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GENERATIVE MODULAR SYSTEM PROPOSAL TO BE USED IN SPATIAL ORGANIZATION BY GETTING INSPIRATION FROM ORGANIZATION LOGIC AVAILABLE IN NATURE

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ABSTRACT

Unprecedented order of nature has always guided the designers. Even though the designers took an example of formal simulations in the past, they then concentrated upon orders logic existing in nature. Orders appeared complex in nature have been observed to have occurred with systematic gathering of several pieces with particular rules.

Within the scope of this study, it is aimed to generate a generative modular system that will be of assistance for creating spatial organization alternatives to architects and to be used for generating new form and generation by getting inspired by organization logic defining order concept in nature. Within the scope of the study, it has been endeavoured to generate a model taking an example from organizational set-up of living beings in nature for spatial organization of the structures with multi-function and likely to grow thereafter.

Key Words: Spatial Organization, Modular system, Generative Approach, Biomimesis

1. INTRODUCTION

Architecture can be defined as an endeavour for creating living areas for maintaining the life of human-being since the first existence of earth. Myriad studies have been conducted for creating ideal environment through the history and it has been benefited from Maths with the notion that this can be achieved with ideal ratios and endeavour of creating ideal form.

Relationship between Maths and Architecture lasts from the first period of history. The reason lies beneath that is not only architecture benefiting from maths but also both systems are in search of a form and aesthetics. (Pekol, 2011) Architectures have used proportional systems and geometry throughout design process for generating and converting form and restricting generated forms (Timuçin,1993).This proportional utilization has created the concept of the modular system for providing coordination between structural products and preventing material losses in following periods. (Gökhan Ç.,Baytin,D.,1979),(Tokgöz H.,Koçak Y.,2009).

Searching for order is of utmost importance in defining modular system. The orders searched for providing especially spatial order only organize the relationships in a formal way and growth of the system is generally one-direction mode because the system generally grow in a single direction organization depending on a single centre. This case has necessitated formation of different searches in the orders defining especially modular system.

Unprecedented order of nature has always guided the designers. ""Knowledge acquisition-interpretation-inspiration-implementation process present in nature of design has brought about scrutinizing of development and conversions of existing formations within the ecosystem where human-beings live and conscious and unconscious interaction together. Even though the designers took an example of formal simulations in the past, they then concentrated upon orders existing in nature. Formal orders appeared complex in nature have been observed to have occurred with organizational set-up gathering of several pieces with particular rules. There exists an organism relationship in interrelation of the pieces creating the living beings or growth of living beings in nature and the pieces defining the organism are organized with a particular systematics. Accordingly, there is a prime element that will enable all organs to be in a particular order. (Skeleton in vertebras, shell in insects etc.) Secondly, organs or systems auxiliary for prime elements defining different systems are interrelated depending on prime element with a functional relationship. The elements in the last group are the connection elements connecting prime and auxiliary elements with one another. Relationship between these elements defines organizational set-up of the living beings. If there was a formal growth, development and change, organizational set-up between these elements would not be changed. This relationship is regarded as a model to be used in organization of spaces defining functional groups and relationships.

Within the scope of this study, it is aimed to create a modular system approach to be used in organization of multi-part spaces or multi-functional spaces by getting inspired by this organizational set-up logic of the living beings. In this way, it is strived to create an organizational model to be used in gathering the pieces incorporating juxtaposition of spatial units and organizing relationship to a whole defining the system. Method of the study has been indicated as identification of an algorithm that will offer different formal alternatives by getting inspired from the order and logic of organizational set-up of the living beings in nature. Living beings in nature have brought about unchanging organization set-up even if it is in different formal orders with different formal relationships and have created different modular system alternatives. Approach created within the scope of the study is the result of search for order between nature and architecture.

2. MODULAR SYSTEM/MODULAR COORDINATION

Architecture has frequently benefited from proportional systems and geometry for creating specific forms and restricting created forms throughout the history. Purpose of using such a system is presence of harmony among elements of the structure. It is intended build an integrity feeding across the structure establishing this beauty. (Timuçin,1993)

This has caused initiation of works in regard to relationship of human and environment together with industrialization. Gradual acceleration of industrialisation has also changed the structure of society in 18th and 19th centuries. Cost-effective generation of products in large numbers quickly and in series has caused development of an era in terms of both design and consumption. (Bayazıt, 2004)(Sak,2014). Increasing competition in generation and varying customer demands have resulted in a trend towards more product ranges and innovation, shorter product life cycle, lower costs and higher product quality. (Rogers and Bottaci, 1997) (Sak,2014). In addition to this, modular generation systems have developed and have brought about mass generation and switching to mass generation has been realized with formation of module and modular systems. (Sak, 2014).

Technology developed after in industrial revolution has created several innovations in social life and accordingly, the need for sheltering has increased. Having worked in the workshop of Perret, Le Corbusier has created "Le Modulor" that can be a response to this need due to the

presence of qualified and fast housing need reaching its peak point following especially World War II together with proliferation of housing density. (www.banupekol.com)

Given the past, we observe that modular system has been used for faster and healthier performance of housing generation; this mass generations is not only in housing but also in structural types such as city hospitals, school complexes, courthouse buildings in line with the increasing requirements of our time. Fast and high quality designs that can respond the needs can be created by using a particular module in juxtaposition of different disciplines in these large structure complexes.

3. BIOMIMESIS AS A GENERATİVE DESIGN APPROACH

Generative design approach is an algorithmic method pertaining to the content of process rather than result of performance of action. (Fischer, Herr, 2001). That design problem is a complex process results in adoption of intuitive decision by observing complex cause and effect relationship and adaptive thinking process of designers. (Herr, 2002). Generative design system should be adaptive and non-restricting, proposing for providing support for this process.

Generative design approach is an algorithmic structure used in creating different formal design alternatives in line with development, change and transformation of any phenomenon (idiom, formation and assets such as plant, animal, organism, cell, language, maths, fractal, community behaviour, genetics) One of these generative approaches is biomimesis.

Biomimesis is a candidate of scientific branch allowing learning from the best ideas of nature by way of imitating live and inanimate objects in nature together with perfection in nature. Investigating transferring the knowledge learned from nature to human-made objects, biologist Janine Benyus (1997) has claimed experience of Biomimicry Revolution in several fields of human beings and has underlined that our form of learning from nature is very different from visual inspirations in the past. (Erdoğan,Sorguç,2011).

Biomimetics Architecture is an innovative approach form blending cellular functions with the-state-of-the-art technology for creating working and living structure such as natural organisms. (Benyus, 2011). Biomimesis investigates how organisms live, how they grow and create crystals and growth and orientation of crystals instead of taking and cloning details of structures of live and inanimate beings in nature in the same way. (Benyus, 2011).

Referred with biomimetric term for the first time in 1969 by Otto H. Schmitt, this concept aims to bring forth solution to the problems through creativity of nature in the face of requirements by investigating, learning, adapting, imitating or getting inspired by the models in nature.
1-"Nature as a model" is the act of solving problems of human-beings by imitating and getting inspired by models of nature. Giving inspiration of leaves generating energy from solar rays to solar cellular designs.
2- "Nature as a meter": Uses ecological standards as an accuracy meter in new inventions and designs. Using age-long experience of nature in designs.
3- Nature as a mentor": Nature is a guide to learn how to generate solution rather than a place where we get solution of world problems through it. (Benyus,1997).

4. MATERIAL AND METHOD- MODEL

When complex-appearing structures of living beings are resolved, it has been observed that specific pieces come together and these rules grow and flourish in a manner that will adapt to its environment by way of repeating these rules several times. This process can be a guiding spirit for handling organization order of multi-functional spaces (Hospital, School etc.) hosting

several pieces and relationships within its body. Within the scope of this study, it is aimed to develop a generative modular system approach that will be used in organization of multi-functional and multi-pieces spaces by getting inspired by this organizational order in nature. As put forward by Benyus (1997), the process of knowledge acquisition-inspiration-interpretation and implementation present in nature of design has been used in setting up generative algorithm defining the method of the study. In this regard, algorithm incorporates the phases of knowledge acquisition wherein modular order is defined and organizational set-up in nature is resolved and generation wherein the rules pertinent to organization of modular system by getting inspired by orders in nature are identified and the rules in respect of spatial organization together with re-interpretation with spatial data are identified and derivation wherein different alternatives are generated in line with the data that will provide especially growth of multi-functional buildings. (Figure 1).

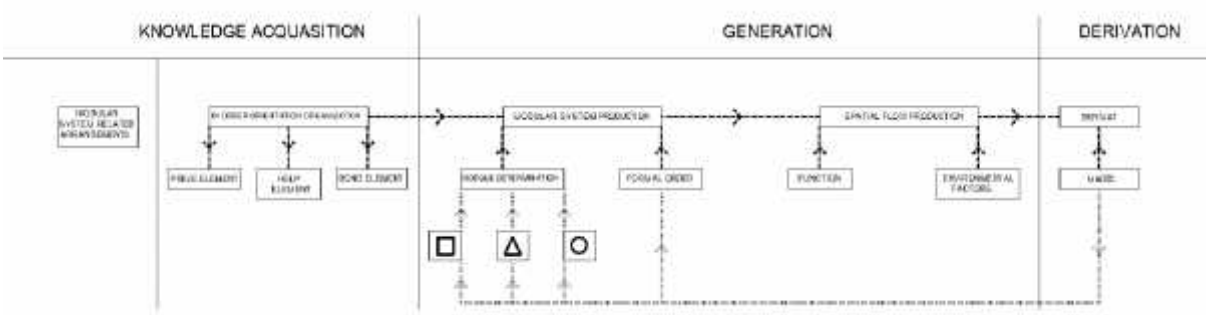

Figure 1. Generative Algorithm Defining Method of the Study

4.1. Knowledge acquisition-Analysis

Basis of concept of modular system is to define with what order concept the parallel modules come together. This order has been defined so far with the orders identified by Euclidean geometry. Ching (1999) has categorized gathering order of the pieces or forms under five

classes as central organization, radial organization, recurring regular organization, linear organization and cluster organization (Figure 2).

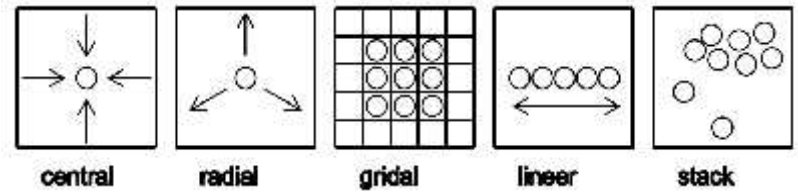

Figure 2. Formal organization in architecture (Ching, 1999)

Providing organization of these orders is restricted by providing expandability and formability parameter required by only modular system. Orders generally allow one way growth such as elongation and expansion. However, these orders are restricted in organizing different formal searches or multi-functional structures such as hospital, school constructed in our time.

Living beings in nature are formed and develop by gathering of several cells just like in modular system. First of all, each cell is reproduced by way of dividing and in this way, it provides both its border and formal conversion and while doing this, it acts within a particular organization order. Thus, explaining this process only with gathering of forms will be restricted. Investigation of organization logic within the pieces we defined as cell has been required.

Different samples present in nature during analysis phase have been selected and their organization order has been analyzed. When different living samples are investigated, it has been identified that there is a prime element that will enable co-existence of cells. Each piece defining the organs and related with prime element defines auxiliary pieces and the element establishes a connection between these two elements defines bond element (Figure 3).

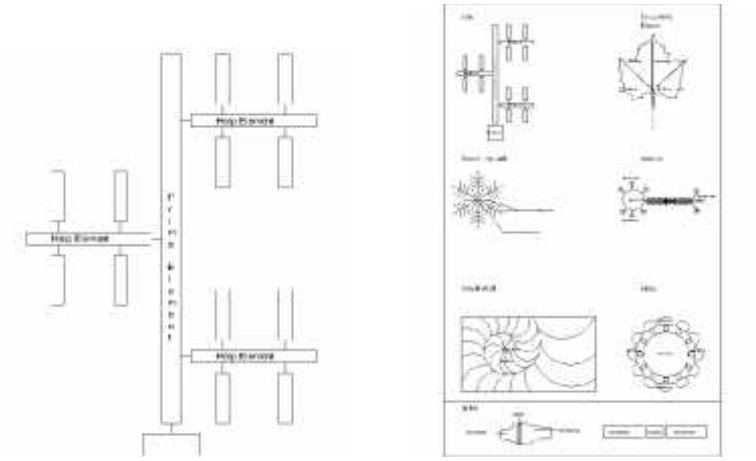

Figure 3. Natural Samples Analysis of Organization Order

These elements defining organizational set-up in living beings are juxtaposed with the same relationship at all time even if the living beings are in different forms. This organization concept so identified can be used as a new model in modular system organization.

4.2. Generation

Generation step of algorithm is the use of the organizational rules obtained as a result of analysis of organizational set-up of the living beings in organizing multi-functional spaces to be organized by using both modular system and modular system itself. For this reason, two phases have been defined in generation (Figure 4).

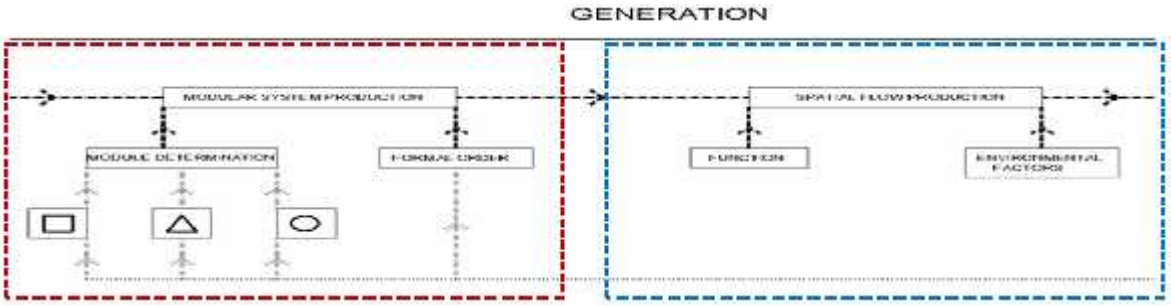

Figure 4. Generation step of algorithm

First phase is generation of modular system. This is the phase wherein which what form variations the prime, auxiliary and bond elements providing organizational set-up can be produced.

Primarily, different living samples are selected and how the modules will be organized under different growth forms is identified. It has been observed that living beings in nature have generally provided organizational formation in three groups.

- Tree structure
- Cycle structure
- Composed structure

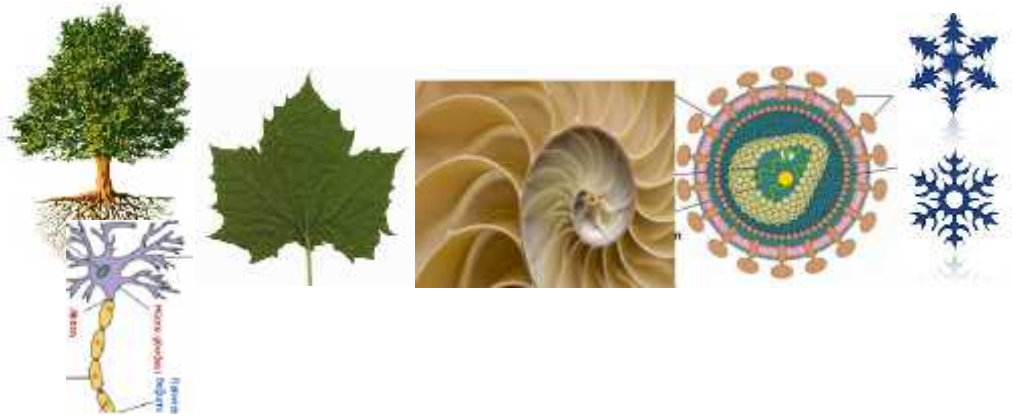

Figure 5. Natural Samples

Living beings organized as tree structure define prime body or auxiliary sub-elements connected to element with dispersed axial structure. In cycle structure, it is observed that the cells defining the living being, organs, in other words, the units defining the living beings are defined by rotating sometimes around the center, sometimes by rotating around both holistic structure centre and unit center. Growth is provided with auxiliary elements and bond elements established in between while defining the cell in the center or prime element of organ living being. Composed structures define the structures wherein both trees and cycle structures co-exist. Different alternatives can be created by juxtaposition in arch forms.

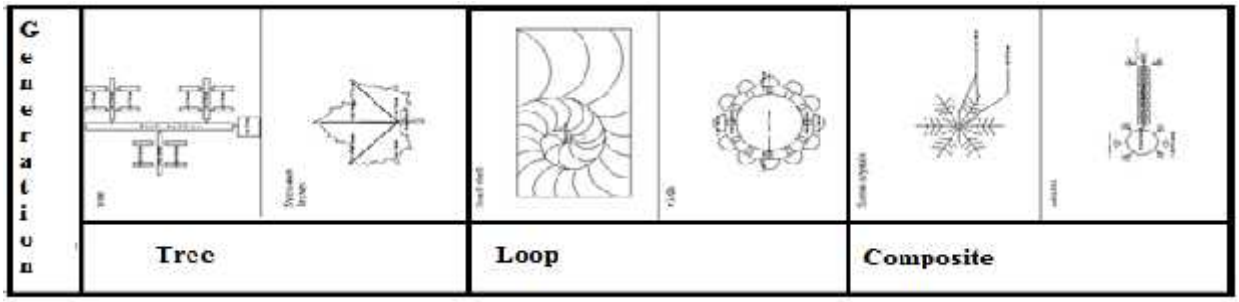

Figure 6. Organizational Formation of Natural Samples

What is identified in second phase is module transfer to these structures. Prime, auxiliary and bond elements defined each living being actually identify juxtaposition rules of the units pertaining to the living beings. Different formal orders can be achieved by appointing a geometrical form (square, triangle, circle) as an element or module instead of these units. Even if organizational order does not change, different formal orders are achieved. Modules juxtapose in numerous numbers for defining prime, auxiliary or bond element and define the units in distinct size.

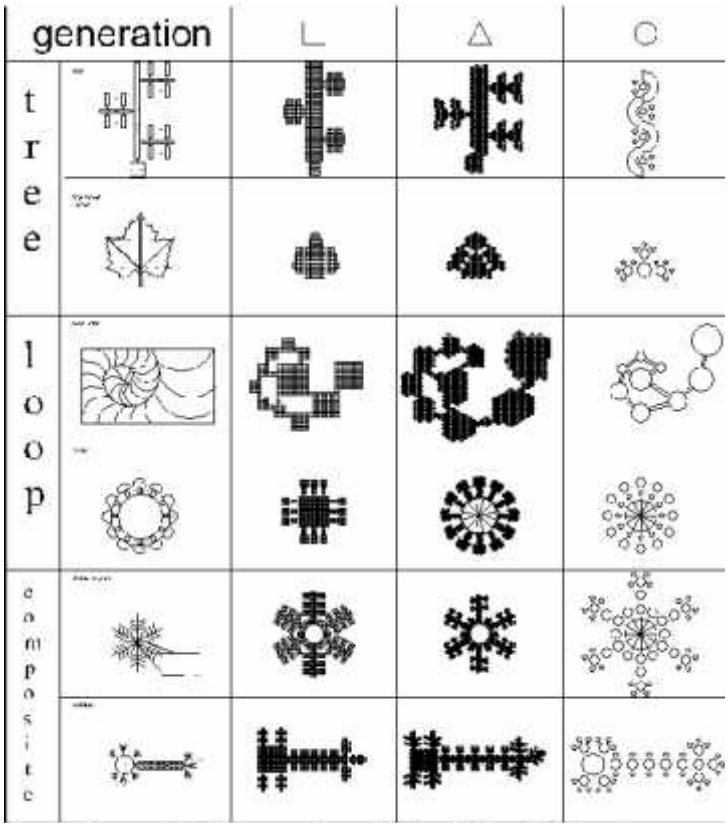

Figure 7. Generation of New Modul System

Second phase of generation is investigation of spatial order generation suitable for module order concept. According to these two basic data group defining the design in this phase, placement of the units and arrangement of organization have been targeted. These data are

- Need program
- and environmental factors.

It is aimed to offer unconventional design proposals by the use of organizational set-up in nature as functional and formal organization other than fast, economic and only formal and intuitive organizations of multi-functional building types (School, Dormitory, Hospital, Hotel etc.), example of which is frequently encountered in our time where human circulation and

density within the scope of the study are abundant. In this regard, function and functional groups defining multi-functional structures and having similar units or modules such as school, hospital, dormitory have been identified. Then, relationships of these units with one another have been identified and prime, auxiliary and bond elements to this have been identified.

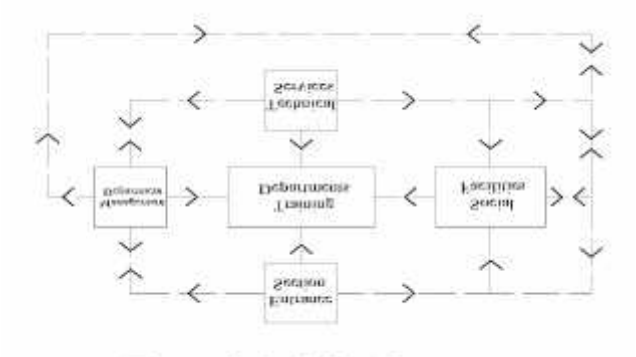

Figure 8. Building Program

Secondly, environmental factors have been identified. How the building and units are positioned has been identified in line with the parameters such as topography, climatic data, direction, pedestrian-vehicle approach. Spatial organization alternatives have been created with different modules and functions.

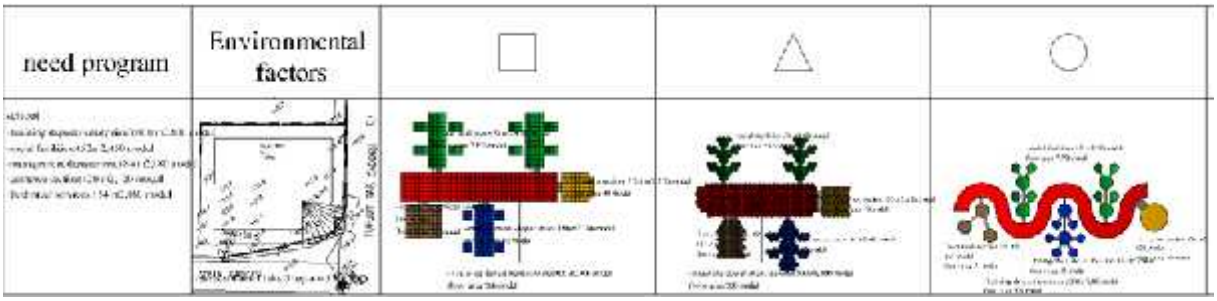

Figure 9.Need Program and Synthesis of the Systems of Environmental Factors in Nature

Then, functional organizations have been arranged for each different module and form.

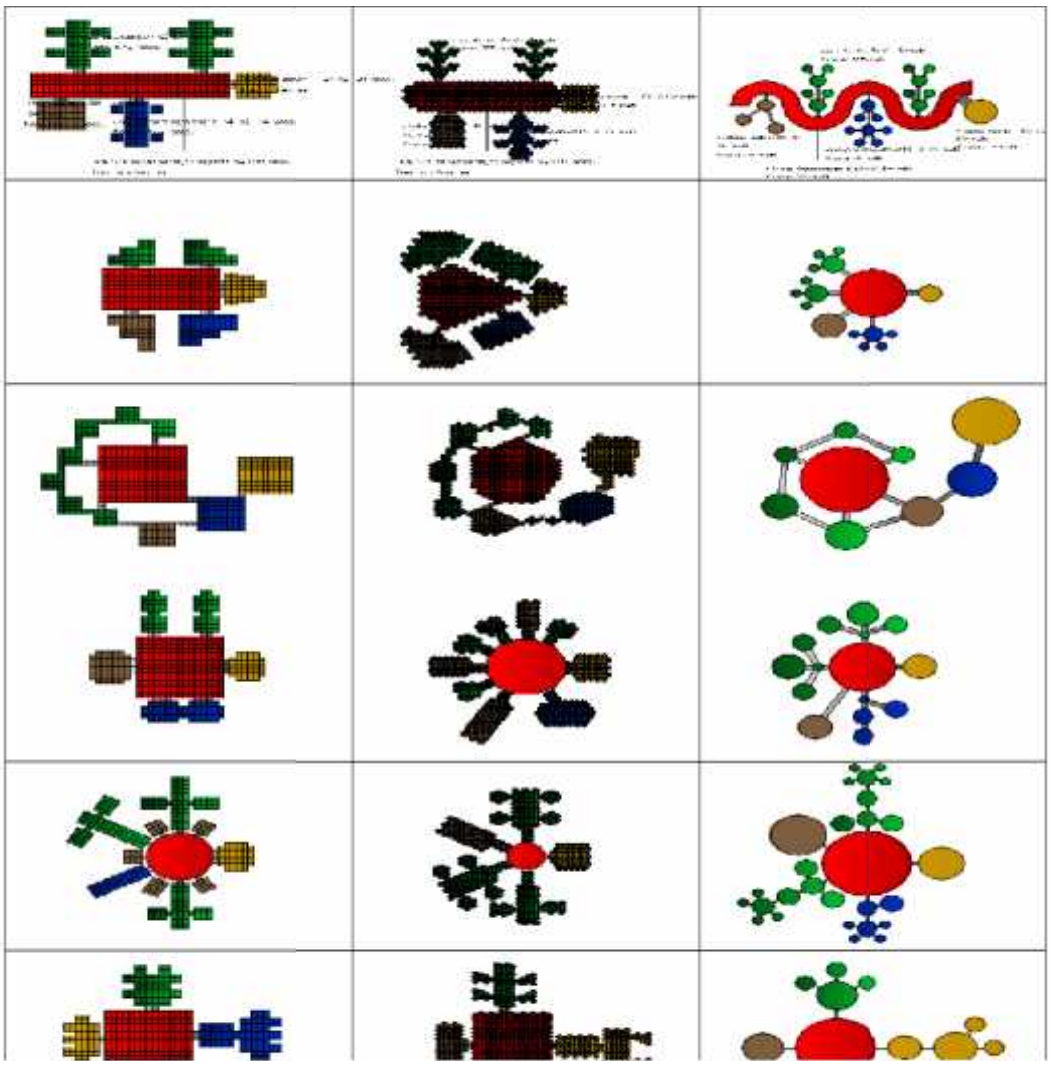

Figure 10. Synthesis of the Systems Selected as a Sample from Nature

4.3. Derivation

Final phase of algorithm is derivation. One of the fundamental parameters required to be considered in design of multi-functional structures is the need of planning expandable structure in line with divergent functions or unit necessity. In this regard, derivation phase is to enable organization that shall provide expandability without disrupting organizational set-up so identified by the units in generation phase. When necessity of juxtaposition of several buildings as a result of the increases of the systems in nature whose generation is defined in the need program is emerged, the building previously synthesized is accepted as a building module and derivation is aimed to be performed in this way. (Figure 7).

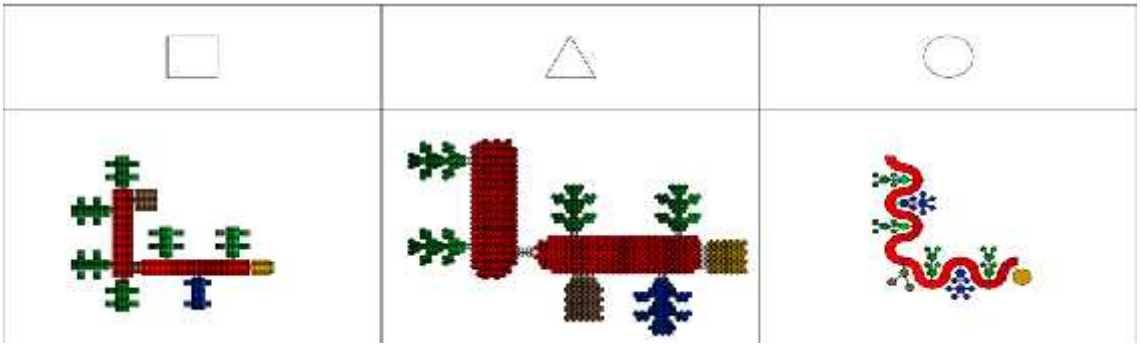

Figure 11. Derivation of building module selected as a sample from the systems in nature

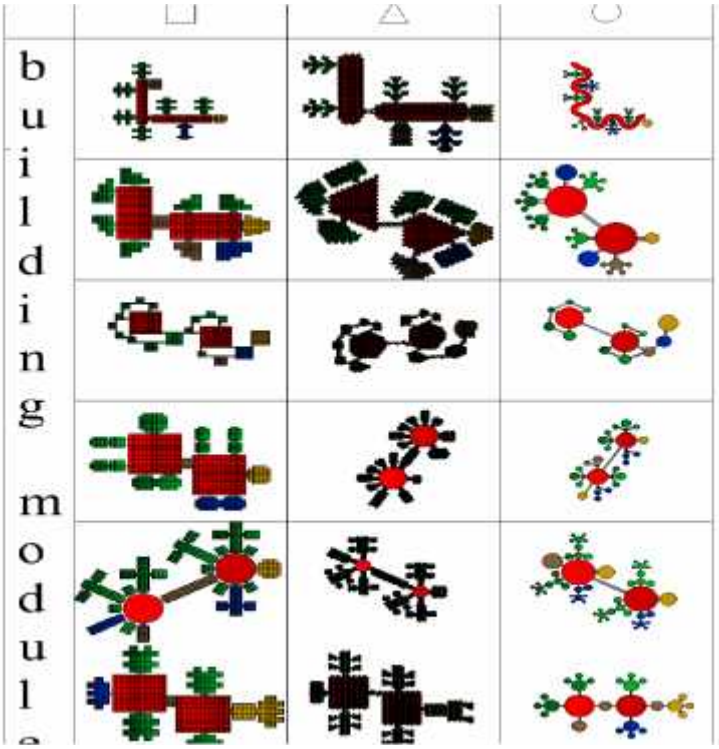

Figure 12. Derivation of building modules selected as a sample from the systems in nature

5. CONCLUSION AND EVALUATION

Investigation of the systems has been conducted by considering the fact that more efficient and more different alternatives can be sustained by investigating the systems taken as an example in building types holding multi-function and taking their advantages and disadvantages as a guide. Natural systems that will provide diversity in the issue of the systems and direct the designs to different schemes and provide multiple alternatives have been investigated and analyzed. Design proposal has been offered by getting inspired from natural schemes that can be grown organically pertaining to the building types having multiple functions.

Input of these schemes in nature to the designs has been provided by taking the rules in in nature as a guide prior to the design. Vital living organs based on the living rules in nature have been accepted as prime element and have been matched as to the order of importance within the need program. Other secondary elements have been accepted as auxiliary element. Starting points allowing different movements to have been accepted as bond element and the system getting inspired from nature has been set up. It has been observed that these natural systems allow different spatial set-ups.

It has been observed that advantage of these systems is that their reproducibility is far more than existing systems. Its difference from the designs made by getting inspired from nature is to allow installation of the system by benefiting from functional features other than only formal features. Following completion of system set-up, environmental data has been taken into consideration. How identification of street and avenue where density of vehicles and pedestrians is available, prevailing wind direction, Northern direction, topography, geography etc. affect the system has been investigated.

This system has been accepted as a building module by assuming the fact that need for several buildings in large scale is in question following completion of the system whose design data

has been processed; how building modules have been juxtaposed under the guidance of these disciplines has been investigated.

Gradual clarification of the process while performing this generation has enabled controlled progress, alteration and expansion of the design within this mechanism. In this study conducted for implementation, the rules and the parameters formally converting the rules have supported that the result product is significant and diverse. In conclusion, it has been identified that developed model will be of significant help for architectures in both generating formal alternative and decision process.

As a result, an alternative model has been created for building organizations flexible for multi-functional growth. It has been observed that this model has been brought forth by using the disciplines within nature to an immense system expanded and jointed to different directions. This system has saved us not only from vicious cycle and customary systems and but also from formal inspiration.

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