NATURAL BEHAVIOR AND COMPUTATIONAL LOGIC FOR OPTIMIZATION OF ARCHITECTURAL DESIGN

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Abstract. In recent years much avant-garde architectural work has been dominated by a process based theoretical paradigm, inspired largely by various thinkers, critics, and philosophers. This particular 'process practice' attempts to address the paradox at the heart of contemporary production, by looking dialectically at the relationship between structure and ornament in nature with brainstorming and use of computer simulation.

The goal of this paper is to develop a computer optimized system that can generate solutions for defining spaces involving a number of contextual relationships of activities. In particular, this research undertakes a pilot study (working team: Ashik Vaskor Mannan, Masrur Mamun Mithun, Lau Hon Yee Damien) on pattern and behavior in nature and implements the findings in to an architectural problem. The Initial Research focuses on *Theory of emergence*, *Analysis of swarm behavior*, and *Analysis of ant system*. Specific urban sites with different behavior patterns are chosen in Barcelona where this process is implemented to examine how they response to this course of action. This method provides an optimum solution instead of a 'top down' solution (where architects play the role in 'God mode' as the only decision makers) for an architectural problem.

1. Introduction:

The term 'emergence' was first used in the study of nature where it shows the optimization of a stable state as combined result of variant surrounding conditions. Starting biology of physical properties to social formations, scientists found rules governing the diversified emergence of structures. Post modern philosopher and critic like Gilles Deleuze and other cultural theorist have started to philosophize and inspire, in recent years, much about architectural work dominated by a self generated evolutionary process. This has led to a new thinking where process is privileged over representation and performance over questions of beauty. However, this process based paradigm always appears somewhat disingenuous, although much

of what emanates from this way of thinking is decidedly beautiful; the issue of beauty is never addressed.

This particular ‘process practice’ attempts to address the paradox at the heart of contemporary production, by looking dialectically at the relationship between structure and ornament in nature with brainstorming and computer simulation. Architecture has always been taught as a ‘top down’ process meaning architects playing their ‘God mode’ in design. They think in their own way and try to convince their own ideas to the client. That’s why it can be unsuccessful design in many aspects. In this paper we describe the “system” which is a “bottom up” process where computer software is used for scripting and generating the result. In this process architects are not the decision makers, they are system simulators and the computers are the simulation tools.

The rise of the modernism enhanced this power play of architects, where universalization of design was prescribed. The post-modern thinking rejected this prescription and locked for more individualistic, regional interpretation of architecture. But still broadly it is a top down process. In the light of advancement in the scientific fields, few scholars are now questioning this very process as the nature itself shows ‘bottom up’ generation in all sorts of structures, even in social structures.

2. Research

The initial research on this project was on:

Theory of emergence: Emergence is the process of complex pattern formation from simpler rules. Emerging behaviour depends on the interaction between components. Emergence structure is the sum of interaction of each part.

Analysis of swarm behaviour: Swarm Intelligence (SI) is the property of a system whereby the collective behaviours of (unsophisticated) agents interacting locally with their environment cause coherent functional global patterns to emerge. SI provides a basis with which it is possible to explore collective (or distributed) problem solving without centralized control or the provision of a global model.

Analysis of ant system: By following simpler relational rules with one ant to its nearby neighbour, ants can lead to optimized solution which results into complex emerging patterns of growth. [Source: www.Wikipedia]

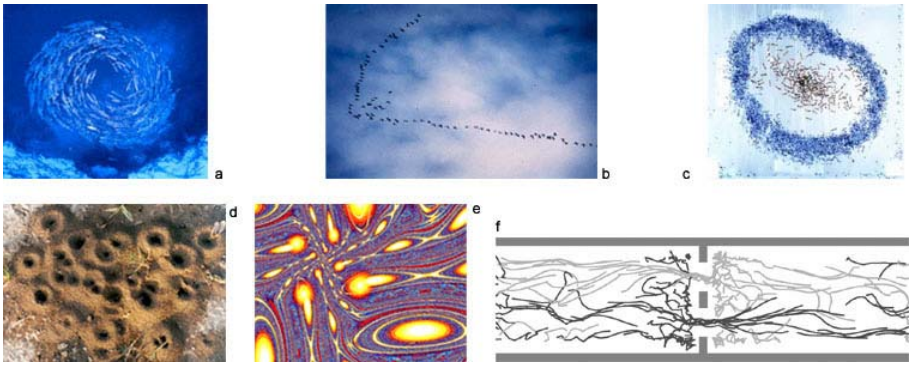

Figure 1 (a through f): Natural and simulated emerging pattern and self organization in living organism and natural landscape. a) emerging pattern of fish schooling.[internet image- @coro Caltech]. b) Birds flocking in V- formation. [Web image- @coro Caltech]. c) Emerging pattern of ant's wall. [Web image- @coro Caltech]. d) Self organization of ant's hill. [Web image- @coro Caltech]. E} Computer generated emerging landscape.[www.ba.infn.it]. f) Self organization by computer generation.

The task for architecture is to delineate a working concept of emergence and to outline the mathematics and processes that make it useful to designers. This means we must search for the principles and dynamics of organization and interaction, for the mathematical laws that natural systems obey that can be utilized by artificially constructed systems.

3. Development of the Idea:

To test the emerging character of space, the study zoomed into a generic test field with given conditions of entry and surroundings. Three elements were taken as components of exercise, the fountain as a static point of attraction in a space, the path, as a dynamic space that relates the surrounding with fountains, and the gates. The exercise was to find out optimized zoning of fountains and paths according to the given context. The first task was to establish the governing rules that relate different type of spaces and the relationship with human being and their movement in the space.

The idea was to develop a system, based on the research findings, which will seek for optimized solution in defining a space. The developed system will consider simpler rules of relationship of spaces with each other and will test people's relation or tendency to use those spaces. Rules for mutual relationship of spaces are context sensitive and need to be figured out carefully considering different aspects of function, usability, social or cultural impacts on attraction of that space etc. [we used MS Excel as a design tool for this phase. Figure 02]

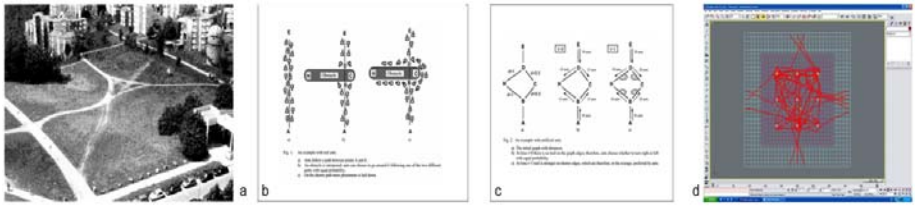

Figure 02 (a through d): Observation and trial a) Human trail in top down designed landscape. B) Experiment with ants trail c) Experiment with ant's pheromone. D) Try the random trail in computer simulated AI implant software [plug in for max 06]

The next step was to design a system of grading or hierarchy of every point in the test to determine whether it is to be a fountain or a path. The grading of the points updates each other according to the rules of influences of neighbouring points. Then in the third phase, the relationship with human movement was taken under consideration and re-graded again. In the resultant grading the element scoring a few points higher than others become the fountain/s. All this process is called 'one iteration'.

Rules for relationship with human involvement are based on human behavioural pattern which eventually take a form of multi agent system. AI implant, a plug-in for 3D Studio Max, and Excel was used as design tools for this phase. From that we developed a system that can be called 'path and fountain system'. This is an exercise to understand the system and computational logic of emergence in computer simulation. The system that has been taken here is adopted from the swarm behaviour, specially ants, and the optimization of uses.

4. Consideration:

Few things are considered here as exercise such as trail and optimization (positioning based on pheromone level like ants) and set rules of criteria that interact with close neighbours and evaluation of them.

To simulate human movement in design space, advanced plugging of simulation software like 3D Studio Max was used. It initiates human like behaviour in the agents, so deciding the behaviours according to all influences, new fountain places are generated, and then they are again tasted in the same manner for the next iteration. After several numbers of iterations, the result shows apparently changeless positions of fountains and paths and hence can be considered as optimized.

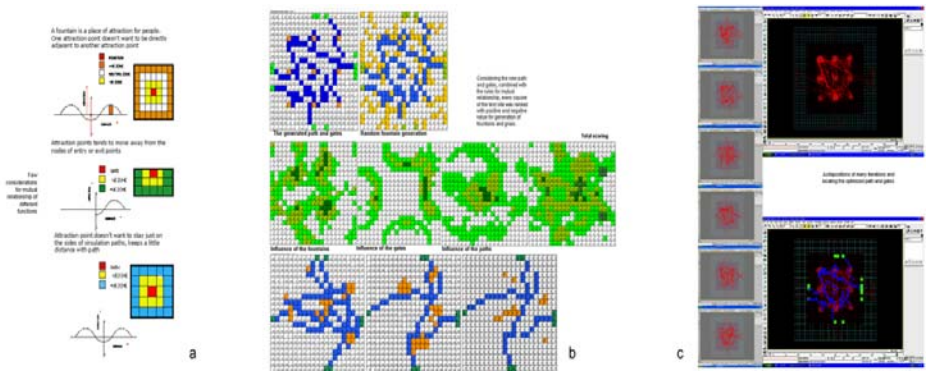

Figure 03 (a through c): Experiment with computer software for optimized solution. a) Creating the rules for a testing field for Excel field. b) Changing of position and optimization of path, attraction point and gate for putting the rules. c) Putting Excel sheet's result to AI implants and traces the optimized trial trail.

5. Implications:

The exercise with the generic test field was later tested in actual site contexts. Three sites in Barcelona were chosen for their diversified criteria. The 'Placea Catalunya' a successful plaza needed re-evaluation of the Public Square, and 'Placea Sant Miquel' a non-functional plaza needed to be redesigned for making it useful. The focus of the third site was on the Ramblas' main linear pedestrian axis (Figure 04), where the dynamic positioning of the street performers or buskers was taken as study element to decide the human landscape of the area. Everyday a large number of people including tourists move in this most famous place in old Barcelona. The site offered complexity as it is a main pedestrian node as well as tourist attractions.

Both the onsite shops and the street performers of Ramblas attract people in different magnitude. For general pedestrian movement, the performers are like obstacles, so they add negative values. The quality of next performer as well as the most populated areas are attraction and at the same time distractions for a performer to stay there. The whole sequence changes in different times of the day as the contextual site forces change.

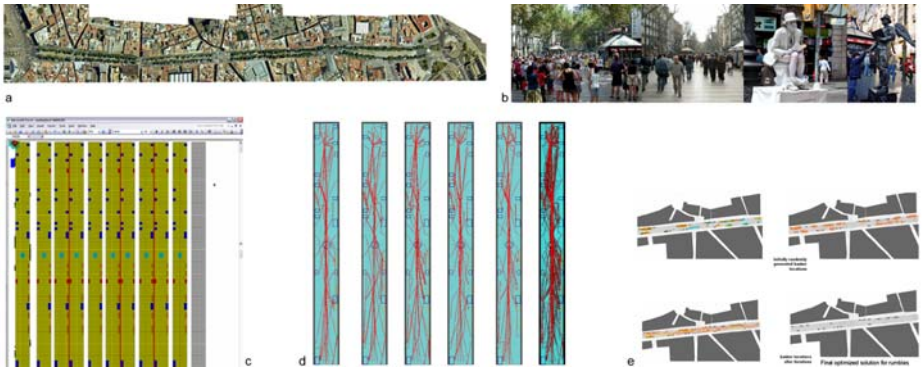

Figure 04 (a through e): Experiment with computer software for optimized solution in La Rambla in Barcelona. a) Google earth view of La Rambla in Barcelona. b) Human activity and buskers in Rambla. c) Microsoft Excel simulation with given rules in Rambla's test field. d) AI testing for optimized human trail. e) Final optimized result for Ramblas.

Therefore it's a complex matrix which influences the positioning of the performers. All these are calculated to generate grading of each point on the site following the exercise done in the previous step.

Then we formulate Microsoft Excel to develop the relationships between all these elements with each other and run AI Implant with developing different attributes by scripting for generating path. The agents in the systems started looking for fountains in the site with attributes like looking for attractions, move away from one attraction to another, avoid obstacle, avoid collision with other agents etc with different speed and different angle of vision like real intelligent people. In addition different sets of agents with faster and slower speed representing older and younger people in varied numbers were also incorporated in this system. Juxtapositions of much iteration give an idea of optimized route and entry gates as they were the resultant paths in the system.

Following the same procedure of human movement in the site, new possible areas are located as potential busker positions. More complexity is added to simulate human movement as there are different types of people with different motive, attraction and pace found in the actual site.

6. Findings:

After each iteration, the results are again tested with the same criteria. Following the same principle of the test phase, the iterations are found to be minimizing in option, hence resulting to an optimized results. Interestingly the test results are already seen in many cases of the actual site context, proving it as a valid evaluation process.

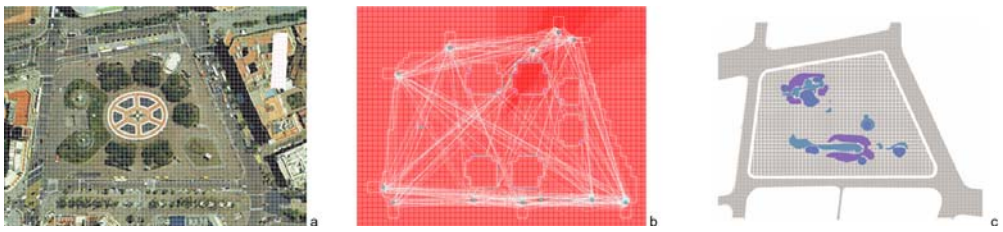

Figure 05 (a through c): Experiment with computer software for optimized solution in placa Catalunya in Barcelona. a) Google earth view of placa Catalunya in Barcelona. b) AI testing for optimized position and path for the placa. c) Final optimized result for all attraction point, path, resting and green place.

Other two exercises with different sites took the same procedure but were adjusted according to their contextual relations. The 'Placea Catalunya' exercise (Figure 05) added one more complex loop in iteration as the results illustrated no need for changes to the original successful design. The 'Sant Miquel' site on the other hand prescribed possible intervention in built form to maximize visibility.

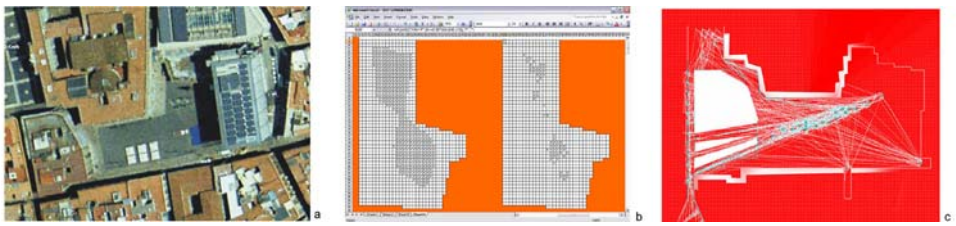

Figure 06 (a through c): Experiment with computer software for optimized solution in Placa Sant Miquel in Barcelona a)Google earth view of placa Sant Miquel in Barcelona b)AI testing for optimized visibility and path for the placa c)Final optimized result- aperture for the obstructed building which create the placa lifeless.

Conclusion:

This system considers simpler and complex rules of relationship of spaces with each other and people's preference to use them. Rules for mutual relationship of spaces are context sensitive and need to be figured out carefully considering different aspects of function, usability, social or cultural impacts on attraction etc. As computational tool MS Excel can be used at this phase as a design tool. Rules for relationship with human involvement based on human behavioural pattern taking the form of multi agent system can be calculated with AI implant. This is an exercise to understand the system and computational logic of emergence in computer simulation. The system which has been adopted from the swarm behaviour, especially ants, can produce an optimized architectural bottom up solution. Few things are considered here as exercise such as trail and optimization and set rules of criteria that interact with close neighbours and evaluation of them.

We can quote: *'It can be no coincidence that commentators from a variety of disciplines are now looking to biological models to understand structures of behavior. From hard-line scientific research to philosophical enquiry they are finding that a constructive engagement with biological models is providing new insights into all forms of natural phenomena. It is as though even the structure of the universe and its continuous expansion cannot be understood using static theoretical models, but need to be exposed to more dynamic models of behavior. And it is precisely studies of the 'life-force' within nature- from cellular organizations to swarming and flocking behaviours of insect, plant and animal life- that are opening up understandings of how human beings themselves behave. Just as we have seen bio-chemistry emerge out to chemistry, bio-technology out of technology, so too we are beginning to see a form of 'bio-philosophy' taking hold within philosophical debate.' Neil Leach, 'Swarm Tectonics' in Digital Tectonics, London, Wiley, 2005.*

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