

The Formal Structure of the Voronoi Scheme and Its Role in Enriching the Decorative Design Considering the Morphology of the Structural Systems of Nature

Aya Mohsen Mashhour

Department of Art Education, Faculty of Specific Education, Benha University, Benha, Egypt

Email address:

ayamohsen1@hotmail.com

To cite this article:

Aya Mohsen Mashhour. The Formal Structure of the Voronoi Scheme and Its Role in Enriching the Decorative Design Considering the Morphology of the Structural Systems of Nature. *American Journal of Art and Design*. Vol. 8, No. 2, 2023, pp. 71-81.

doi: 10.11648/j.ajad.20230802.18

Received: May 21, 2023; **Accepted:** June 12, 2023; **Published:** June 27, 2023

Abstract: The modern movement in design did not emerge from non-existence but has been the result of constant and significant development in the new construction methodologies that are followed by many, such as the ones focused on nature that have regular or irregular construction systems which are superimposed or grids. As well as others that are aligned with the role and aesthetic value that distinguishes each element from one another, one such grid structure is evident in the dragonfly wing. This structure was one of the most important sources for Voronoi Diagrams that enables the dividing of surfaces and spaces in an unconventionally engineered method. Therefore, the designs were implemented using the real color combinations that belong to the external appearance of a dragonfly in nature that has always provided a wealth of examples, as it is the source and backbone of the study. Nature is the first tutor for man and the source from which every artist has adopted their fine artistic values through direct observation and analysis of its elements which he observed and formulated through his own and diverse method. After the study of the morphology of the dragonfly the researcher has foreseen that the utilization of the true colors of the external appearance of the dragonfly and Voronoi diagrams as a structure will enrich the designing experience and offer the designer new and innovative solutions.

Keywords: Voronoi Scheme, Formal Structure, Design, Structural Systems, Morphology

1. Introduction

By beginning of the twentieth century, there was a general boom in all fields, specialties. This boom was a result of the scientific development and the technological revolution in all fields. The plastic art was one of the fields that have been hugely impacted by such development, the artistic work had become a broad field for examining different materials and adding new techniques which are turn contributed in emergence of many modern artistic concepts. The decorative design in specific is one of the fields that emphasizes on studying the variable and fixed systems in nature to identify the variable formal structure of natural components through a new vision, such vision inspires the designer to follow the formal structures, components and grid system of nature through modern vision. One of those systems was the Voronoi Diagram as a formal structure inspired from the

morphology of the nature formal structure. The studies conducted by natural scientists have played significant role in revealing such systems as well as detecting the natural phenomena secrets and illustrate them. Therefore, the artists had benefited from such applications and especially in the field of decorative designs. Accordingly, modern designs emerged based on the philosophy of many of those theories since the formal structure can be utilized through studying the Formal Structure of the Voronoi Scheme¹ and its Role in Enriching the Decorative Design Considering the

¹ Georgie Voronoi* (1868-1908), inventor of an original method of schemes, and pupil of renowned mathematician Andrey Markov. Georgie Voronoi graduated from the Department of Physics and Mathematics at the University of St. Petersburg, and later served as Professor of Mathematics at the Imperial University of Warsaw. One of his students was a prominent Polish mathematician in the future Wacław Sierpiński. In his short French, he described the method of schemes, or polygons, which became known as the method of Voronoi schemes. [1]

Morphology of the Structural Systems of Nature in terms of figure, color, function, texture, compositions and other aesthetic values of the designing operations and utilizing that for enriching the decorative design. Therefore, the science has contributed in creative, innovative and unique artistic movement in terms of form and content which was achieved by designers who could illustrate the analytic vision relied on the accuracy of scientific observation.

1.1. Issues Raised by the Study

The nature deserves to be studied in order to reveal its artistic values and formal structures that represent triggers and passion sources for the designer and his creative ability that enable him to practice, experience and benefit from such factors in formatting creative designs through using the variable formats in nature that represent the basic source for inspiration in designing. Therefore, the research urge for contemplation on beauty of nature figures and formats to achieve the best creative designing solutions.

- 1) What is the possibility for benefiting from morphology of nature formal structure as an inspiration source for innovative decorative designs?
- 2) What is the possibility for benefiting from Formal Structure of the Voronoi Scheme and its Role in Enriching the Decorative Design Considering the Morphology of the Structural Systems of Nature?

1.2. The Study Objectives

The study aims to:

- 1) Identifying the aesthetic dimensions of formal structure relations and its' impact on the decorative design.
- 2) Benefiting from the formal structure for impacting the decorative design.
- 3) Studying the Formal Structure of the Voronoi Scheme Considering the Morphology of the Structural Systems of Nature to inspire creative decorative designs.

1.3. The Study Significance

The study significance can be summarized in the following points:

The formal structure can be utilized and methods for analyzing it through studying the (Voronoi Scheme) and dragonflies morphology in terms of shape, color, function, texture, composition and others to enrich the decorative design.

2. The Study Terms

2.1. The Formal Structure

The structure of the external appearance of shapes. Such structure can be reflected in the formal structures as various systems such like regular and irregular natural networks. Structures may be geometric or organic structure, through analyzing such structure we can reconstruct them in a new form.

2.2. The Voronoi Scheme

A method for fulfilling the spatial data into polygons around each point in a manner makes each point of a surrounding area of certain point closer to such point than any other point. This method was invented by a professor at University of Warsaw more than 100 years ago and it has been applied in several specialties of science all around the world and it has been applied in modern applications in the digital era as well. [1]

2.3. The Decorative Design

Decorative design is known to be re-organizing and rearranging the components based on various iterations using grids and structural systems to create new and creative figures based on integrated system to achieve specified thought using formal particulars based on number of structural basics aiming to achieve the expressive notations to reflect the aesthetic values.

2.4. Morphology of the Structural Systems of Nature

Is the iterative and structural process through which the nature components shape to create integrated figure that apply the aesthetic laws. The Voronoi Schemes are included within the grid Structural Systems.

3. The Methodology

The study applies the descriptive analytical approach in the conceptual framework and the quasi-experimental approach in the experience applications:

3.1. First: The Conceptual Framework

- 1) Study of the structural form in designing processes.
- 2) Study the relations in design structure and the role of Formal Structure and the Voronoi Scheme.
- 3) Study the Morphology science for dragonflies in nature.

3.2. Second: The Applied Study

- 1) The dragonflies was selected due to the aesthetic elements of it that enrich the decorative design field. We always seek for creating modern executive and designing methods, therefore we have to go on continuous innovation to make modern art works.
- 2) Implement designs inspired by Voronoi Scheme as form structural of decorative design.
- 3) Implement designs in real color groups, especially for the exterior appearance of dragonflies in nature. The nature is rich of systems, its' the source and the store and considered the first tutor for man and the source from which each artist gets the plastic art values through meditation and direct analysis for nature components as he shape its' components using his own style. Hence, I believe using the real colors of exterior appearance of dragonflies will enrich the design experience and provide the designer with modern and

creative solutions.

- 4) Decorative designs of 25 X 35 CM area were implemented using structural axles inspired by Voronoi Scheme using gold leaf, white and black ink pens to create some texture as well as using the colour gradients distinguishing the dragonflies and papers shaped as foliage. As for the dragonflies shape, it was implemented using 3 Doodler pen for the wings, pulp for body and was then painted using the proper colour gradients inspired by the colour gradients of dragonflies in nature.

4. The Integrative Relation Between Nature and Art

The nature is the store of shapes where the man wanders, since the first day on earth, man was doing his best efforts to make natural resources matching him and fulfilling his human needs. This process was the main condition for resources exchange between human and nature and the standing condition the nature imposes on human life.

When man depends on his senses to understand the nature, this can be only achieved through direct vision to the surface captured by eye, ear or touch sense only. But man had strived and invented means allowing him to see more such like magnifying lenses, microscope and telescope, such inventions helped him to record what happens under the seabed or at the lunar surface. The super-fine cameras could record facts exceeding the human senses, these tools helped man to see and study the nature, reveal its' secrets and see invisible beings.

The concept of nature for the designer varies according to the different situations. At ancient time, the concept of nature identifies according to what is seen by naked eye or touched by hands. The relation between nature and art was associated with simulating the nature until recently. No matter how the shape of those structures changed through diversion or abstraction, some representation of nature remains.

The relation between nature and art began with artists and philosophers under the theory of fully simulation of nature; this theory has then developed to include the nature in addition to the artist sense and character without breaking the laws of nature, then the concept improved to include essence of figures in nature till it comes to abstraction and separation between art nature as the art is a human and creative work representing the human values, hence, there is no unified shape for representing the nature, it varies with artists, their believes, eras and thoughts. [2]

The structure of the transformation in nature means any change occurs in the formal and internal structure.

That is, each element of The formative elements possess constructive systems.

Such as terms of transformation in Movement trend, situation, growth or gradual increase in Size as occurring in the natural.

The substance in nature is transformed in special circumstances from a state of Untied status and vice versa. [3]

5. The Significance of Studying the Structural Systems of Nature for Designer

The concept of nature varies for artist according to the different environmental situations. All of us appreciate the beauty of flowers, tree leaves and other figures at nature, even the wonder world under telescope have its' concept and features for scientists. There are some realities of designs at those various shapes and there are other multiple models reflect the system and designing in nature.

The nature has special significance for the artist since it represents the nature store surrounding him, it shapes his artistic memory and support his expressive emotion and provide him his motivations to interact with it in his artistic works. Such impact may be direct through simulation or indirect through the expressive reflection.

Adapted from: Ihab Besmark "The multiple shapes nature has reflected on the artists' works after they felt it by their instincts, there are similarities between the Elementary Forms that shape the nature and can be observed everywhere in the globe such like the vast distances between stars and in cells and molecules of microscopic material, each of them follow simple mathematics laws and reflect the existence of well-structured organization in the appearance and interior of nature. [4]

If we look at the significance of nature for the artist, we will find that the nature is the sole criterion to search for figure. The term nature represents the organic and motor life process, so it includes man also. Through describing such figures and their features and aesthetics traits we will discover how such description was impacted by its' individual and primary characteristics, but the general characteristic lies in the fact beyond causes of organization. All figures and structures are correlated with its' role in nature and life. The basics beyond the natural beauty is the structural law that parts and components of natural figures was organized based on it, such structural laws can be simply turned into mathematical laws and theories and turn into inspiration sources for the artist.

5.1. What Is Design

The design is the implemented invention that meet man needs in life or the creative work that achieve its' purpose. Also, design can be turning of certain subject or thought into figure includes artistic values.

Hence, The design is the process of configuration and innovation, i.e. gathering figures from the environment into certain figure to create something with function or meaning. Some people may differentiate between configuration and design. Configuration is a part of the designing process that merges the human thinking with the personal experiences as a basic human act. Configuration also is the process of organizing and harmonization of elements or inner parts into a whole figure, so it combines between the aesthetic and practical side.

The good design is the creative output that achieves its

purpose. i.e. the parts of design were made using suitable materials. Finally, if the general figure is finished in a well-organized manner we can classify the design as good design.

The design is a process carried out by people to improve the quality of their innovations. Design and planning is correlated, the main difference between them is that when you reach a certain level of experience and awareness we can call such action a design not planning. So, when the project reaches high level of complication, the term "planning" become unsuitable for it and the term "design" becomes the suitable term to describe it.

5.2. Phases of Designing Process and Inspiration from Nature

Allah "Almighty" created beauty in everything in nature, human being or animals and distinguished man with mind to innovate and realize the beauty around him.

The design elements are the vocabulary of form used by designer, the designer go through two processes during drawing inspiration from nature as follows:

(1) Internal Process:

Connected with his cognitive abilities i.e. culture and good selection abilities.

(2) External process:

Represented in the relations with nature, since the design process relies on the visual organizing and how the designer sees the nature. The more the attraction of nature the more the need to reflect its' beauty in an automatic way. The nature is the main source of inspiration for the designer since it includes multiple components of designing elements and it's distinguished by ever-changing in visual features according to changes in the environment.

The human being connects with his environment through the perception process. The perception process allows him to know the external world in a sensual manner. Through the continuous connection with environment and world, the human being acquire and accumulate his experiences, hence, the perception process is an ongoing and progressing process.

The art student usually start their study by studying the elements and principles of design along with the natural sources that shaped the multiple and overlapped figures. The nature and its' systems and laws is the first rich source for the artists to extract their elements and structural vocabularies. The designer may use the circle as a basic unit of design with fixing its' space and color and changing its' movements and iterations only. The designer may increase density of circle at some parts of his artist work and reduce it in some other parts to achieve the sense of depth or distance. The visual nature in its' shape and infinite forms the richest source of designing elements. On the other hand, the invisible nature that can be observed and analyzed by the nature scientists using the telescope also reveal many cosmological mysteries where several aesthetic relations exist.

5.3. The Intellectual Trends of Contemporary Design

Refers to the trends, principles and visions adopted by the

designer to reach successful designing solutions.

The designer is the first party on the designing process who adopts the certain trend or approach to express it through his work and the recipient is the second party who make effort to understand the art work and interact with it.

By the early 20th century, several designing trends emerged generally. A huge trend towards nature had emerged such like the environmental and organic thought in all fields of designing.

The structure of visualized figure in the applied aspect or in art includes many morphological and shaping treatments, such treatments stemming from the variety of formal drafting. Success of such structural designs depends on the success of designer and artist in selection, organizing and formatting the structural relation he adopted taking into consideration the ideal selection of configuration as one of the most significant structural approaches responsible for transmitting the included visual message directly to the recipient.

6. Manifestations of Formal Structure in Nature

The modern designing movement hasn't come by chance; it's the output of observed development in the modern structural approaches. The formal structure systems in nature varied, some of them may appear in the form of a compound with a regular or irregular repetitive structural system, other systems may be intertwined, reciprocal and other structural systems that are commensurate with the function and aesthetic value that distinguishes each element from other elements.

The structural systems are among the natural phenomenon with broad spread, it can be found in many natural images and elements. Some structural systems exist on earth, others may be at deep-sea, in the plant world and human. Others may be in more precise parts that can't be seen by naked eye such like some species of bacteria, fungi or insects, etc. Each structural system have its' format that form according to systems and laws reflect the creativity of Creator and His greatness Almighty.

Many artists have adopted the formal structure in their various art works as one of the important design relations that add aesthetic value to the art work, enrich it and distinguish it from other works, whether this structure was (total or partial, real or imaginary) along with variation of materials used which play a role in shape and nature of the compound.

6.1. The Aesthetic Images of Formal Structure in Nature

Refers to the abstraction of the formal structure from the nature to the structural relation of the image, so it is shorthand to elements represent the units used in the structural design.

In order to reach this phase, we shall go through several phases, as follows:

(1) Simplification and summarization.

(2) Distinguishing and classification of elements into

various patterns.

- (3) Dividing and fragmentation of units into structural units.
- (4) Highlighting the formal structure distinguishing the elements in form of formal structure.

6.2. The Formal Structure in Nature Can Be Divided into

- (1) Formal structure visible by naked eye.
- (2) Formal structure visible by telescope.
- 1) Formal structure visible by naked eye.

It can be realized and seen without any telescope. Through seeing the outer surface of the elements or the inner element shaping such elements through analyzing horizontal and vertical sectors of some natural elements where the structural system exist at its' inner parts whether those elements are living beings or inanimate objects.

- 2) Formal structure visible by telescope:

There are many figures and natural elements that can't be seen by naked eye to realize the different forms and shapes of compound. The naked eye is a term used at the scientific references that refers to seeing certain object or event without using visual aids. The beings study concept has been changed as a result of the modern scientific changes and the various discoveries. Realizing and understanding the formal structure is no longer depending on the external figure only, it has been broaden to include the system underling inside the shapes and the laws control the growth of the nature that can't be seen through the direct vision.

The Morphology of any figure is the shape of this figure parts that interlink with the outer line of the figure, such part has a room of space and basic features that could be felt and realized by touch or through the shade of such figure.

7. Morphology

Morphology is the branch of biology dealing with the form and structure of organisms and its' distinguishing characteristics in term of shape (form, structure, color, pattern and size) as well as the figure and components of the inner parts such like bones and organs (anatomy). Morphology is the opposite side of the physiology that basically concentrates on the function. Morphology is a branch of life sciences that deal with phenotypic structure of an organism or taxon and its constituent parts. [5]

7.1. The Dragonflies Main Morphological Qualities

Dragonfly, (suborder Anisoptera), also called darner, devil's arrow, or devil's darning needle, any of a group of roughly 3,000 species of aerial predatory insects most commonly found near freshwater habitats throughout most of the world. [6]

The dragonflies have super-fast flying speed and high maneuvering abilities due to its exceptional design wings and supernatural vision system that make it a source of inspiration for the major helicopter manufactures. The dragonflies is distinguished with its' external solid structure.

The dragonflies also have back wings short and wide if compared by the front wings, the dragonfly's body looks like spiral structure encased in metal since the wings harden with the body, their color is graded from the snow blue to dark red. As for the dragonfly's eyes, they are considered an innovative model for insects eyes, each of which is approximately half the size of the head. The abdomen is long and cylindrical in many species, but it may be short and relatively wide in some species. The dragonflies have pair of legs.

7.2. Differences Between Dragonflies Male and Female in Term of Figure

- (1) Male:

The dragonfly male is little bit thin in the abdomen in some species and has genital appendages.

- (2) Female:

Abdomen of the dragonfly female is more thick and has egg-laying appendage at the end of abdomen. (figures 1, 2)



Figure 1. The dragonfly male The body seems thin [7].



Figure 2. The dragonfly female The body seems more thick [7].

The dragonfly has a pair of spherical compound eyes that can distinguish colors sharply; In the forehead there are three eyes that can distinguish between light and dark and help in navigation during flying. In the dragonfly's forehead there are two short antennae, those antennae are tactile receptors. The mouthparts are on the underside of the head and include the mandibles for chewing. The dragonfly is one the biggest insect in terms of eye size comparing with the head size since the two eyes represent half of the head size, in front of each eye there are lenses. The super vision system distinguishes dragonfly, the full image for the dragonfly is forming from all images received from those small lenses. This is due to its' large eyes that extend till back of the head and enables it to

monitor everything around, it provide it with 360 degree field of vision.

The dragonfly speed is another feature distinguishing it and helps it in hunting; dragonfly speed reached 95 km/h, it can make acrobatic movements in the air that no other living being can do, as it make sharp horizontal and vertical maneuvers, which help it to catch the flying insects that it feeds on, therefore dragonfly was classified as predatory

insect that feeds on other insects. [8]

Dragonfly wings have a network of veins, the wings between such veins are generally transparent, but it may be partially colored. Usually the wings are colored and boarded with veins that is distinguished with natural structural network (figure 3), such structure was the main source for Voronoi scheme to divide the surfaces and spaces in non-conventional geometric manner.

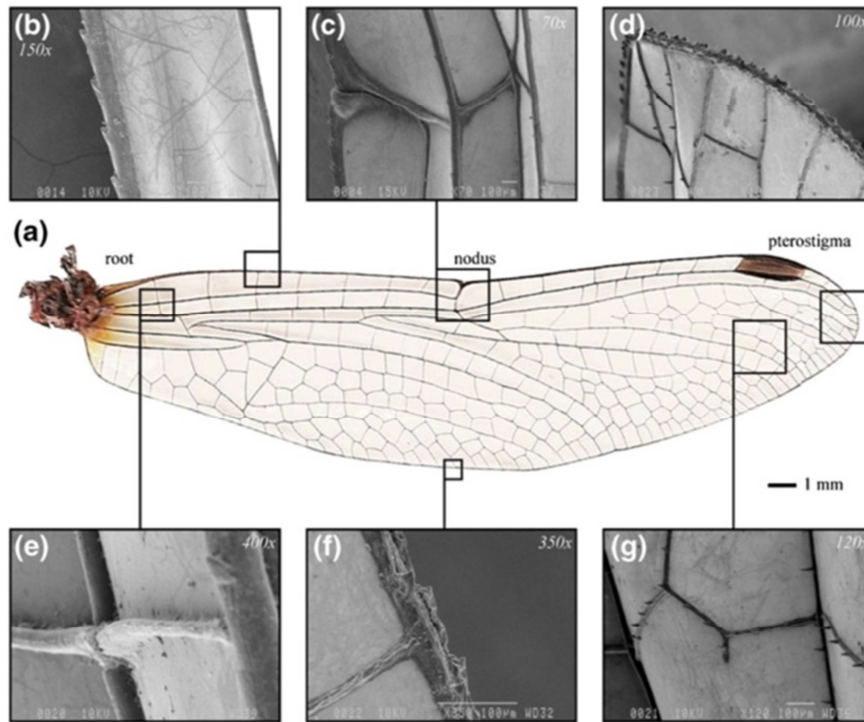


Figure 3. Illustrating the network of veins that shape the wing of a dragonfly, which is the most important source for the Voronoi scheme [9].

The dragonfly wings are also considered sources of inspiration for many scientists. Depending on the nature simulation theory where the industrial products are developed through simulating the nature, dragonfly wings seems like bejeweled wings. [8]

The secret of dragonfly speed lies in the strong wings that

consist of thousands of small pieces linked to each other, it seems like a chart full of connected lines which enhance its' strength. The dragonfly speed, strength of wings and horizontal and vertical maneuvering abilities have inspired the helicopters manufactures to simulate this insect (figure 4).

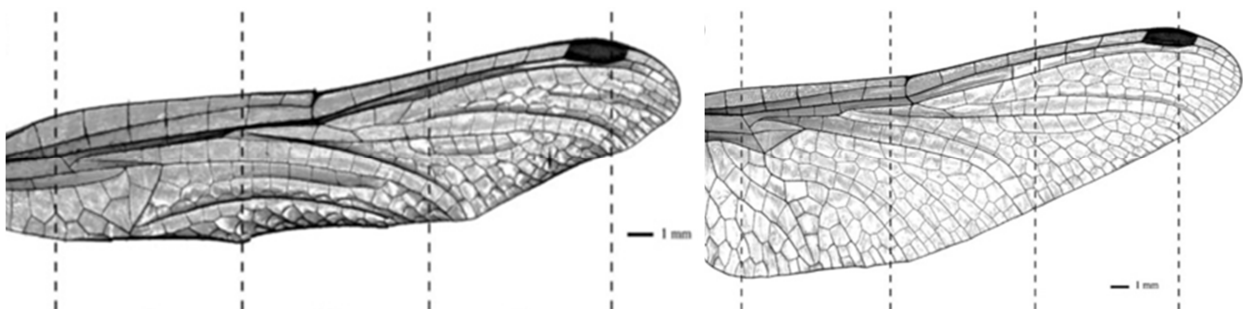


Figure 4. Form of dragonfly wings Morphology and differences distinguish each of them according to the environment of coexistence Example of dragonfly Morphology [9].

The legs are used for catching and handling prey, for catching females, for fending off rivals, and for clinging while sitting. There are long spines on the femur and tibia of legs.

The aesthetic and designing systems of dragonfly figure:

Dragonflies are spread in almost all countries of the world, but they tend to live in moist and watery environments, as they are very suitable areas for laying eggs. Dragonflies are

abundant in fresh water, ponds and swamps, and some species are able to adapt near brackish water environments [8].

Morphology and food-related behavior similar to the shape of climbers and their prey treatment at larval habitat. The studies have shown that morphological features are affected by the presence of predators, and they are usually permanent, such as the shape of the backbone that acts as a defense against fish attacks. There is a close relationship between morphology and coexistence. [10] All animals are following specified behaviors to ensure surviving and protect its' selves from risk of predation. The defending approaches of dragonflies may be Morphological and also sometimes behavioral.

Dragonflies are generally classified as carnivores; this is due to their sharp teeth. Dragonflies is from (Odonata), (Odonto) class which means teeth, legs of dragonfly help it to catch the prey, its' body is divided into three parts with four wings and six legs. [8]

In some Asian countries such as China and Japan, dragonflies have a long history of being involved in leisure and recreational activities. In contemporary Japan, dragonfly enthusiasts, like birds elsewhere, take great pride in learning about the many different species of dragonfly.

Many seminars and festivals usually provide Japanese dragonfly enthusiasts with an opportunity to practice and master their skills. Dragonfly aggregations (such as censuses and educational outings). Facilitating the growth of these recreational activities, but more specifically dragonfly-watching, is the availability of books, field guides, associations, and websites dealing with insect-human relationships along with highlighting the contribution of dragonfly species and its' pioneer role in social and cultural traditions as well as tourism and leisure activities [11] This insect is non-toxic and harmless to humans, so it is sometimes used in biological control and helps to balance the environment by eating some harmful insects such as mosquitoes, so it has a role in nature as well. Their sensitivity to environmental change makes them one of the most important indicators of wetland health and diversity. [8]

7.3. The Grid Structure and Voronoi Scheme of Dragonfly

The grid structure of some natural elements that can be seen by naked eye or through the telescope whether one or two or multiple dimensional in order to reach several type of networks a rich source for the artist and his creativity. As the nature is rich with several phenomenon, systems, laws and aesthetic values.

Among the structural networks in nature, there is the structural network of insects. The insects are characterized by variety in the geometric systems through their visual structure or telescopic one. Through analyzing the fine structure of wings we will find several systems of linear networks in insects. The geometric structure of the dragonfly can be found through the tiny hairs of its' wings. It consists of straight lines one parallels each other's to make an geometric network of similar cells. Those cells are surrounded by larger

veins, each two veins are separated by quadrangle cells making one row of quadrilateral cells each raw meets the other at an angle, gradually turning into a regular hexagonal grid.

8. The Voronoi Scheme

Voronoi Scheme It is a mathematical and geometric system which. Voronoi Scheme is a special kind of metric space decomposition defined by a discrete set of points. Voronoi Scheme describes many structures in nature whether visible or invisible, such as dragonfly wings, turtle shield, beeswax structure...etc. Studies indicate that the Voronoi Scheme is created by a series of points because it creates a cellular pattern (i.e. each of these points includes an area surrounding the point, that form a group of shapes look like honeycomb cells, crystals or rocks. The flexibility of the Voronoi scheme allows the large scale implementation of it. [12]

8.1. Emergence of Voronoi Scheme

The Voronoi Scheme had been first used informally in 1944 by Descartes. The Voronoi Scheme was discovered through mathematics studies by Georgy Voronoy- an Ukrainian a mathematician who studied in Saint Petersburg and worked as professor at Warsaw University. His works concentrated computational methods of architectural design, i.e. structural plans derived from the leaves of locust plants - giraffes, dragonflies...). The Voronoi Scheme is defined as a means of dividing space into a number of regions. [13]

8.2. Voronoi Scheme in Nature

Nature is one of the main sources of inspiration for artist or designer due to endless elements and systems existing in nature, the artist contemplate the nature to interact with its' elements and decompose it into primary elements to reassemble those elements in new structures and add new approach to it, to that nature is the inexhaustible source of inspiration for artists. Through imagination and contemplating in nature we can find the integration in shape and function for all beings including human being. Man began draw inspiration from nature through the visual approach then the structural inspiration that reach the levels of nature governing laws for structures and level of contents in a manner enables the artists to realize and analyses the freeform and find the designing solutions. Sources of inspiration in nature is classified into three trends for purpose of counting them, those trends are: The mechanism, the structures and the systems. Each of those trends had contributed in facilitating the human life so that all designing features were used. Voronoi Schemes were among those elements and systems that artist or designer could draw inspiration from. Voronoi Schemes is a new type of irregularly shaped polygons in nature.

The designer had gone beyond understanding and realizing the visual aspects in nature as he broached deeper cognitive

process by analyzing the mathematical patterns codifying the self-construction of surrounding organic shapes and understanding rules and mathematical theories controlling the shaping process. Such mathematical relations have been transformed through computer into formulas offering reliable source for the designer to produce creative set of out of the box shapes which is looked for by all designers. Voronoi Scheme is considered as form of biological formatting for shapes in nature and how to theorize it into mathematical formula through which inner and outer spaces can be addressed on two and three dimensions level. Voronoi Scheme concept demonstrates clearly in the analyzing process of some insects wings divisions such like the dragonfly, the beehives and the outer shell of some types of snails [14].

8.3. Voronoi Scheme Applications in Designing

Voronoi Scheme is broadly used in architecture and interior design; such usage can be found in several axes reflecting the practical usage of Voronoi theory in designing. The Voronoi Scheme can divide the surface and spaces in an unconventional way from formatting the structure of the space up to formatting the unconventional shape in a manner that make designers use Voronoi Scheme to create designs with future features in terms of being unfamiliar and represent linear relations generating creative space divisions as an abstraction level of the structure where the physical image turns into a set of formatting laws governing the relations between the design components and elements.

So By utilizing Collage, Montage and Assemblage, contradictory elements are boldly combined. Unconventional ideas revive the sense of the world and remove masks. This is the secret behind their beauty. The artist turns shapes upside down and his art can showcase amazing ideas in design. [15]

9. Designs

9.1. The First Design

Description: The designer used colors that add new dimensions in terms of conductive capacity and effective psychological impact. The colors was inspired by (Draner Dragonfly) that lives at water bodies in USA and distinguished by its' black body spotted in blue.

As for the dragonfly figure, the designer used the paper pulp to create the structural form of the dragonfly body and 3 Doodler pen to add new dimension. The gold leaf was used in the design to reflect the shining colors of dragonfly wings, pens and touchers were used to emphasize the shades and stencil tree leave was used to add permanent feeling of nature.

Structural and formal basis: The background was divided into vertical axes using the soft lines. Lines are the indicators that lead the eyes to the center of attention. In the middle of the structure there is the morphological structure of Veronoi scheme distinguishing the dragonfly wing.

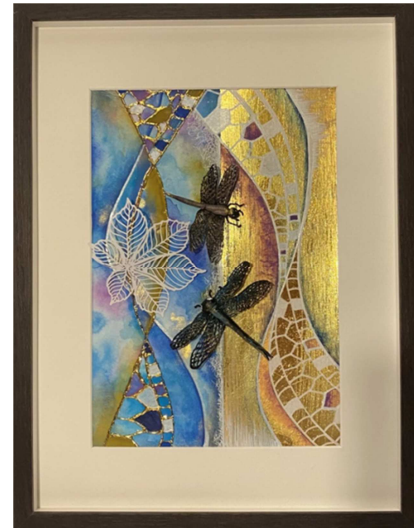


Figure 5. Design No. 1 implemented by the researcher.

Class: design (decorative painting)

Dimensions: 25 X 35 cm

Materials: gold leaf and gold leaf glue, stencil paper- 3 Doodler Pen- Ink pens (white)- paper pulp- Pebeo colors- relief transparent pens (gold leaf has been added to it to seem like two dimensional

9.2. The Second Design

Description: The designer used colors and formal structure inspired by (Hawker Dragonfly) that lives at North America. Hawker Dragonfly is classified as biggest Dragonfly with some yellow lines and colored spots and special eye size. The gold leaf was used to reflect the shining color of dragonfly wings. Adding golden paper to the design in thin lines adds rich view. Stencil tree leave was used to add permanent feeling of nature.

Structural and formal basis: The designer had relied on highlighting the aesthetic values of the structure along with adding transparency to the design in a manner that adds attracting and simple view along with amazing effect that enrich the design. The designing treatment of the background was divided into axes and complex color spaces distinguish with transparency in a manner generating compounding between those spaces and transparency which is the main feature distinguishes the dragonfly wing In the middle of the structure there is the morphological structure of Veronoi scheme distinguishing the dragonfly wing.



Figure 6. Design No. 2 implemented by the researcher.

Class: design (decorative painting)

Dimensions: 25 X 35 cm

Materials: gold leaf and gold leaf glue, stencil paper- 3 Doodler Pen- Ink pens (white)- paper pulp- Pebeo colors- relief transparent pens (gold leaf has been added to it to seem like two dimensional).

9.3. The Third Design

Description: The colors and formal structure were inspired by Spiketail Dragonfly that lives at forested or mountain areas in USA. Spiketail Dragonfly are tall with dark abdomen and its' shining tends to Yellow, with distinguished eye size. The gold leaf was used to reflect the shining color of dragonfly wings. Adding gold leaf to the design in thin lines adds rich view. Stencil tree leave was used to add permanent feeling of nature.

Structural and formal basis: The transparency in the design is achieved through compounding more than one surface in a manner that add more details through the hidden details which add distinguish figure to the work. Through the compounding we can find the effects of each elements is clear and not hidden, the overlapping includes the compounding in a certain part. We can see each element like if some parts is hidden from its middle due to passing of other elements parts in a manner that give impression that there is penetrations between the elements. Through the overlapping, we get new visual elements of the linear axes. In the middle of the structure there is the morphological

structure of Veronoi scheme distinguishing the dragonfly wing.



Figure 7. Design No. 3 implemented by the researcher.

Class: design (decorative painting)

Dimensions: 25 X 35 cm

Materials: gold leaf and gold leaf glue, stencil paper- 3 Doodler Pen- Ink pens (white)- paper pulp- Pebeo colors- relief transparent pens (gold leaf has been added to it to seem like two dimensional)

9.4. The Fourth Design

Description: The designer used colors that add new dimensions in terms of conductive capacity and effective psychological impact. The colors was inspired by (Peltail Dragonfly) that lives all over the world, especially in Australia, Peltail Dragonfly has a long straight tail looks like the flower petals. And Tigertail Dragonfly that lives wet places in Australia, it is small and thin at the abdominal with yellow and black lines in its' tail. The gold leaf was used in the design to reflect the shining colors of dragonfly wings, pens and touchers were used to emphasize the shades and stencil tree leave was used to add permanent feeling of nature.

Structural and formal basis: to achieve the holographic and the spatial dimension in the artistic work, color plays with shapes and spaces effective role to achieve systems and artistic harmonies through the designing basics. Lines, spaces, touchers and colors are gathering together in visual harmonized relations. The design vitality is achieved through

the general color character distinguishing it and creates an integrated unit. In the middle of the structure there is the morphological structure of Veronoi scheme distinguishing the dragonfly wing, the overlapping here is based on a system of interactive relations inside the formal structure. Such system will be useless unless it's working within a context or a system based on contiguity.



Figure 8. Design No. 4 implemented by the researcher.

Class: design (decorative painting)

Dimensions: 25 X 35 cm

Materials: gold leaf and gold leaf glue, stencil paper- 3 Doodler Pen- Ink pens (white)- paper pulp- Pebeo colors- relief transparent pens (gold leaf has been added to it to seem like two dimensional)

9.5. The Fifth Design

Description: The colors and formal structure were inspired by Clubtail Dragonfly that lives at water bodies in North America with a tail looks like racket and distinguished eye size. The gold leaf was used to reflect the shining color of dragonfly wings. Adding gold leaf to the design in thin lines adds rich view. Stencil tree leave was used to add permanent feeling of nature.

Structural and formal basis: The design with curved lines is distinguished with gentleness, tenderness and tolerance, when the curved and circled lines increase in lines or in spaces and masses it add meaning of relaxation, using the lines with wide curves in the structure add feeling of

calmness.

In this case, the line takes the eye up or moves down or toward another line, the line describes the focal movement but the real effect of movement comes as a result of spaces. Different types of lines have several variables with impacts on the design aesthetics. Those variables need several trials till achieving the result that enrich the image. In the middle of the structure there is the morphological structure of Veronoi scheme distinguishing the dragonfly wing.



Figure 9. Design No. 5 implemented by the researcher.

Class: design (decorative painting)

Dimensions: 25 X 35 cm

Materials: gold leaf and gold leaf glue, stencil paper- 3 Doodler Pen- Ink pens (white)- paper pulp- Pebeo colors- relief transparent pens (gold leaf has been added to it to seem like two dimensional)

10. Conclusions

- 1) The formal structure of the Voronoi Scheme enriches the decorative design considering the Morphology of the Structural Systems of Nature.
- 2) The decorative designing field is a broad field for trying different materials and adding new techniques to find technical and formal solution for the structure of Voronoi Scheme and morphology of dragonfly along with abilities to use it in aesthetical manner.

11. Recommendations

- 1) There shall be constantly urging to study the aesthetics in nature and various sciences. The aesthetics system and laws of nature are unlimited and provide always with sources of inspiration as elements and formal vocabularies. Such elements shall be drafted under new visions to reach the aesthetics that enrich the plastic art field.
- 2) There shall be more interest in science and linking it with arts in a manner that achieve creative aesthetics and unique movement for the arts in terms of form and content.
- 3) Draw inspiration of Voronoi Scheme in producing unconventional designs.

References

- [1] Wojciech Pokojski, Paulina Pokojaska. 2018 Voronoi Diagrams – Inventor, Method, Applications, Article in Polish Cartographical Review Vol. 50, no. 3, (p: 141: 142) DOI: 10.2478/pcr-2018-0009.
- [2] Yasser Soheil: 2015 The Designing In Applied Arts And Architecture, Dar ALKitab AL Hadees, (p: 49).
- [3] Marwa Ezzat Mostafa. 2019, Form The Structure Of A Shift In The Light Of Quantum Theory As A Source Of Decorative Design, journal of Applied Art and Science, (ISSN 2537-107X) Vol. 6, No. 5, (p: 112).
- [4] Ihab Besmark Al Seffy. 1998, The Aesthetic And Structural Basis In Design, ALKitab El Masry for press and publish, (p: 89).
- [5] www.Lexico.com (OXFORD)
https://www.lexico.com/definition/morphology The American Heritage, Science Dectionary, 2011, Published By Houghton Mifflin Harcourt Publishing Company.
- [6] www.britannica.com
https://www.britannica.com/animal/dragonfly written and checked by: The Editors of Encyclopaedia Britannica.
- [7] Thomas Schneider, Dietmar Ikemeyer, Ole Müller & Henri J. Dumont. 2018, Checklist Of The Dragonflies (Odonata) Of Iran With New Records And Notes On Distribution And Taxonomy, ZooTaxa, Magnolia Press, (p: 19, 34) Doi.org/10.11646/zootaxa.4394.1.1.
- [8] Mark Klym and Mike Quinn. 2003: INTRODUCTION to Dragonfly and Damselfly Watching, Texas state Publications, (p: 2: 6).
- [9] S. R. Jongerius & D. Lentink. 2010, Structural Analysis of a Dragonfly Wing, Article in Experimental Mechanics, (p: 1325, 1326) DOI 10.1007/s11340-010-9411-x.
- [10] Göran Sahlén, Susann Haase & Frank Suhling. 2008, Morphology of dragonfly larvae along a habitat gradient: Interactions with feeding behavior and growth (Odonata: Libellulidae), International Journal of Odontology, 11 (2), (p: 226) Doi: 10.1080/13887890.2008.9748325.
- [11] Raynald Harvey Lemelin. 2007, Finding Beauty in the Dragon: The Role of Dragonflies in Recreation and Tourism, Article in Journal of Ecotourism, Vol. 6, No. 2, (p: 139, 140) Doi: 10.2167/joe161.0.
- [12] ADAM DOBRIN. 2005, A Review Of Properties And Variations Of Voronoi Diagrams, Whitman, (p: 4: 15).
- [13] Dalia Ali Abd Elmonean Abdulaziz, 2017 The Impact of Voronoi Diagram on the Construction of the Ceramic Figure, published study, Art and Architecture journal, Vol. 8. (p: 4) Doi: 10.12816/0040798.
- [14] Ahmed Abdulaziz Al Shakhs, 2020 The Impact Of Using Voronoi Diagrams On The Contemporary Interior Design, published study, Art and Architecture journal, Vol. 5, (19) (p: 53) Doi: 10.21608/mjaf.2019.13732.1215.
- [15] Mohsen Mohammed Atia. 2007, The Semantic Interpretation Of Art, Alam Al Kotob, Cairo, Egypt. (p: 41).