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The Parametric Fashion Design Using Grasshopper -Focused on Skirt Silhouette-

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generative design,
Grasshopper,
parametric design,
parametric design thinking
(PDT)

Abstract

The purpose of this study is to explore a three-dimensional (3D) simulation of skirt shape concepts by manipulating circumferences and lengths via parametric design in the fashion design concept stage. This study also intends to propose a modeling method that can judge and transform the shape through immediate parameter adjustment. We looked at cases that utilized parametric design in other fields of fashion design, reviewed and analyzed the variables used in each study, and constructed parameters suitable to implement skirt fashion design. The traditional design elements required for skirt design, namely waist and hip circumferences, were set as variables in this study. The parametric design was developed to generate ideas of two skirt silhouettes (tight and flared) and three lengths (mini, knee-length, and maxi). To apply the skirt design implemented through variables to the actual 3D human shape, the shape data of women in their 20s and 30s were randomly selected from the 5th human data of Size Korea. Skirt design silhouette modeling was performed by adjusting the variable values according to body type. Parametric design has the potential to help develop design ideas in the field of fashion design, considering the method and characteristics of parameters of the variety of variables and rapid modification. Furthermore, if systematic research on variables and options among fashion design elements is conducted, the possibility of converging them into customization or co-design fashion design processes could be confirmed.

I. Introduction

Fashion design is a field where creative ideas must be constantly presented. Previously, creative designs were generated only by relying on people's thoughts and senses, but now research is underway to develop designs with the help of technology. Recently, the fashion market has begun to develop and recommend designs tailored to each customer's individual preferences, such as customization and AI technology-based style recommendations. This can also be interpreted as meaning that consumers want more creative and new designs in existing fashion designs. Accordingly, designers combine their individual abilities with various information and communication technologies (ICT) to derive creative ideas, one of which is parametric design.

Parametric design is a method of establishing various conditions and relationships that determine the final result and algorithmizing the design process to obtain creative and complex design results according to the conditions and relationship variables (Kim & Choi, 2017). In the field of fashion design, it is also introduced as parametric or general design, but it is still insignificant.

Recently, the Korea Electronics and Telecommunications Research Institute developed artificial intelligence (AI) technology that designs new fashion products by analyzing various single-person media platforms (Electronics and Telecommunications Research Institute, 2021). It is a technology that collects the latest trends through personal tastes and data from social network services (SNS) and designs new clothes and even virtual costumes that reflect this data. Currently, SNS is the most important means of promoting and reflecting trends in the fashion field, so design technology based on it is expected to be useful. In addition, introducing personalized recommendation services and various designs from the perspective of consumers, such as recommending styles based on purchase data, is also a current trend to be noted in the fashion industry. If research on applying parametric design to the fashion field and technology development on actual application methods are carried out according to this trend, the scope of the field of fashion design and the field that combines technology is expected to expand.

Previous studies on fashion design related to parametric and generative design can be divided into studies on design and products mainly shown in the fashion field and the development of prototypes using parametric design methodology. The former includes research on participatory fashion design case analysis using generative methodology (Lee, Lee, Cho, Yang, & Kho, 2017), costume sculpture case analysis using parametric design (Yoo & Cho, 2019), and fashion design analysis using generative design methodology (Kim & Choi, 2017). The latter includes research on 3D printing of fashion bag production using generative design methodology (Lee & Kim, 2018), textile design using generative design (Yang & Lee, 2018), and development of parametric design-based fashion detail (e.g., color, cuffs, pockets) prototypes (Seomoon, Ju, & Kim, 2020).

The purpose of this study is to explore a 3D simulation of the skirt shape idea by manipulating circumferences and lengths via parametric design in the fashion design concept stage. This study also intends to propose a modeling method that can judge and transform the shape through immediate parameter adjustment. To this end, cases using parametric design in fashion and other design fields, were studied to identify and implement variables and parameters suitable for fashion design.

As a research method, a case study was conducted with both Korea and English keywords: 'generative design' and 'parametric design' (search date 2021.1.15.-2021.4.15). It was collected mainly from design journals in fields such as domestic and foreign architecture, industrial design, fashion design, and art. Among them, software such as Grasshopper and Rhino was used, and analysis was conducted by selecting or applying existing designs by setting design variables. Among the cases, the traditional design elements of each field were reviewed, and then the parametric variables and example images used in each case were extracted and examined. Based on the case analysis, the use of

parameters in the design process was reviewed and compared to the traditional design process, and various skirt design prototypes were proposed. The parameters and designs proposed in this study can be used as basic data in researching and utilizing parametric designs. In addition, it is expected that through this process, it is possible to develop fashion designs in various directions and propose new creative designs.

Ⅱ. Theoretical Background

1. Parametric Design

Parametric or generative design is one of the methods that generate designs using mathematical algorithms consisting of various variables (Jabi, 2013). This method is conducted by accurately calculating results according to set rules and input values without intuitively exploring the design to be created. In addition, this design is considered to be an alternative that presents a new approach to design creation using digital technology after the period when designs were unfolded only by human creation. This technique is achieved through analysis and systematization of the inherent logic and is designed to increase the accuracy and efficiency of the project by linking the designer's experience with data in modeling the designer's knowledge (Park, 2012). In addition, it has recently been used in architecture, industrial design, and fashion design fields. It can create new values by including not only geometric information about each element that constitutes the design, but also abstract meanings of design components.

As for the differences between parametric and generative design, in parametric design, researchers deal with only one or a few variables, and can then directly evaluate and further transform the process of repeated calculation. Through this, the optimal design is derived. These tools save time and effort, and it is entirely the researcher who controls this process and the outcome. On the other hand, in generative design, several complex variables are put into tools such as algorithms or artificial intelligence (AI) so that the tool itself generates variables. The biggest advantage of parametric design is that it can handle a lot of data and variables quickly and extract optimized designs that have been verified in various meanings in a short time through continuous feedback. In other words, it is difficult to predict changes in the physical properties of materials such as wood, concrete, and soil and changes caused by external stimuli.

Parametric design produces much more diverse and complex outcomes than is usually expected. It shows many more results than expected variable values through algorithms and programs built with variables. In addition, the complex and interconnected environment between variables leads to more new designs. It has multiple variables, not one variable, and forms a complex network between variables, creating a link of numerous design processes within them. In addition, the algorithm can change itself to maintain a stable configuration within a changing environment. Due to these characteristics, the outcomes of the parametric design are more flexible, collaborative, and evolutionary than traditional design, which confirms the variability of the parametric design (Choi, 2011; McCormack, Dorin, & Innocent, 2004). By utilizing these characteristics, it is possible to create new and creative designs in response to rapidly changing trends in the field of fashion.

Various software programs are currently being used in the field of parametric design. Representatively, Rhino and Grasshopper are widely used. Grasshopper is a program released by AutoCAD, the manufacturer of Lino, in a plug-in format to secure Lino's flaws, and is currently used in most parametric design cases. There are many tools that can create circular or planar patterns in most modeling software, but Grasshopper is the only one that can create other types of patterns such as curved and perforated patterns. In addition, a program called Dynamo based on Revit is attracting attention overseas in that it has a function similar to that of Grasshopper. However, there are many limitations to the possibilities of the Dynamo program itself because the 3D library of Revit is very small compared to that of Lino. There is also a program called Catia. This program is mainly

used in the architecture world, and it has great advantages in that it can visualize even small parts such as bolts in 3D and can be drawn for production without having to work separately. However, it is not commonly used because of its high licensing price. Grasshopper plug-in is a program that designers often use because users can edit algorithms in a visualized manner without the expertise of programming or scripting. It is also actively used in various generative design fields, and it has the advantage of being able to make various design changes delicately through immediate parameter changes, so it is quite applicable to the fashion design field.

2. Parametric Design Thinking(PDT)

The design problem-solving process is a series of processes that determine design concepts and develop and conclude ideas through a process of divergent and convergent thinking. Research on the cognitive process of designers implied in this process has continued steadily since the 1960s (Cross, 2001). Previously, theories and studies on traditional design methods were mainly discussions on the designer's cognitive process using pen and paper. However, each field of design has embraced new digital software, devices, and digital methods that have revolutionized design processes and outcomes, which are now quite naturally embedded in each field of design (Oxman, 2006). Digital design methods utilize design thinking that has never been experienced before, and each design field recognizes and explores this.

Studies in the field of apparel design on cognitive thinking using digital methods include research on the fashion design concept development thinking process using 3D sketches (Lee, Ahn, Kim, Kho, & Paik, 2018) and design thinking process of 2D digital design and VR design tools (Lee, Yang, & Sun, 2021). A few prior studies share their own design procedure for fashion design development using new digital tools (McQuillan, 2020; Lee, 2020; Särmäkari, 2021).

Parametric Design Thinking (PDT) is a concept that combines parametric design and design thinking (Oxman, 2017). Unlike traditional design thinking, new languages and tools in the digital age appear and design is expressed through computer thinking. Researchers argue that theoretical establishment and research on parametric design thinking viewed from this perspective are necessary (Oxman, 2017). Various studies are being conducted on PDT to analyze the process and capture the cognitive thinking of discovered designers in the field of architectural design, which mainly utilizes parametric design (Caetano, Santos, & Leitão, 2020; Hernandez, 2006).

3. Design Elements and Principles

Various design elements and principles are used in the design field. Different design elements are used in various fields but often share the same design elements and principles. In the case of the design field, which derives the form of a 3D space as a result, it can be shared through the concept of Color-Material-Finishing (CMF).

CMF is a design term that means color, material, and finishing, and is a key factor that determines the design and value of a product. Currently, it is mainly used in the field of product design, but the concept can be applied to any type of product. It is mentioned as a design core element that can stimulate the public's emotions in the 21st century when an emotional design has become a trend. Above all, in the current era, "design as a process" is being created that is integrally related to design in every product development field. Parametric design goes through the process of creating algorithms by combining various design variables. Applying the CMF concept when building a design algorithm will help develop new creative ideas.

Color is the first design element that people recognize. Various colors are used regardless of which field of design, as the initial means of expressing the sensitivity of the product. In the field of fashion design, it is a factor that not only enhances aesthetic effects but also forms a new image of the product. Parametric design has the advantage of being able to assess various colors in advance through programming.

Material can be the most different design element

depending on the field. As the sensory expression of materials becomes increasingly important, 3D technologies that feel the texture are continuously being developed away from the existing 2D static technology. Finishing determines the touch or visual elements of the product. In fashion design, textures are implemented using fabric or various notions.

There are various factors to consider when designing fashion. Various factors should be considered, such as the shape of a person's body, movement of joints, and so on. In addition, there are formative elements that are the basis for developing fashion design and principles for creating these elements by transforming them in various ways. The formative elements of fashion design include silhouette, fabric, colors, appearance, and details (Ellinwood, 2001). The principles of expressing formative elements include repetition, parallel, continuity, intersection, emphasis, and proportion (Han & Kim, 2014) (Table 1). These formative elements and principles are combined to generate the result of fashion design.

Ⅲ. Parametric Design Case Study

Parametric design is currently used in various design fields. Research cases in various design fields were collected and analyzed to understand how parametric design and what variables were used in other design cases. The cases were classified and studied based on criteria such as the design field, researchers, traditional design elements, design variables (parameters) selected in the study, and design advantages using those parameters (Table 2).

In the field of architectural design, it is difficult to review the correlation and structure due to the deformation of various elements in the design of buildings in large spaces, it takes a considerable amount of time to model and design, and it is difficult to compare. In the case of Choi, Lee, and Kim (2016), the roof, an essential design element of an entire building, was designed using parametric modeling of the Spoke Wheel structure, and through this, an efficient thinking

Table 1. *Principles of Fashion Design*

Principle	Definition	Type
Proportion	Relationship between each element when more than one area size exists	Harmonic proportion, Analogical proportion, Contrast proportion
Balance	State of distributing weight and force equally around one axis	Symmetrical balance, Asymmetrical balance, Asymmetrical unbalance
Unity	Beauty that is expressed by harmonizing and organizing various individual elements without being separated from each other	Organized unity, Transformational unity
Rhythm	Using lines, shapes, etc. as design elements, Give design continuity	Repetition, Continuous Progression, Radiation, Change
Harmony	A state in which two or more design elements are combined or contrasted with each other with their respective characteristics	Analogical harmony, Contrast harmony, Disharmony
Emphasis	Dominating certain design elements to focus attention and make them the center of the design	Concentration, Dominance, Contrast

**The authors reorganized the materials from Han and Kim (2014)*

process was derived by creating and structurally evaluating design alternatives. Hwang and Lee (2019) and Ko (2020) investigated a design process of windows and louvers (panes that highlight the exterior of buildings) designed to communicate with customers and team members through real-time simulation.

In the case of product design, a variety of design patterns such as parts with holes in the interior of a car and the outside of an air purifier are applied (Jeong, 2019). In addition, a parametric design can be used to find a way to optimize the design for drones that needs to accurately measure lift and weight in the air (Matsunaka, 2020).

An analysis of mechanical structural design elements was verified according to various spectra of the design field, and it was found that they were more actively used in the fields of architecture and products combined with the design. In the case of shoe and chair designs, we can quickly present and test various and unexpected unique sculptures rather than verify relatively structural designs (Jordahn, 2019), or we can examine examples of applying parametric designs in a way that allows us to propose custom designs efficiently and quickly to individuals (Tara, 2016).

In the field of fashion design, there have been few cases of design development applying parametric design. In the case of Lin (2022), research was conducted by applying a practice-led-research method, and a parametric design was applied to propose the deformation of the shape and texture of the human body-oriented costume. In addition, the development process was closely shared. In the case of Jeong, Park, Lee, Kang, and Chun (2021), a part (panel) of dress clothes was developed by applying a parametric method. Various texture forms were tested by applying algorithms to the surface part of the costume, and it was produced using a 3D printer.

The results of examining design cases in various fields other than fashion that applied the parametric method are as follows. In the field of architecture and interior design, it was mainly used for real-time feedback with clients or to measure the efficiency of the functional aspect according to the alternatives of the structure. In the case of smaller-scale product/industrial designs, the combination of each design element, such as shape, material, and weight stability of the design output, was mainly used to find an optimized interface. Product/industrial design requires finding an optimal plan because the next step leads to mass production. However, in the case of fashion design development research, when proposing a solution to the structural aspect, there are fewer restrictions compared to other design fields such as architecture and manufacturing. In the case of research on the development of fashion design parameters, it is believed that many new alternatives were mainly proposed by algorithms beyond the control of designers.

IV. Fashion Design using Grasshopper

1. Method

This study proposes a skirt design method using a parametric method through Rhino and Grasshopper, a plug-in program of Rhino. The waist and hips, which are traditional design elements necessary for skirt design, were set as variables, and a parametric design was developed to generate designs of two silhouettes (tight skirt, flared skirt) and three lengths (mini, knee-length, maxi). To apply the skirt design implemented through variables to the actual 3D human shape, the human shape data of women in their 20s and 30s were randomly selected from the 5th human shape data of Size Korea. Skirt design silhouette modeling was performed by adjusting the variable value of the parameter according to the body type. Rather than suggesting a design that can cover various female body types in Korea, this study was conducted with the intention of creating a customized skirt shape design for different customers. Although there may be no significant difference in each dimension of the selected body types in their 20s and 30s, each has its own human body shape value, allowing users to design a skirt by adjusting the parameter value.

Table 2. *Parametric Design Cases*

Design Field	Researcher	Traditional Design Elements	Selected Design Variables (Parameter)	Benefits of Using Parametric Method
Architect/Interior Design	Choi et al. (2016)	Line, Surface, Form/shape, Volume/mass, Space, Material,Pattern, Color, Light, Flow planning, Function, Safety, etc.	Numbers of spoke wheels, Outer circle radius, Height of inner struts, Inner circle radius	Significant improvement in structural modeling efficiency, create multiple alternatives and compare them efficiently
	Hwang et al. (2019)		Vertical and horizontal of a window, Horizontal position value, Width and height of a window	Real-time reflection of the window design feedback process
	Ko (2020)		Depth of louver, Interval space between louvers	Real-time simulation based on design intentions
Industrial/Product Design	Tara (2016)	Line, Surface, Form/shape, Texture, Pattern, Color, Material, Function, Ergonomics, etc.	Durability, Flexibility, Density	Shoe design : Discover optimized structures based on individual weight and force points of action
	Moore (2019)		Stress, Load, Weight, Material, Manufacturing method	Reduced tire wheel weight
	Jordahn (2019)		Stress, Load, Weight, Material, Manufacturing Method, Cost, Constraints	Forming a unique design, Possibility of mass production
	Matsunaka (2020)		Size, weight, material, manufacturing method	Lightweight, secure stability
	Jeong (2019)		Whole pattern (surface of industrial design)	Improvement of work productivity, Reduces simple repetitive design process
Fashion Design	Lin (2022)	Line, Silhouette, Fabric, Texture, Color, Detail, Fit, Construction, etc.	Dynamic body, Textile fluidity	New ways of design thinking, generation of a wide range of design options
	Jeong et al. (2021)		Texture, Body shape	Exaggerated shape, incorporation of new material (3D printing)

1) Parametric Configuration

The parameters configured in this study were set as variables such as waist circumference and hip circumference. Four coordinate points were set around the waist and six coordinate points around the hip to adjust the x, y, and z values for each coordinate to suit each body type of women in her 20s and 30s. In the case of the hip circumference, six coordinates were set, which is more than the waist circumference, because the curvature is larger. The set coordinate values were

combined to form one circumference, and the coordinate values around the waist and hip were adjusted according to the skirt silhouette and length.

To implement the two skirt silhouettes planned in this study, the silhouette was properly implemented only when a curve with the shape of the skirt silhouette was set on the side of the human body. Curves suitable for each skirt shape (front and rear) were used by setting a total of six curves according to the skirt shape and length. The starting point of the side curve is connected to the waist and hem of the previously set parameter as a starting point and an endpoint.

The shape of the skirt silhouette was created by the Sweep function using waist circumference, hip circumference, and side curves. The Rail1 part of Sweep was connected to the waist circumference parameter, the Rail2 part to the hip circumference, and the side parameter to the Sections part to complete the parameters of Figure 1.

2) Skirt Design Composition

The four parameters of the waist circumference designed in this study were set to P1, the center point of the front waist was set to P1, the right side was set to P2, the rear part to P3, and the left side was set to P4. The waist circumference of a woman in her 20s adopted in this study was 68cm. The X coordinate value of the side point was set to the same length value because the left and right intervals should be the same at the center of the waist. Since (P2:12.5, P4:−12.5) is also on the same line, the values of the Z coordinates of all points are set to the same values. (Z:1.04) The values of the Z coordinates of P1 and P3 were not set. The reason is that the starting point at the waist is set when two curves are drawn from the side, so it is set to the Z coordinate values of P1 and P3 in that part. The X coordinate of P1 in the front was set to 0.8 and the Y coordinate was set to −6.209. The X coordinate of P3 on the back was set to 4.797, and the Y coordinate was

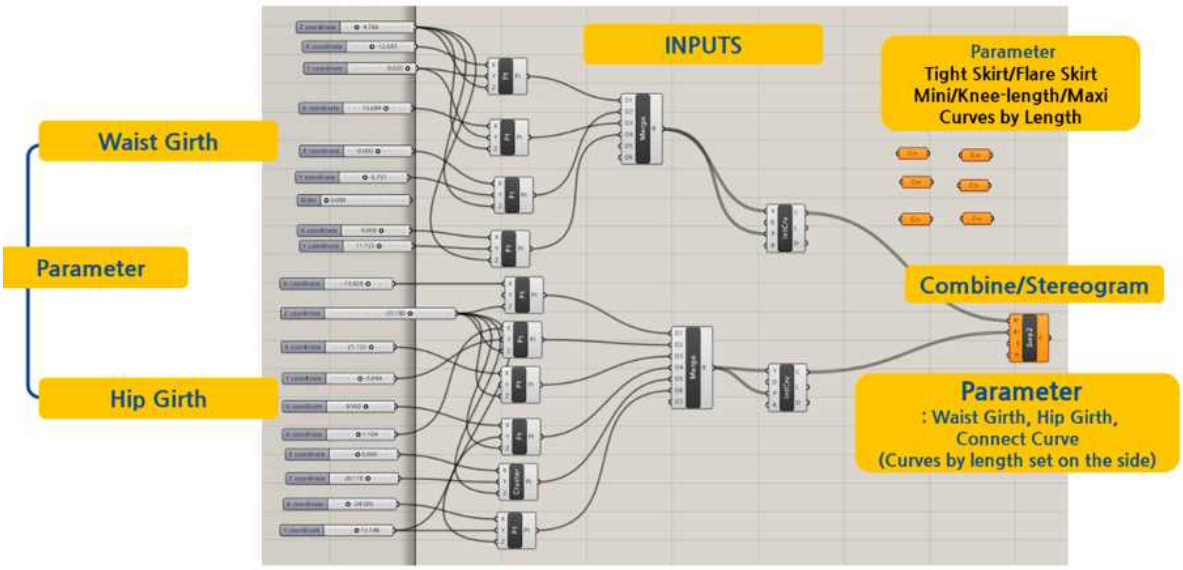


Figure 1. *Parameters of Skirt Design from Grasshopper*
(taken by authors)

set to 11.393.

The six parameters of the hip circumference designed in this study were set to Q1, the right pelvis was set to point Q2, the right hip apex was set to point Q3, the left hip vertex was set to point Q5, and the left hip was set to point Q4, and the left pelvis was set to point Q6. The hip circumference of a woman in her 20s adopted in this study was 82 cm, and the coordinate value was adjusted accordingly. Since the Z coordinates of all coordinates are on the same line, they are set to the same value (Z: −22.172). Since the X coordinates of points Q2 and Q5 should have the same left and right intervals at the center, the same length value was set (Q2: 16.332, Q5:−16.332), and the value of the Y coordinate was not set. In the case of points Q3, Q4, and Q5, which are set for a curve around the hip, the Y coordinates of points Q3 and Q5 are located on the same line, and the X coordinates are set at the same position with the same left and right intervals. The X-coordinate of point Q3 was set to 5.609, the Y-coordinate was set to 18.315, the X-coordinate of point Q5 was set to −5.609, and the Y-coordinate was set to 18.315. The Y coordinate of point Q4 was set to 18.667.

2. Results

After adjusting the coordinate values according to the body shape and setting the circumference, the skirt shape was implemented by putting the curve set according to the shape and length of each skirt in the Sections part. As described above, women in their 30s also set variables by adjusting the waist and hip circumference coordinate values according to their body shape in the previously configured parameters. The waist circumference of women in their 30s set in this study was 74cm and the hip circumference was 105cm, so the circumference value was set larger than that of women in their 20s. The skirt design implemented according to each body type is shown in Table 3 for the design tailored to the body type of women in their 20s and Table 4 for the design tailored to the body type of women in their 30s.

For each skirt design, skirts with a total of three lengths were modeled, and for this purpose, X, Y, and Z points were set at the waist, hip, and hem parts, respectively, and in the case of coordinates of the X-axis, only the +, − values were set differently.

In the case of women in their 20s, skirts with three lengths of mini, knee-length, and maxi tight skirts were

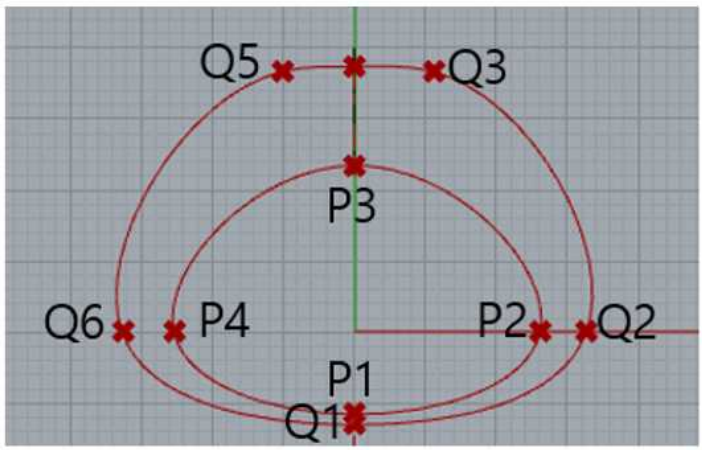


Figure 2. *Coordination the Value of Waist Circumference and Hip Circumference*
(taken by authors)

Table 3. *Formation of Skirt Design Model for Women in Their 20s*
(taken by authors)

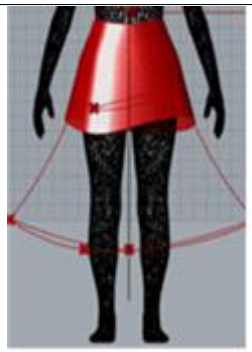
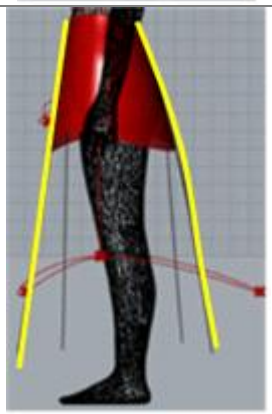
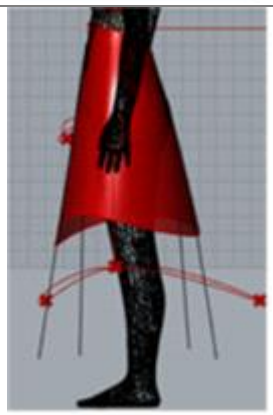
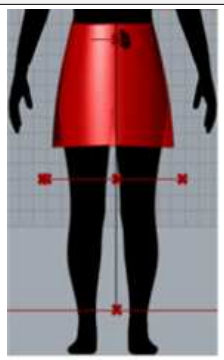
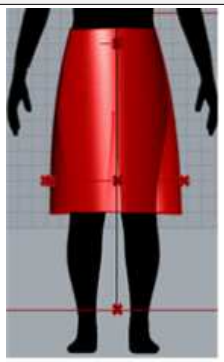
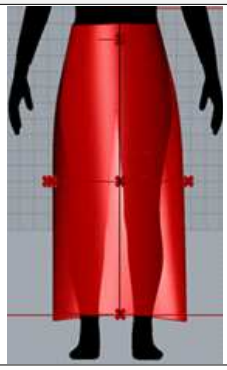
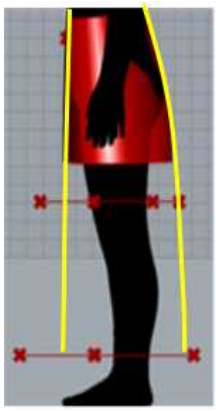
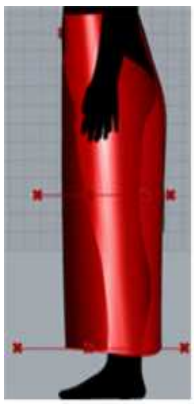
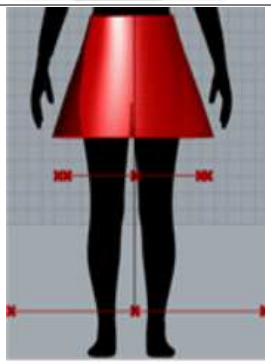
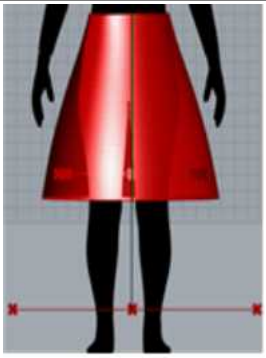
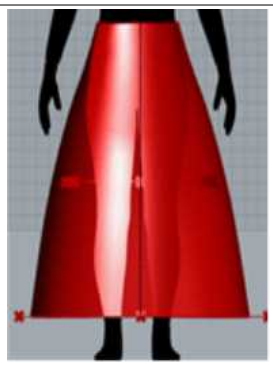
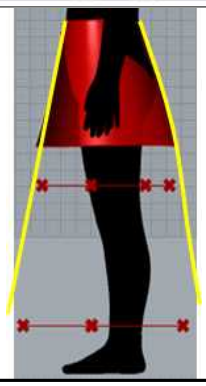
Skirt Design	View	Mini	Knee-length	Maxi
Tight Skirt	Front			
	Side			
Flared Skirt	Front			
	Side			

Table 4. *Formation of Skirt Design Model for Women in Their 30s*
(taken by authors)

Skirt Design	View	Mini	Knee-length	Maxi
Tight Skirt	Front			
	Side			
Flared Skirt	Front			
	Side			

extended by changing only the position of the Z coordinates which determines the length of the coordinates around the bottom of the mini skirt. In other words, the length was extended by moving only the length coordinates around the hem while maintaining the coordinates around the waist and hips of the mini skirt. In the case of a flared skirt, since it is necessary to maintain the shape of a flared skirt that spreads even if there is a change in length, the values of not only the Z-axis coordinates of the bottom part but also the X, Y, and Z-axis coordinates were changed. The coordinate values of the Z-axis representing the length of both skirts were set to mini −6, knee-length −25, and maxi −77.

In the case of women in their 30s, skirts with three lengths of mini, knee-length, and maxi in tight skirts, similar to women in their 20s, only the Z-coordinate value around the hem was modified to extend the length. Likewise, the flared skirt deformed all the X, Y, and Z coordinate values around the hem to maintain the shape of the flared skirt, and the coordinate values were deformed. The coordinate values of the Z-axis representing the length of both skirts were set to mini −6, knee-length −25, and maxi −70.

The following differences were found when changing the values of the X, Y, and Z coordinates of the waist, hip, and hem using Grasshopper to make a skirt shape according to the body type of the two age groups. First, women in their 30s have a larger waist and hip circumference than women in their 20s, so the curved part of the skirt was steeper in the process of transforming the shape of the flared skirt. The difference in the X-coordinate values of the waist and hip circumference of the flared skirt of women in their 20s was waist circumference X coordinate -14 and hip circumference X coordinate -22, but for women in their 30s, it was waist circumference X coordinate -23 and hip circumference -35. In addition, in the process of setting the Y-coordinate value around the hip, the Y-coordinate value at the back of the hip was larger than the Y-coordinate at the front. In addition, the Y coordinate value was larger because the hip circumference length in the women in their 30s was larger, while the women in their 20s were -3, while the 30s moved by -8 to set the coordinates of the hip curve. In this study, two design elements of the silhouette and length of the skirt that fit the actual body scan model body type in their 20s and 30s were set as parameter variables, and the 3D design silhouette was implemented. In this study, mini, knee-length, and maxi skirts were the three determined lengths in text, but through minute changes in values, the degree of skirt length and tightness of the silhouette could be gradually modeled and extracted.

V. Conclusion

The purpose of this study is to explore a 3D simulation of skirt shape design ideas by manipulating circumferences and lengths via parametric design in the fashion design concept stage. This study also intends to propose a modeling method that can judge and transform the shape through immediate parameter adjustment. In the field of fashion design, research on parametric design development has not yet been actively conducted, so we analyzed cases of parameter design use in other design fields covered in 3D space and summarized the expected effects. In addition, design variables used in the studies were identified and used to develop fashion design ideas using the parametric method.

In the parametric design conducted in this study, the waist and hip circumferences required for skirt design were set as variables, and parameters that could implement two skirt silhouettes and three skirt lengths were constructed. In addition, the skirt design was implemented by adjusting parameters according to the body shape of women in their 20s and 30s.

The significance of this study is to navigate the possibility of Parametric Design Thinking (PDT) in fashion design. The parametric modeling system (Rhino and Grasshopper) used in this study enables us to generation and modify the skirt shape design simply by changing parameters. This process can be later associated

with producing codes and automatic algorithms, that are aligned with the role and impact of parametric thinking in the design field (Oxman,2017; Woodbury, 2010). However, since this study is still in the early trial stage, there is a limitation in that only waist and hip circumference variables and skirt length were modified among various design elements and principals to develop skirt shape ideas. Furthermore, this study sets curves that fit the skirt silhouette and length one by one, and it has not implemented variables of material or color. In the future, research could be conducted to construct parameters to implement more diverse obedience and design, and to apply various design elements such as materials and colors. Through this, a parametric design method that can quickly utilize many design elements and principles to implement design and provide feedback will be established, improving the design development process.

Parametric design has been steadily used in design fields covered in 3D spaces such as architecture, interior, industrial, and product design. The parametric design method is thought to support the field of fashion design considering the composition and characteristics of parameters, the utilization of variables used, and the possibility of quick modification. Above all, if systematic research on variables and options that can be used as parameters among fashion design elements is conducted, the possibility of converging them into customized or nose-design fashion design processes could be realized. It could be a design method that can coexist with the development of big data and AI, such as the instant generation of various designs to communicate with consumers in real-time or developing algorithms that allow designers with little design knowledge or experience to freely propose designs through several codes.

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