A Comparative Study on the Modern Jewelry Design Using Mathematical Principles -Focused on the Digital System-

Jae-won Yoon

Abstract : Background/Objectives: There is a surprisingly complete order in the natural world where we live, and this order is shown in a certain pattern on all living creatures including humans, animals, and plans.

Fibonacci sequence that pursues to maximize the propagation in the nature and golden spiral that creates a beautiful figure are all examples that show the secret of mathematically designed living creatures. It has been reviewed that mathematical principles in such a nature and values currently activated in the jewelry industry were related to each other.

Methods/Statistical analysis: In order to clarify the theoretical basis of naturalism that has not been studied in the field of ornaments, the use of naturalistic terms in various fields is to be examined deriving the nature and design characteristics of naturalism through previous studies related to naturalism.

It is also aimed to develop the design of ornaments applied with the design of digital system (CAD/RP) as well as naturalistic golden ratio and mathematical principle of Fibonacci sequence while systematizing related characteristic.

Findings: This study has suggested a new method in the use of computer for jewelry design by utilizing mathematical principles used in the nature. At the same time, the purpose is to expand the area of expression for the design advancing the expression method in up-to-date mode and improving diverse and accurate manufacturing methods and productivity.

Expressing dynamic image shown in the end of century when jewelry design area started actively being advanced with organic harmonization and forms on the jewelry, the identity of modern jewelry has been established.

Improvements/Applications:In this study, the importance of creative design is emphasized. At the same time, it is anticipated to enhance the value of design products and develop functional, aesthetic, and creative design products in modern ornaments design. Through the application of the golden ratio of the mathematical principle existing in the nature, utilization of Fibonacci sequence and the process of digital system (CAD/CAM/RP), and the nature-friendly and advanced production technique of modern ornaments, people can wear more aesthetically and friendly ornaments. Naturalistic ornament design that makes a free expression not only look at an appearance when dealing with objects but also pursues to switch internal and external structure by focusing on the internal aspects. Seen in this perspective, it is expected that design will be developed in more unique and diverse perspectives. At the same time, the field of design will be expanded along with application to proceed a diverse scope of activities with work.

Keywords: Nature, Math, Digital, Jewelry, Design, Fibonacci sequence

I. INTRODUCTION

Humans are able to mathematically think or express a number of living creatures or life-related phenomena in the nature. Especially, it is possible to observe how mathematics exists behind the formative beauty. In addition, we are able to design and express orderly and planned patterns from such mathematical principles [1].

The field of design art related to mathematics entailing objective and strict proof and subjective and sensual aesthetics seems not to be formative at all. However, as quantitative concept such as mathematics exists in the criteria of beauty such as the Golden Ratio or Fibonacci sequence, it is predicted that there are still many quantitative elements we have not found yet. Furthermore, connection of mathematics, geometry, and aesthetics indicates that these two fields have been developed in the same context throughout the history. Therefore, it seems to be a natural result that computer science was developed with mathematics and incorporated with design to create the area of computer graphics. [2]

This study has identified why mathematics was regarded to be artistic and how mathematics influenced on music and fine art. At the same time, it dealt with mathematically beautiful form that people frequently dealt with in the nature or their lives. Expected effects of this study are as follows.

First of all, it is to consider mathematical characteristics of design in the nature selecting and analyzing materials based on various fields and utilizing them as a fundamental resource as a new expressive form.

Secondly, it is to identify overall design elements and characteristics of mathematics and confirm the possibility of development in the field of modern ornaments.

Third, it is to apply the Golden Ratio and Fibonacci sequence as a language for formation in the nature based on mathematical principles confirming the possibility of development in ornaments by expanding the scope of design for modern ornaments.

Lastly, it is to apply digital system (CAD/RP) applied with mathematical values researching for how

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to reduce time and a range of errors when manufacturing trial goods or samples.

II. MATERIALS AND METHODS

It This study examines mathematical data analysis as the theoretical foundation of modern ornaments for the application of the Golden Ratio and the Fibonacci series, and various fields that are closely related to the Golden Ratio.

It is intended to examine the research subject through the analysis of the ornaments applying the mathematical principle of the Fibonacci sequence and the golden ratio as the naturalistic formation principle and the actual manufacturing. The research method is as follows.

First of all, it is to review the features of mathematical design in nature and select and analyze data centering on various fields.

Second, it is to apply the digital system in the mathematical design utilization and illustrate the works through the existing preliminary research and literature survey on design and analyze and verify the flow of modern jewelry.

Third, it is to develop designs using ornaments and CAD/RP that use the principles of mathematics and maximize the effects of the principles of mathematics.

III. GENERAL CONSIDERATION IN MATHEMATICS AND DEVELOPMENT OF DESIGN

3.1. Beauty of mathematics

Just like art, the most fundamental application in the creation in mathematics lies in beauty for creating structure, order, and life on them. Structure indicates the existence of form, harmonization, and balance. The reason why structure is the most important in mathematics is because it is possible to create something new by researching for structure. For example,

x2 + y2 = r2 is an equation for circle on the plane.

x2 + y2+ z 2 = r2 is an equation of a sphere in three dimensional space.

x2 + y2+ z 2+ w 2 = r2is an equation of hypersphere in four dimensional space. This can be expanded to a random sphere.

As for artistic creation, relation between parts and between parts and the entirety shall be harmonized and balanced. This applies to mathematics. Mathematical creation is proceeded with harmonization and balance on one dimensional logic [3].

3.2. Role of mathematics in the design

Topology deals with a three dimensional space that has been much influential in various areas in modern society. As shown in [Figure 1], representative outcomes in the design field are three dimensional computer graphics based on Descartes coordinates. There is no need for a designer who deals with three dimensional graphics to study for topology. However, there is a need for them to understand how three dimensional space or object they are dealing with is created.

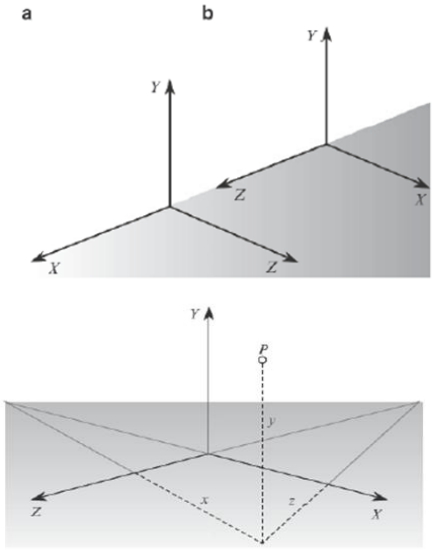


Figure 1. Descartes coordinates used in the three dimensional computer graphics

It cannot be denied that mathematics is a very objective and quantitative field of academia. However, it was made by humans and has been applied in many areas and developed in new forms. Now is a period when new artistic values inherent in strict rules shall be found instead of recognizing mathematics as a rigid and tedious calculations or formulas. Godfrey Harold Hardy, a mathematician in England, said that a true mathematician had a permanent aesthetic value just like

Mathematics in ancient Greek while providing fervent emotional satisfaction to people even thousands years later just like the best literature [4].

There shall be mathematical principles related to the beauty needed for design elements.

3.3. Mathematical design in the nature (Golden Ratio and Fibonacci sequence)

3.3.1. Meaning of Golden Ratio

Golden Ratio indicates the ratio of length and breath as 1:1.618... as the most stable and beautiful proportion <Figure 2>.

As shown in the <Figure 2>, rectangle divided in Golden Ratio becomes a similar rectangle from the previous one when keeping on dividing. If repeating this work, it is possible to make unlimited number of rectangles with the same proportion. On the other hand, if connecting square on the larger side of a rectangle in Golden Ratio with length and breath, it is possible to create a rectangle with higher Golden Ratio. This work can be proceeded unlimitedly. With this method, it is possible to create spiral shown in several shellfish. [5] From the past, humans have applied this Golden Ratio to architects and artistic works. This ration is widely used in modern era. Why do humans feel the most stableness and beauty in this geometric ratio? The secret lies in the nature, and the solution is also found in the nature.

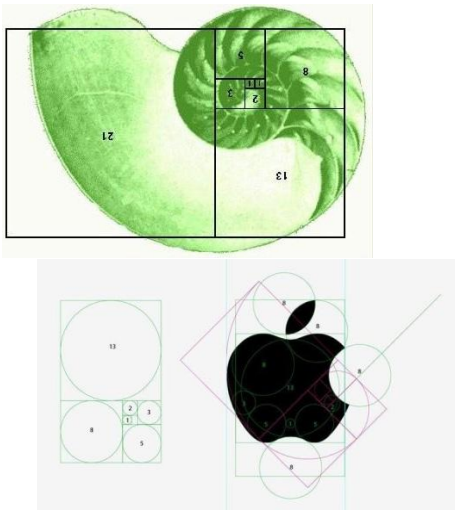


Figure 2. Golden Ratio of nautilus and Apple-logo

Logo of Apple is known to be drawn with the golden ratio and was designed by the designer, Rob Janoff, as one of the representative logos applied with the Golden Ratio [6].

3.3.2. Meaning of Fibonacci sequence

Fibonacci sequence starts from 1 and is formed when adding two previous terms to create the next term (However, if there is only one previous term, the second stage is omitted). Therefore, Fibonacci sequence starts as follows.

1, 1, 2, 3, 5, 8, 13, 21, ••••••••

This sequence is seen in the spiral arrangement of sunflower seeds. There are two types of spirals, one for rotating to the right and the other for rotating to the left. The number of spirals is different in each sunflower. However, it includes 34 and 55, 55 and 89, or 89 and 144. When carefully observing cones, it is confirmed that pieces like scales are crossed with right-rotating and left-rotating arrangement. The number of lines is 8 and 5. This means that 8 and 6 are a pair of adjacent terms in Fibonacci sequence [7].

IV. UTILIZATION OF DIGITAL SYSTEM IN THE APPLICATION OF MATHEMATICAL VALUES

4.1. Flow of modern jewelry design in the application of digital

Due to the superior effect over the conventional manual design, the usefulness of computer graphics is especially remarkable in designing ornaments that require delicate expression.

For example, when designing ornaments, it is possible to quickly express the desired shape with the advantage of the computer that is easy to modify and repeat. By efficiently performing the drawing management using numerical values, and finely performing the expression enlarging function that is difficult to be achieved by hand, it has been evaluated as a very effective tool. In addition, it can enhance efficiency in terms of time and cost through simulation by realistic expression such as real objects by various colors and intensities of light.

The biggest advantage of computer is that developers are able to proceed all the stages in data management including design, manufacturing, and advertisement by sharing the bond of sympathy. These advantages make it feasible to proceed development in each major according to printing technology and technology differentiation as shown in [Table 1 and 2] that 3D design data in the early stages are consistently used, and three dimensional CAD design data are used based on consistent flow.

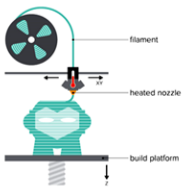
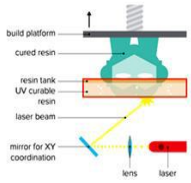
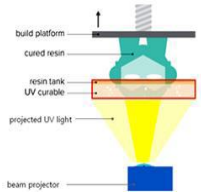
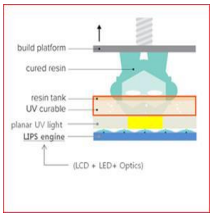
With the industrial development, computer is more widely used. Especially, there has been an increasing trend of using computer in the jewelry industry. With the industrial demand, computer is used and directly connected with production to manufacture in the use of CAD/CAM/3D printer (RP) [8-9].

Table 1: Initial 3D printing mode

Types of technology	FDM	SLA	DLP	Poly jet	SLS
Hardening method	Heat	Laser	DLP	UV LED	Laser
Materials	Thermosetting resin	Light-hardening resin		Light-hardening resin	Solid powder
High speed formation	✕	△	◯	△	△
Preciseness	✕	◎	◎	◎	◎

◎ Very good, ◯good, △ normal, ✕bad

Table 2: Differentiation of 3D printing technology

	FDM	SLA	DLP	LIPS
Work mode				
Differentiation of technology from work type	LIPSvs. FDM : Outstanding preciseness and printing speed compared to FDM ▸ Outstanding speed and quality (preciseness) Characteristics of FDM method: Affordable price on materials but much loss in materials. Significantly low printing speed and preciseness of products LIPSvs. SLA : Simple product configuration, low operation cost, and outstanding printing speed compared to SLA LIPSvs. DLP : Compact size of device compared to DLP, low operation costs, large area formation, 1:1 matching form with Mask			

4.2. Analysis of jewelry design in the use of mathematical principles

In the perspective of expressive effect that requires accurate values and modeling on the drawing and expected objects in the course of manufacturing jewelry, it is required to utilize the digital system with higher efficiency compared to the planning, demonstration, and development of manual design in the past.

First of all, when designing in the course of manufacturing the jewelry products, it is possible to utilize advantages of digital system with convenience of modification and copy if requiring mathematical and accurate values as shown in the [Figure 3] proceeding one modeling procedure and swiftly realizing the design in need of copying functions. At the same time, this has been well-recognized as a very efficient tool when expressing details through efficiency of establishment of database and the 3D expanding function that is difficult to be expressed with manual work. Secondly, virtual rendering function among the features of CAD makes it feasible to fully review and analyze design with various materials with realistic expression in each material from diverse colors and intensities of the light. At the same time, it simulates with realistic expression to come up with more complete design and reduce disadvantages of time and cost in the product manufacturing process. Third, it is possible to explore three dimensional design in the design performing stage. Therefore, designers are able to build three dimensional way of thinking and visually suggest issues of products and suggest solutions in advance according to the three dimensional review as shown in [Figure 4]. Lastly, this makes it feasible to suggest real objects from accurate expression of design according to the consumers who prefer various life styles and communicate with each other [10-11].

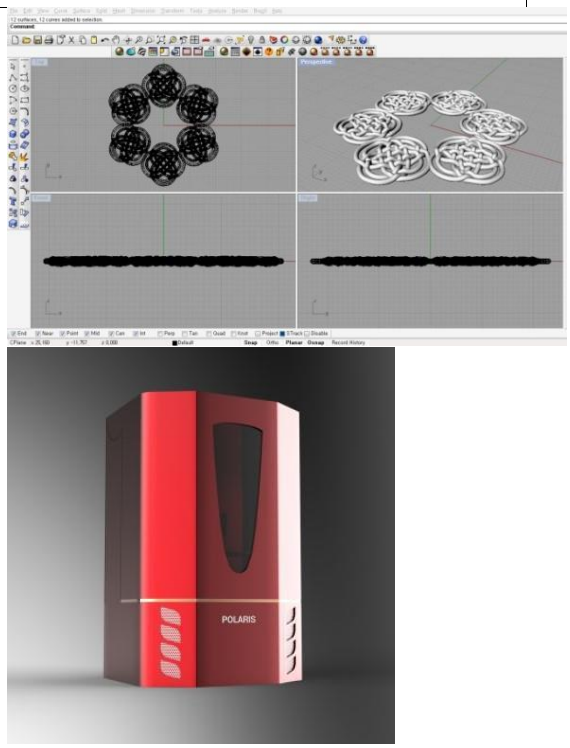


Figure 3. Rhono CAD work and 3D print(RP) device

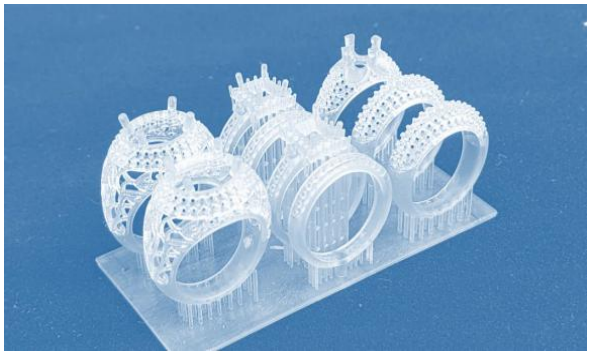


Figure 4. 3D print output

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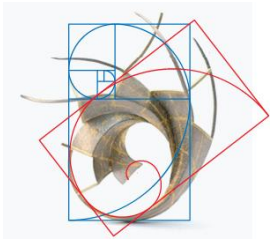
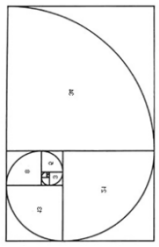
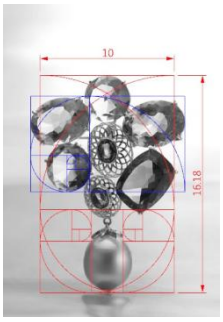
V. RESULTS AND DISCUSSION

It is aimed to examine the design elements and characteristics of the overall tendency of modern naturalism and identify future developments in the field of modern ornaments.

With aforementioned research, it is intended to expand the range of modern design and confirm and contribute to the design of modern ornaments by applying the golden ratio as a naturalistic formation principle and manufacturing and interpreting modern ornaments.

By utilizing the advantage of being able to see the design from various viewpoints, it is possible to search stereoscopic design from the design execution stage making it feasible for designer to develop the strength of stereoscopic thinking rather than the planar thinking. At the same time, as shown in [Table 3], size, structure, and shape of the product are visually displayed in a three-dimensional manner to make designers sufficiently review and analyze the product for more complete design. Hereupon, this application of computer graphics technology will contribute not only to rationalization and rapidity of design development, but also to production of excellent products.

Table 3: Analysis of Fibonacci sequence and golden ratio of modern ornaments

Author	Work	Application
Will Evans		
	Fibonacci Brooch	Brooch in the application of Fibonacci sequence principles
Judy Hoch		
	Brooch	Brooch in the application of the golden ratio
Myungji Ye		
	Net Collection	The crossed area is located in the center when distributing golden square to the left and the right based on the pearl in the middle.

VI. CONCLUSION

In order for jewelry products in the international competition industry to be competitive, scientific design process and systematic production management are required. At the same time, it is expected that the efficiency of digital system usage is improved in the jewelry design and manufacturing process with the enhancement of function of jewelry design software and automatic production system from digital distribution.

In the field of jewelry design, development of

Jewelry CAD and Rhino CAD program also necessitates the introduction of digital system in the field of jewelry production.

Designers are facing an assignment for having to know everything including new technology, trend, and requirements of consumers. Therefore, the role of jewelry designers is becoming more important.

The design of ornaments in the naturalism has expanded the concept of ornament design by incorporating various artistic values in the nature. Harmonization with the nature based on the golden ratio and Fibonacci sequence and various symbols have enhanced the artistic value making jewelry an independent subject for creating artistic sentiment beyond the limit as an object. Ornament design in the naturalism for freely expressing internal values off the boundary of external values not only sees external appearance when dealing with a certain object but also pursues to switch internal and external structure by focusing on the internal aspects. Seen in this perspective, design is expected to be developed in unique and various perspectives in the future. In addition, it is expected that design area and applications of them are expanded proceeding various forms of activities.

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