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An analysis of the Poly-dimensionality of living

An experiment in the application of 3-dimensional self-organising maps to evolve form.

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Abstract. The architect and sculptor Fredrick Kiesler opposed the linear mechanics of modernity. As so efficiently defined in Margarette Shutte Lihotsky's Frankfurt kitchen, his work expressed the 'act of body motion', in the view that people inhabit buildings in a dynamic and vicissitudinous way. Representative of a world essentially understood to be deterministic and ordered, the Frankfurt Kitchen encapsulated the dweller in a standardised, industrial environment. Opposed to the scientific ordering of task management, Kiesler argued that the linearly devised two-dimensional methodology of architectural design is out of context with the dynamic of living and developed his ideas in the endless house; a form in which its inhabitants could live in a poly-dimensional way.

This work focuses on the development of a design process, which may reflect the character and sinuous properties of an individual's pattern of living. The study will develop a process, investigating the application of self-organising maps as a tool for the definition of space, towards a result which is emergent. The parameters that define an individual's pattern of living, will be instigated in an array of three-dimensional self-organising activity maps, towards the development of form.

Keywords. 'self-organising maps', pattern, forming, emergent, dwelling.

Introduction

This experiment adapts the technique of self-organising maps as a pattern recognition tool, towards the development of emergent 3-dimensional form. The study looks to develop a process of emergent spatial morphology, investigating the embryology of a house, in relation to living patterns.

Defining the problems of a traditional design process:

Standardised patterns of living, outlined as typical concealed Euclidean plans, such as Lihotsky's Frankfurt kitchen and the guidelines set by the 'Parker Morris' and 'Space in the home' reports, are defined as restrictive to the dynamic of living.

Design is a complex organisation of elements and associations between social, practical and contextual relationships. The physicality of any solution is left open to expression or stylistic opinion, as defined in the 'artistic studio' of the designers mind. Unlike tribal or primitive design a modern design solution is judgmental, dependent on the juggling act of fundamental requirements, opinions and ideas. Christopher Alexander argued that "the parameters defining a design problem are a complex array of factors, which the

designer simplifies to devise a calculable solution". Thus the solution will only reflect an abstract reality of the problem, a compromise of lesser parts shrouded in the designer's individual assumptions, style and form. (Alexander, 2000) This condition reflects humankind's historic relationship with nature and the universe. Characterising the universe a determined calculable system, nature and matter have been defined the result of a hylomorphic schema. (De Landa, 1988)

This work takes the viewpoint that modern architecture and the built environment is primarily the sum of linearly defined Euclidean forms that have little significance to the way people move or live.

Defining a design approach to uncover patterns of living:

Hugo Harring argued "The spatial order of a building should be taken from the order of the activities that the building is to house – an order to be uncovered, not imposed".

People move in a fluid and dynamical way, something that Kiesler coined as Poly-dimensional. His ideas on space and the 'elasticity of' rendered the house as a living organism. "The house is the skin of the human body". Mashall McLuhan defined the house, like clothing as an extension of our private skins, as a bodily-heat control mechanism. Kiesler believed that the house should be an extension of man; a manifestation of the dynamic forces created through movement and mans connection with the universe. He opposed linear or enclosed space, as the alliance of space to the visual, above the dynamic properties of that which forms its enclosure. Kiesler defined the house, as the sum of every possible movement its inhabitants can make within it. His ideas consummated in the Endless house, below.

The realisation of such form, at Kieslers time

Figure 1. Inside the Endless House and model

depended on his skill as sculptor. The typical hylomorphic schema and 2-dimensional linear exercises of architecture will not translate, to define a form such as the figure above. The process that Kiesler adopted to realise this final form was to build a model, large enough so that he could fit within it, and to push and mould the form with his hands. It may be considered that this is a method of defining space relative to parameters epitomizing 'the act of body motion'.

The design of a building, as the ordering of spaces, is really about the ordering of relations between people and the ordering of activities in relation to people's routine. This looks to a design process based on an adaptable structural system. Highlighted in the work of Steadman and March is a design approach based on syntactics. The value of syntactics is adaptation and the expression of definite parameters in relation to context, in view of an unfolding process. This may be explained by the dynamic of the DNA process.

…a test of the overall similarity of DNA shows that humans share ninetyeight percent of the genetic material with chimpanzees. We trace relatedness to the rest of the animal kingdom as well, ….with rabbits and plenty of remote branches of existence, from bacteria to yeast's to bananas……proves the unity of existence. It also defines the limits of what biology can say. A chimp may share ninety-eight per cent of its DNA with ourselves but it is not ninety-eight per cent human: it is not human at all – it's a chimp. (Jones, 2000)

This is to demonstrate that though the dweller

is individual, all dwellings must conform to similar and definite activities and routines. But the expression of any routine may be depicted in an array of ways, as defined by the individual's character and association with the activities within their routine. Frank Lloyd Wright's houses, analysed by Steadman and March, illustrate the genotype of a building. The analysis illustrates the dynamic of how a building genotype may determine an array of results, as below.

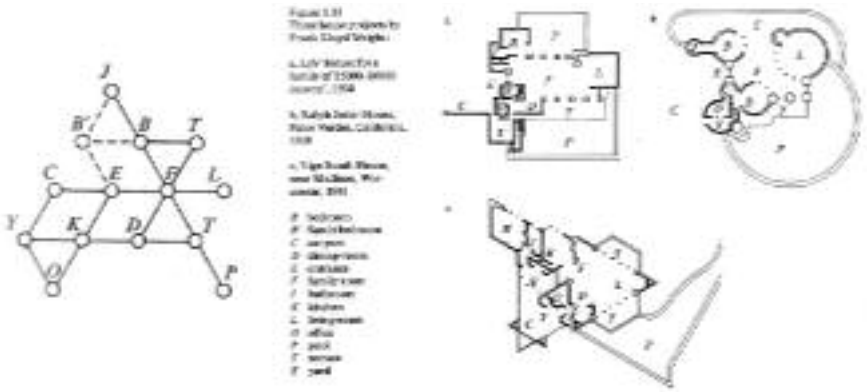

Figure 2. Three houses by Frank Llyod Wright analysed as having the same syntactical structure, thus defining a genotype, illustrated on the left.

Syntactics provides a platform in this work from which an emergent process to define an individuals living pattern may be developed. In extending the analysis above towards an emergent process, we develop a spatial morphology tool to define form relative to an individuals living pattern.

Activities are not specific in terms of spatial delineation, whereas rooms have an identifiable composition. Typically, designer's treatment of planning room layouts is defined by some kind of association. An activity is more difficult to define in context. It may be considered as an action that happens in a location. Spatially defined by the extents of motion carving out space through the act. Whitehead and Elders, in their paper on the circulation problem, defined an activity 'as any process, which is or may be carried out at a point separate from other processes'. Activities are not uniquely tied to a location, as typically defined in rooms. (Steadman & March, 1971)

Designing a computational method to uncover patterns of living:

Unfolding the elementary act's that define an individual living pattern, a syntactical approach, based on the works of Steadman & March, is used to define a structural order, defining the parameters towards an algorithmic process. Employing the inherent self-organising qualities of S.O.M's, the process experiments with manipulating an array of S.O.M's, adapting the typology and mapping parameters relative to the internal mechanics of habitation.

Space is defined through the boundaries and interrelations of the self-organising activity maps. The environment is composed of a variety of these, each searching their neighbourhood for

others, with whom they share some association. In this sense each activity map is a discrete entity, which through association will assemble to form a whole. The overall task is for individual activities to recognise relationships that are a good fit, in order to illuminate the emergent pattern.

In this experiment space and form is defined through the construct of associations between activities, on the theory that the internal dynamics will define an order of space. Hillier defines the problem of syntactical space definition, "Space is an abstract construct defined on semantic reason and the result of construct and boundary". Therefore the organisation of spatial parameters defined in isolation of construct and physical boundary, relies on the framework of association defined through a dynamic process, which allows the realisation of an abstract definition. In relation to the topic of society and urban typologies, Hillier summarizes, as a spatially continuous system, composed of large numbers of autonomous, freely mobile, spatially discrete entities called individuals. The intention here is to define a global form, which is an abstract visual representation of individual habitation, defined through the emergent order of the parameters, describing the discrete entities (being activities). An example of a discrete system composed of nothing but mobile individuals, is the 'Cloud of midges by Rene' Thom. The global form, the 'cloud', is made up only of a collection of individual midges that manage to constitute a recognisable cloud. The cloud retains a certain 'structural stability', which we see as any object, even though the constituents of the cloud appear to be randomly moving, discrete individual midges. (Hillier, 1984.)

Activity involves the use of tools and objects, which aid in the space carved, but it is beyond the limits of this work to account for the artifact. Focus will be on an abstract definition of form, representative of the dynamics of association, defined through the emergence of activity parameters.

A typical method of design development is the bubble diagram. A circle represents a room and is linked to another by a line, representing communication. Relationships and order are thus defined through abstract geometry. The intention is a simple process to determine an ordered structure to a problem. Utilised by Steadman and March as a graphical analysis to determine a building's genotype.

Looking to the mathematical possibilities of this method, a perspective as to the exhaustive possible connotations may be appreciated. For four related activities there are 24 possibilities, being 4 x 3 x 2 x 1 = 24. For 10 there are three million, six hundred and twenty eight thousand and eight hundred. (March, 1976) The argument by Alexander as to the modern designer's inability to realise the optimum solution is quickly put into perspective. In the context of this work the problem is exemplified, due to the breaking down of rooms into their constituent parts. Although many activities will cross the boundaries of rooms, lessening the array of configurations, the fact that activities will undoubtedly cross those boundaries, is deemed to support the intention of this paper.

Association diagrams

A structural diagram of hierarchical classification identifies an activities individual association. This basically orders the classification by points and represents the level of communication between points by lines of equal length.

The association diagrams represent a study of the relationships between individual activities, defining the internal mechanics and a structural order. Not all activities have the same association value, and as a matter of defining structure to the hierarchy of association, levels of association were established: integral, interrelated and com-

patible†. The analysis highlights compatibility on a two-way basis. i.e.; cooking and eating is not symmetrical. If cooking you will undoubtedly eat, but you may not have cooked to eat. Further to the association between activities, the 'character' of an activity was considered. Taking a number of routes, one was frequency. Activities differ in how common they are, relative to their dominance within the daily routine. In this sense each activity is classified in a hierarchical table; routine, standard or custom‡. Graphically, at this stage, each activity is represented by a colour, and the frequency by the size of the point. The larger the node, the greater the frequency.

The graphical analysis of Steadman and March favoured Venn diagrams. They relied on translation of geometry into binary, only to be translated back to geometry. Our graphical approach is primarily to determine a structural order to the individual entity (activities) parameters. The 'scaling classification method' which is

Figure 3. The association diagram for eating above and the combined association diagram opposite.

ordinal and not numerical, can relay the information in a graphical representation, which reflects the information corresponding to the association diagrams and allows a homogenous illustration. This method of graphical analysis is topological, in the sense that it relays the location of an element in terms of it relationship to others. It relays association through distance, which must just be relative to each relationship. This method works by placing the most connected activity at the center, with each activity taking position on ever decreasing circles relative to their connectivity. Lines are then drawn between those activities that are associated, creating an 'association network'. These lines represent the relationship between each activity, relative to their individual association diagram, as below. Here we bifurcate to translate the analytical methods of Steadman and March towards automaton, and the definition of 3-dimensional form. See below, association diagram for eating activity and the combined association diagram for a rationalised version of an individuals living pattern.

Computer application.

This experiment adapts the technique of self-organising maps as a pattern recognition tool, towards the development of a structural cognate tool for spatial morphology. The use of S.O.M's in pattern recognition has been utilised to determine Euclidean forms, and thus serve to indicate S.O.M's as a tool for the development of space. The self-organising properties of the Kohonen principle invites the development of the technique towards emerging 3-dimensional forms, used previously as an analytical tool to define urban typologies relative to programmed parameters. (Derix, 2001).

The environment consists of an array of

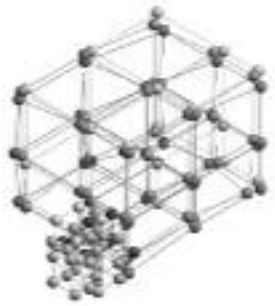

Figure 4. An array of activity maps redefining their typologies relative to their association parameters. Two groups are visible. Those interrelated and those integral.

S.O.M's, each an individual entity, representing an activity. Each S.O.M consists of a number of 'nodes', which search their immediate context for others, and respond relative to programmed parameters.

In the translation from graphical to automotive, the following variations infused.

1) Each activity is represented by an individual self-organising map.

2) The frequency of an activity is defined by the number of 'agents' each self-organising activity map has.

3) The association level is defined by a level of attraction.

The metamorphosis of an activity map is a transformation of form in relation to a good fit to its environment. Nodes position themselves in the environment relative to their association with others, within their immediate context. A node identifies what other nodes there are, and makes a move relative to their association (parameters). A move reflects the unity between entities, and determines the degree to which the boundary of an entity encroaches upon another.

Adapting a Self-Organizing Feature Map (SOM) for the analysis of morphologies

Conventional artificial neural networks (ANN) are fed with inputs of numerical data between 0.0 – 1.0. In the case of an SOM the features that the network is supposed to organize can be any kind of numerical input. Therefore, even geometrical input, such as vectors can serve as features to be organized.

If the typical adjustment of weights through the change of directions of normalized vectors or the values of numbers between 0 and 1, is replaced with Euclidean distances between three-dimensional vectors which serve as the input to be learned by the network, the network will display changes in its morphological structure while maintaining its topological order.

All three main aspects for the training of an ANN have been conserved: the data-input to the input layer via winner-takes-all where all nodes read all input (activation function); the competitive learning (Hebb's learning); and through the self-organized adjustments of the weights, an output directly onto the input layer. The input as well as the output is represented through three-dimensional geometrical points, making the tool here applied a geometrical analysis tool.

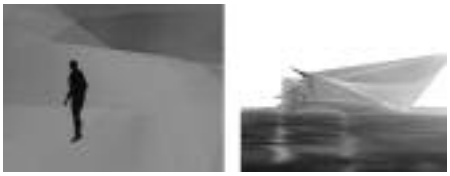

Figure5. A rendered image of the emergent outcome.

While the above mentioned aspects of the SOM have been conserved, slight changes have been made regarding the scope of each node in the network. Each node apart from transforming and feeding back information into the network also has the extended task of analysing the input it reads towards compatibility with the network which the node itself belongs to. On the basis of that autonomous reading it influences its potential positions in space (its geometric transformation) and thus compromises the purity of the SOM. As such the nodes are not always just local actors but can in certain circumstances interfere with the emergent global organization. For that reason, the present tool is not strictly representing a SOM or any other ANN but only borrows from the principles of the SOM.

Conclusion

The results provided a model, which served as

Figure 6. Plan view of the process after 10 generations, resembling typography of combined association diagram in figure 3

an emergent 3-dimensional structural cognate diagram that defined an abstract model of an individual's living pattern, below.

The result reflected the typology of the combined association diagram, evolving the pattern into a 3-dimensional form. The emergent properties of the process gave rise to an unanticipated quality, that the activities formed social and private groups. On reflection the association diagrams show this, through the array of links an activity houses, though the dynamics of the process unveiled this property, exposing a dynamic that was not programmed, but emergent. This is illustrated by the location of the 'work' map, which is nested within what are private activities (toilet, sleeping, etc.) with which it held no association, rather it held 'weak' links with more social activities. Two clusters of nodes are visible in the diagram. Top right are the private activities with weak links (of which work is nested), which encroach upon each other less and the social group which have strong links and thus are tightly packed with their boundaries merged, as below.

The working model is being extended to include further parameters, in order to develop an architectonic quality in the model. Spatial characteristics defined in the program incorporate; view, human-scale and light.

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