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SPACE EMERGENT FIELD

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Abstract. Architecture has always been founded upon ideologies. However could the influence of human interactions create a new perspective for space form evolution? To create a spatial adaptive system, to the influence of culture and behaviour of human being? The output of this spatial system is the determination of optimised values for spatial configurations by biomolecular, self-assembly computation for emergent spatial forms.

Keywords. Spatial; adaptive; biomolecular computations; self-assembly.

1. Introduction

The design process stems from having a clear and comprehensive design brief. This contains a set of requirements and statements of the intended use of the building to fulfil the activity tasks within. It is the skill / experience of the designer to interpret the brief into a design solution, the concept. This approach has no supporting tools to test or validate the design solution. However this is in contrast to the sciences where sequences assessment points are defined, evaluated to determine if results meet objective aims. At the 'end of this process, the analyst has to interpret and obtain some conclusions' (Cobo et al., 2011). This is performed by software tools by extraction of data, to discover possible positive synergies. This form of analysis is in contrast to the design process. 'The designer's greatest gift, his intuitive ability to arrange physical form, is being reduced to nothing by the size of the task in front of him' (Alexander, 1964). This coupled with the technical application to form a problem solving direction is undermined by the ever increasing amounts of data, by the functional requirements of standards, codes, specification to give regulation conformity. It is this complexity that will mask, shroud and obscure the direction of design process. 'Unlike other design fields where targets are set to solve a particular problem in the best possible way, architectural design is open-ended' (Terzidis, 2006). In this environment the designer will revert to past experiences and

knowledge to identify the final solution as 'the end of the design process requires experience and judgment' (Lawson, 2006).

The aim of the research, can there be progression of the design process to enable spatial arrangement creation by the influence of:

- Human interactions by regional cultural adaptation.
- Optimisation by critical evaluation by autonomous computation.

2. Spatial Change

Architectural design is influenced by current tastes, fashion or style to model our buildings to suit the current trends of the day or display wealth to others to meet society expectations. Sociological fashion may change 'like the continuously changing arrangements of office furniture governed by the market forces at work in high-rise buildings' (Reiser et al., 2006). However these arrangements of spatial activities in the 'built environment are dominated by two types of spatial organisation: the open plan and the corridor / cellular room arrangements. Both are defined by a specific attitude' (Hensel et al., 2006). This attitude is intrinsically linked to the building typology, the function of the building, whether a theatre, school, hospital or office. These space activity arrangements within a building are predetermined forming the correlationship to the building function – the typology. This building typology creates a systemised architectural design that is the fundamental basis and principle of current design thinking.

Architectural theorist Kwinter (2001) describes current building approaches to architectural style and theory in the modern age, as being lost and without direction, as he refers to this as formalism. 'A sloppy conflation of the notion of form with that of object.' May it be possible to consider another design process path: to go beyond the current thought to one without preconception, to give evaluation and imagination based upon what is present rather than, what may be tailored to fit? To employ strategies as a logic system to comprehend and enable understanding in addressing complex design objectives? The creation of a new design pathway to form spatial awareness to the application of the brief, with human beings at its centre. To enable movement away from the reliance of standardisation of the solution by designers.

3. Spatial Devision – Current Space Methodology

Architectural design is influenced by a pre-defined morphology, set by spatial standards and relationships as defined, described and imposed by the A J metric Handbook, 'Metric sizes indicated throughout this handbook do not necessarily imply dimensional standards for actual objects or furniture shown, but refer

generally to the space required to accommodate them within the overall design.' (Fairweather, 2008). The determination of the defined space activity is broken down into the following criteria:

- Introduction of controlled environmental conditions on the design.
- Best functional metric dimension [size] for the new design.
- Design need to be dimensionally co-ordinated with other units.
- Overall dimensioned pattern from the activity point of view.
- Controlled dimension the product should conform to.
- What range of module sizes are required.

This source of standardising to define space in a two dimensional form of activity space is self-limiting, as this suggests people throughout the globe have no social differences between them and the environments which they are placed are without contrast. Anthropologist Edward Hall of MIT in 1966 studied and defined spaces by cross cultural communication reaction of differing cultural settings, social orders and behaviour patterns of humans being, to view how surrounding space was perceived by them, defined by the Theory of Proxemics – the study of the human use of space within the context of culture.

It is this loss of connection to the human being by standardisation and loss of contact with our surrounding which is not reflected in nature. Nature's biosystems have the ability to adapt to changing environmental condition and control material composition. These are evolving systems as they learn, defend, communicate, and protect themselves by the mechanisms of synergy to environmental influence. Nature uses these mechanisms in an evolutionary perspective of actions to give adaptable strategies. Our 'planet is not inanimate. It is a living organism. The earth, its rocks, oceans, atmosphere and all living things are one great organism. A coherent holistic system of life, self-regulating, self-changing' (Lovelock, 1991).

3.1. AUTOCHTHONOUS: A NEW UNDERSTANDING OF DIFFERENCE

The question: Can cultural setting shape spatial arrangements for human habitation? To give true connection to the spaces humans inhabit to enable any sustaining kind of authentic culture in the future, will depend ultimately on our capacity to generate vital forms of regional culture and civilisation. Hall (1976) describes cultural space as a ' organising frame for space as a system of communication, and for spatial aspects of architecture and city planning'. This cross cultural communication is communication and communication is culture and it is this human interaction and their environment participates in moulding each other was described by Hall. Humans have the ability of creating the cities in which we live, to determine the spaces that define interactions, contact and communication

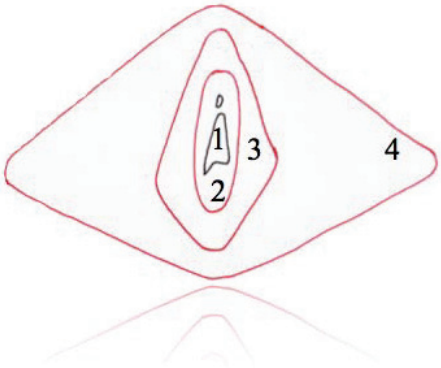

Figure 1. Reaction bubbles by Hall.

between us all. This perception of space of how peoples requirements are influenced by their environment is controlled by the human sensory system. The feeling of discomfort, that is afforded to interactions between cultures and individuals, was defined by Hall into four areas called the reaction bubbles. These spaces are defined as intimate, personal, social and public spaces, as indicated by Figure 1.

- 1 – Intimate space: defined 0.46 – 1.2 metes. Closeness of proximately space to connection with another, that is given or enforced upon by social requirement: circulation space queuing, transportation- lifts, trains, aviation.
- 2 – Personal space: defined 0.61 – 1.2 metes. Spatial zone afforded to first contact with another for whom the individual is not known – social requirement: meetings, introductions, social engagement – restaurants.
- 3 – Social space: defined 1.2 – 2.7 metes – close phase, defined 2.1 – 3.7 metes – far phase. The distance of formality and impersonal contact between another for communication and contact – social requirement: Business, formal meetings.
- 4 – Public space: defined 3.7 – 7.6 metes – close phase, defined 7.6 > – far phase. Limited interconnection between individuals or groups.

Hall (1976) further investigated the sense and pattern of spatial understanding as ‘the sense of space is moulded and patterned by culture’. He investigated the Arab understanding of space and compared it to the European perspective. An Arabian home avoids the division of space by walls as the culture does not wish to remain by themselves. This culture has a high sensitivity to crowding, this view and understanding is not representative in the US model, which suffers accordingly by the movement towards defining human space relationship by structured forms and the importance of culture is minimised.

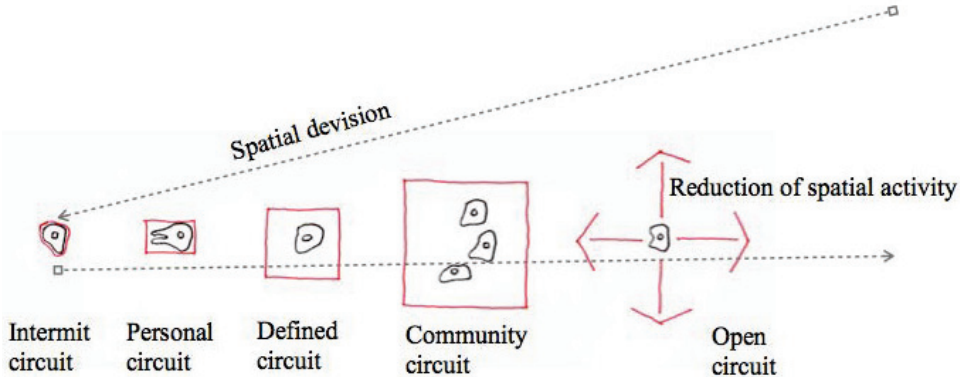

Figure 2. Definition of space to activity function.

The hidden dimensional field creates the framework defining and organisation of space that changes dependant upon pattern of cultural, social setting and knowledge of a individual – the evaluation of a new understanding of difference to human space perception.

That if applied incorrectly may lead to failure of communication and status. Hall further investigated the influence upon fixed and semi-fixed spaces, halls with furniture arrangements, building and cities giving differing understanding and expectations upon the human senses. Could this extension to expand social science of collective consciousness be embraced within the creation of the spaces we inhabit to give a human sense of space?

To expand the current understanding of the definition of space to activity function use by convention – A J metric. Figure 2 defined functional space activity by convention.

- Intimate circuit: defined per individual: theatre seating – 0.375sqm, AJ metric handbook, 10 person passenger lift – 0.182sqm Stannah lifts, Aircraft passenger seating 0.40sqm – European Aviation Safety Agency, rail travel – 0.25sqm Southwest trains. A spatial pattern to form arrangement – theatre seating, transportation, etc.
- Personal circuit: defined per individual: Restaurant and bar table – 0.96sqm AJ metric handbook, reading / study seat- plus area around for using it- 1.39 to 2.78sqm – computer work station – plus area around for using it – 1.85 to 5.57sqm depend upon type of use, short term, long term, individual or group (Erikson et al., 2007).
- Defined circuit: close contact to give intimate connection to the task activity – example Nursery provision – Children < 2yrs – 3.5sqm per child, Child at 2yrs – 2.5m2 per child, Children 3 to 5yrs – 2.3sqm – (DfEE Section 337: Day Nurseries, 1999).

- Community circuit: defined – cultural communication, example community halls. Spatial need of human interaction and connections to form activity – event spaces, congregation, social gathering, courtyards, squares – Piazza del Campo Siena.
- Open circuit: defined, separation of human interaction for activity connection to the landscape.

4. Evolving Spatial Circuit

Could a cumulative relationship of the two spatial systems achieve spatial optimal values to enable movement to facilitate an embryological approach to combine the two spatial systems (spatial proxemics + defined space active behaviour) as a singularity, a blue-print to a generative engine to absorb the two systems, to form a new understanding of spatial functional creation?

- To develop a new spatial codification system of the understanding of the specific and defined requirements to form a 'reservoir of architectural species' in a new 'genetic pool' (Zaera-Polo et al., 2004).
- To find relationship linkages between humanism and form to give a sense of connection to the spaces we inhabit. May this new understanding of generative species enable an evolving resilient new human spatial order. 'A long awaited paradigm shift, occurred not in the designers mind but in the creation of this new codification of the design process' (Terzidis, 2006).

To enable integration of two seemingly contrasting worlds of culture and the defined fixed spaces to give generative species development of the current building typology. This combinational system could give systematic connectivity to the human senses, to enable movement away from the reliance of standardisation of the solution (Figure 3).

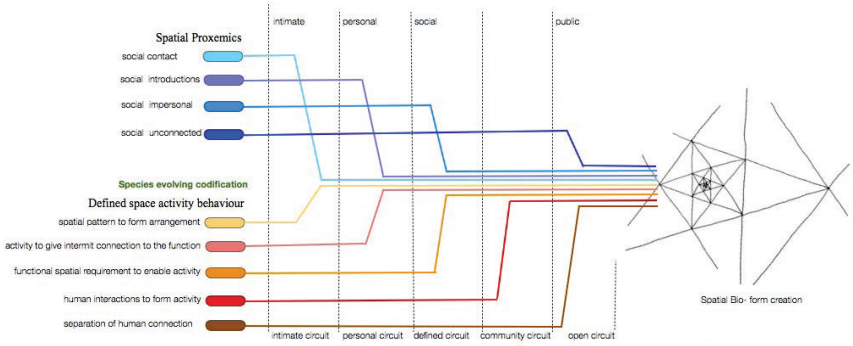

Figure 3. Schematic model.

Could this evolving species based upon quantifiable data, form a new codification system based upon collective mathematical data solution analysis. This new design pathway, a route map of creative form finding, as a combinatory solution binding the social sciences and defined space activity behaviour. The aim to enable a new generative spatial mechanism to drive design solution evolution, by the approaches of human interaction.

Objective:

- 1. To gain encoded values inputs between the two spatial systems as defined in Figure 3.

5. Genetic Algorithms as a Computational Technology

Defining architectural forms by current computations has focused upon geometric proportional rules, arrangements of activity spaces functions within the building and the technology use to construct it. This has been achieved by building complex 3D forms by starting with a limited number of primary geometric shapes, for example: pyramids, wedges, blocks. Eastman and Henrion (1977) used these principles to develop Glide. Their research was to investigate if the application of algorithmic processes could create self-replication as an expression of form development to enable application. Glide analysed this task by forming three levels of hierarchy to determine a 3D form, based upon the primary geometric shape of a polyhedron. These three hierarchical elements are: Image, Shape and Object. The knowledge of the assembly for the construction of the various edges and folds, that governed their behaviour was achieved by halfedges using the Euler Operator to form shape creation, under the umbrella of Unix®.

However could the objective be: ultimately building not from solid modelling as an abstract solid form, but as a collection of voids enclosed by surface. These voids could contain the encoded spatial value functions in determining the spatial surfaces around, by the application in the developments of DNA computation.

6. Biomolecular Computing Systems

Biomolecular computations are methods for executing programming of DNA by systems and software tools that aid the design, verification and simulation by using DNA as engineering material. DNA has the ability to self-assemble and execute operations autonomously by encoded sequences of strands to form DNA nanostructures.

The manipulation of DNA to enable increasing functionality, communication, and control is achieved by interface sequence optimisation system, for designing

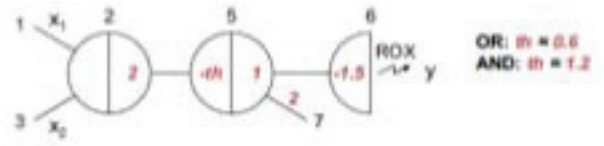

Figure 4. Abstract (taken from Qian and Winfree, 2011).

DNA nanostructures focused upon sequential Boolean computation. Figure 4 is an abstract of this, developed by the research of Qian et al. (2011). This abstract represents the process: x1 and x2 are the inputs to gate 2 and resultant output is feed into gate 5. The threshold level *th* determines the logic and makes the circuit compute the OR of x1 and x2 and while setting *th*=1.2 makes the circuit compute AND of x1 and x2. This sequential Boolean computation function of using purely operations of AND and OR 'are executed by seesaw gates, and restoration to the digital values is through thresholding gates followed by catalytic amplification of any leftover signal' (Chandran et al., 2011).

This Boolean function has been applied to form spatial configurations Chandran et al. (2011) in the creation of addressable reaction spatial network formations. Below are the simulation steps how this could be applied:

- Start initial spatial configuration of the system.
- Calculate the probability that the next event will be a ligation or restriction.
- Calculate the probabilities of various ligations and restrictions.
- Perform those events with the calculation probabilities.
- Update the configurations of the system and concentrations of the spatial patterns and follow link connection.

The reaction spatial network circuit output of this is the creation of autonomous executions of reactions in Figure 5. This example illustrates the Boolean function of x1. x2 + x3. x4 with the initial species highlighted in the darker boarder.

This computational sequence could process and help to solve complex problems in the field of architecture. This ability to form self-assembly by reaction networks to create structured and sequenced spatial arrangements at a nano scale level could be scalable and transferrable to create the spatial functions to activity relationship of spaces to the built and human environment.

Computations spatial patterns have been applied before, to form understanding of the 'behaviour of Pharaoh's ant colonies where the interest was to model individual ants in such a way that the whole system will show a reliable self-organisation and exhibit emergent behaviour' (Gheorghe, 2004). This research has progressed further through self-assembled 3D nanostuctures where the spatial arrangements were formed by carving and creating the forms from solid

Figure 5. Reaction circuits (taken from Chandran et al., 2011).

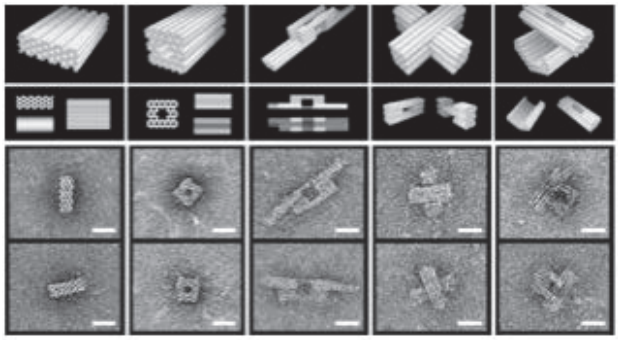

Figure 6. Nanostructures (taken from Cadnano, 2011).

3D honeycomb-like structures. This was achieved by design automation software (Cadnano, 2011) (Figure 6).

This approach to form complex spatial formation of these 'networks provide a powerful means of expressing patterns that can be self-organised. They can capture simple patterns that are directly expressed in terms of local interactions, and they can be combined to form more complex pattern networks' (Coore, 2004). This evolution in the creation of nanostructures by self-assembly principles to form materials and objects, could, as Reif et al. (2005) expressed, be a basis for potential large scale demonstrations.

Objective:

- 2. To use encoded values inputs (Figure 3) to extract optimised values for experimental spatial conditions, configurations and constraints upon relationship to form new emergent spatial formations, by application of biomolecular self-assembly computation.

7. Conclusion

Could there be evolution of our understanding of space by the integration of two seemingly contrasting worlds of culture and defined fixed spaces. To facilitate an embryological approach to combine the two spatial systems as a singularity, to determine output values. To use these encoded values as inputs to create generative space forming, using biomolecular computation. This computation could enable spatial arrangements being generated by a collection of voids enclosed by surface, that contain the encoded spatial value functions in determining the spatial surfaces around them. This self-assembled 3D spatial system could be formed by carving and creating the spatial voids from solid 3D structures to create spatial geometries.

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