
(3) Functional-decorative
(4) Subtle-bold

2.3 Shape Grammar

The development of shape grammar involves three parts. First is the theory and standard of shape grammar. Second part aims the generating design style, and this is applied most. The third part is

shaper grammar interpreter system [11] uses for implications on computer aided design domain. Designer can use the program of shape grammar to generate design.[3]
Stiny [17] defined 4 basic elements of shape grammar, and they are shape, label, rule, and initial shape. He also mentions 5 procedures of shape grammar for developing design language in Kindergarten grammars [18]:

(1) Vocabulary,
(2) Spatial relationship,
(3) Shape rule,
(4) Initial shape, and
(5) Shape grammar.

According to Knight [8], shape has different functions and attributes depend on the order of applying rules and number of selectable paths. There are six type of shape grammar with different orders of applying rules and format of rules:

(1) Basic grammar,
(2) Non-deterministic basic grammar ,
(3) Sequential grammar,
(4) Additive grammar,
(5) Deterministic grammar, and
(6) Unrestricted grammar,

3. Research Methods

After surveying the reference about structure of decorative patterns and stylistic analysis, there is an interview implemented with five graphic designers to conclude the procedure of creating or modifying decorative patterns at first. According to the results of interview, the needs of designers will confirm and be the principle for developing the user interface. Secondly, this research will integrate the theories of structure of decorative patterns and stylistic analysis to build a style description system for decorative pattern of plant. The collected decorative patterns of plant will be analyzed in terms of the standards system defined, and the outcomes are going to become style profile models and form elements database. Finally, shape grammar will be established to generate decorative patterns of plant.

3.1 Style Description System

In addition to "Color treatments", "Materials", and "Textures", this research will focus on "Form elements", "Joining relationships", and "Detail treatments" form the categories of SDF. These are the main principles to build a style description system for describing the stylistic features of decorative patterns. Designers are able to define the characteristic of the patterns they are going to create.
The components of decorative pattern such as curves, outline of form, foliages, scroll, and other decorations belong to "Form elements." The subordination of curves and relationship between form elements and curves are analyzed by "Joining relationships." "Detail treatments" decides the type of lines.
This research selects these 7 classical styles and 20 representative decorative patterns for each style to analyze by style description system:

(1) Gothic
(2) Renaissance
(3) Baroque
(4) Rococo
(5) Neoclassicism
(6) Victorian
(7) Art Nouveau

Designer gets various visual elements to imitate different styles in terms of the condition "Form elements" gave. "Joining relationships" provides different rules to support designers to generate curves and "Detail treatments" choose different rules for various types of lines. These will describe detailedly in the later section.
The polar adjective pairs of "Form elements" that SDF gave:

Attribute (Code)	Polar Adjective Pairs	
Categrories of Parts (COP)	Harmonious	Contrasting
Form of Element (FOE)	Homogeneous	Heterogeneous
Consist of Element (COE)	Geometric	Biomorphic
Structure of Element (SOE)	Pure	Impure
Relationship of Element (ROE)	Balanced	Unstable
Context of Element (CXE)	Low cultural reference	High cultural reference

Table 3 Polar adjective pairs of "Form elements"

The polar adjective pairs of "Joining relationships" that SDF gave are not appropriate to describe the relationship of decorative pattern of plant. Here are the redefined ones list below:

Attribute (Code)	Polar Adjective Pairs

Curvature of Trunk (COT)	Straight	Winding
Curvature of Branch (COB)	Straight	Winding
Arrangement of Branch (AOB)	Regular	Irregular
Similarity of Branch (SOB)	Similar	Variational
Rank of Branch (ROB)	Single	Multiple
Arrangement of Leaf (AOL)	Regular	Irregular

Table 4 Polar adjective pairs of "Joining relationships"

The polar adjective pairs of "Detail treatments" that SDF gave:

Attribute (Code)	Polar Adjective Pairs	
Type of Line (TOL)	Uniform	Multiform
Edge of Curve (EOV)	Angular	Rounded
From of Curve (FOV)	Functional	Decorative
Shape of Curve (SOV)	Subtle	Bold

Table 5 Polar adjective pairs of "Detail treatments"

One style "st" can be represented as:

$$S(st) = \{st, \{ev, [a(1), ev(1)],[a(2), ev(2)],...[a(n), ev(n)]\}, \{cf, [a(1), cf(1)],[a(2), cf(2)],...[a(n), cf(n)]\}\}. \quad (1)$$

$$a(n) = \{COP, FOE, COE, SOE, ROE, CXE, COT, COB, AOB, SOB, ROB, AOL, TOL, EOV, FOV, SOV\}. \quad (2)$$

"a" means the class of attribute style description system defined, and "n" is the number of attribute. "ev" and "cf" are the identifiers for the estimated value and confidence factor respectively.

3.2 Shape grammar and Generation

3.2.1 Label Points

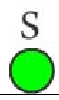
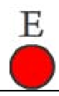
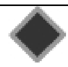
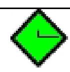
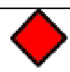
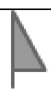
Name of Label	Icon
Start Node	
End Node	
Normal Node	
Controlled Node	
Branch Start Node	
Branch End Node	
Leaf Node	

Table 6 Icon of Labels

Start Node, Branch Start Node, End Node, Branch End Node, and Leaf Node have two common

attributes: coordinates and angle.
Normal Node and Controlled Node will become straight lines or curves depend on applying rules. One curve group involves one Controlled Node and two Normal Nodes, and Normal Nodes can be used collectively by another curve group.

3.2.2 Curve Group

A curve group constructs from two Normal Nodes and one Controlled Node and identifies one quadratic Bezier curve. The path of quadratic Bezier curve tracks by the function B(t) which hinges on P_0, P_2, and P_1 (represent two Normal Node and one Controlled Node respectively):

$$B(t) = (1-t)^2 P_0 + 2t(1-t)P_1 + t^2 P_2, t \in [0,1]. \quad (3)$$

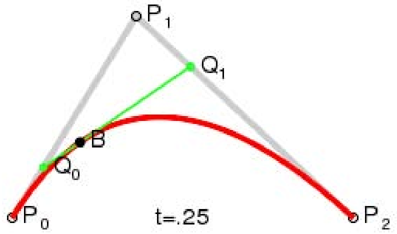


Fig 9 Construction of a quadratic Bezier curve

3.2.3 Generation process

First, a type of outline of form must be selected, and the Start Node is the “initial shape”. After choosing outline of form, the shape of frame will determine the rough external, symmetrical way, and the potential purpose of this pattern. Secondly, the Trunk, Branches, Leaves and other decoration motifs are “vocabularies.” At last, “Spatial relationship” contains the subordination of curves and relationship between form elements and curves, and these will be converted to parts of “shape rules.” All of the above are the basis to create “shape grammar.”
According to the orders of applying rules to generate curves and form elements are not sequential, and there are different paths able to chosen by designers, this research use “Unrestricted grammar” with least restrictions and most powerfully design language generation ability.
The generation process divides into six stages:

A. Choosing form of outline and setting the coordinate of Start Node;
B. Producing Trunk and modification; produce
C. Producing Branches and modification according to Trunk;
D. Producing Leaves and modification;
E. Detail treatments for Trunk, Branches, and Leaves;
F. Making all curves and nodes duplicate with symmetrical, reflectional, or rotational.

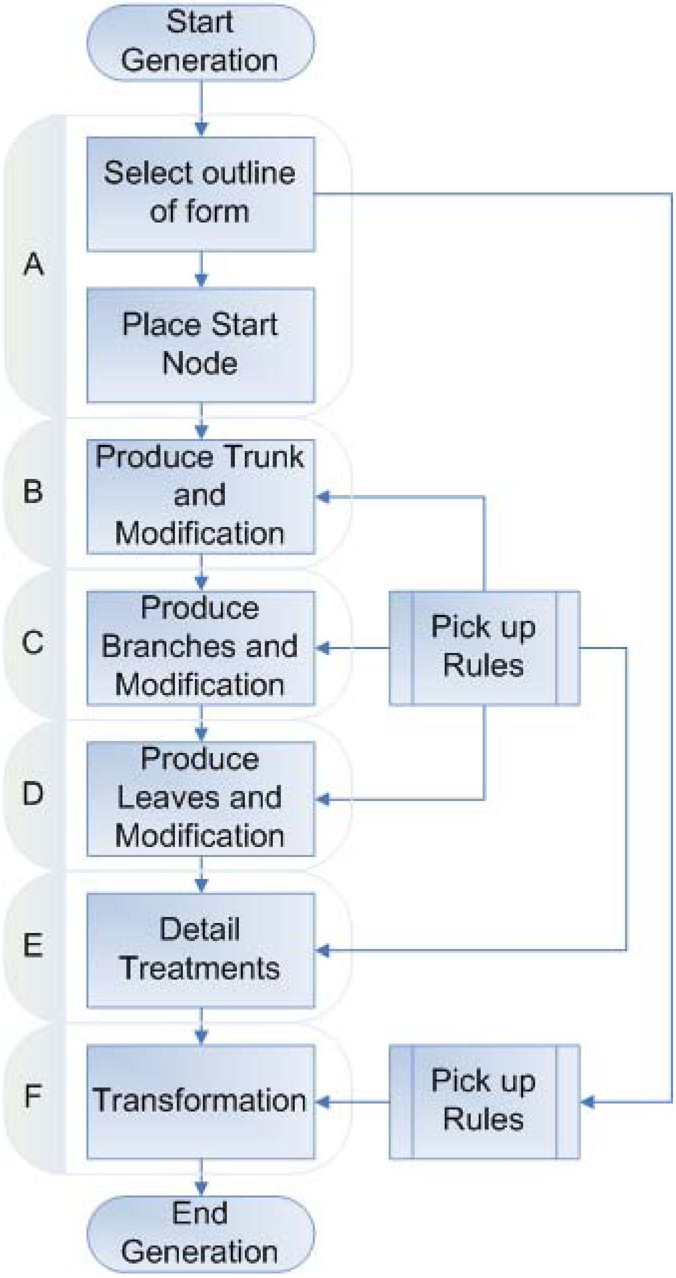


Fig 10 Generation process

(1) Stage A of Generation

Start Node is the initial shape. Depending on the selection of outline of form will effect upon the final result of generation. Here is an example of "partial form" without symmetry in the future.

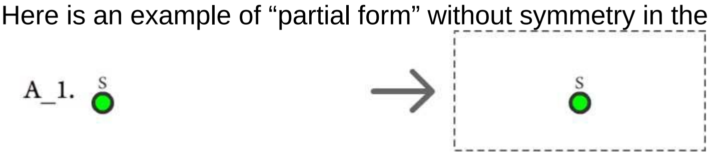


Fig 11 Rules of Stage A

(2) Stage B of Generation

In order to generate the Trunk, designer first applies ruleB_1 on Start Node. End Node and one Controlled Node will be placed in the frame of initial shape. Start Node, End Node, and one Controlled Node construct a curve group. Then designer can apply ruleB_2 to increase the Trunk more complicated. There is a limitation that ruleB_2 can only apply on the curve with End Node to ensure the path of curve won't be divisive. RuleB_3-4 is used for modify the curve. To maintain the harmonizing of curves, the Controlled Node desire to move must be one point on the straight line construct by the collective Normal Nodes and the Controlled Nodes which use the collective Normal Nodes, and the Normal Node desire to move must be one point on the straight line construct by the Controlled Nodes which in the same curve group.

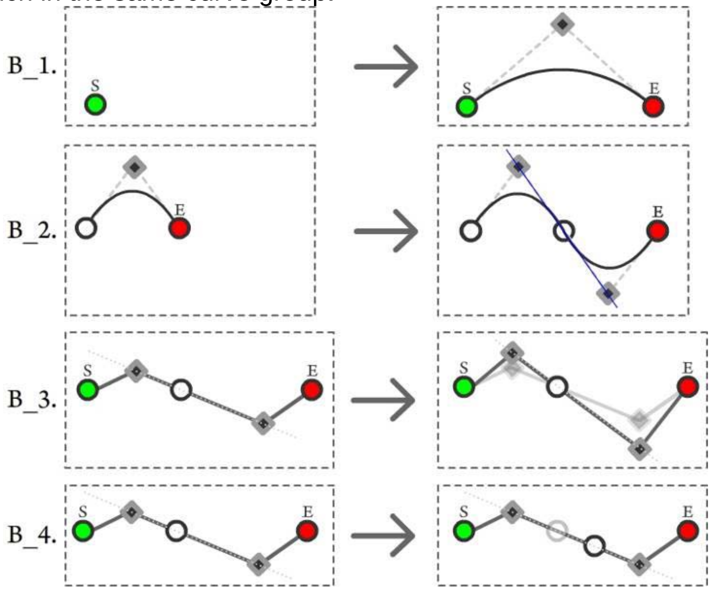


Fig 12 Rules of Stage B

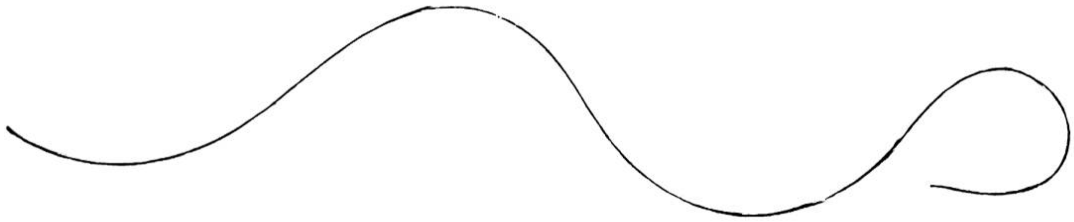


Fig 13 Trunk generated by Stage B

(3) Stage C of Generation

RuleC_1 is used to create a Branch Start Node on Trunk, and ruleC_1-2 are used to increase curve groups the same as ruleB_1-2. The new generation curves of Branches can also apply ruleC_4 to attach another new Branch Start Node, and the new node's rank value increase 1. The rank value is one of the attribute of Branch Start Node identify the level of this curve group of Branch. RuleC_5-6 are applied to modify the curves of Branches.

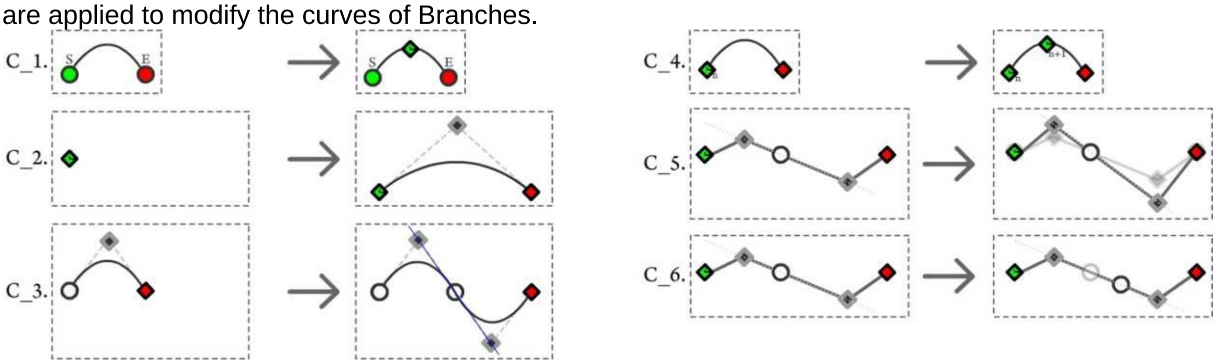


Fig 14 Rules of Stage C

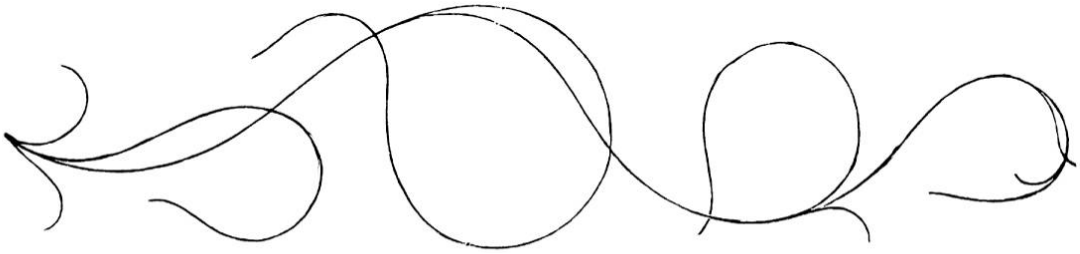


Fig 15 Branches generated by Stage C

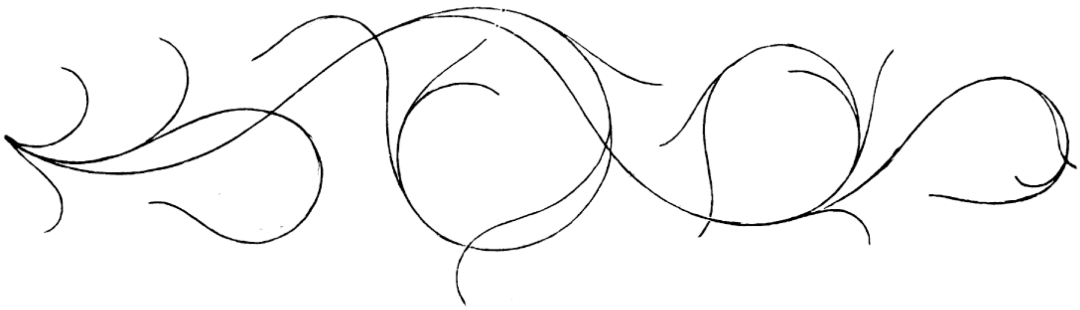


Fig 16 More Branches generated by Stage C

(4) Stage D of Generation

Repeatedly applying ruleD_1 to attach Leaf Node to curve of Trunk and ruleD_2 to curves of Branches. Finally, applying ruled_5-7 to attach the form elements to replace the labels, and ruled_3-4 to remove the Normal Nodes and Controlled Nodes

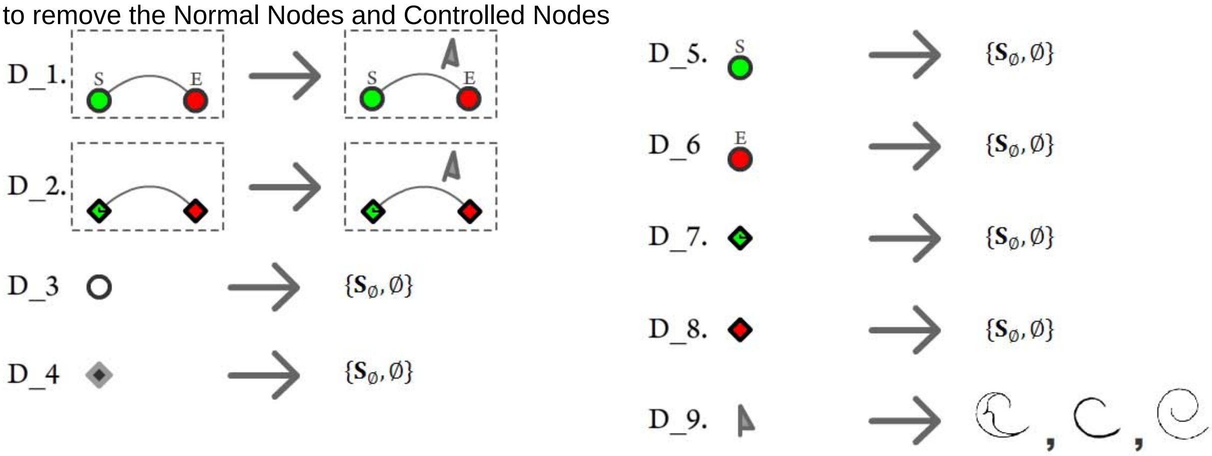


Fig 17 Rules of Stage D

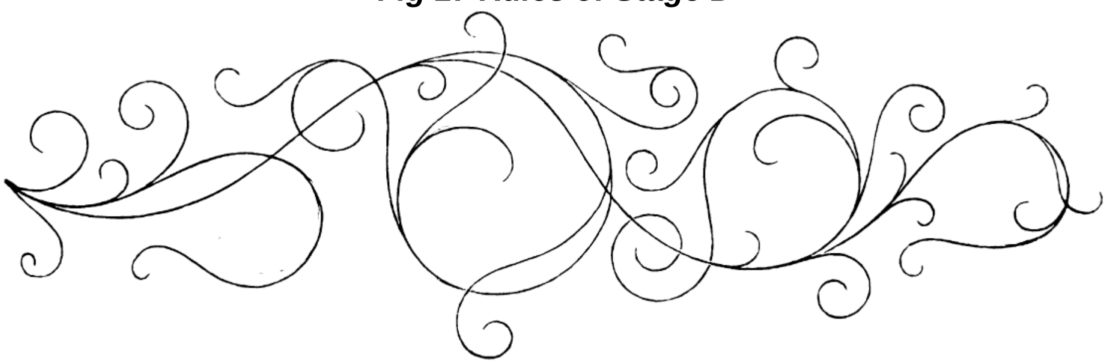


Fig 18 Leaves (scroll) generated by Stage D

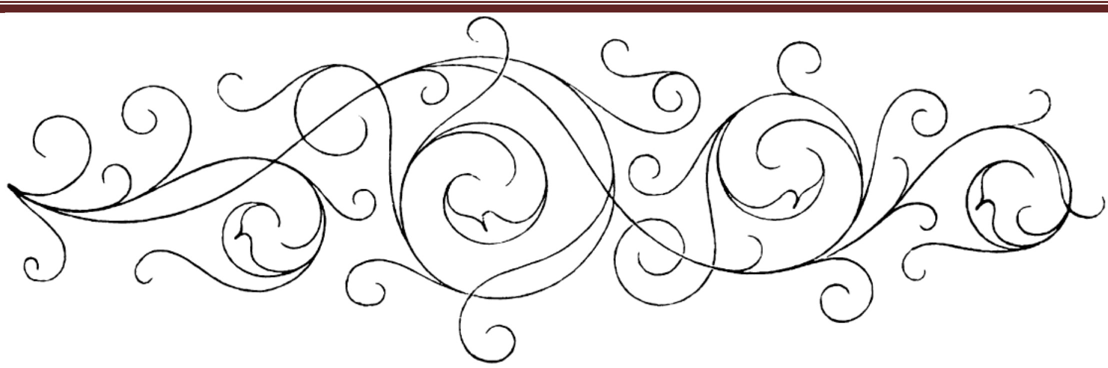


Fig 19 Leaves (scroll) generated by Stage D

4. Implication

The implication system, Sheni, will use Action Script 2.0 of Adobe FLASH to develop the user interface and use the program language of Active Server Page (ASP) to be the middleware connects with database. User can manipulate Sheni through internet by using browser and save the pattern results as files or the style profile models and step records.

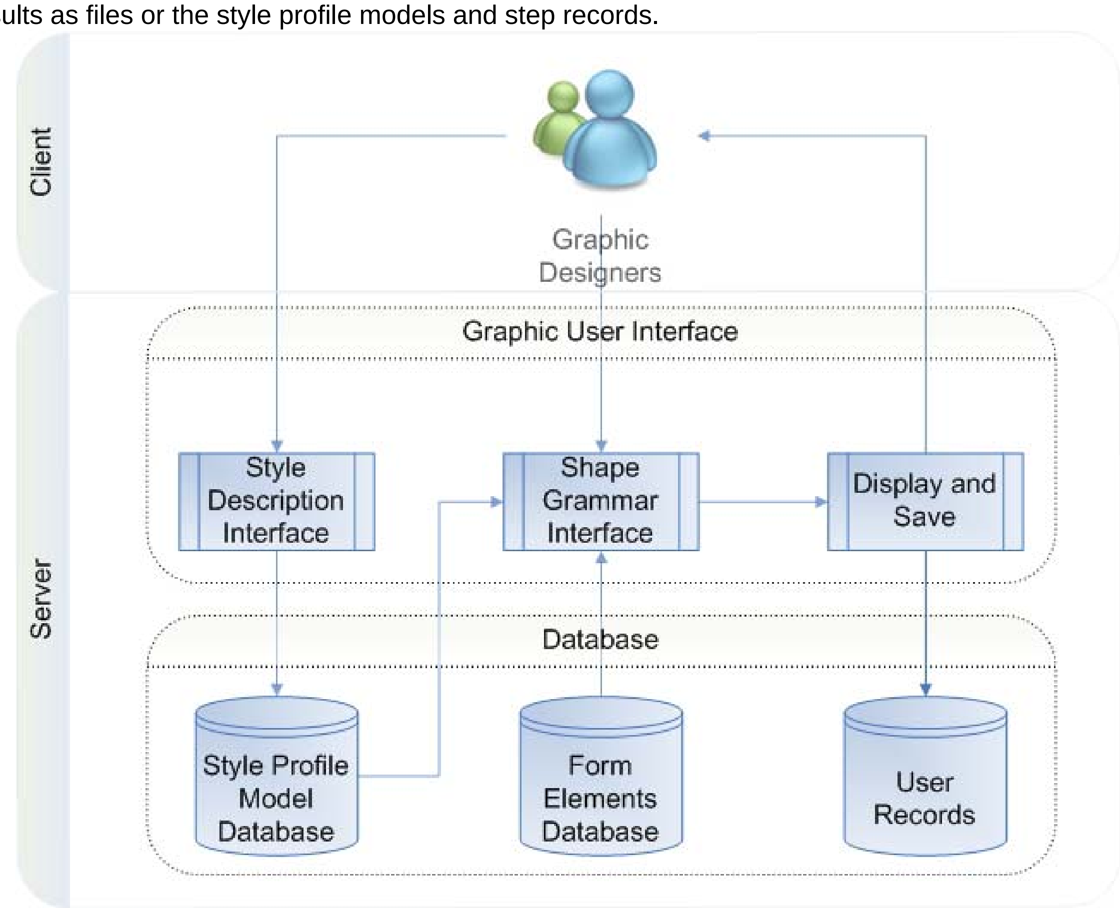


Fig 20 System architecture of Sheni

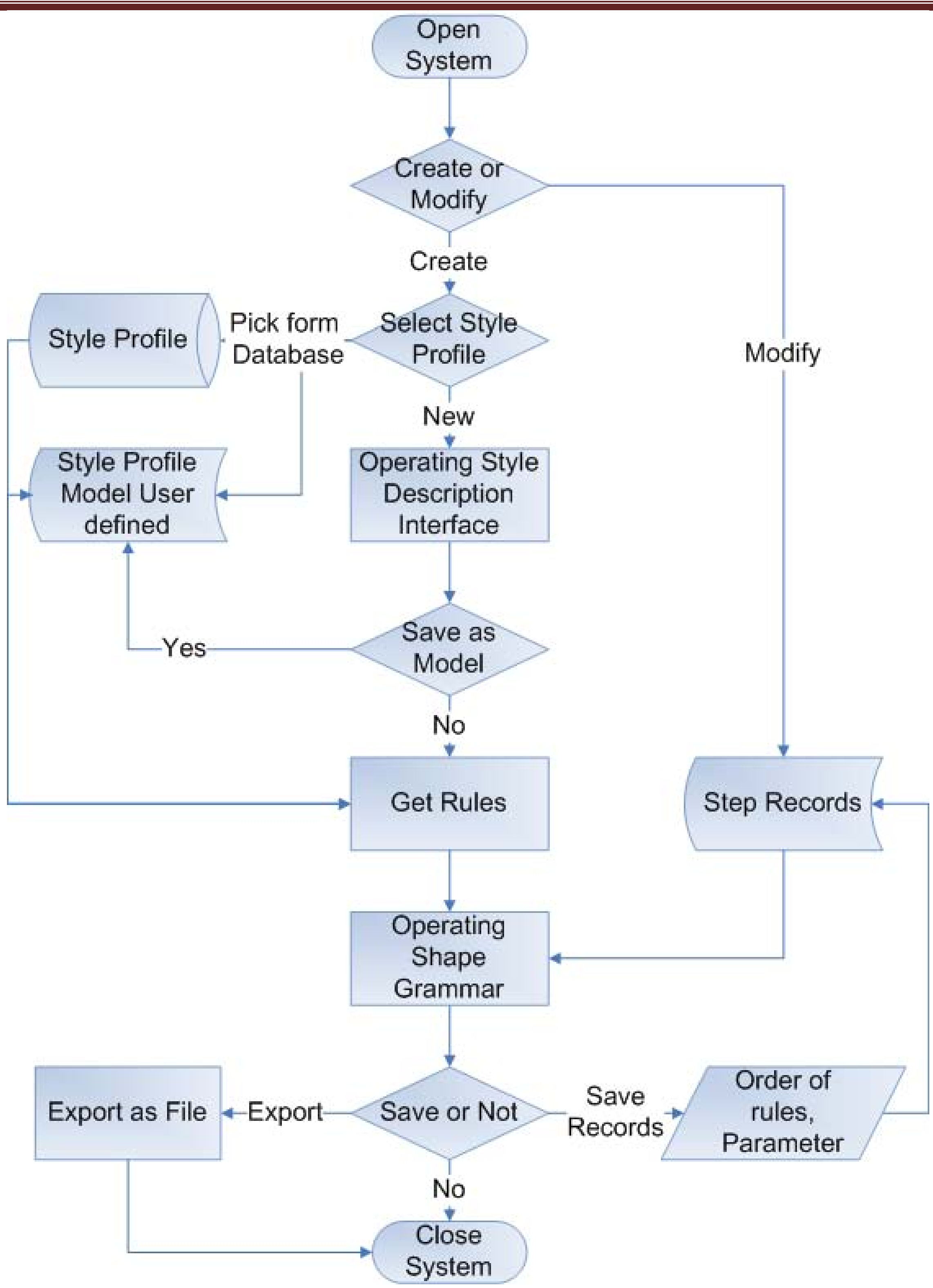


Fig 21 Procedures of operating Sheni

4.1 Style Description Interface

The interface of style description system. After designers defined the features of style which they are going to use to create decorative patterns, the interface connects to the style profile model database to choose the grammar to apply for designers.

4.2 Style Profile Model Database

Besides the seven classical style profiles, and the models defined by designers are saved here.

4.3 Form Element Database

According to the decorative patterns this research analyzed, there is a summarization of the simplest form elements with tags depend on the classification of structure of decorative patterns, and the form elements will be saved in the form element database. The style description system will set the message of tags to get the form elements designer needs.

5. Conclusion

5.1 Contribution

Sheni provides a object-oriented base system for generating decorative patterns of plant. Graphic designers can fast create or modify decorative patterns by manipulating shape grammar or step records.
Another reason is that designers usually not exactly so understand the characteristic features which constructed the style. They may use incorrect subjective judgments to describe a style, and this make the representation of style has deviations. The style description interface of Sheni makes designers know the classical style depend on the style profiles or understand how other designers think as they are creating patterns through style profile models defined by others.

5.2 Future Work

This research merely analyzes decorative patterns of plant of seven classical styles. The future research can focus on a more general classification to discuss and improve the shape grammar to gain more powerful generation ability.

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