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Parametric Design in Interior Applications in Terms of Design and Ease of Production; The Example of Parawave

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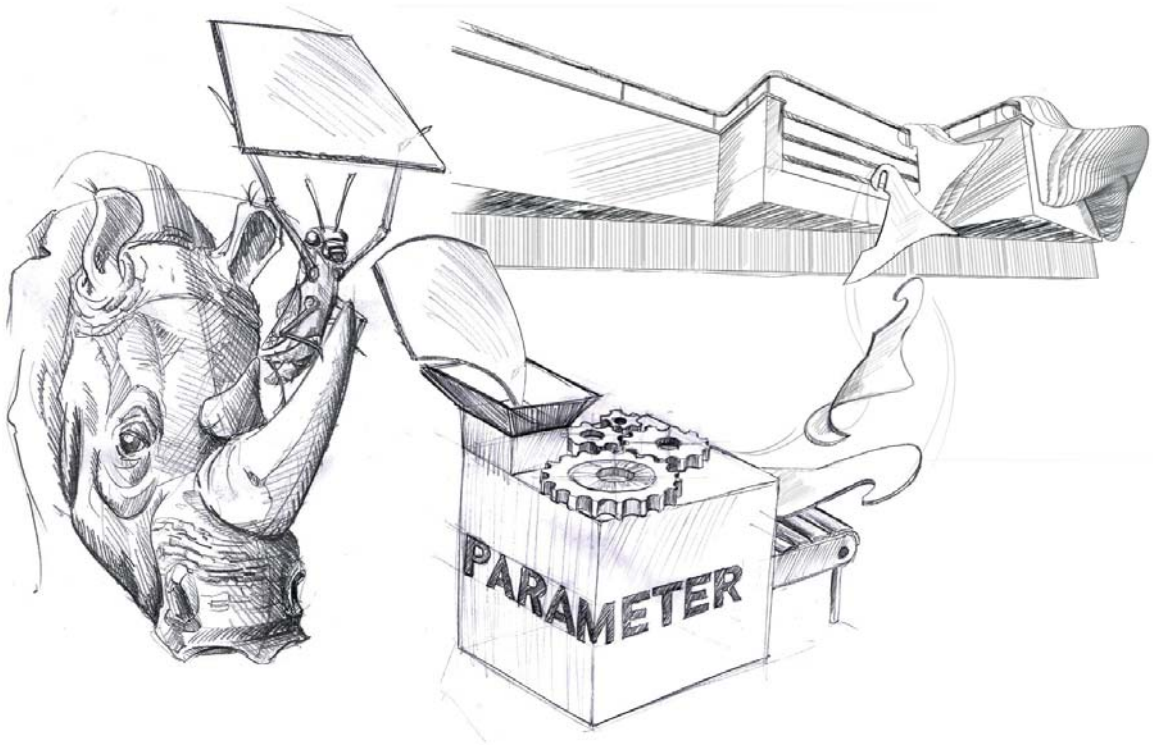
Abstract In today's rapidly developing technology; computers have become indispensable tools in many art, design and engineering fields. Computers' ability to communicate with production machines bring speed, precision and stability to production processes. The parametric design concept provides maximum efficiency from the computer's potential, and the designer has great benefits in many processes, from design to production. This scope of work; the concept and history of parametric design has been addressed. Within the Parawave application; the problems encountered in the process from design to the last minute of the application and the solutions to the problems of parametric design have been experienced and explained.



1. Introduction

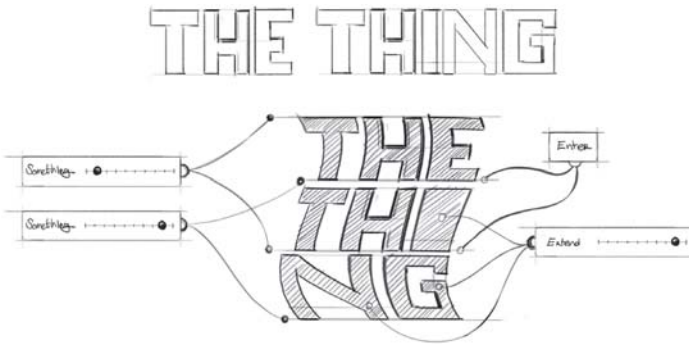
Interior design applications have also been affected by the developing digital world. Computers and CAD software are actively used in the interior design discipline. This study focuses on parametric design applications in interior spaces. To understand the process and the final product, it is necessary to firstly understand the concepts of parameter, algorithmic thinking and parametric design. "Although computational thinking approach or algorithmic thinking model emerged in the mid-1900s, its active use in the field of design dates back to the recent past. The computational thinking approach has a long history in computer science. This thought systematic, known as algorithmic thinking in the 1950s and 1960s, means a mental orientation to formulate problems as the transformation of some inputs into an output, and to search for algorithms to perform transformations (Eryarar, 2017:15)". Computers and parametric CAD software have many benefits such as speed, versatility and precision in the design and production processes. These benefits form the basis of the methodology behind the final product. In this context, this article accepts parametric design and manufacturing processes as a methodology for reaching the final product.

2. Focus of Research

In this study, computer aided manufacturing is exemplified on an interior design artifact, to discover the benefits and shortcomings through the process of design and production. This article begins with the definition of the term parameter and the parametric design concept, then touches on the relationship between parametric design and Sagrada Familia church, one of the first architectural examples of parametric design. Next, the methodology, design and production processes of the Parawave application, which is the final product of the article, are explained.

2.1. Understanding Parameter as a Term

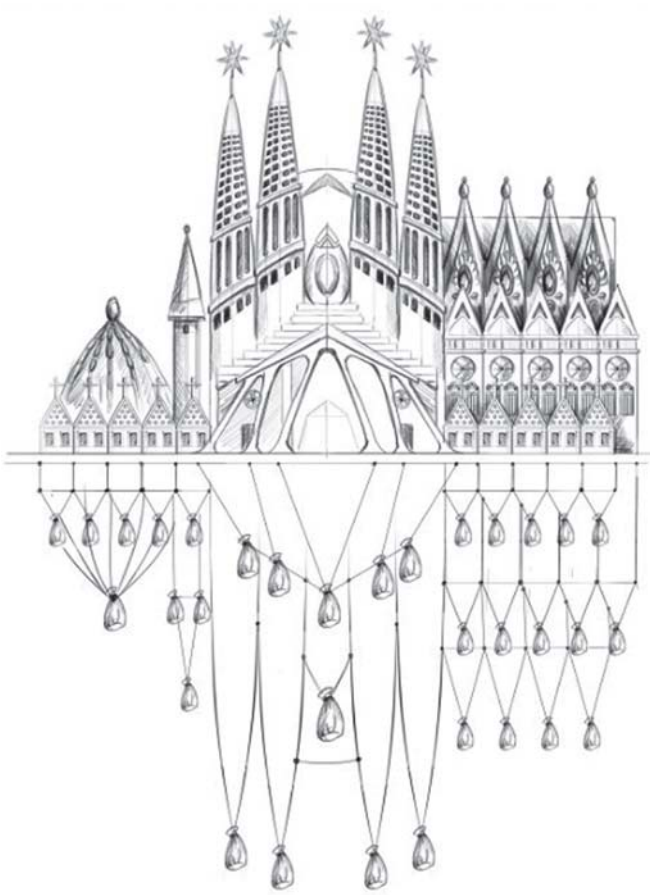
The etymological origin of the word parameter is based on the Ancient Greek era. Parameter is the combination of the prefix para- "beside, subsidiary", and the word metron "measure". Oxford Dictionary defines parameter as "something that decides or limits the way in which something can be done". Parameter also can be described as a measure that changes depending on another value or set of values. At the present time parameter is mostly used as the meaning of variable.



2.2. Parametric Design

Parametric design is a system with data inputs and data outputs that can create design areas and mechanisms to achieve results. Data inputs are parameters, data outputs are variations that occur as a result of changing parameters (Glymph, et al. 2004:187-189).

"Parametric Design is the process of designing in environment where design variations are effortless, thus replacing singularity with multiplicity in the design process. Parametric design is done with the aid of Parametric Models (Hernandez, 2006:310)". Every parametrically designed product or space is a system design in its background. This system actually determines the geometric boundaries of the final product. "Boundary determination process based on the design parameters of the parametric geometry and the shape of the final product must be constructed capable of diversifying the desired level (Burry & Murray, 1997:4,15)". In short, parametric design is the geometric expression resulting from the relation of variables to which data input in a defined volume. According to Nonell & Burry (1992:22-25), Sagrada Familia Church, designed by Antonio Gaudi between 1883-1926, is described as the first known parametric design. The design of many structural elements such as the columns, arches and domes of the church is based on Gaudi's parametric models. While Gaudi was designing the domes of the church, he hung ropes from the ceiling, tied different weights on these ropes and tried different design options by moving these weights on the ropes. The values of the weights and their positions on the ropes were variables of this design. Gaudi did not have the current technological possibilities in his time. Yet he was the owner of the first architectural work that designed parametrically by using the possibilities of his time and the force of gravity. The reason why the work stands out so much is that the parametric design makes Sagrada Familia different from the examples of its period.



2.3. Benefits of Parametric Design

Parametric design has become a rising value with the developing technologies and computers whose processing capacity has expanded in recent years. Goldberg (2009), explained the development of high-performance computing platforms in the early 1990s parametric design began to be perceived as different from its traditional understanding of manually managing variables on a linear plane.

In many different design disciplines, designers are going through a difficult period in the early stages of the design process about deciding the form. Parametric design allows these processes to be overcome more easily, and the various variations of the design can be visualized very quickly in digital environment. According to Hensel & Menges (2006), Geometry has always played an important role in architectural di scourse. Architectural designs have transformed into dynamic & geometric relationships using parametric modeling and digital calculations as tools.

"Calculations in parametric modeling do not have a static geometry setup as in traditional design and construction processes (Özdemir, 2016)". Every changing parameter can appear as a different design alternative in the final product. It is possible to obtain many variations of the design in line with the change of parameters entered in the parametric design setup. In this way, efficiency in design increases and design becomes open to innovations.

Although understanding and setting up the system required for parametric design is complicated and takes time at first, once the system is installed, the final product can be changed very quickly. The parametric model can be modified and analyzed. According to Terzi (2009), different uses of existing geometries emerge with parametric design technologies. Kaya Kızılkaya (2011), compared traditional CAD software and parametric CAD software in the table he prepared as follows;

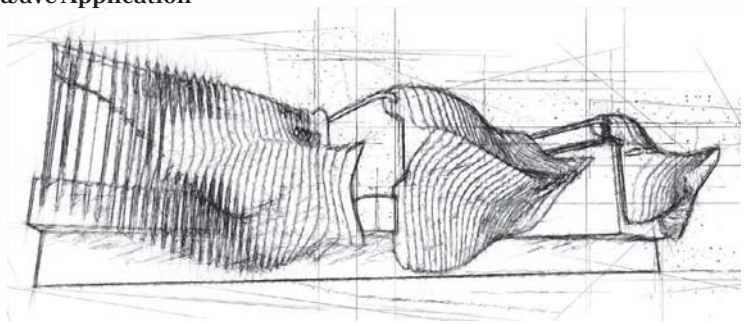
Traditional CAD Software	Parametric CAD Software
Offer only one solution.	Offer a range of multiple (Complex) solutions.
They are stable systems.	They are variable systems.
Design develops hierarchically.	They do not require hierarchy in multiple design with the concepts of components and database.
It is necessary to go back to the beginning to change the design.	The design changes simultaneously.
It cons ists of one piece.	It consists of components that are integrated with each other.
The design study is partly intuitive.	The design study is done more rationally.
Data are brought together analogously.	Data are entered systematically.

As seen in Kızılkaya's table, parametric design software provides a great advantage over traditional software. In addition to its multi-solution range and variable structure, it does not operate in a hierarchical order and the simultaneous reflection of changing parameters on the final product is one of the most striking advantages of parametric design.

3. Method

In this study, an interior facade application has been made to experience the design and production processes of the parametric design concept. A traditional CAD software Rhinoceros 3D and a parametric CAD plug-in Grasshopper were used in the design process. After the design phase was completed, corrugated cardboard was chosen as the material and laser cutting was used as the production method. The methodological path between the idea and the final product is examined under two separate headings as the design phase and the production phase.

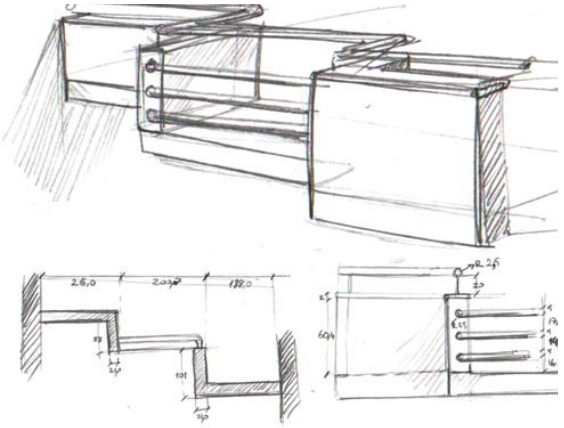
3.1. Parawave Application



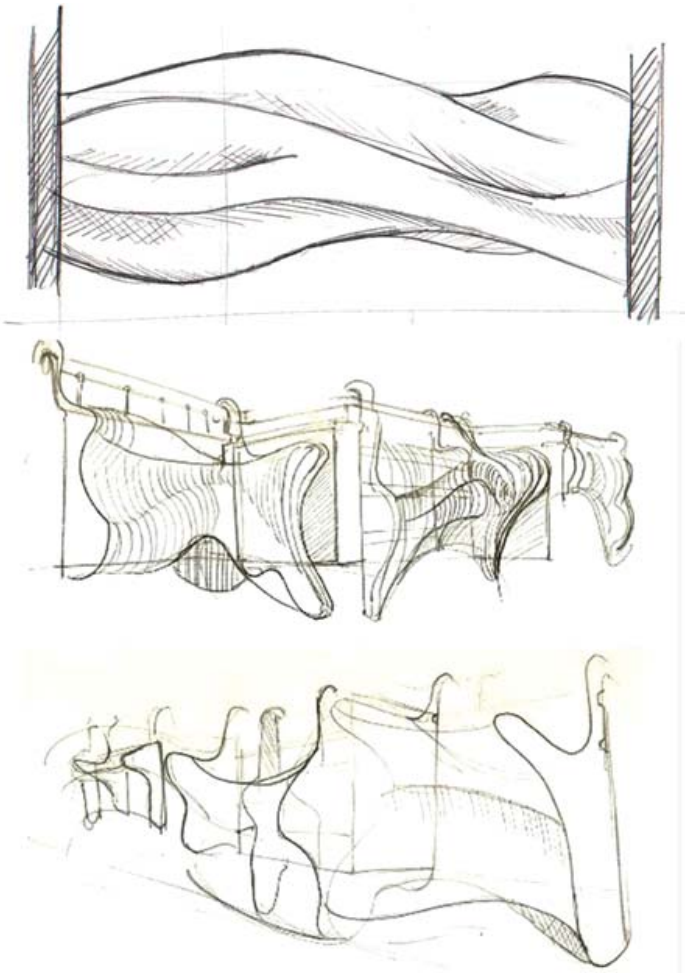
Parawave is an interior facade application designed and manufactured parametrically. Parawave's field of application is the entrance area of the Department of Interior Architecture, Eskişehir Technical University.

3.2. Design Phase

The design phase for this study starts with the determination of the application surface and area. For this, 3-dimensional modeling of the application area and its surroundings was prepared by making survey drawing. In the design phase of this study, Rhinoceros 3D and Grasshopper were used as CAD software. Rhinoceros 3D is recognized as a traditional CAD software. Grasshopper is a parametric design plugin which developed for Rhinoceros 3D software.



Afterwards, idea sketches were drawn to determine the rough form of the final product. The predicted resulting product has an undefined geometry and free form.



After this point, the parametric design process begins. As mentioned earlier, the things that make up the parametric design are fixed and variable values. It is a design decision to hang the product on the handrail instead of being mounted on the application surface. In addition, the width of the surface on which the design will be applied is certain. The handrail which the product will be hung and the width of the product constitute fixed values of this design. Studies to be done within the length and depth of the product also constitute the variable values of the design.

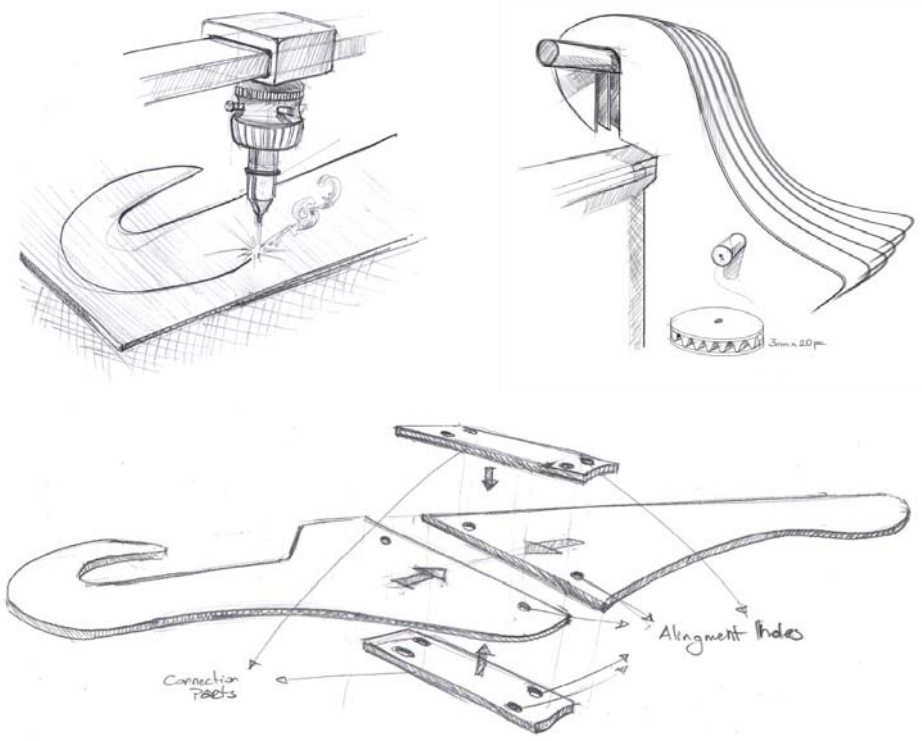
While starting the modeling, firstly the curves that will define the rough form were drawn. Afterwards, maximum and minimum values were determined for the length and depth of the product. Design variations have been tried within the specified values. After the final form was decided, the form was sliced. The distance between each sliced piece is also a variable value. Variations in the distance between the parts have been tried and the appropriate spacing has been decided in a way that does not disturb the perception of fluidity in the final form.

3.3. Production Phase

The last processes of the design phase and the first processes of the production phase are intertwined. Preparation of the final version of the design for production in computer environment is examined under the title of the production phase. While the design was prepared for the production phase, the technical drawing of each part was created and numbered. Precision in production is provided. Part numbers follow each other in sequence. This provides speed and convenience in production and assembly processes.

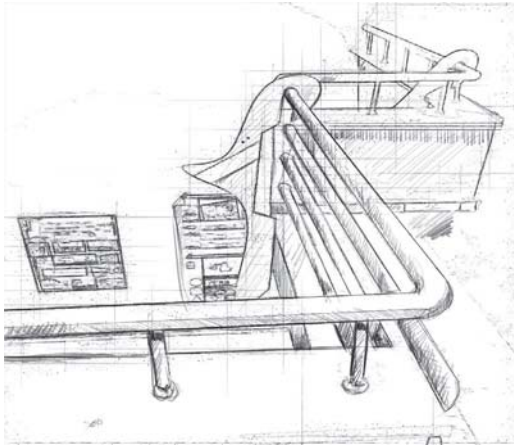
The main and only material of the product is 4mm corrugated cardboard. Laser cutting is preferred as the production method. All parts were cut out from 800x1200mm plates. Since most parts of the design are larger than the plate dimensions, they are divided into two pieces than connected with assembly parts. All the assembly parts and alignment holes also designed and prepared for production in Grasshopper. After all the main, assembly and spacing parts cut out with the laser cutter, they moved to application area to assembly on-site. All parts were combined and assembled according to their numerical order. Fast glue is used while combining the parts. Finally, all the parts were assembled and the design was completed and hung on the railing.

Due to the parametric design software and the sectioning method, it has become possible to produce a form with a large volume, fluid and complex geometry with planar material. Generally, various molding techniques and techniques such as engraving from cast materials or block materials are required to produce such an amorphous structure. Neither plate material nor a 2-axis production method is suitable for such a form. However, the parametric design concept provides designers with the opportunity to evaluate different alternatives in production method and material options, while offering many variations for the form.

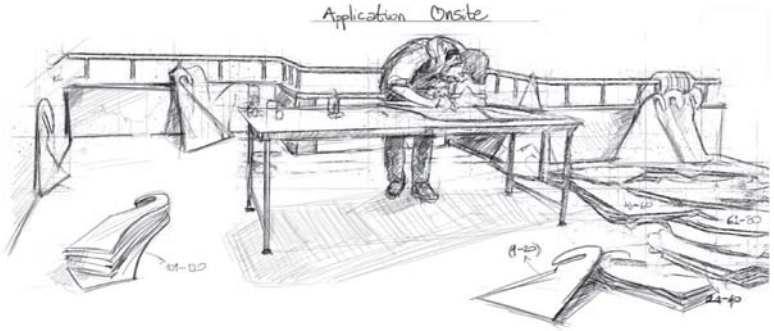


4. Findings

Before the design was completed and the production phase started, in order to check the accuracy of the design, the cross-sectional parts that coincide with the key points were produced and tested on site. As a result of the trial, it was determined that the survey drawing was wrong and the design was corrected. The correction process took about half an hour. If the design process was done with a non-parametric software and an error is encountered in this way, it would have meant repeating all the modeling steps from the beginning rather than correcting a portion of the design. One of the benefits of parametric design is the non-hierarchical design system. In the system, only the parameters of the relevant section were changed and this change was simultaneously reflected in the final product. Parametric design has provided a great gain in time, energy and workload.



Making the product ready for assembly parametrically during the design process can be considered as another advantage of the parametric design. The numbering each part of the product sequentially and the determination of all assembly points parametrically during the design process made it possible to work systematically during the assembly and application phase of the design and provided saving time. All the pieces that bring together the final product are positioned exactly where they should be, just like a puzzle.



5. Conclusion

The path opened by today's technologies, parametric design has reached high levels and the benefits for the designer are great. Creating forms, one of the most challenging processes of a designer, becomes easier. In the concept of parametric design, the designer designs the system that goes to the final product, rather than the final product. In this case it provides the opportunity to visualize the possible variations of the design faster than ever. In addition, the design of the system ensures that the parameters in the system can be changed easily, retrospectively and the changes are reflected on the final product simultaneously. Considering the situations that may require revisions after production tests, it saves a great deal of time, energy and workload. Another feature of parametric design is that it increases different material choice and production method options for the designer, especially in designs with large volumes. In short, the parametric design concept has evolved to a very important point for the designer in terms of producing and optimizing the form in addition to time and workload gains.

6. Further Research Question

It is foreseen to work on different materials and different production methods in the future. Plate wood types, sheet metals and plexiglass are considered as materials. The contribution of different material potentials to design is intriguing. Laser cutting method was as production method on Parawave. More complex designs can be produced with the support of 3D printers in the future and different production methods can be combined.

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