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Explaining a Jewelry Design Process: Using a generative Design Method Called Shape Grammars and Producing the Product with 3D Printing

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Abstract

It is a practice-based research that studies a generative design method called shape grammar to create original forms for a jewelry product. In the research, the snowflake geometry is examined. New geometries are created based on the rules of shape grammar. In the second phase of the design process, the 3D printing production technique is worked on. Depending on the limits of the 3D printer, the final details of the necklace are decided. Finally, the design is tested and produced by a 3D printing machine. The research aims to experience a new production technique with a design method.

Keywords

Generative Design Methods, 3D Printer Technology, Jewelry Design, Snowflakes

1. Introduction

Technological developments led to several changes in all design disciplines. The impact of 3D printing technology and generative design on jewelry design has been significant and transformative. 3D printing has created intricate and complex designs previously difficult or impossible to achieve with traditional manufacturing techniques (Dragu, 2023). It has also enabled designers to test the strength and integrity of their designs before investing in expensive and time-consuming mold-making (Dragu, 2023). 3D printing has reduced the time and cost of production, allowing designers to spend more time on the final piece of jewelry. It has also allowed for the rapid repair of tiny pieces (Dragu, 2023).

On the other hand, generative design has allowed the creation of unique and personalized jewelry designs by manipulating wave patterns using computer programs (Green & Bootman, 2023). It has also enabled designers to create elaborate and intricate designs that were once limited by traditional manufacturing constraints (In3dtec, 2023). AI algorithms in jewelry design have also allowed for creating of new and appealing designs by analyzing vast amounts of design data, historical trends, and customer preferences (Bennett, 2023). Combining 3D printing, generative design, and AI has created highly personalized and unique jewelry pieces that align with evolving tastes and preferences (Bennett, 2023). The future of jewelry design is expected to be custom, on-demand, and perfectly sized, with 3D printing and generative design playing a significant role in the industry's transformation (Hendrixsen, 2020). As a designer and researcher, I aimed to examine the new production method of 3D printing. Every production technique has its advantages and disadvantages. I wanted to explore those advantages and disadvantages while studying the shape grammar generative design method. The paper starts by explaining practice-based research and shaping grammar design methods. In the following parts, the design process is described.

2. Materials and Methods

2.1. Practice-Based Research

We can define practice-based research as genuine exploration, which is preferred to have information using practice and the outcomes of that practice. The original conclusion and the contribution to the knowledge of the study can be shown by creative outcomes, which may include objects like images, music, designs, models, digital media, or other outcomes such as performances and exhibitions. The outcomes of the practice as reference are essential to give complete knowledge of the research's significance and context (Candy, 2006). Practice-based research can contribute to the design process by providing a way to explore and gain new knowledge through creative practice. Practice-based research is a systematic approach that involves making things part of the research process. This approach allows researchers to incorporate their creative practice, creative methods, and creative output into the research design and as part of the research output (Gauntlett, 2021). By engaging in practice-based research, designers can explore new ideas, test new methods, and develop new approaches to design. Practice-based research can also help designers better understand recurring questions in projects that they need more time to delve into during the traditional design timeline. Through practice-based research, designers can advance their knowledge and designs, leading to better buildings and more innovative solutions (Love, 2020).

2.2. As a Design Inspiration, Snowflakes

I must choose a primary shape since I will use shape grammar as a generation method. Therefore, I chose a snowflake geometry. I assume these shapes are suitable for generating original forms by a generative design method. Snowflakes are hexagonal because water molecules stack together to form a hexagonal lattice when they freeze into individual ice crystals. The snowflake curve is a well-known mathematical curve used in shape grammars. Shape grammars are used to generate a new class of reversible figures, and they are given for some well-known mathematical curves, including the snowflake curve (Gips, 1975). The snowflake curve is a fractal curve generated by repeatedly applying rules to a line segment. Therefore, choosing the snowflake as the initial shape for shape grammar may be due to its unique and intricate shape, which can be generated using a set of rules (Gips, 1975). Under the favor of several scientific researchers, it is learned that all snowflakes have unique geometric shapes. Today, several geometric shapes are known as snowflakes, and as a semantic figure, those shapes are commonly used in designs to recall winter. In **Figure 1**, we can see some photographs of snowflakes (Libbrecht, 1999).

2.3. A Contemporary Design Generation Method: Shape Grammars

Shape grammar is a generative design method with transformation rules carried out repeatedly to an initial form, generating new forms. George Stiny invents it.

We can define shape grammar as a generative design tool in which the drawings are generated by applying algorithm rules, allowing the exploration of new concepts and solutions (Knight, 2000).

We can see examples of shape grammars as a foundation for art and architecture, such as Chinese lattice designs (Stiny, 1977), window designs of Frank Lloyd Wright (Rollo, 1995), traditional Turkish houses (Cagdas, 1996), ornaments on ancient Greek potteries (Knight, 1986) chair designs of Hepplewhite (Knight, 1980). In **Figure 2**, we can see a shape grammar example whose rules are based on the rectangular geometries and the rotations (Liew, 2004). In **Figure 3**, we can see generative designs whose initial shapes are Islamic figures.

2.4. Blinking an Eye to a New Production Technology; Trying Out 3D Printers

3D printing, or additive manufacturing, creates three-dimensional objects from a digital file by adding material layer by layer. This technology has been around for over 30 years, but it has only gained popularity in the last ten years due to the rise of desktop 3D printers. 3D printing is a game-changing technology that has

Figure 1. Microphotographs of Snowflakes (Libbrecht, 1999).

the potential to revolutionize all industries, from manufacturing to healthcare. It allows for the creation complex shapes and geometries that would be otherwise impossible to construct by hand. There are many methods of 3D printing, and each has its strengths and weaknesses. The most common 3D printing process is fused deposition modeling (FDM), which uses a continuous filament of a thermoplastic material (Placek, 2023). 3D printing is a versatile option for manufacturing, and it is being used in almost all industries, including consumer products, industrial products, dental products, prosthetics, and architectural scale models. 3D printers are a new kind of technology that is a popular subject in many disciplines, from health to architecture. It also has examples in fashion design and jewelry design. **Figure 4** shows an example of a dress produced by 3D printers and designed with kinematics (Nervous Systems, 2014).

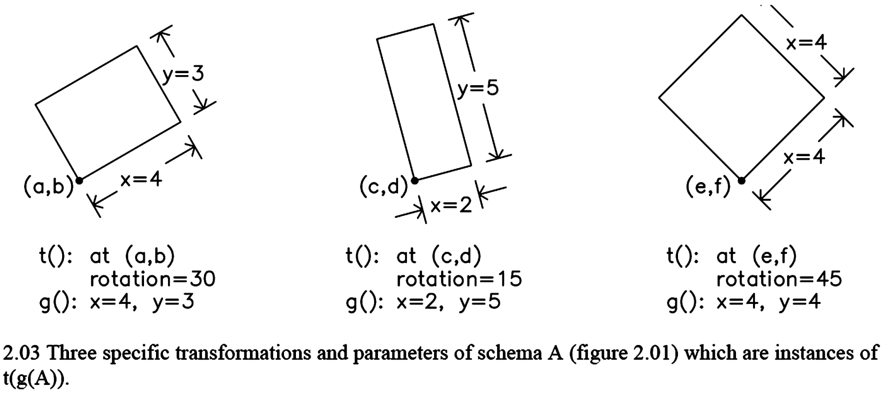


Figure 2. Representation of the movements and dimensions of shapes (Liew, 2004).

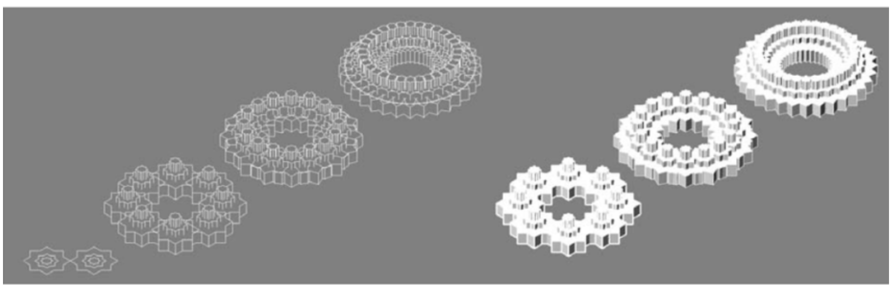


Figure 3. The Islamic Figures' initial shapes and the 3D dimension shape (Cenani & Gülen, 2007).

Figure 4. Dress is produced by 3D printers (Nervous System, 2014).

3. Results

3.1. Analysis of Chosen Geometry

In Figure 5, we can see the chosen geometry of snowflake.

As seen in Figure 6, the shape is formed with six branches, with eight branches of various lengths.

1) The end of the branches forms a hexagon.

2) The angle between the two main branches is 60˚.

3) The angle between the small branches is 10˚.

3.2. Design Process Outcomes

Before starting to repetitive design, the piece of the shape is decided. The four branches from the top were picked to repeat. It can be seen in Figure 6. It is chosen because it is seen as the smallest part of the snowflake character.

Every branch of the snowflake was named from A to F. It can also be seen in Figure 6. Every shape could only join with the shape that was 90˚ to the other. In Figure 7, this principle can be seen.

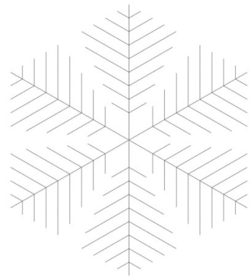
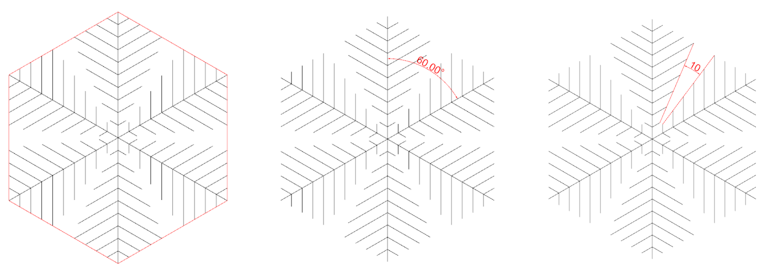


Figure 5. The first vector shape which is designed.



1) 2) 3)

Figure 6. Analysis of the initial shape.

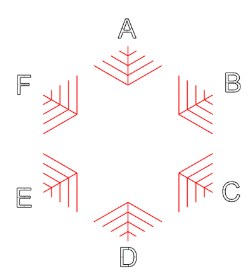


Figure 7. Shapes and the names of the shapes.

After the principles are decided, some experimental shapes are created with different rules. In **Figure 8**, we can see some 2D outcomes that are created, and in **Figure 9** we can see the decided shape.

3.3. Final Design Decision

The shapes which are generated can be used for several design problems. In this study, I designed a necklace to use those geometries. As fashion objects, jewelry requires more aesthetic priorities than design details like durability and efficiency. However, accessory designers cannot avoid the ergonomic and material details of the jewelry (Bayazit, 2009). The render of the designed necklace can be seen in **Figure 10** in two different angles—the details of the necklace designed for the 3D printing production. First, a symmetric rule is chosen for the necklace in the decided shape. Because the necklace needs to stay in balance on the neck, the shape grammar rules can also give us a shape-like chain that is a suitable detail for a necklace design.

3D printer production technology allowed me to design the montage detail of the necklace before the production. Therefore, there is no need for any post-production montage after the 3D printing process. The pieces are connected naturally. You can see this detail in the picture below (**Figure 11**). All the 3d drawings for this necklace were done with the Rhinoceros program and rendered with the Vray program.

In the 3D printing production process, certain phases are followed. Even

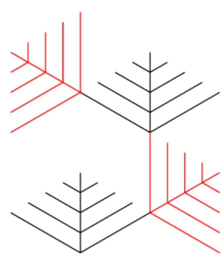


Figure 8. Decided shape and the shape grammar rule: ABAF.

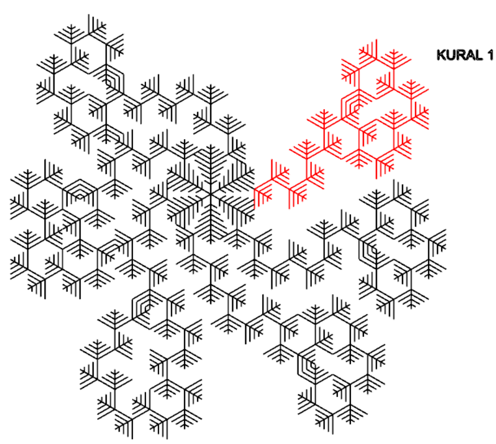


Figure 9. Decided shape and the shape grammar rule: CBCBABABCDCBABAFAFED.

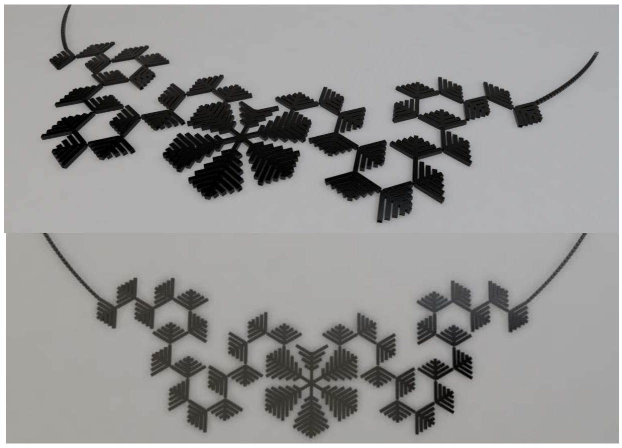


Figure 10. Decided shape for the shape grammar rule: ABCDCDCBABAFABCBC.

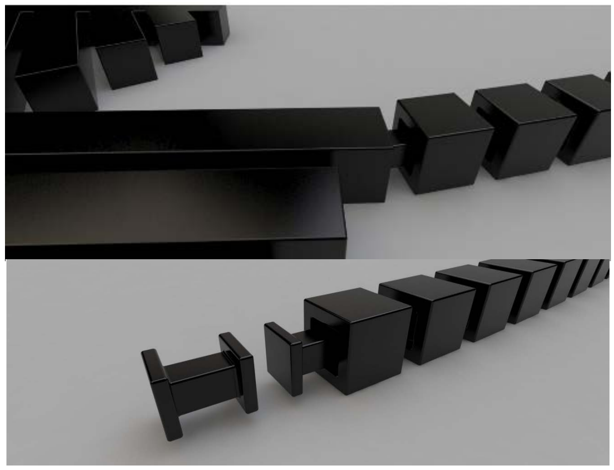


Figure 11. Mounting detail of the necklace.

though slight differences depend on the material, design, and the 3D printing machine, I will summarize the process as follows.

File Preparation: Once the 3D model is finalized, I prepare for 3D printing by converting the digital design into a format that the 3D printer can understand (STL (Standard Triangle Language) file).

Material Selection: Common materials for jewelry include various types of plastics (such as resin or PLA), metals (like silver or gold), or even ceramics. The material choice depends on budget, desired aesthetics, and functional requirements. In this project, I used PLA.

Slicing: The 3D model is sliced into thin horizontal layers using slicing software. This software generates the instructions the 3D printer needs to build the object layer by layer. The slicing parameters, such as layer height and print speed, are determined based on the chosen material and desired quality.

3D Printing: The sliced file is loaded into the 3D printer. The printer then deposits material layer by layer to build the physical object. The printing process can take varying amounts of time, depending on the complexity and size of the necklace. During this phase, support structures may be added to the design to help with overhangs and intricate details.

Post-Processing: Once the 3D printing is complete, the necklace is removed from the printer. The support structures that were added during printing were carefully removed.

To the detail below in Figure 12, the necklace can be produced by a 3D printer without any post-production. Every part of the necklace is joined each other like a chain. Because of the limits of the 3D printer (it can only print 200 mm long and 2 mm details), all parts of the necklace could not be produced. A small piece was produced in a 3D printer to test the joining detail. It can be seen in Figure 13 with the rapid prototyping machine used.

4. Conclusion

First, as a practice-based research, this paper touches on an important future technology and tests its possibilities. It is essential to have practical research in the design disciplines since design is a practice-based activity. The more design studies about experiences in new technologies are done, the more developments can occur.

Second, generative design methods are essential tools to create original forms. Even though I did not use computing technologies, shape grammars can also be developed as a computing design tool due to its coding ability.

Finally, 3D printing technologies have much potential. 3D printing technology has come a long way in recent years, and its potential uses are seemingly infinite. Here are some suggestions for future usage of 3D printing technology:

3D printing can streamline prototyping technology for inventors and companies looking to innovate and create new products. 3D printing can be an essential supply chain management tool. For example, it can enhance readiness to support soldiers on the battlefield. 3D printing can replace rare parts that are no longer in production. 3D printing can create customized products like dental prostheses, inlays, and other implants. 3D printing can be used to scale from

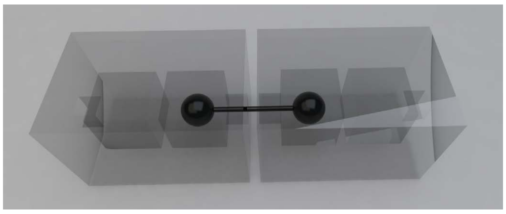


Figure 12. Joining detail of the necklace.

Figure 13. The printing machine (rapid prototype) and testing part of the necklace.

rapid prototyping to production. 3D printing can automate assembly technology, including multi-part assemblies, to provide access to part production across metals and plastics simultaneously. Researchers at Stanford have developed a method of 3D printing that promises to create prints faster, using multiple types of resin in a single object. One of the significant advancements in 3D printing has been the development of new materials, including metals and fiber-reinforced composites. 3D printing can create smart materials, such as shape memory alloys, which can "remember" their original shape. These are just a few examples of the potential uses of 3D printing technology. As the technology continues to evolve, its practical uses will continue to expand and evolve as well.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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