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Self-Organization Analysed in Architecture using Voronoi Tessellation and Particle Systems

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Abstract- Natural environments if observed closely are in transition, activated by unseen forces, the undefined rules of selection, and intricate relationships. One of these inspiring phenomena is commonly known as self-organization which can be witnessed in almost every living organism. This research is delving into experimenting with translating this complex natural phenomenon into architecture applications by using Voronoi; a digital plug-in Rhinoceros that can help to translate self-organizing systems into architecture. This academic research elaborates on how this plugin can be used to design complex spatial forms and different elements of an architectural structure to produce inimitable solutions. Various systems are developed with the help of Voronoi tessellations on Grasshopper linking it to different self-organized organisms. This transformation of self-organization phenomena into architectural elements is then compared to present out of the box opportunities for architectural projects.

Keywords- Voronoi Tessellation, Self-Organization, Sustainable Architecture.

I. INTRODUCTION

Every climate and environment have such organisms that can exist, survive and adapt themselves to particular conditions but human beings are a superior species that have to create an adaptable shelter according to their surroundings and fit in with the context of the site. But in today's world, human beings are creating such structures that are impacting the environment negatively. There is a need for such structures that need to act like an organism of nature and contribute to improving environmental health. Self-organization in nature is the ability of a structure to adapt to natural and social changes that occur over time. The Voronoi plugin rhino is a mathematical tool that helps to apply self-organization systematically. It is a bionic method that divides the surface in such a manner

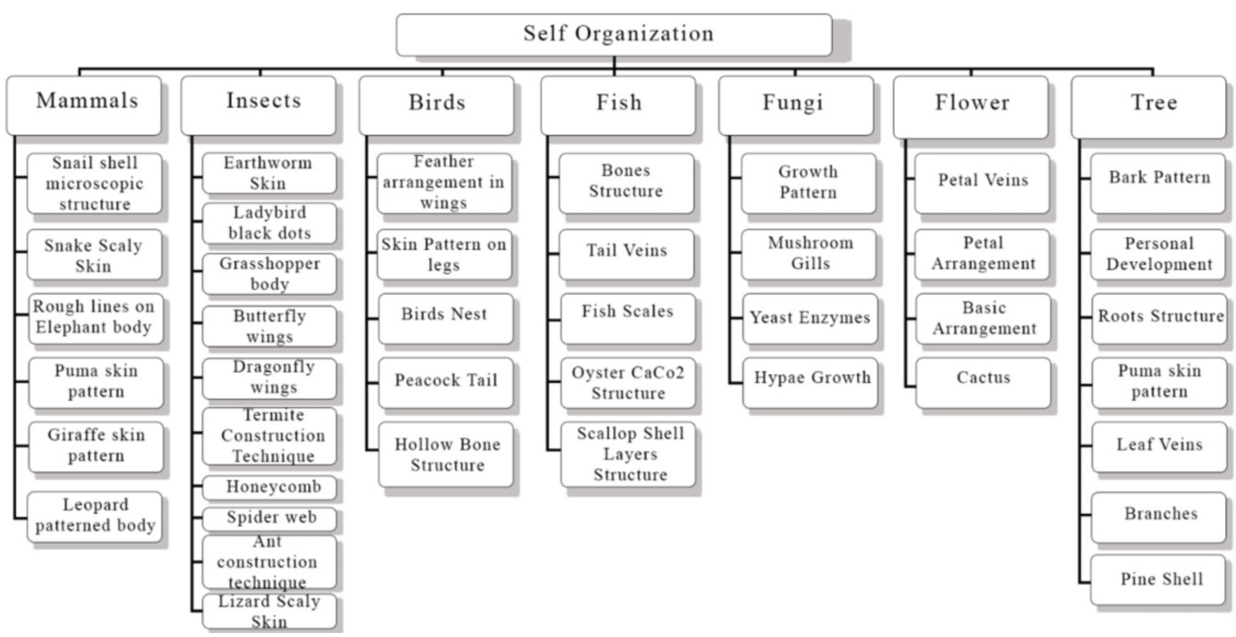


Fig 1: Self-Organization through Voronoi Diagram in Natural Organisms. Source: Author

that new original structural elements can be designed in architecture. It is an optimal solution to space division. The purpose of this research paper is to study self-organization systems in nature and how can Voronoi diagram be used to transform these complex systems into architecture. Self-organization will be called, spontaneous order, where different parts of an initially disordered system help to achieve an ordered pattern from local interactions. The method will be fast and spontaneous when an optimal amount of energy and light-weight is available, irrespective of the control by any external agent. A decentralized, distributed over all the components of the system organization is achieved.

Self-Organization in nature:

Order out of chaos theory alludes to a wide scope of pattern- arrangement forms in both physical and biological frameworks, for example, sand grains amassing into undulated ridges, chemical reactants shaping whirling spirals, cells making up profoundly organized tissues and fish combining in schools. An essential element of these different frameworks is how they get their order and structure. In such frameworks design arrangement happens through interactions inner to the system, without outer coordinating impacts [5]. Figure 1 shows that self-organization occurs in almost every specie in nature.

Voronoi Diagram

The Voronoi map produces a space-filling topological structure and is one of the most principal and essential constructs characterized by unpredictable and irregular lattice, underlining its great pertinence in displaying natural phenomena, the examination of their numerical, specifically, geometrical, combinatorial, and stochastic properties, and its PC based constructability and portrayal. The Voronoi approach partitions the entire space into a lot of sub-spaces as indicated by the appropriation of the articles. Every vertex speaks to the focal point of a Voronoi-cell and accordingly has its own Voronoi space which characterizes verifiably the spatial contiguousness with the adjoining objects (or the "impact space" of the objects). Inside the Voronoi-cell, contained areas are nearer to that object than to some other, and along these lines make a spatial relationship.

Voronoi is mathematical formula or tool for the division of spaces into sub-spaces in an organic manner. The use of the parametric design in Architecture and Urban design has increased the use of the Voronoi diagram. Architects and designers take inspiration from self-organizing systems in nature and adopt it in aesthetical and structural elements of architecture. Architects are using a Voronoi tool to obtain organic pattern buildings and natural patterns. The same methodology is being adopted here to study the results generated.

II. Literature Review

Mathematical models are used to represent the processes in nature and ideologies of the self-organization of biological structures. Voronoi may be a technique that permits dividing a multi-dimensional space into sub-spaces. The purpose of this research paper is to understand self-organization and its relation to the Voronoi diagram for establishing a self-organizing system that is flexible and adaptable to the environment. Self-organizing systems discuss the category of systems that may transform their internal structure and their function in response to external environments [1]. Over the last decades, a large number of features have been identified as typical for self-organizing systems. Self-organizing systems are dynamic, non-deterministic, and open and exist far from equilibrium. They are discovered both in living and non-living objects in nature [1].

In modern design architecture, there is a trend of developing complex spatial systems inspired by patterns in nature. Voronoi tessellation constitutes bionic methods of dividing the surface that can be used in architecture to design several original structural elements. It is observed that bionic structures like Voronoi are part of optimal solutions constituting rational bar systems due to the assumed minimum criterion [2].

Modern design methods depend upon understanding the processes of nature, by mathematical models that depict the principles of self-organization of biological structures. Bionic design plays a more meaningful role in shaping contemporary architecture and concrete spaces. The Voronoi tool and tessellations are an example of leading trends in architecture design. The Voronoi Tessellation describes a system of the self-organization of biological structures visible on the wing of a dragonfly, the turtle shell, honeycomb, or the shell of a sea urchin.

The purpose of using Voronoi is to ascertain a communication system and active response to changes and properties of the environment during which space it belongs to. The Voronoi geometry is an organizational phenomenon that's sometimes named “nature's rule”. they will happen at a spread of scales with different materials and forms [3]. The Voronoi Tessellations have been invented by observing the wings of a dragonfly, turtle shell, honeycomb, and the shell of a sea urchin. Times Eureka Pavilion designed on RHS Chelsea Flower Show in 2011 is an interesting example of an open pavilion. The formation of the pavilion structure was inspired by the principle of natural structures, their development and growth of plants, and then implementation of the Voronoi diagram in it. A similar example is the Alibaba Building Headquarters in Hangzhou in China. The Voronoi plugin is used to create its structure including deck atrium combined with the outer structure of the building [4].

The dynamic development of digital technologies provides architects with a new tool to shape the increasingly interesting spatial forms as a result of the multi-criteria optimization process. In modeling complex linked systems that accompany the architectural design, algorithms play an important role. Algorithm implementation is a form of the computer program which makes it possible to generate complex bionic structures. The process of area discretization using the Voronoi tessellation should be conducted differently in each case, just as there are different user needs and designer ideas.

III. METHODOLOGY

This academic research has been carried out by 4th-year architecture students under the guidance of the author. The main aim was to explore and learn from this unique yet very common phenomenon in nature and then trying to bring creativity in architecture by looking at the abstract possibilities of the process. The other important learning that is taking place in this digital studio is learning to maneuver this new plugin VORONOI for it to be used in architecture. The studio learning process of digital design often adheres to one of the biggest challenges which are the building the gap that exists between learning the details of architectural design with the help of digital tools and at the same time decoding the digital tools, skills, and techniques obligatory for instigating these set rules. We have been using generative design systems as valuable new tools but this study emphasizes design conceptualizing and critical thinking linking it to architecture design. The major intent is to adopt both formal and conceptual approach to be to developed simultaneously to produce out of the box design. Four different self-organized processes are selected and the work on those projects is presented here. Students were instructed to study and devise strategies that can translate self-organizing systems by using the Voronoi technique in Rhino and Grasshopper, to achieve unique results. The paper discusses the main theory and software results achieved by this exploration and presents a critical observation. Lastly in the discussion section, limitations of the Voronoi tool and its interpretation in architecture are discussed with specific attention to their role in digital design education. This purpose is achieved by looking at different natural systems in nature like honey bees, termites, etc., developing the systems in the Voronoi plugin inspired by the specific self-organized system and then producing proposals for their use in architecture.

Exploration I:
Swarm theory and its interpretation as structural components

"No ant sees a big picture. No ant tells the other ant what to do next. As a result, no leadership is required. Even complex behavior may be coordinated by relatively simple interactions."- (Swarm Theory)

The development of an embryo to the organization of large animal populations in nature highlights the mechanisms of Self-organization**.** Ants are a perfect example of how organisms build their structure through self-organization. Ants pick up grains of sand and drop it at a certain place at a constant rate of 2 grains per minute leaving a trail of chemical cues for other ants. In this way, the ants know where to drop the net grain of sand, forming a pillar. Thus, different environmental conditions, such as heat and humidity, affect the evaporation of the chemical pheromone which in turn influences the structure of ant nest. In this way, ants construct complex yet fully functional and reactive structures. It is also interesting to note that insects use self-organization to escape any hazard. The insects assemble into rafts made up of up to 100,000 members. The buoyant structures, that are as large as a dinner plate, can float for months, by making the colony enable them to survive and find a new home. Ants construct such structures for themselves that are breathable and waterproof. The ants create air-pockets by facing away from the ant it is connected to in the structure which results in a buoyant raft that is 75% air. Multiple connections among individual ants. The ants at the bottom of the structure survive by creating a water repellent lattice.

Interpretation through Voronoi:

To interpret this process on Voronoi a closed curve is taken, extruded, and connected to a z component in the grasshopper circuit shown in Fig 3. The extrude component is connected to the population 3D component which results in a 3D cuboid form as shown in Fig 3 and 5. A number slider is joined to the height value of the component and this helps in varying the height of the structure. The Voronoi 3D component is connected to the face value of the 3D component which divides the surface into discretized Voronoi polygons or cells. Brep component is the boundary representation element that defines the composition of multiple surfaces. If certain Voronoi cells are subtracted from the cuboid and the existing and the resultant form is will be able to sustain its form and be able to endure lateral and vertical loads. This configuration can help make building structures that are environmentally stable and can survive in natural disasters. The Voronoi cell can be used to divide a building block in such a way that it distributes the lateral forces equally in the whole structure. This helps in enduring earthquakes and tsunamis. Hexagonal shaped structural slabs inspired by honey bee cells can help in reducing the amount of material used and the cost of the project. Section's overall efficiency is increased by reducing its weight as the voids in the hexagon hollow out the slab. It eliminates the need for a post-tension slab.

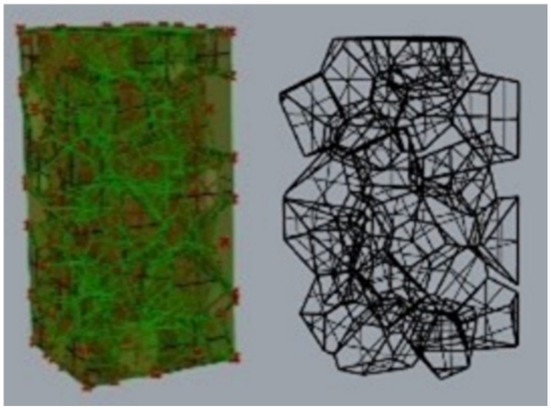


Fig 2: Application of Voronoi Diagram on 3D Cuboid Source: Author

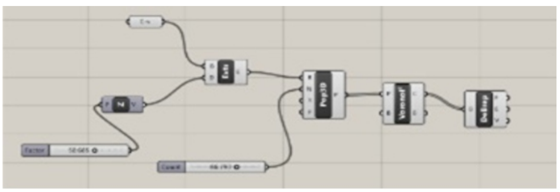


Fig 3: Grasshopper circuit Source: Author

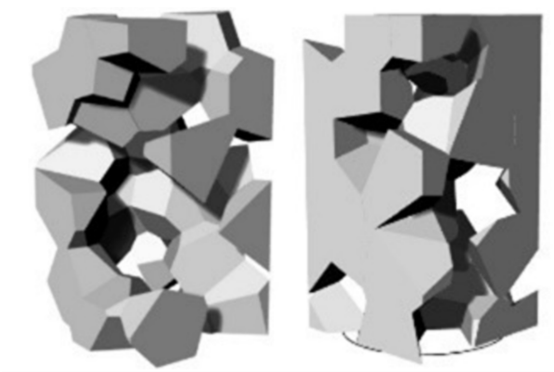


Fig 4: Rendered Voronoi 3D on Cuboid (Rhino) Source: author

Exploration II:
Honey bees nest construction versus space distribution in Voronoi

Space distribution is one of the biggest challenges that a designer generally faces during the design process. Honeybees construct their nests that consist of regularly arrayed hexagonal shells. Firstly, they form the baseline of the honeycomb by constructing a straight linear sequence of tetrapod structures. It is unknown how honeybees construct that initial pattern. After that worker honeybees secrete and attach wax, and excise the attached wax. The isotropic wax growth becomes the reason for tripods to connect. On the plane, several tetrapods connect horizontally in one direction and the elongation of cells starts. This structure also repeats in the vertical direction again and again until the whole honeycomb completes as shown in Fig 5.

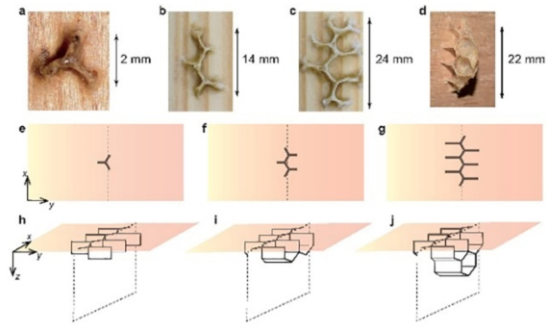


Fig 5: Self-organization in Honey Comb (http://journals.plos.org/plosone/, 2019)

Interpretation through Voronoi system:

In this method, the first two points are taken and connected to a box component to create a mesh in Rhino as shown in Fig 6 and 7. The mesh is then extruded and connected to the Z factor component so that a number slider can be used to change its height. A point in the mesh is taken in rhino and connected to the point parameter in grasshopper. It is then connected to the Voronoi cell component and the previous extruded

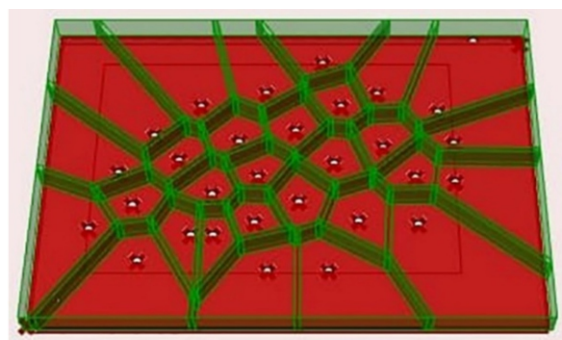


Fig 6: Voronoi cells formation in Rhino Source: Author

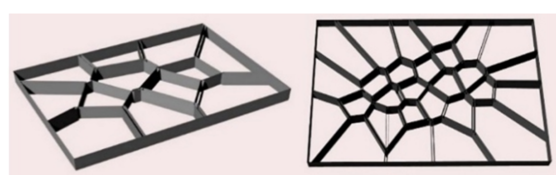


Fig 7: Rendered Voronoi cells in rhino showing it is top and perspective views Source: Author

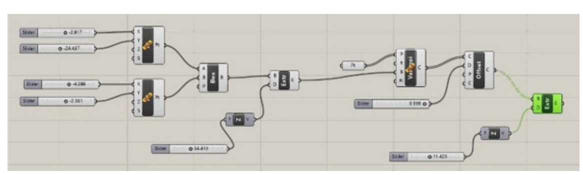


Fig 8: Grasshopper Circuit depicting the formation of Voronoi. Source: Author

surface is connected to the boundary value of the Voronoi. The cell value of the component is connected to the offset component and then extruded. This results in Voronoi cells that have several divisions that can be changed by the number slider shown in Fig 8.

Exploration III:
Leaf structure and bird flocking to create patterns for facade

Nature is not random but more geometric than we can imagine. It has its techniques and rules to make its structure unique, strong, and complete. Leaf of a plant also has a web of veins that divide its surface into many subparts and these subparts again divide themselves. This division method repeats and finally make the shape of a leaf. The division found in the leaves is Voronoi tessellation. By following the rule of Voronoi veins of a leaf spread throughout the structure in such a way that every cell gets an equal amount of carbon dioxide and water.

When a leaf starts growing, its major division starts that divide the leaf into two parts. After that, these two-parts start dividing further, and, in that way, the cycle goes on as shown in Fig 11. The major veins grow in a polygon pattern and mostly found in the central region where stress is maximum. The major primary vein's Voronoi pattern gives tensile strength against wind and the secondary veins increase the flexibility of the very structure. All the veins are connected and self-organize themselves in a way according to space and requirements as shown in Fig 9. Stomata are placed at the point of Voronoi cell and contain a space around it which is called the Voronoi space depicted in Fig 11. The number of stomata present in a leaf decides the final shape of a leaf and also the shape of every Voronoi cell. The more the number of stomata, the smaller the Voronoi cells and vertices of each cell.

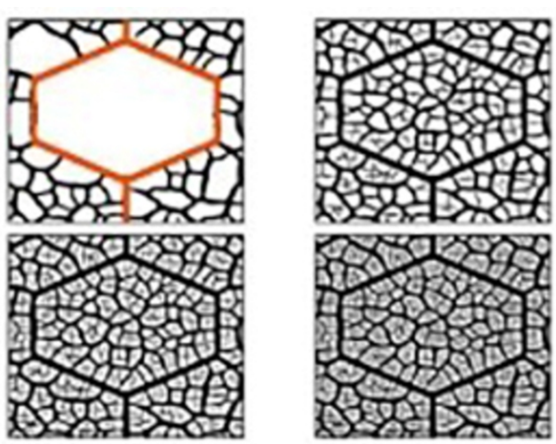


Fig 9: Voronoi pattern in the leaf
Source: Laguana, 2008

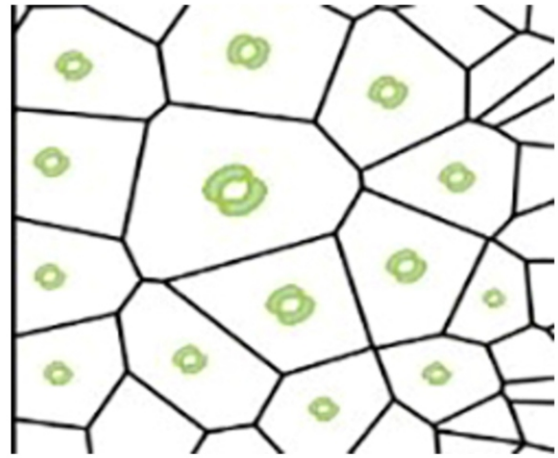


Fig 10: Stomata at the center of Voronoi cell

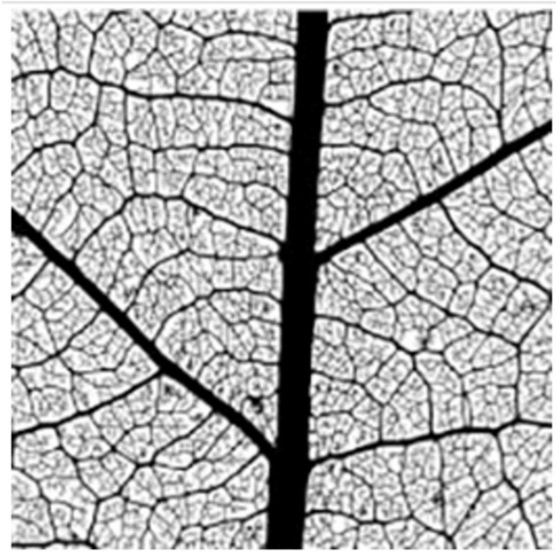


Fig 11: Process of Veins web division Source: Laguana, 2008

Plants are often thought to be stationary organisms. However, because the plants grow, they modify their shape and even positions. They are transported to other locations by the wind as they are normally hanging from the branches of the trees. Plants also show movements to adapt itself to external conditions, e.g. sun-flower buds can track the sun, touch-me-not Mimosa and Venus flytrap have movement abilities and stimuli by closing leaves to safeguard them and capture insects. Some plants are very sensitive to light and change their position or shape when getting a specific amount of light, whereas others, such as the Mimosa, are sensitive to touch. And we can also find such plants that follow the movement of the sun to get a specific amount of light and to stimulate their reproductive organs.

Interpretation on Voronoi:
In this method, the first two points are taken and connected to a box component to create a mesh in Rhino.
The mesh is then extruded and connected to the Z factor component so that a number slider can be used to change its height. A point in the mesh is taken in rhino and connected to the point parameter in grasshopper. It is then connected to the Voronoi cell component and the previous extruded surface is connected to the boundary value of the Voronoi. The cell value of the component is connected to the offset component and then extruded. This results in Voronoi cells that have several divisions that can be changed by number slider shown in Fig 12. In this way, this structure can be used horizontally (space division of a site or a room) and vertically (building façade).

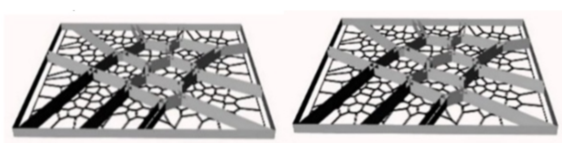


Fig 12: Primary and secondary Voronoi webs make the structural grid stronger than any other grid
Source: Author

Exploration IV:
Bird flocking
The self-organization phenomenon is depicted well in the Bird flocking as no individual bird is responsible, yet the flock as an entire organizes itself into beautiful patterns. Each bird adjusts itself according to its neighbor's position and direction of motion, but nobody is that the leader. Bird flocks self-organize themselves and make v formations so they travel long distances, this formation allows the birds to save lots of energy, by taking advantage of the upwash generated by the neighboring birds. Birds can self-organize supported the air pressures generated by the opposite birds and by communication during flight formation [6]. The individual birds fly while employing ingrained rules that separate themselves from their neighbors. However, the looks and behavior of the flock tell us nothing about how each bird is behaving. to reply to the actions of predators, birds flock constantly change the form. Yet, the behaviour of the flock is defined solely by the actions of individual birds who are each following a group of inbred flying rules that relate only to keeping a specific distance concerning each of their nearest neighbors, obstacles, and predators. you may never add up each of the individual bird's actions to define the shape and behavior of the airborne flock. this can be characteristic of a fancy system.

Interpretation on Voronoi:
The Hexagonal component genes used to create a hexagon grid as shown in Fig 13. The output points give center to each hexagon. This is used to measure distance and as scaling centers of hexagons.
The distance component plays a key part in this process. It is used to measure the distance from the attractor point to the center of each cell. As an output, it gives one value for each hexagon in the grid. Now we have to adjust the effect of this output value. we use the division component. It divides the distance by a factor, shrinking its effect or area of influence. Finally, by limiting the effect to shrinking the hexagons rather than making them larger, a minimum component is used to return the smaller value – by using a scale factor of 1 as shown in Grasshopper Circuit in Fig 14. The values are larger than one will be set as one. This keeps the distant hexagons beyond the range of influence at their original size.

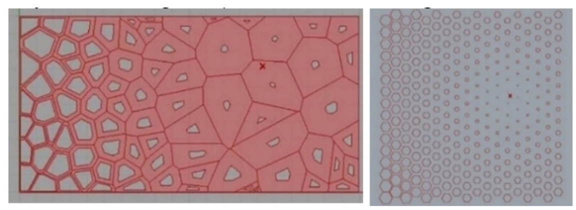


Fig 13: Variations in the Voronoi cells

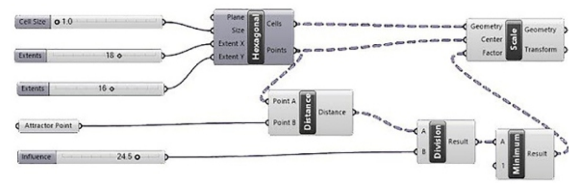


Fig 14: Grasshopper circuit

IV. Discussion and Analysis

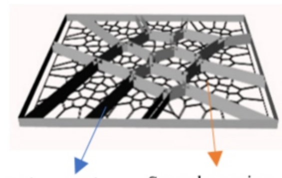
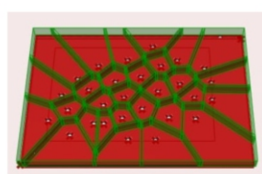
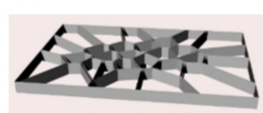
With the thriving invention of the digital design techniques and processes, the designers are becoming more aware of the insertion of knowledge from natural processes in architecture. The added advantage in this age and era is the easy access and the ability to use generative modeling tools and techniques for innovative and sustainable solutions to architectural problems.
Self-organizing systems are dynamic so dynamism is the next path to follow for the architectural process as well. Such systems require continual interactions among lower-level components to produce and maintain the structure as they are dynamic which ultimately carves out the self-organizing systems. This point is made is more clearly by contrasting a dynamic process of pattern formation with an alternative, essentially static process illustrated by the assembly of a jigsaw puzzle [5]. A jigsaw is a global structure with an intricate pattern formation constructed from lower-level subunits, the pieces of the puzzle. The pieces are put together in a precise manner to create a pattern. Each piece of the puzzle has a particular shape and set

of markings that complement the shape and markings of the pieces to which it fits. To create the global pattern, one carefully matches the pieces together, and once the pieces of the are fit together the action stops. The patterns and structures are locked into place. Edelman [8] provides a lovely metaphor for such a static mechanism of pattern formation in his discussion of the role of cell-adhesion molecules in regulating cell movements and morphogenetic processes during embryological development. This is shown in Table.1 which shows a comparison between the Application of Voronoi Diagram in Architecture by Taking Inspirations from Nature.

There are two alternative ways patterns might be formed at the cellular level without the direct intervention of some kind of' 'little architect" or "constructive demon". The first way requires pre-labeling all cells with molecular markers [presumably proteins], each one spatially complementary to some other marker on a cell to be placed next to it in the pattern [8]. This is essentially how parts of the great offshore abbey of Mont-Saint-Michel were built. Stones were cut and shaped on the mainland, marked by their makers and reassembled on the island according to a plan. The Mont-Saint-Michel model is a metaphor for various “chemo affinity” theories of cell adhesion. The major difficulty with such theories is that if the pattern to be formed is complex, it has many variations in shape or as many elements and much local detail [for example in the brain] then the number of specific surface markers determining each cell's location must be enormous. Since such markers are most likely to be specific proteins, each encoded by a different gene, the number of genes would be correspondingly large…. Moreover, a pattern made this way is prefigured and essentially static: once the right markers come together, no further dynamism is necessary [5].

This methodology to evolve architectural design by getting inspired by these organized systems which are adaptable and transform according to the surrounding environment is pertinent for the architecture of the future. The use of these latest tools to produce multiple and unique solutions for certain parameters is very useful for the development of sustainable design in the future. Voronoi is a very useful plugin for space discretization methods it can be easily used for architectural and structural efficiency. After performing these test runs of self-organization methodology with the help of the Voronoi diagram, it can be stated that several proposals can be presented to improve the design process of a building beginning from the design of a façade to space allocation to interior wall meshes design. During the current era, there is a pertinent need to make structures that goes well with the environment as well as improve environmental health. The projects presented here suggest a methodology that how by taking inspiration from a natural process like self-organization and Voronoi plugin one can produce some realistic options to certain problems in architecture [7]. The experimentation like these should be conducted and adopted by designers so that we can produce, sustainable, environment-friendly, and user-friendly structures in the future. This methodology will not only improve the environmental and structural problems but also is beneficial for architectural students to think differently and learn from mother nature. These type of spatial diagrams as produced by these experimentations processed through simulating singularities of space, material, surrounding environment, and sequential reactions emphasizes that contemporary architecture is evolving into a simulation. The education of contemporary architecture, therefore, has to involve simulations and tessellations as a self-sufficient design-tool and methodology to comprehend complex integrated relationships. These simulations produced by the Voronoi systems depict that use of algorithms in programming with these novel tools are transforming architecture [4]. When we are conducting experiments like these and developing languages as in Grasshopper or Voronoi, the lesson learned was that it is important to develop an eye to identify and decipher the pattern that is essential for the development of design process. Therefore, the personal involvement between student and the process of system algorithm ensure better understanding and knowledge about patterns, their associations, and linkages. This methodology teaches one to work with process whether visually or in a form of tessellations, generated by the students' decisions. The “system-view” of architecture which has the objective of designing a system rather than a form will change the approach in which we study and practice architecture; and will likely create an increase of quality in architectural design [7].

Table 1: Summary of Application of Voronoi Diagram in Architecture by Taking Inspirations from Nature

Type	Inspiration from nature	Application in Architecture	Author Interpretation	Author Interpretation
A Voronoi diagram in leaf structure	It makes the structure of a leaf by dividing its surface into smaller parts and distribute carbon dioxide equally . It also plays an important role in making the structure strong and flexible.	It can be used as a structural grid in the building façade. Building blocks constructed from Aerogel or concrete can also make the structure strong, flexible, and environment friendly.	Basic Leaf Veins Complex  Primary veins Secondary veins	Primary and secondary Voronoi webs make the structural grid stronger than any other grid. This structure can be used horizontally (space division of a site or a room) and vertically (building façade)
Termites	Termites pick up grains of sand and drop it at a certain leaving a trail of chemical cues for other ants. In this way, the termites know where to drop the next grain of sand, forming a pillar. Air-conditioned by internal tunnels often oriented along the Earth's north-south magnetic axis.	Being used in Robotics to construct self-organized pyramids, castles, and towers. Building environmentally stable structures.	Application of 3D Cuboid on Voronoi   Exoskeleton Rendered form	We have used the Voronoi cell to divide a building block in such a way that it distributes the lateral forces equally in the whole structure. This helps in enduring earthquakes and tsunamis. Application of 3D Cuboid on Voronoi
Honey Comb	Honeybees construct their nests that consist of regularly arrayed hexagonal shells. A hexagonal cell stores the maximum amount of honey by utilizing the minimum amount of wax used for its construction.	"A hexagon is the most appropriate geometric form for the maximum use of a given area." Stable structure Help reduce the material used and increases stability.	 honeycomb chambers and cells Points around which cells are made.  3d rendered form	Honeycomb hexagonal structure is an efficient way to divide a surface into subparts. It can make a delicate yet strong web that can make the framed structures and surfaces by dividing the load equally in all parts. It can be used as the façade of building by covering the front wall and the cells inside the frames can be used as windows. This structure can be used vertically as framed walls as well as horizontally as space planning.

V. CONCLUSION

The internal features of their components determine that self-organization is an effective way to construct complex structures. During evolution, selection occurs of the most stable, flexible, modular systems capable of self-organization. Physical and topological rules are essential for biological systems as an imperative that restricts and directs biological morphogenesis. The selection of self-organizing systems and self-unfolding modules of development leads to an increase in sustainability, reliability, and flexibility, i.e., adaptability and the ability to evolve. The selection of systems able to evolve leads to the acceleration of evolutionary transformations. Evolution itself is a self-developing, self-organizing, and accelerating process.

In the age of technology, the use of the Voronoi diagram is helping to shape structures innovatively and creatively providing a new working tool for an architect. It is being used as a model to generate multivariate solutions to a single problem. With the advancement in the digital design optimization process and the increased interest and awareness of architects and designers of bionic structures, Voronoi diagram has become a powerful tool to design several original architectural elements such as roofs, walls, façades, etc. As a result of the author's exploration of the Voronoi diagram in Rhino and grasshopper software, it is observed that the Voronoi diagram is flexible and can adapt and transform, an important feature of digital modeling. It can generate complex bionic structures within the boundaries of the chosen shape, it is possible to generate an infinite number of premises, links, etc. And verify the quality of the obtained solutions. This is a considerable advantage of digital space discretization and helps to enhance architectural and structural efficiency. In addition to space optimization, it is observed that the Voronoi diagram helps to reduce the material consumption and maximizes the structural strength of the structure, hence reducing the cost of the project. Today, we observe an increased interest in biomorphic trends, and the digital tools supporting architectural design with the use of different methods of the surface simulate the laws governing processes in nature.

The use of dynamic Voronoi façades helps cater to environmental pollution since the Voronoi cells have the ability to increase the surface area such that dirt particles stuck in them and only allow air to pass through them. The Voronoi façade makes the inner atmosphere clean. The Voronoi diagram also brings aesthetic to the form of the building by making it look like an organic structure. In this way, these diagram enables to build bionic structures that are inspired by self-organization in nature. On the other hand, the process of self-organization which has been touched mildly here is very complex and has many layers attached to it in complex ways [5]. This research opens doors for the academicians to further explore the subject and its complexity. The real challenge is to transform the knowledge extracted from this natural system into architecture. This requires a series of experiments with the help of the Voronoi plugin. The projects shared above are an attempt to perform this kind of experimentation. Results produced might be just basic and not very elaborate but few important observations are evident.

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