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Principles of Designing Decorative Metal Units within the Framework of Fractal Geometry and Islamic Art

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ABSTRACT

There is a close relationship between fractal geometry, Islamic decorations, and nature. This relationship is evident in fractal geometry, which emerged as an extension of the theory of creation in nature. This theory offered a new perspective on the workings of the cosmic system, which is far removed from regularity, consistency, and predictability. The importance of fractal geometry in design lies in its ability to bridge the gap between design and the decorative metal units and mathematics, as well as between nature and its properties, and to describe the complex forms it contains. For example, decorative metal units using a mathematical basis followed by a description of design decorative metal units involve developing a systematic research process based on identifying the basic grid, forming a multi-scale grid, developing a hybrid grid structure, and studying the effect of interference on the potential to increase structural strength, starting from the geometric patterns of Islamic art. The study explores the generative potential of the extracted fractal dimension as a design criterion for new forms. The shapes or decorative structural units and their repetition patterns represent the primary characteristic—those shapes and units created by the designer for geometric compositions with star-like, hexagonal, and other forms. Decorative structural units are often formed through creative processes. Further modifications to these structural elements, achieved by incorporating repetition through inlays or design units, enhance the approach to geometric form, granting flexibility and the ability to flow within the design of repetition for contrast, symmetry, and other effects. This is achieved by designing units that appear geometric shapes due to their simplification and their significant distance from natural forms. The research problem here focuses on the need to explore the nature of fractal geometry in Islamic art to shed light on its characteristics and patterns of design decorative structural units. It posits that its inspiration can be applied to various interior spaces as a novel approach to simple design and also focuses on understanding the relationship between nature within the decorative metal units of fractal geometry and Islamic art by utilizing the nature of fractal geometry in Islamic art to design simple decorative structural units, thus enriching the field of designing decorative metal units used in metalwork. The research hypothesis: The researcher posits that the concept of design in fractal geometry and Islamic art helps in constructing decorative designs and in finding simple design approaches. The importance of this research lies in revealing the structural and aesthetic foundations of repetition, exploring fractal geometry and Islamic art, and opening avenues for students to experiment and discover new relationships and innovative arrangements.

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INTRODUCTION

Nature plays a pivotal role in designer thought. Natural forms are characterized by an organized structure, and fractal geometry offers a clear method for understanding and interpreting this structure. Fractal geometry has been widely used since the inception of Islamic art. Islamic motifs embody a cultural trend. The integration of decorative metal units with the context reflects the Islamic worldview. Thus, Islamic geometric decorative metal units arise from a design perspective that transforms classical natural motifs and places them within an entirely different cultural context. Fractal geometry and mathematics, rooted in the seemingly chaotic and irregular nature of nature, provide designers with a framework for creating unique and innovative designs. (1) The designer's perspective here is one of contemplation and depth, so the universe, for him, has a mathematical logic and the system and structure inherent in the visible design organization. The mathematical and geometric aspect had special importance because it is based on the diverse lines between the curve and the straight line and the decorative metal units that can be repeated, generated, and grown within spaces through which circles, squares, triangles, and rectangles are formed in complex relationships that require systems for the observer to perceive and to discover their structural foundations and aesthetic values and a philosophy that governs the structural design based on the abstract design in geometric relationships, that is, based on the strict mathematical premise to achieve the marriage between the organic and geometric relationships that the designer sought to emphasize. (2)

Islamic geometric patterns represent the pinnacle of the use of geometric decorative structural units, incorporating more complex shapes such as hexagons, octagons, decagons, and multi-pointed stars. Their intricate arrangements, stemming from the simplicity and unity of natural and geometric construction, reveal fundamental relationships that, in turn, transform into hierarchical or fractal relationships in complex designs. One of the most distinctive features of Islamic art is the process of repetition and extension of an elongated form without limits. This repetition is governed by a mathematical foundation and logical reasoning to establish relationships between one decorative structural unit and another within the framework of continuous repetition. (3) Repetition is considered one of the structural principles employed by designers when designing decorative structural units.

Design and the System of Repetition:

Repetition is a universal phenomenon and part of the rhythm of this universe since time immemorial. Repetition as a design solution has been known in previous civilizations and arts. However, the repetition of each civilization represents its different perspective, even though there is a thin thread and some convergence between them all. (4) In Islamic art, however, repetition translated many formative and philosophical aspects stemming from the faith design which the designer drew his inspiration. The representation of decorative metal units and the system of their repetitions are the main characteristic and essential features of good design. These are the designs and decorative metal unitsthat the designer created for geometric compositions with star-like shapes, or asdecorative metal unitsthat appear as geometric shapes as a result of their simplification and their extreme distance from the manifestations of nature. This approach to geometric form gives it flexibility and the ability to flow within systems of repetition, contrast, symmetry, and so on. The concept of repetition is also linked to the meaning of attractiveness, similarity, and the value of production in design work. Repetition has multiple manifestations, ranging from the simple to the more complex and from the part to the whole, where structural units are composed of parts within wholes according to repetitions that vary and multiply in their patterns. (5)

Repetition is considered one of the simplest decorative metal unitsof a design, but not every design is considered repetition, and the patterns of repetition are determined according to the design in which they are formulated. Repetition is also considered one of the structural foundations that the designer resorted to in designing structural units, and the designer's understanding of the structural function of repetition have a clear and tangible effect in creating formal models that are compatible with the nature of the design to be designed. (6) Also, there are three-dimensional objects whose design and shape carry the characteristic of repetitive construction, such as the cube, the hexagon, and other dsigns. Designers have benefited from them in multiple designs, from which the designer chooses whenever he wants. However, the freedom to choose is conditional on the function that this design performs so that the design's decorative metal unitsare repeated regularly within the design work in the form of diverse elements and different designs and in representation, symmetry, exchange, and sequence, or reducing and enlarging the same design element, or splitting it, or moving it upwards, or on an inclined, triangular, square, or circular lineso that it designs a variety different from the nature of the original unit.

Construction Methods of Fractal Geometry:

Fractal geometry deals with the study of geometric structures composed of fractals (the plural of fractal). A fractal is defined as an irregular geometric particle with infinitely small dimensions. The term "fractal" is derived from the concept of breaking something into smaller, similar parts that resemble the original part. The word "fractal" is derived from the Latin word "fractus," which means irregularity or fracturing. This geometry has achieved considerable success in its applications. This geometry inherently embodies the concept of infinity, and its most important characteristic is self-similarity, where the components resemble the parent particle regardless of the degree of magnification. Fractal objects are often formed through recursive or iterative processes. [(7)]

The term "geometric fractions" also describes irregular shapes and complex objects that exhibit self-similarity at every magnification level when subjected to a specific iteration process. This is because fractal geometry is a branch of mathematics that studies the behavior and properties of fractals, which differ from other shapes due to their progressively increasing and decreasing size. It describes any geometric shape that can be broken down into parts, each a mirror image of the larger shape. [(8)] Another definition describes it as a repeating geometric pattern at increasingly smaller scales, resulting in irregular shapes and surfaces that do not conform to Euclidean geometry. Some have also defined it as a form of high artistic and aesthetic value closely linked to how the world around us is organized. It has also been defined as complex geometric shapes resulting from the application of certain mathematical rules that transform the basic shape from one stage to another, either by adding to it or by developing it. [(9)] These operations can be repeated indefinitely. Furthermore, it has been defined as the images resulting from the repetition of nonlinear equations, composed of simple, recurring geometric shapes such as triangles, circles, squares, rhombuses, and so on. Organizational structures arranged in diverse ways through repetition, entanglement, and complexity form intricate groups. [(10)]

It reflects multiplicity within unity in terms of geometry. If a line is divided into two equal halves, the two halves will be a monotonous repetition of the same thing. There is neither multiplicity nor unity within geometry, and this is possible because these things are formed through a process of repetition. According to Lorenz, a self-similar structure changes by modifying it with the same scale factor: "The new shape can be smaller or larger, rotated or inverted, but the shape remains the same. [(11)] Through the method of correlation, geometric shapes are defined by rules of coordinates, dimensions, angles, proportions and relationships with other geometric shapes, in addition to the new iterative rule of fractal geometry. Although the rules used are written for a specific example, they can be generally applied to any similar pattern by changing the programming code and values. Thus, an infinite number of design variations are generated based on the fractal geometry of a given pattern. One of the most important characteristics of fractal geometry construction methods:

1. **Repetition and balance:**

The concept of geometric repetition of shapes according to a specific rule is a key characteristic of fractal geometry, highlighting its aesthetic aspects. Repetition is a fundamental property in form creation, and this property can be achieved through various transformational processes, yielding all the characteristics of a fractal structure. [(12)]This results in a rich and varied outcome, avoiding monotony and boredom. Therefore, geometric repetitions should be considered exceptionally beautiful and aesthetically pleasing, whether at the level of structural elements or decorative structural units.

2. **Similarity-Self:**

Self-similarity is a mathematical term used to describe a change in the dimensions of a structure by a scale factor. The new design may be smaller, larger, more complex, or transformed, but it retains its original shape. Self-similarity means that the proportions between the internal dimensions and angles remain constant. If a shape changes unevenly in one or more dimensions, self-similarity means a change in the point of intersection, and therefore the internal angles of the shape or the proportions of its dimensions are not the same. Self-similarity is a property associated with the use of proportions in certain patterns, such as details and elements that repeat at different scales. [(13)]

There are many examples of fractal shapes in nature, from trees to galaxies, which involve a flow of self-similar shapes. Self-similarity means that the proportions between the dimensions of a shape and its internal angles remain constant. If an object is transformed unevenly in one or more dimensions that object is self-similar. The interior angles of a shape may not be identical to the proportions, but the length, surface area, or volume of the fractal structure increases as it undergoes self-similar transformation. For example, the golden ratio, often used by designers, is an example of self-similarity, where a spiral is created based on a self-similar rectangle. [(14)]

At the microscopic level, fractal shapes are composed of subsets, and these subsets are further composed of even smaller subsets. These subsets are similar to the larger ones, a property known as "microscopicity'" Self-similarity and repetition are clearly evident in the variations at the subscale. This self-similarity is also present in the formation of patterns. Therefore, self-similarity is the similarity between the constituent parts of a shape; that is, a part of the whole is exactly like the whole. If we add an integral part of the constituent parts of a fractal shape and then magnify it several times, we will eventually obtain the original shape. Self-similarity is further divided into [15]

- Perfect self-similarity, which is identical on all planes. The parts have the same shape or structure as a whole. This is the strongest type of self-similarity, and the fractals appear identical at any scale.
- Near-perfect or apparent self-similarity, in which the shapes appear slightly distorted. The shape is highly irregular or fragmented and remains so regardless of the scale of the examination.
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- Statistical self-similarity, which repeats a random pattern so that numerical or statistical measures are maintained across scales, is the weakest type of self-similarity, where particles give constant statistical and numerical measurements with varying degrees of magnification. [16]

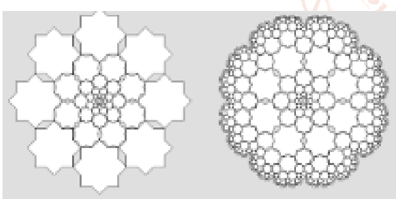

Figure (1) division of stars from a state of unity to a pattern of self-similarity, the base model on the fractal pattern consists of three main elements, including similarity, change in size, and repetition.

The presence of self-similarity in design refers to the same shape being repeated at different scales more than four times. In Islamic art, self-similarity does not mean exact sameness or repetitive echo, but rather it is closer to likeness or the same kind between the parts at different scales. The connection of the property of self-similarity to transformations is called by other names, such as "self-transformation affine," where the reductional transformation of the thing is not equal in one way or another. As for three-dimensional repetition, muqarnas are considered among the most prominent three-dimensional designs in Islamic architectural style. [17] They are used extensively and densely, in carefully planned rows of arrangement and composition, adjacent and towering, so that each group of muqarnas resembles a honeycomb or a honeycomb structure.

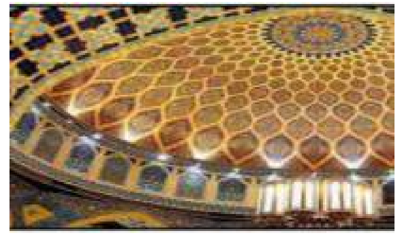

Figure (2) shows the top dome of the Taj al-Muluk Mosque in Isfahan—the principle of self-similarity through the proportion between the whole and the part and the repetition of more than four levels. The designer imitated nature's creativity in replicating the dome as a sunflower.

Theirdecorative metal unitsare closely packed together, and their elements are united by harmonious lines and masses, mathematically designed and meticulously precise, fulfilling a specific function and an aesthetically pleasing decorative role. With muqarnas, spaces do not end; rather, some walls connect to others, and to ceilings, domes, and balconies. The eye is never confined, as if bound to an ornamentation whose lines have no beginning and no end.

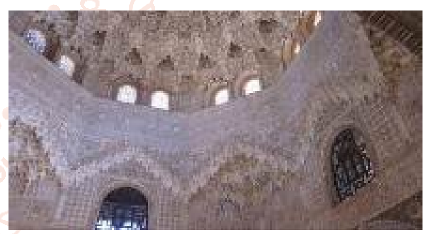

Figure (3) of the domes in the Alhambra Palace in Spain clearly demonstrates the extent to which the angular dimension was utilized in Islamic architecture and its connection to the Kushite curve.

Figure (4) of the muqarnas dome in the shrine of Sitt Zubayda in Baghdad is shown, and the designer imitated nature's creativity in mimicking the dome from the sunflower.

The stages of generating fractal patterns for muqarnas are fully multiplied, such that in the first stage the base rhombus pattern exhibits maximum multiplicity and frequency on its surface, overlapping with varying degrees on a wide scale across several successive levels. Then, in the second stage, the multiplicity of the base pattern is gradually reduced, as is the pattern of variation in size and complete similarity. (18) With its low extension to the minimum possible extent, fractal characteristics can be observed, as illustrated in the example of the Islamic star. The underlying forces shape the spaces into a fractal form with a specific direction and scale, transitioning from a state of unity to a state of division to clarify the design objectives.

3. Fractional dimension:

The fractional dimension is a specific and preserved numerical measurement regardless of the different magnification scales. Fractional dimension has found many practical applications in the analysis of chaotic processes. Therefore, the fractional dimension in general is neither a number nor a numerical value. The Sierpinski Triangle is an example of this by repeatedly removing the middle triangle from the previous generation. (19)

The German mathematician Helge von Koch conceived the idea of minute branchings in the world of mathematical structures, which later became known as Koch curves. He did this by imagining an equilateral triangle with another equilateral triangle at the midpoint of each side. By continuing and repeating this process, branchings will occur around the perimeter of the shape we have formed, called Koch curves. (20) When looking closely at these curves, they appear very similar to the original branchings in the basic model.

Fractal Geometry as a Basis for Structural Forces in Design Units:

Nature itself is a series of fractal details, and the perception of rhythm in fractal geometry is an inexhaustible source of design ideas for designers seeking to understand the complex expression of nature. Fractal geometry is a new vision of the geometry of natural structures, discovered and presented by the French mathematician Benoît Mandelbrot as a true geometry of nature. Nature can be translated into design, and beauty is the best way to highlight objective details. Evaluating the properties of a structure in fractal geometry allows the use of many formal similarities, such as dynamism, proportion, and scale, as a design tool. (21)

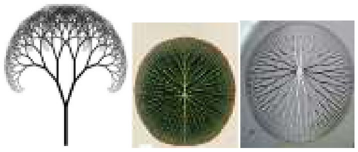

Figure (5) shows models of the fractional tree and three results with different coefficients of angle between branches and forces acting on them, which affects the development of the final structural forms in nature.

The Structural Dimension in Fractional Geometricdecorative metal unitsand Islamic Art.

The execution ofdecorative structural units, for example, within a circular shape leads to respect for proportions and balance in the design. The distribution of elements within a mass further solidifies the structural design units in the two dimensions of aesthetic appearance and visual balance, i.e., entering from the design unit. This is manifested through the creative designer's control over mass and space. (22) If we examine design models, the initial criterion for design construction is the design structures, which necessitate a limited quantitative distribution of units. This distribution is governed by the background of the formation according to the material and technique. (23) For example, we cannot say "eighth-pointed star" unless we define its circumference, which is eight equal and symmetrical points, and vice versa. The distribution parameters in its designs vary according to the different types of lines. If we want to arrange geometric shapes according to design strength, the triangle comes at the top of the pyramid, followed by the overlap between triangles, then the circle and the hexagon, and finally the cubic shapes as artistic design strengths. It should be emphasized that design strength depends not only on shapes but also on the mathematical geometric ratios used in each element. A 1:1 ratio, representing symmetry, and a 1:3 to 2:3 ratio, representing one-third to two-thirds, are among the best design ratios, along with the golden ratio, considered optimal for designing geometric shapes. For example, the triangle is one of the strongest geometric shapes to use due to its rigidity and structural strength when following a pyramidal design. Its lateral sides taper upwards, resulting in the greatest load at the bottom and the lightest load at the top. Weights are distributed equally in a triangle from the apex of its base, facilitating load distribution due to the symmetry of the triangle's shape. (25) One of the most famous uses of the triangle is transforming it with a quadrilateral base into a three-dimensional pyramid, such as the magnificent and mysteriously awe-inspiring Egyptian pyramids.

The circle is considered one of the strongest geometric shapes after the triangle due to the various arcs that can be carved from it. These arcs have long been considered among the strongest and most important structural elements in architecture and abstract forms. 24) The hexagon is also one of the most important and strongest geometric shapes in design. Beehives are composed of small decorative metal units' deisgn in a hexagonal shape, which is symmetrical and thus distributes the load equally across all sides, making them sturdy and robust.

Repetition and Design Structure in Islamic Art

Repetition is a form of decorative composition in designs, represented by the succession of decorative units and elements. For example, you might see a decorative drawing of leaves arranged side by side, alternating or contrasting, or arranged in a gradual progression of size from smallest to largest or vice versa. Repetition comes in different types, which can be divided according to the movement, transition, extension, juxtaposition, and succession of decorative elements at regular intervals into the following categories:

- Regular Repetition: This is when the decorative unit used in the drawing is repeated in a regular, consistent manner and in a fixed position that does not change along the length of the drawing.

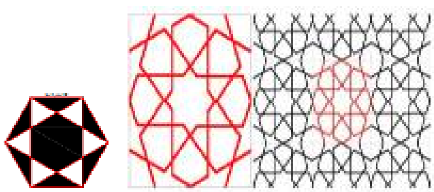

Figure (6) of the regular repetition pattern

Alternating repetition: This is the use of two or more decorative units in the drawing, each of which differs in its elements, sources, and areas. Reverse repetition: This is when several decorative units are placed together within the drawing in a reverse manner and in different positions; sometimes they extend from bottom to top, sometimes they meet and contrast, and sometimes they are arranged from right to left. This type is commonly used on extended surfaces. Circular repetition: It is also called axial and central repetition, which is when the decorative units on the drawing are adjacent to a certain point, as if they all emerge from one center. This type is commonly used in some designs of rooms, halls, walls, ceilings, and floors. Its various forms range from simple to more complex, from part to whole. The pattern consists of parts within wholes, arranged in repetitions that vary and multiply in their patterns. [26] Repetition is considered one of the simplest forms of a system, but not every system is a repetition, and the patterns of repetition are determined according to the system in which they are formulated. The formal element is regularly repeated within the design in the form of diverse elements and different systems in representation, symmetry, exchange, and sequence, or by reducing and enlarging the same formal element, or splitting it, or moving it upwards, or on a slanted, triangular, square, or circular line, thus creating a variety that differs from the nature of the original unit. [27] The designer has tried to express the Islamic vision of the world through the simplest means represented by the abstract single unit and the systems of its repetition. In repeating decorative metal unitstime after time, through precise geometric organization, a distinctive rhythm is gained despite the insistence on repeating them, and at the same time, there is no feeling of boredom. This is the meaning of repetition that some critics see as a manifestation of the urgency to reach the absolute true existence. [28] Rhythm is the organization of the spaces between decorative structural units. Repetition only occurs if the element is repeated and spread. From its repetition and spread, new relationships are formed for new forms, creating rhythm through their meeting, encounter, and formation. From this emerged the formulation of systems and repetition. These meanings take the concept of repetition in that art beyond being merely decorative embellishments that do not serve the purposes of design but rather consider it an expressive value with its own originality and symbolic connotations linked to the Islamic conception of existence, the universe, and humanity. [29] These meanings added an emotional dimension to the essence and the symbol, in addition to the components of the aesthetic organization of the form. The aversion to emptiness among Muslim designers led them to embrace repetition or infinite repetition. It compels the viewer to follow the lines in all directions and return from the confined spatial boundaries of the design work to continue viewing it through imagination. The essential basis of this design lies in the continuity of vision for the viewer so that his imagination becomes capable of imagining the continuity so that his mind moves in constant motion in pursuit of infinity. In general, the types and patterns of repetition in Islamic art are based on geometric elements, representational forms, and abstract shapes. The designer follows specific principles and rules to achieve these patterns and their various forms through geometric and mathematical laws. This allows for recurring relationships through the organization of elements, resulting in an aesthetically pleasing form. The division of repetition patterns depends on the imagery created by the use of each decorative structural unit, meaning that the repetition pattern is achieved through: [30]

- Based on the use of the point.
- A second type is based on the use of a line.
- A third type is based on the use of the individual element of the geometric shape.
- A fourth type is based on the use of the individual element of the (representational) shape.

The pattern of repetition is based on the kinetic events of the system, meaning that there is a type of repetition pattern that achieves dynamic organization and another that achieves organization based on stability or staticity. Through the types of repetition used, the designer was able to occupy many surfaces with their different units and imbue them with movement that leads to a kind of rhythm resulting from the time intervals the viewer's eye takes to move from one element to another and from the starting point to the ending point, thus achieving the characteristic of continuity in those structural decorative structural units. Repetition is divided into categories:

- Repetition based on constant decorative metal unitsand constant intervals; repetition and extension.
- Repetition based on constant decorative metal unitsand constant intervals, but with varying unit positions.
- Repetition based on constant units and varying intervals.
- Repetition based on varying units and constant intervals.
- Repetition based on varying units and distances.

Thus, repetition consists of one or more elements that follow one another, yet it carries a tone, rhythm, and variety that draw the eye due to the movement it creates within the design. Despite the inherent risks of repetition in design, as it can introduce a degree of monotony, the designer approached it confidently. The designer sought to express the Islamic worldview through the simplest means: the abstract, single unit and its repetition. By repeating units time and again, within a precise geometric arrangement, a distinctive rhythm is achieved despite the insistence on repetition, while simultaneously preventing boredom. This is the meaning of repetition that some critics see as a manifestation of the urgency to reach absolute or eternal true existence. The abstract meanings in Islamic art emerged from the formulation of systems and repetition, meanings that take the concept of repetition in that art out of the scope of being merely decorative ornaments that do not serve the purposes of decoration but rather consider it an expressive value that has its own originality and symbolic connotations.

From the perspective of most mathematics teachers, fractal geometry can unleash creativity and imagination and cultivate spatial awareness and intuition in designers. Designers have recognized this, producing designs characterized by the infinite properties of lines inspired by the Creator's artistry, the boundless extension of natural formations in geometric and floral patterns. [31] In Islamic art, fractality is a characteristic of anything irregular and irregular. The Islamic designer was able to employ abstract form to create an unlimited world, moving from the finite to a world that suggests infinity. Repetition and extension in Islamic art serve as a proposed approach for constructing the decorative structural unitin the desired design.

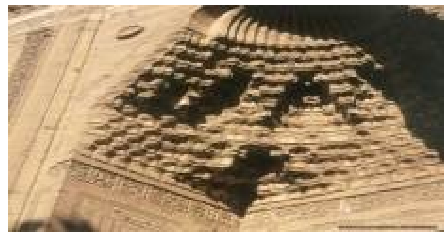

Figure (7) the fractal motif in Sultan Hassan's muqarnas demonstrates the characteristic of self - identical repetition of the same design unit, exceeding four levels of similarity.

Principles of Decorative Metal Unit Design:

The designer's perspective is typically one of contemplation of the universe, imbued with mathematical logic and the inherent structure and organization of visible forms. The mathematical and geometric aspects hold particular importance, as the universe is based on diverse lines curves, straight lines, and units capable of repetition, proliferation and growth within spaces that give rise to circles, squares, triangles, and rectangles in complex relationships. [32]

The designer usually works with groups of elements, which may be lines, arcs, triangles, or squares. In any of these cases, the designer resorts to repetition, which is the application of multiple forms to construct abstract or representational structures? This is achieved by employing these forms through repetitions without any apparent departure from the original. It might occur to one that repetition is an ally of boredom and monotony. However, when a designer repeats, they first intensify, focus, standardize, and refine. After this refinement and scrutiny, they establish their units, specifications, dimensions, and systems, resulting in forms that appear richer than when they consisted of only one or two units. The more units are repeated, the greater their aesthetic appeal and the more closely interconnected they become. [33] Often, the designer expresses the continuity and growth of nature by starting with a single unit, adding to it, modifying its form, and repeating it, so that each time it takes on a new appearance laden with different meanings. This can be achieved by changing the proportions or sizes of these units, or by establishing a geometric basis for them, making all forms formulated and adhering to that geometric foundation relevant. Sometimes their features appear similar and other times identical, whether in their themes, composition, or regular, sequential distribution. [34] Thanks to technology and computers, it has now become possible to create all kinds of realistic fractal images and landscape images with greater accuracy. Some fractal shapes that resemble natural shapes can also be created using feedback and repetition systems.

Fractal geometry is linked to repetitive geometry, allowing for the repetition of geometric shapes by understanding the aforementioned properties and their presence in natural and fractal shapes. Inspired by the five-pointed and six-pointed stars found in nature, these can be used to create patterns for design. These patterns are characterized by self-similarity, size, strong centers, local symmetry, and overlap. By applying specific mathematical rules, such as scaling and rotation, the repeated shape is ensured to resemble the original, maintaining the characteristics of self-similarity and symmetry that define the patterns. [35]

The fractal process involves successive steps that lead to the creation of new formations, where each formation replaces the previous one, becoming more complex while occupying the same space. Therefore, when constructivist modeling is approached according to a hierarchical logic defined by the designer, which differs from an iterative system, iterative logic involves returning specific values based on the nature of the grid's subdivisions, while iterative logic deals with specific values during deletion. This logic empowers the designer to produce multiple and varied aesthetic designs, depending on the number of grid subdivisions. The more subdivisions or their variety, the more outputs the designer can generate, enabling them to produce more aesthetically pleasing constructivist values. This is achieved by following the steps for constructing a grid by repeating the square, as follows:

Step 1: Create the initial shape by drawing a square using a constant-spaced, unit-repetition method.

Step 2: Invert the initial shape using a constant-spaced, unit-repetition method, but with different unit positions.

Step 3: Add two squares along the free sides of the triangle. Repeat the same steps for the two new squares in the following steps, after modifying the previous shapes by replacing the equilateral triangle with a right-angled triangle and repeating the previous steps indefinitely. The final result will resemble natural shapes.

Step 4: Add a right-angled triangle to one of its sides along its hypotenuse (here, two equal sides). Then, place the shape resulting from Step 3 on either side of the shape resulting from Step 2. This is a constant-spaced, unit-repetition method.

Step 5: When the initial shape needs to be enlarged. Iteration based on constant units and varying distances, and the resulting shape may be enlarged based on iteration based on varying units and varying distances.

Meanwhile, the use of square root ratios and the golden ratio systematically regulates the relationships between the basic square and the subdivided squares.

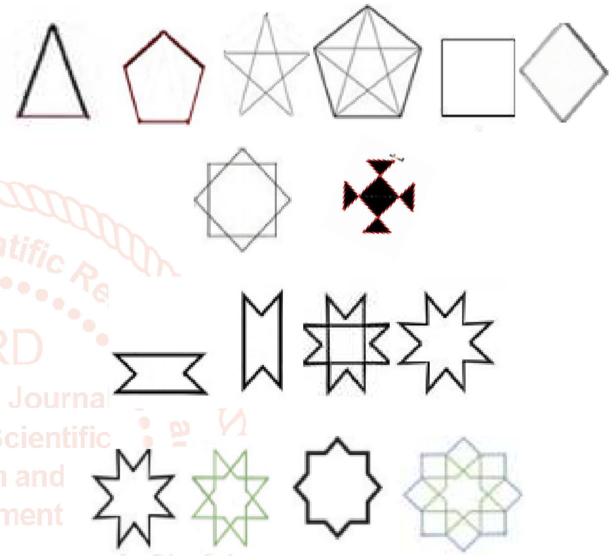

Figure (8) the decorative structural unitof the triangle and square are subjected to a number of transformations, resizing, and rotations of 45 and 30 degrees to generate Islamic patterns.

Through this system, certain opposing, sequential, or alternating repetitions are achieved, taking on several directions, whether vertical, horizontal, or diagonal, accompanied by a kind of rhythm through the movement of the line. The final shape will be used for designing decorative metal unitsusing the square dimension, where all blocks are assembled according to a specific pattern, ultimately producing the resulting image. We can create a rectangle with a line attached to it representing the stem, then apply the same steps to the three rectangles and repeat the process indefinitely. The patterns may be repeated with a specific scale factor, as the geometric design essentially begins with a square or a circle. For example, the basicdecorative structural unit shapes are sequentially a honeycomb sub-network, a single honeycomb unit, a circular pattern of a honeycomb unit, and a star structure. When choosing a honeycomb lattice structure, the basicdecorative structural unit is nested with a single honeycomb unit at the center. Our aim is to study the effect of introducing mass into the central honeycomb units on the bandgap properties of the structural framework. These changes are influenced by the localized construction, which produces a repetition that varies depending on the insertion location. The hexagonal metal inserts are made of structural steel, and their detailed properties are shown in a diagram illustrating structural designs characterized by various interlocking lattice structures. Multiple unit patterns can be represented by arranging unit decorative metal unitsto form complete two- and three-dimensional structures. The structure properties of simple structural designs, such as pentagonaldecorative metal unitswith positive and negative interior angles, are extensively studied through experiments, numerical simulations, and mathematical analyses. Relevant lattice structures can be classified based on different decorative structural unit types, taking into account angle, arrangement, and symmetry.

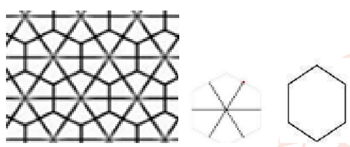

Figure (9) illustrates how the hexagon shape is employed in its formation and then the element repetition property in fractal geometry is utilized in different positions and directions

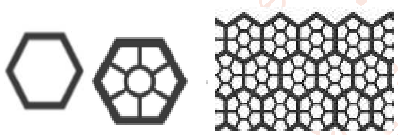

Figure (10) illustrates a hexagonal grid pattern with various geometric motifs representing repetition on a two-dimensional plane, according to geometric processes and networks characterized by infinity

For other structures, we study the different overlap arrangements of these decorative metal unitsand how different arrangements can be used to create complete, branching structures. There are fractal structures of different orders and corresponding changes. Also, as the fractal order increases, the structure becomes more rigid. This is especially true for units with, interlocking structural structures, self-similarity, heterogeneous distribution and continuity, periodicity and gradient, wedge-shaped interlocking multi-unit patterns, and gradient multi-unit patterns (two-dimensional decorative structural units). The basic decorative structural unit and secondary decorative metal unitsare represented. Secondary decorative metal units serve as nested components of the underlying structure from which each structure is designed.

Discussion

This study concludes that decorative metal unitsorder geometric fractions. Common decorative metal unitsare used as basic lattices. A complex array of basic lattices can be used to create diverse and interesting decorative metal unitsfor structural design within different arrangement ranges. It relies primarily on abstraction and the line in its various forms and angles, and from it, the designer has created works with geometric lines and others with softer or more fluid lines. Designers typically work with groups of elements that may be lines, triangles, or squares. In any of these cases, the designer resorts to repetition. Sometimes they are combined, and this repetition is governed by arithmetic and mathematical laws and principles, as well as geometric and numerical sequences. Repetition only occurs when an element is repeated. From its repetition, new relationships are formed, creating new forms and generating rhythm through their convergence and juxtaposition and formation. Rhythm is the organization of the intervals between the decorative metal unitsof the design work. With his keen sense, he was able to utilize the single unit, whose foundation rests on simple geometric shapes, adding to it, modifying its form, and repeating it so that each time it takes on a new appearance laden with different meanings. This may be achieved through changing the proportions or sizes of these units or by making these units the geometric basis, thus making all the forms formulated and adhering to that geometric basis related. Sometimes their features appear similar and other times identical, whether in their themes, their composition, or their sequential and regular distribution. The division of the repetition pattern is based on the kinetic events of the systems, meaning that there is a type of repetition pattern that achieves a dynamic organization and another that achieves an organization based on stability or steadiness, which helps the designer to use types of repetition that occupy many surfaces with their different units, achieving the characteristic of continuity in those decorative structural units. The order of repetition of a specific parameter within the structure of these elements can be observed, with each iteration building upon the previous one, thus guiding the decorative metal unitstowards equilibrium. When was developed using a multiscale geometric attention mechanism. This model can predict the formation of complex multiscale patterns and their bandgap properties using a portability scheme based on the existing one. We believe this will facilitate the efficient generation of numerous complex, customizable patterns for decorative structural units. - The designer's understanding of the decorative structural units' function of repetition has a clear and tangible impact on the creation of design models that harmonize with the nature of the intended decorative structural units. Repetition is also one of the systems used in employing decorative metal unitsin metal design, whether simple, in a single form, or complex. The concept of repetition is also linked to the concepts of appeal, similarity, and value in design. It might seem that repetition is an ally of boredom and monotony, but when a designer repeats, they first intensify, focus, standardize, and refine. After this refinement and scrutiny, they create their decorative structural units. Their specifications and dimensions are very good. The more decorative metal unitsare repeated, the greater their aesthetic appeal and the more closely interconnected they become. Therefore, repetition does not align with or ally with boredom; on the contrary, it fosters it. This is ultimately due to the depth of the designer's vision, which, after examination, yields expansive, coherent, and enduring aesthetic values that multiply and expand.

-The fractional dimension is a mathematical criterion used to determine its complexity. This property is called the decimal dimension. In decorative structural unit design, scale is a technique used to move selected forms to another location by separating them from the main fabric and transforming the initial form by reducing or increasing its dimensions. Attention should be paid to algebraic fractions, which are created by repeatedly calculating simple or complex equations. The need arises to analyze fractal patterns derived from forms with roots in Islamic art. This requires identifying their fractal properties and then drawing inspiration from them to create designs that are both original and contemporary. - By studying the properties of fractal geometry, whether in nature or otherwise, we can utilize them to create works that are both repetitive and contemporary. Different types of decorative metal unitsfor structural design can be classified based on their lattice structures. -Fractal growth is considered a type of evolution in living organisms. We can say that fractal bodies (biologically and geometrically) are generated through repeated processes, where both the initiator and the generator are repeated an infinite number of times. Consequently, a part of the fractal is equal, similar, or identical in all its parts. The golden ratio is an example of self-similarity, which has proven to be a valuable tool for designers. This technique focuses more on arranging available fixed elements next to each other. The golden ratio creates a spiral shape of a self-similar rectangle. Unlike traditional geometry, fractal geometry is a better technique for explaining and constructing natural phenomena.

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