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An Analysis of Fractal Features in Textural Patterns of Spatial Surfaces in the Context of Selected Design Principles

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ABSTRACT

Since the beginning of civilization, the relationship between human beings and nature, natural phenomena, and natural texture have been a source of inspiration and focus of interest for artists, designers, and architects as well as for researchers and scientists. Accordingly, Mandelbrot, a mathematician, put forward the concept of fractal geometry as an extension of classical geometry with no conformity to its rules. Mandelbrot claimed that the concept of geometry was inadequate to explain the formal language, diversity, and cellular compositions of nature with the geometric axioms and proportions put forward by Euclid around 365-300 BC. Fractal geometry allowed an understanding of the formation of complex, chaotic, irregular, randomness, organic shapes and forms in nature and many natural phenomena. On the other hand, Bauhaus School introduced design disciplines in the 20th century, which were developed with industrialization. The basic design principles, which have complex and deep roots in the language of art, design and psychology, have succeeded in moving from thought to application and practice. With the simultaneous development of materials and technology, it has targeted and made it a necessity to exhibit concrete integrity and more scientific working discipline in order to reveal the designer's artistic approach and imagination. This study included a characteristic analysis of 20 buildings that best reflect the principles of fractal geometry and design. It was considered that these principles would help a concrete design concept by making a matrix table study including their characteristic features.

Keywords: Fractal Geometry, Design Principles, Architectural Surfaces, Spatial Ornamentation, Basic Design

Introduction

Upon review of nature, which is the basis of creative thinking and the source of inspiration for a variety of design ideas, from a perspective of a philosophical architectural design approach, the internal rhythm of nature plays a unique and effective role in the nature-inspired forms and shapes. As a textural and sensory phenomenon, design reflects the aesthetics of nature onto space, while various principles subsistent in the roots of the design are associated with the aesthetics and attractiveness of the design.

Fractal geometry introduces the unique beauties of nature and many unknowns in nature with advancements in technology, offering a different perspective, a new viewpoint, and suggesting an infinite number of design potentials in the world of design. The combination of technology and nature is associated with aesthetically striking and functionally novel designs as well as new domains in the world of design. In this context, this study reviewed certain design principles and fractal geometry features of selected works/buildings. Accordingly, it was hypothesized that nature, design principles, fractal geometry, and architecture had an inseparable, integrated relationship with design. A diagrammatic representation of these relationships is shown in Figure 1.

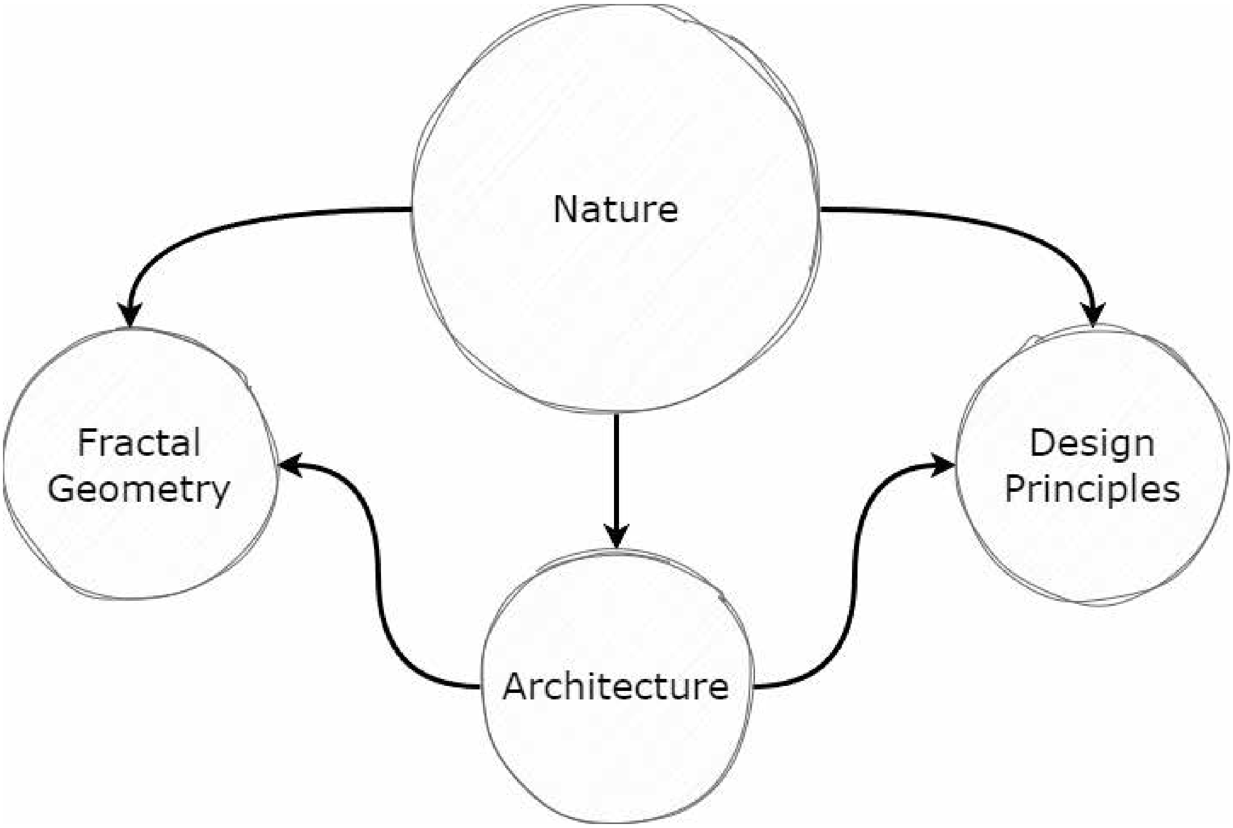


Figure 1. Relationship Diagram

During the post-Second World War period, a number of designers and theorists, especially including Gropius, Albers, Itten, Kandinsky and the Gestalt School, focused on the senses and creativity vis-a-vis the traditional architectural approach. Basic design and principles provide a theoretical and practical foundation for designers. Bauhaus approach focused on originality and creative thinking as an initiative to introduce a mode of production based on a combination of art, science, and technology. (Lazzari, 1990)

Bauhaus aimed to raise the awareness of designers in alignment with the scope of social needs of the early 20th century with an aim to bring solutions to a variety of problems to the welfare of society, and therefore brought together a range of branches of art and design, including such as graphics, industry and architecture. Accordingly, Bauhaus successfully filled the gap between different branches of art with the combination of craft and artistic thought and production techniques. (Frampton, 1992)

One of the founders and early practitioners of Bauhaus approach, Johannes Itten strived for developing an objective and intuitive understanding of certain principles that constituted the basis of design theory. As a result of his scientific and technological research, Itten suggested that it was important for the outer and inner worlds to be balanced, and that mind should also be used as an instrument for the benefit of creativity. Accordingly, Itten prioritized inspiration from nature, examination and study of structural, textural, and organic characteristics, revitalization and presentation of materials, creation of compositions using diverse materials, and put an emphasis on the analysis of old designers/masters. (Seylan, 2019)

Gropius described the outcome of the plain, original, and creative approach, which constituted the bases of the Bauhaus idea, combined with biological, social, and technical requirements, “as a reflection of life”. (Gropius, 1943, as cited in Berkin 2018)

Although design principles associated with introduction of a design idea, which are effective on the design parameters, may be a product of different perspectives among designers and the design world, the general principle follows the same steps. These different approaches are rooted in diverse perspectives on architectural design, art, and painting. A review of these principles may help with understanding any given design. The aforementioned design principles are shown in Figures 2 and 3 based on the suggestions of Ching and Adams.

Ching (2012). Classified the design principles under the name of "design vocabulary". The designer or architect synthesize different compositions of these principles to create her/his overall design.

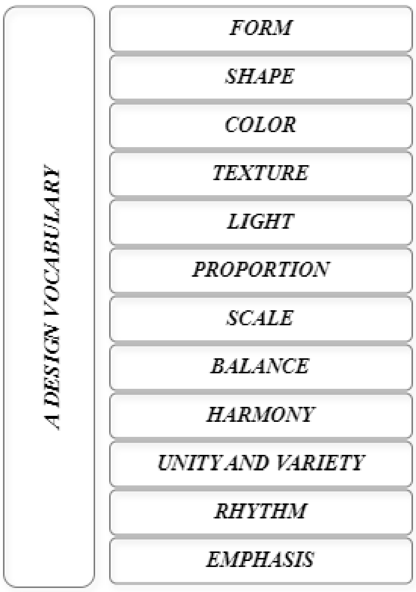


Figure 2. Dictionary of Design. (Ching, 2012)

Adams (2013). Pointed out that different approaches were adopted by design and art in the use of these rules and formulas in the language of design, yet it was important to distinguish certain principles in architectural designs. These principles are shown in Figure 3.

These principles as utilized in design compositions aim to refer to the whole and bring together perceptual and semantic constructs rather than focusing on geometric approaches. If design is considered an organization of components that express and bring to life an idea, the basic principles used in this process can be defined as intermingling coordinated elements, which conform to the purpose and need, through the first stage, organization, and completion.

Although it was French mathematician Gaston Juliat, who conducted the first studies on fractal geometry, or mathematical oddity as referred to in the scientific world, which plays a historical role in the development of pure mathematics, fractal geometry was conceptually suggested by the Polish mathematical theorist Benoit Mandelbrot in the early 20th century. Based on Mandelbrot's work during the 1975s and with the development of computer technologies, fractal geometry was put into use in a number of scientific branches, including physics, chemistry, biology, and fluid mechanics in explaining the complex structures found in nature. The concept of fractal geometry constantly evolves and has been a source of inspiration for designers.

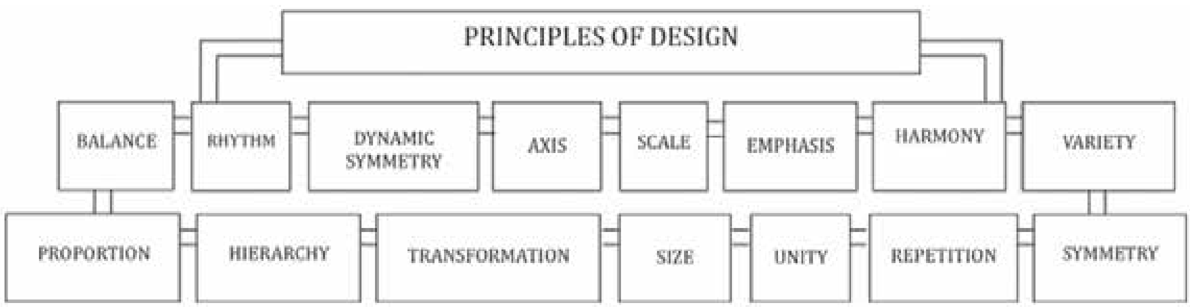


Figure 3. Rules in Language of Design. (Adams, 2013)

Labelled as formless and amorphous by Euclidean geometry and with no conformity to the laws of classical geometry, which rejects the examination of these forms, fractal geometry is also described as the order of disorder or the geometry of nature. While classical geometry provides an approach to the physical structure of objects by transforming our spatial intuitions into objective notions, the fractal concept, which translates conceptual thoughts into artistic and formal thought, urges us to examine its amorphous morphology (Mandelbrot, 1983). Mandelbrot used the word Fractus, literally meaning irregular, fragmented, self-similar shapes in Latin, to describe indented and protruding (rough surfaces) shapes. Studies aimed to explain mathematical complexity of nature concluded that a non-linear structure had a complex and fractal structure rather than a simple and regular embodiment.
In the light of Baudrillard's philosophical approach to the fractal concept, Baudrillard suggested that the whole represented the parts, and the parts represented the whole, and that was a manifestation of an uninterrupted series based on productivity that we frequently encountered in daily life and had an infinite dynamism. (Baudrillard, 1994).

The fractal concept has an important place in Baudrillard's terminology, reflecting a complex and apparently disordered order that infinitely repeats the same form, shape, and texture. This concept has been used to transform the complex order in nature transparent to make it conceivable. Baudrillard suggested that one of the fundamental forms that determined the world in which we lived was the fractal. As microscopic particles within this colossal process, we maintain our very existence within a system that seeks to be transmitted from a particular central axis to the whole.

In the light of Barnsley's philosophical view, the danger of a deep scrutiny into fractal geometry, which is a diversion of classical geometry, is a likely change in conceptual thought and perspective. Therefore, after the clouds, trees, galaxies, leaves, flowers, and many other forms in nature are studied from a fractal perspective, our perspective will never be the same (Barnsley, 2000).

The evolution of natural processes and the behavior of microorganisms in nature can be explained by means of the association between chaos theory and fractal geometry. Accordingly, upon a review of association between fractal geometry and chaos theory, the evolution of processes in nature over time can be examined by chaos theory, while fractal geometry will prove to be more helpful in understanding and analyzing the structural forms and shapes created by a chaotic and complex system. This context offers a holistic theory that triggers the understanding of balance, harmony, order, and symmetry in nature (Hariis, 2012).
Upon a review of similarities in basic approaches of theorists with diverse views in the context of the characteristic of fractal geometry, there are five basic features that can be suggested under the title of "characteristics of fractal geometry". These features are given below in respective order;

- **Self-Similarity:** Self-similar forms and shapes, smaller versions representing the whole and which create the whole.
- **Iteration:** A combination of repeating textures and elements, and the organization of the same textures in a certain order.
- **Fractal Dimension:** In calculations, fractal dimensions are divided into squares or triangles (divisibility condition) free from the traditional concept of dimensions, the ratio of parts to each other is expressed in fractional numbers (fractional dimension), and this system is suggestive of the complexity and structural depth of the fractal.
- **Complexity:** A complicated appearance at first glance, featuring an order behind this complexity, a symmetry and rhythm in its internal structure.
- **Infinity:** Fractal forms and textures continue forever. Emergence of new forms and structures as they are broken down into smaller scales.

Accordingly, in addition to the fractal formations in the textures of the buildings selected from different periods along with the complex and dazzling structures and shapes formed by a number of similar geometric shapes from large to small, which extend to infinity, design principles are also included in the designs very effectively as a reflection of nature.

Table 1. Theoretical Views and a Fractal Generation Process

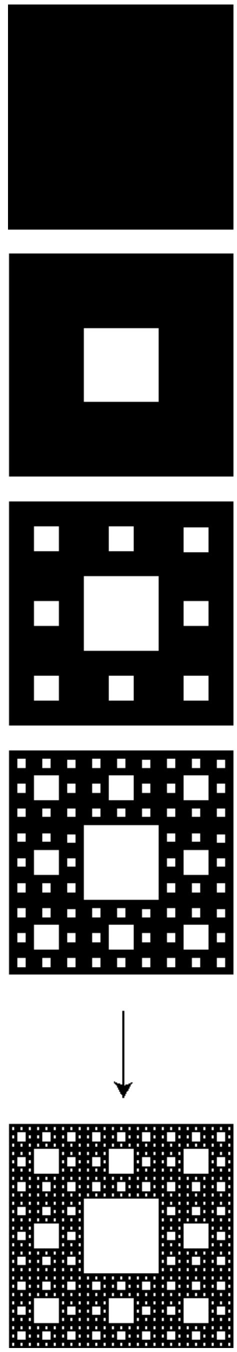
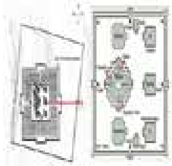
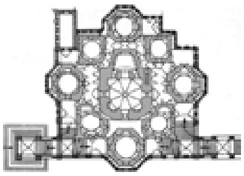
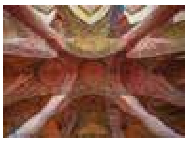
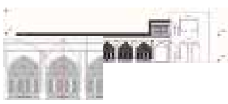
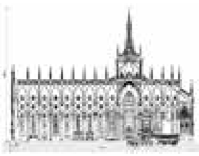
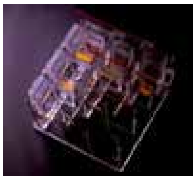
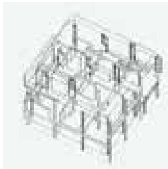
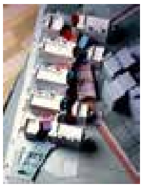
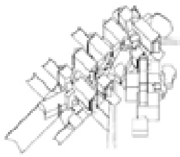
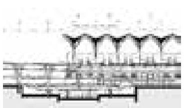
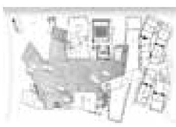
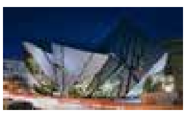
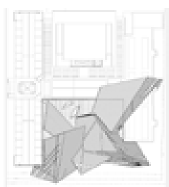
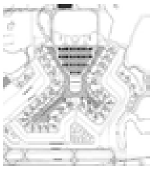
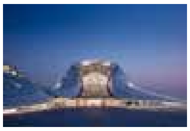
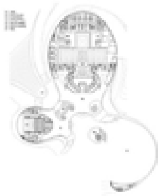
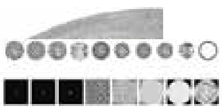
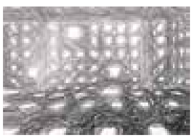
Eglash, 1999	Offering a new perspective on infinity by building a bridge between mathematics and technology, fractal geometry is considered an important tool of modeling natural sciences.	• Repetition/Recursion • Scaling • Self-Similarity • Infinity • Fractional Dimension	
Lorenz, 2003	Indicates the characteristic features of fractal geometry by emphasizing the infinite details of infinitely complex fractal forms.	• Infinity Complex • Developed Through Iteration • Dependence on Starting Conditions • Common in Nature	
Harris, 2012	Underscores the basic and characteristic features that help fractal forms being attractive and at the center of attention, complementing each other, and supporting integrity.	• Self-Similarity • Holism • Structure • Generative Quality • Dimension • Organizational Depth • Recursive/Nested Quality • Geometric Diagram	
Lee, 2014	As a creative and formative principle, emphasizes the characteristic features of fractals in the study of complex and irregular forms in nature.	• Self-Similarity • Non-Linearity • Randomness	
Falconer, 2003	Emphasizes the array of complexity and detail in nature through a study of fractal structures, life, and living organisms.	• excellent detail sequences • Complex and irregular structures • Non-Euclidean forms • Self-Similarity • Topological and fractional dimensions • Iteration and Repetition	

Table 2. Design Principles and Structures that best reflected Fractal construct

1			Prambanan Temple, Central Java, Indonesia	850 AD	Architect's identity is unknown. Influenced by Hindu architecture, this temple complex conforms to the hierarchical structure of the built environment. Horizontally and vertically iterative patterns and overlapping forms represent the desire for infinity.
2			Saint Basil Cathedral, Moscow, Russia	1561	Architect's identity is unknown. A basilica with a construction that complements each other in different domains, domes symbolizing movement and dynamism in different ways, color organization, a mixture of different and contrasting patterns, and a symmetrical approach on the plan axis.
3			Sagrada Familia, Barcelona, Spain	1882	Antoni Gaudi's Sagrada Familia is marked with non-Euclidean geometric forms as a combination of three-dimensional complex forms with an effect on the sound and light quality of the building. A building that symbolizes order and chaos as well as nature and divine connections.
4			Nasir-al-Molk, Shiraz, Iran	1888	Mohammad Hasan-e-Memar, the architect, designed Mohammad Hasan-e-Memar on a rugged terrain based on the principles of solidity and unity with naturalistic column arrangements, where geometric forms and spatial ornaments were prominent, and every arrangement led to a combination.
5			Milan Cathedral, Milan, Italy	1965	Designed by Donato Bramante and Pellegrino Tibaldi this building, the focal point of the built environment with its monumental elements, features octagonal and complex forms, a spiritual and mystical approach with its style, scale, emphasis, symmetry, and a play of light through its stained-glass windows.

6			House II, Hardwick, Vermont, USA	1970	Peter Eisenman aimed this building to meet structural requirements on a rugged terrain by means geometric approaches and emphasized uncertainty by eliminating specificity of scale by accommodating different scales.
7			JW Goethe University Biocenter, Frankfurt, Germany	1987	Peter Eisenman made use of DNA helices and the productivity of biological processes and expressed the uncertainty of ornaments, ensuring the necessary tensile strength of the structure by precise sequence of the DNA strand and geometric shapes in place.
8			Galinski School, Berlin, Germany	1995	Zvi Hecker's building complex, positioned asymmetrically around a helical and spiral axis, represents a constantly changing, dynamic, and iterative series sunflower forms and the mathematics of nature.
9			Lisbon Oriente Station, Lisbon, Portugal	1998	Santiago Calatrava adopted a parabolic approach with his expressionist attitude, achieving the whole through the iteration of geometric shapes, which exhibit an axial and modular attitude, in this translucent symmetrical building complex.
10			Federation Square, Melbourne, Australia	2002	LAB Architecture studio used geometric patterns forming zigzag and irregular U shapes, ground figure, and a design that is indicative of movement and visual connection.
11			Royal Ontario Museum, Toronto, Canada	2007	Daniel Libeskind's Royal Museum, which aims at to achieve the whole with nature, culture, and the built environment of the city based on an expressionist approach, is inspired by crystal and prismatic forms with an inviting attitude through its dynamic and vibrant design.

12			Mumbai Airport, Mumbai, India	2008	Skidmore, Owings & Merrill LLP used fractal roof canopy with thirty mushroom columns with references to the local Indian pavilion. The complex structure and perforated modular ceiling are made of fiberglass and reinforced plaster materials. (GFRG)
13			Louis Vuitton Foundation, Paris, France	2014	Frank Gehry adopted an innovative approach that abstracts vintage rose motifs to bring forward the dynamism and transparency of the building with the help of digital technologies, and the mobility in the form unites the surroundings with the environment.
14			Harbin Opera House, Harbin, China	2015	Ma Yansong, MAD Architecture, as inspired by the harsh and wild nature, embeds this structure in the city's wetland, which is reminiscent of snow and crystal peaks with its sinuous and amorphous form, in conformity with the topography, and its geometric and light diagrid approach.
15			Agri Chapel, Nagasaki, Japan	2016	Based on a completely renovation system, this Yu Momoeda Architecture design includes the characteristics of Gothic chapels by integrating its self-similar structure with proportion, scale, and inductive qualities.
16			Louvre Museum Abu Dhabi, UAE	2016	Jean Nouvel aims to introduce a combination of the complexity and repetition of geometric patterns on the ceiling plane, their overlapping, the play of light and shadow in the space, and reflection and serenity. A focal point designed in complete contrast to the Arab architectural traditions.
17			Lideta Mercato, Addis Ababa, Ethiopia	2016	With a design aimed to benefit from similar structures and the principle of iteration, Vilalta Studio has managed to keep the air quality in the space balanced by using a Sierpiński carpet pattern, where the volumes are interlocked and removed.

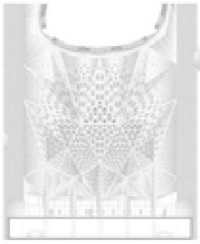
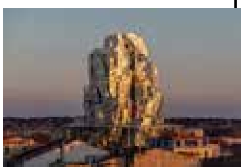
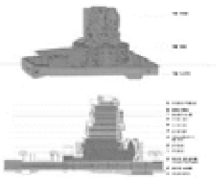
18			King Abdullah Petroleum Studies and Research Center, Riyadh, Saudi Arabia	2017	Designed as a unified whole adopting an environmental attitude, this structure by Zaha Hadid features a cellular and partially modular system, with solid and void hexagonal prismatic geometry and the unification of patterns.
19			Morpheus Hotel, Macao, China	2018	The world's first free-form high-rise design with Zaha Hadid's high-level use of geometric shapes and patterns inspired by jade carving, rich structural elements as well as form deformations, the principle of contrast alongside iteration, and a monolithic void in the atrium area symbolizing sublimity.
20			Luma Arles, Arles, France	2021	Located on a former railway and wasteland, Frank Gehry designed this building as a metaphor for a living organism, the principle of order, the balance between functionality and form, which augments the habitability and maximum efficiency of the building.

Table 3. A Matrix of Design Principles and Characteristic Features of Fractal Geometry

Evaluation Chart of Study Buildings Based on Design Principles	Prambanan Temple	St. Basil Cathedral	Sagrada Familia	Nasir-ol-Molk Mosque	Milan Cathedral	House II	Biocenter	Galinski School	Lisbon Oriente Station	Federation Square	Royal Ontario Museum	Mumbai Airport	Louis Vuitton Foundation	Harbin Opera House	Agri Chapel	Louvre Museum Abu Dhabi	Lideta Mercato	King Abdullah Petroleum Studies and Research Center	Morpheus Hotel	Luma Arles
The Design Principles in Architectural Design																				
1. **Emphasis**																				
Form/shape	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	✓	✓	✓
Scale/Size	✓	✓	✓	x	✓	✓	x	x	✓	✓	✓	✓	✓	✓	✓	✓	x	✓	x	✓
Texture	✓	✓	✓	✓	✓	x	x	✓	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓
Color	x	✓	✓	✓	x	x	✓	✓	✓	x	x	x	✓	✓	✓	x	✓	✓	✓	✓
Orientation	✓	✓	✓	✓	x	x	✓	✓	✓	✓	x	✓	✓	✓	✓	✓	x	✓	✓	✓
2. **Rhythm/Iteration**																				
Texture/Pattern	✓	✓	✓	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Form/Shape	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Color	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3. **Unity and Variety in Form and Texture**																				
3A. Form																				
Abstract geometrical form	x	✓	✓	✓	✓	x	x	✓	x	x	x	x	✓	x	x	x	x	x	x	x
geometrical form	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	✓	✓	✓	✓	✓	✓
Organic form	x	✓	✓	✓	x	x	x	x	x	x	x	✓	✓	✓	x	x	x	x	✓	✓
3B. Texture	✓	✓	✓	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4. **Harmony**																				
Form-2D-3D	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Texture	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Color	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Orientation	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	✓	x	✓	✓	x	✓	✓	✓	x
Scale/Size	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	✓	✓	✓	✓	✓	✓	✓	✓	x
5. **Symmetry, Balance, and Hierarchy in the Structure**																				
Symmetry	✓	✓	✓	✓	✓	✓	✓	x	✓	x	x	✓	x	x	✓	x	✓	x	✓	x
Asymmetry	x	x	x	x	x	x	x	✓	x	✓	✓	x	✓	✓	x	✓	x	✓	x	✓
Visual	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	✓	✓	✓	✓	✓	✓	✓	✓	x
Radial	✓	✓	x	x	x	x	x	✓	x	✓	x	✓	x	✓	x	x	x	✓	x	✓
Axial	x	x	✓	✓	✓	✓	✓	x	✓	x	✓	x	✓	x	✓	✓	x	✓	✓	x
Central	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	✓	x	x	x

	Features of Fractal Geometry																			
1. Self-similarity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2. Iteration/ Recursion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3. Fractional Dimension	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4. Complexity	x	✓	✓	✓	x	✓	x	✓	✓	✓	✓	✓	✓	x	x	✓	✓	✓	✓	✓
5. Infinity	✓	✓	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

CONCLUSION

In conclusion, it was understood that fractal geometry, which clarified the complexity of nature and allowed modeling thereof, and design principles, which are at the core of design, influenced the design approaches of selected buildings upon a review of previous studies and were occasionally hidden in the design processes and played an important role.

Therefore, the results of the analysis of selected buildings, which intensively incorporated characteristic features of fractals and design principles and expressed in the best way, are listed as follows.

Natural and Organic Approaches:

The design principles that subsisted in the design language and its very foundations leave more permanent and effective traces in the design world with the combination of geometric approaches and organic forms in natural processes. Although this combination points out the importance of Biomimesis and Biophilic design approaches, it is also evidence of how nature-inspired designs could be incorporated in an aesthetic and functional approach.

Role of Technology

It can be suggested that more rational and innovative designs emerge from the combination of these principles considering all the developments in the design world, especially the contributions of computer technologies in understanding these processes, and modeling and analysis. Utilizing computer software (e.g., Parametric software) and simulation tools, may allow designers to produce complex and complicated geometric forms and structures more easily and quickly, while also saving cost and time.

Incorporating the Algorithm into the Design:

Original design ideas can be derived from the combination of the principles of design and certain differential geometry principles in a computer environment, in case certain algorithmic sequences and some iterative principles are used within the framework of certain rules. This approach will have a positive effect on creativity in the design process and can also allow the development of original and functional solutions. Incorporating the algorithm into the design will ensure rapid testing and optimization of design alternatives by adopting generative design approaches and techniques.

Complex Forms and Textures:

Complex forms, patterns, and textures generated in the computer environment within the framework of these principles can offer innovative ideas and solutions for the future of design. This type of design action can create a rich effect in terms of both aesthetics and functionality, and with regard to improved user experience and harmony with the environment.

Previous studies and analyses of buildings in question, which were designed in different periods, suggest that all the buildings sustain a conscious or unconscious connection with nature, fractal patterns, and design principles. It is an important point that these buildings used the same fractal patterns before the current technological processes. Today, the effects of constantly changing and developing technology and materials are clearly evident in contemporaneous buildings.

Based on the results of the present study, it can be suggested that the combination of fractal geometry and design principles opened new horizons in the design world and were effective and contributed to the development of creativity and innovative thinking. Therefore, designers can create more rational, sustainable, aesthetic and functional designs and achieve the desired results if they incorporate and abstract the complexity of existing structural principles in nature by means of technology and algorithmic thinking.

References

Adams, E. (2013). The Elements and Principles of Design: A Baseline Study. International Journal of Art & Design Education, 32(2), 157–175. doi:10.1111/j.1476-8070.2013.01761.x

Barnsley, F. M. (1998). Fractals Everywhere. Second Edition. Morgan Kaufman Press, San Diego.

Baudrillard, J. (1994). Simulacra and Simulation. The University of Michigan press.

Berkin, G. Civelek, Y. (2018). Modül ve Mimarlık. Nobel Yayıncılık Eğitim Danışmanlık Tic.

Ching, Francis D.K., Binggeli, C. (2012). Interior Design Illustrated. Third Edition, John Wiley & Sons, Inc

Eglash, R. (1999). African Fractals: Modern Computing and Indigenous Design. Rutgers University Press.

Falconer, K. (2003). Fractal Geometry: Mathematical Foundation and Applications. John Wiley & Sons Ltd, England.

Frampton, K. (1992). Modern Architecture. A Critical History, With 362 Illustrations. Third Edition: Reviswd and Enlarged. Thames and Hudson Press.

Gropıus, W. (1943). Scope of Total Architecture. Collier Books.

Harris, J. (2012). Fractal Architecture: Organic Design Philosophy in Theory and Practice. University of New Mexico Press, Albuquerque.

Lee, M. S. (2014). Application of Fractal Geometry to Architectural Design. ArchitecturalResearch, Vol. 16, No. 4, ss. 175-183. doi.org/10.5659/AIKAR.2014.16.4.175.

Lorenz, W. E. (2003). Fractal and Fractal Architecture. Faculty of Architecture and Spatial Planning, Technical University of Vienna.

Lazzari, M. Lee. C. (1990). Art and Design Fundamentals. Van Nostrand Reinhold, New York.

Mandelbrot, B. B. (1983). The Fractal Geometry of Nature. W.H. Freeman and Company, New York.

Seylan, A. (2019). Temel Tasarım. Yapım Evi Yayıncılık. Yem Yayın.