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Parametrıc Desıgn and Futurısm: A Theoretıcal Analysis

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ABSTRACT

In recent years, accelerating technological developments have dramatically transformed architectural design methods, paving the way for new creative paradigms. Within this rapidly evolving context, parametric design has emerged as an innovative methodology that enables the modelling of complex geometries, the generation of alternative solutions, and the optimisation of multi-variable design processes. Futurism, on the other hand, originated as an artistic movement characterised by its emphasis on technology, speed, fluidity, and dynamism. Although historically rooted in the early 20th century, its conceptual and formal influence remains visible in contemporary architectural production. This study explores the conceptual, formal, and technological relationship between parametric design and futuristic architecture.

KEYWORDS: Parametric Design, Futurism, Futuristic Architecture, Digital Design, Architectural Technology

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1. INTRODUCTION

As a result of advancing technology and the pursuit of innovation in architectural design, by the time the 20th century arrived, alongside traditional practices in architecture, there were also fundamental changes and developments in digitalization and software. In line with these developments, software and drawing programs developed specifically for architectural design have not only made design easier, but have also provided significant benefits in terms of time usage, one of the most important criteria in design (Yüksekkaya, 2020). As these software programs have become an integral part of the design process and continued to evolve, it has become possible to shorten the architectural design period, allow for alternative proposals, and calculate many criteria, such as cost, in a short time (Erbaş, 2013). Unlike traditional design methods, these software programs offer the ability to intervene in the design process and apply multiple changes simultaneously. This has made it possible to design and produce complex forms that were previously undesigned or undesignable (Yüksekkaya, 2020).

Technology has brought about changes in our lifestyle in many areas. These changes have also had an impact on design practice, offering many alternative design methods alongside traditional ones. Today, within the scope of computer-aided design, many stages can be handled simultaneously with the calculation of variable parameters, and the changes to be made can be applied in real time (Oxman, 2017). As a result of these developments, the concept of "Parametric Design" has come into frequent use, and evaluations have been made within the scope of this concept for complex structures designed using various software.

Before evaluating the concept of parametric design, the concept of "parameter" must be explained. In its basic sense, a parameter can be considered a quantity defined for a situation and possessing the property of being changeable. The number of parameters may vary depending on the conditions. At this point, it is important that the relationship between the parameters is established correctly and can be managed as desired (Erbaş, 2013).

With the advancement of technology, it has become essential for different disciplines to come together in the field of architecture. Programming using parameters should not be seen as an add-on to architecture, but rather architecture should be considered in conjunction with programming (Erdoğan and Sorguç, 2011). In this regard, parametric design created using parameters can be considered a coordination tool that establishes relationships between different disciplines in complex designs and ensures that changes are implemented seamlessly (Eltaweel and Su, 2017).

As the process progressed, the ability to design complex forms more easily through parametric design led to the perception of parametric design as a style that uses form as a visual focal point. However, when the concept of parametric design is examined in depth, it becomes apparent that this concept, which is seen as an inseparable whole with software, is a process that can also be sustained using traditional methods (Yüksekkaya, 2020).

Architectural design is the determination and interpretation of the formal, functional, and structural characteristics of all elements in the conception of a structure that will fulfill the functions defined according to needs (İzgi, 1999). According to this definition, the integrity between requirements and form must be ensured in the architectural design process. Although this has been a topic of debate among designers for a long time, many opinions have been expressed on this subject. Designs that prioritize form created through software are one of the issues that bring the form-function relationship in architecture to the fore. The idea of "form follows function," which emerged in 19th-century modern architecture, has influenced architectural designs for a long time. On the other hand, many designers argue that function should follow form and that form should be a more prominent feature. The complete prioritization of functionality led to the emergence of 19th-century modern architecture, which was repetitive in form. However, designs that prioritized form over function resulted in functionally deficient designs. At this point, it is evident that approaches that are entirely functional or purely formal have a negative impact on architecture (Yüksekkaya, 2020). The evaluation of the relationship between form and function in architecture within the scope of parametric design necessitates an examination of the historical development of the concept of parametric design. One of the most important ideas that requires questioning the relationship between form and function in architecture is futurism and futuristic architecture.

Futurism, first articulated by Italian artist Filippo Tomasso Marinetti, emerged in Italy in the early 20th century and later spread to many countries, particularly in Europe. It is a philosophy that rejects attachment to the past and aims to focus on the future, advocating that technology and mechanization should also be incorporated into designs (Çakmaklı and Selçuk, 2019). Futurism emphasizes that life is changing and that art and design must break away from the past and change in a future-oriented way. Initially emerging as an art movement, futurism can now be seen as a platform where people who think about the future on any subject come together under the same roof (Kısa and Özer, 2019). The term "futurist," used for those who embrace futurism, refers to a person who designs the future and is innovative (Akbulut, 2019). First emerging in the fields of painting, literature, and sculpture, this movement has also made its mark in design and architecture with the acceleration of scientific and technological developments.

Futurist architecture presents itself as a design language that utilizes more fluid, dynamic, and flowing lines rather than primary geometric forms. With futurist architecture, curved forms and lines have been employed, emphasizing the continuity and boundlessness of designs. Sant'Elia, one of the first representatives of futurist architecture, likened cities to rapidly developing machines. In line with this, futurist architecture, which is expected to keep pace with life, has seen an increase in the use of glass and metal materials with the development of technology, reflecting a trend towards mechanization. It is considered that the projects designed by futurist architects emerged as an expression of emotional thought without considering the details. For this reason, it is noticeable that none of the designs were ever built. However, these ideas have been a source of inspiration for later designers and architects.

In this context, while the technical dimension of parametric design has been extensively examined in the literature (Schumacher, 2008; Jabi, 2013), studies that evaluate the conceptual and formal relationship between parametric design and futuristic architecture within a holistic framework are limited. This gap indicates that interdisciplinary approaches emerging at the intersection of the two concepts have not been sufficiently addressed. In current publications, parametric systems are mostly addressed from a software-based perspective, while futuristic architecture is interpreted through formal representation. However, examining these two concepts together provides a necessary perspective for understanding the architectural design vision of the future.

This study contributes to the literature with a theoretical and analytical perspective by revealing how parametric design shapes futuristic architecture, the dynamics with which it interacts, and why it plays a critical role in contemporary architectural production.

In this context, the research questions and hypotheses are outlined below:

RESEARCH QUESTİONS

1. How do parametric design methods contribute to the development of fluid and dynamic forms seen in futuristic architecture?
2. How do the concepts of form, movement, and fluidity envisioned by futuristic architecture correspond with parametric design software?
3. In what ways does the development of parametric design tools increase the applicability of futuristic architecture?

Hypotheses

1. Parametric design software facilitates the production of complex geometries envisioned by futuristic architecture and increases formal diversity.
2. Parametric design tools technically support the applicability of futuristic architecture on a modern building scale.
3. There are structural and conceptual similarities between futuristic design principles and parametric design methodologies; therefore, the two approaches reinforce each other.

1.1. Problem

With the advancement of digital production technologies, architectural practice has transcended the limitations of traditional drawing and design methods. In particular, parametric design tools have enabled the modelling of complex geometries and the management of multi-variable design processes. However, although futurism and futurist architecture historically advocated formal dynamism and the ideal of technological speed, the technical feasibility of this vision remained limited at the beginning of the 20th century. Today, parametric design provides the necessary infrastructure for realising the fluid, dynamic, and technology-centred architectural forms envisaged by futurist approaches. However, it is evident that comprehensive studies evaluating the conceptual, formal, and technological relationship between these two approaches as a whole are limited in the literature. How parametric design has transformed or supported the formal and ideological characteristics of futurist architecture has not been sufficiently clarified.

1.2. Objective

The aim of this study is to examine the relationship between parametric design and futurist architecture in its conceptual, technological and formal dimensions; to reveal how parametric tools enhance the applicability of futurist design concepts; and to evaluate visions for future architectural production within an analytical framework by identifying the points of intersection between these two approaches in modern architecture. Furthermore, it aims to examine the effects of parametric software on form generation, system integration, and structural analysis through selected example structures, using concrete data.

1.3. Method

This study was conducted using qualitative research methods; literature review, theoretical analysis, and architectural case study techniques were applied. The concepts of parametric design and futurism were examined from the early period to the present day, and articles, theses, books, and digital sources were evaluated. The following criteria were considered in the selection of examples:

- Curvilinear/geometric complexity,
- Modelability using parametric software,
- Representation of futuristic design principles.

2. PARAMETERS AND PARAMETRIC DESIGN

The concept of parameter is derived from the Greek words ‘para’ and ‘metron’ (Oxford Dictionary of English, 2010). For this reason, the concept of parameter must be viewed from two separate perspectives. Firstly, it refers to a modifiable quantity with a specific scope and limit, and secondly, it refers to a measurable factor that determines the operating conditions of a mathematical system. In short, a parameter is a quantitative (such as wind, height, width, environmental conditions) or qualitative data that can be changed according to a specific need (Patrick-Kaushik, 2013). According to the Turkish Language Association (TDK), a parameter is defined as a variable quantity that enters the coefficients of an equation in algebra (Türkçe Sözlük, 2009). In computer science, a parameter is defined as the processing of data entered into the system by commands (Akipek and Önceğlu, 2007). In design, a parameter can be defined as a factor that defines or limits any system.

The parameters that constitute a design define the data belonging to many functional and formal elements of the design and the relationships between these data. Even a change in a single parameter causes the entire design to change. Therefore, the designer must be aware of the parameters, their complex relationships in parametric design, and their effect on the design. The concept of parameters is often used interchangeably with the term “variable.” However, the concept of parameters is more specialized. The concept of parameters in CAD software produced for parametric design purposes is generally expressed as a variable term in equations. One of the most important features of parametric design is that changing the values of a few parameters can affect the entire design (Yüksekkaya, 2020).

Parametric design, which results from the use of parameters, is presented as a computer-aided design (CAD) tool. Parametric design is created by defining parameters rather than drawing lines, and subsequently emerges in accordance with the constraints and rules entered into the program (Baykara, 2011).

Architecture, which emerged with the existence of humanity, has always progressed within certain rules and an order. Products created within specific rules have emerged through designers correctly establishing relationships between parameters linked to certain elements. The correct relationships between parameters defined the design and enhanced the quality of the resulting product.

The design method based on variables, which has existed since the dawn of architectural history, gave rise to the concept of "parametric design" that we use today to define complex forms and led us to adopt this concept as a design system (Yüksekkaya, 2020).

Parametric Design is essentially a design system that multiplies design alternatives, aims to improve the design process, and has certain concepts within itself. However, it is known that architecture, which has existed alongside humanity, has been approached in different ways with specific parameters in each period. For this reason, the concept of parametric design has also been defined in many different ways.

Jabi states that "designers establish relationships between various parameters throughout the design process using parametric design software, and that new design alternatives are created by making changes to these parameters using this software" (Jabi, 2013). Schumacher defines parametric design as "a method that reshapes the complexity of contemporary architecture." Parametric design is also referred to as "relational geometry, constraint-based design, relational modeling, or variational design" (Schumacher, 2008). The emergence of so many different definitions of parametric design shows us how effective the parameters set by designers are on the design.

Until the 1940s, architects used their own traditional design methods. However, by the 1960s, digital production tools developed for design purposes (Figure 1) enabled parametric systems to gain significant momentum and expand their areas of application (Yüksekkaya, 2020).

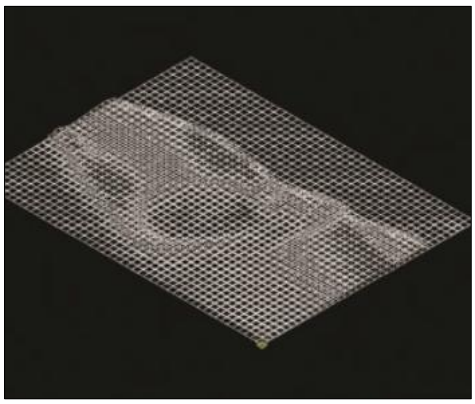


Figure 1. Surface Design Created with Parametric Design Software (Yüksekkaya, 2020)

There are significant differences between the traditional design process and today's parametric design process. (Figure 2) The traditional design process essentially begins with drawings on paper using pen and paper, is developed using graphical methods, and results in a tangible product through the use of models. This process continues until the optimal design is achieved. Any change made to a parameter within the traditional design process means that the entire process must be repeated. This time-consuming process brings challenging conditions in complex projects. For this reason, the use of parametric design methods is of great importance in this process (Eltaweel and Su, 2017). Unlike the traditional design process, adjustments and updates made in parametric design are automatically updated on the model. There is no need to repeat the entire design process from start to finish. Therefore, parametric design emerges as a system that establishes relationships between different disciplines and can operate complex connections within specific coordination.

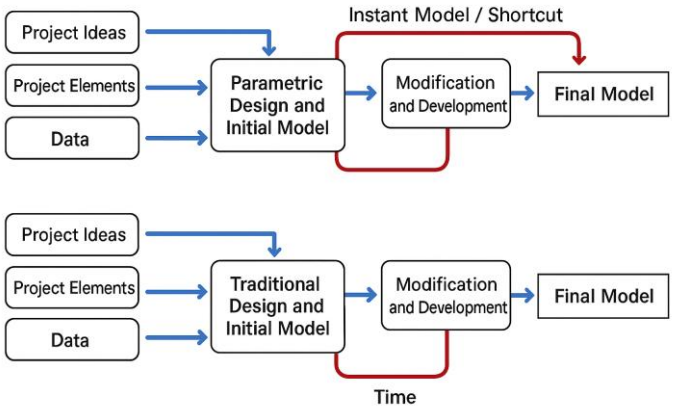


Figure 2. Comparison of Traditional and Parametric Design Processes (Şekerci, 2020)

With the advancement of technology and the emergence of digital production tools, products that were once produced uniformly and in series can now be modified in various ways to meet specific requests. The introduction of digital tools in parametric design has enabled designers to work in a more flexible design environment, providing significant benefits in terms of cost calculation and design time. Parametric design allows different ideas to be implemented quickly during the product design and manufacturing process. Parametric design is not only a design method but also a tool that enables faster and more varied alternatives in design and manufacturing (Basu-Ghosh, 2017). Parametric design allows for different applications and reshaping without redrawing or erasing the created model. In this respect, it offers us various design alternatives due to the ability to continuously update the design and provide flexibility.

Parametric design systems are supported by a number of digital software programs today. However, it is also possible to implement them traditionally without the aid of digital tools. Parametric design is frequently applied in the following situations: It is used in products that require continuous updating during the design process due to their fluid and flexible form or structure (Figures 3 and 4).

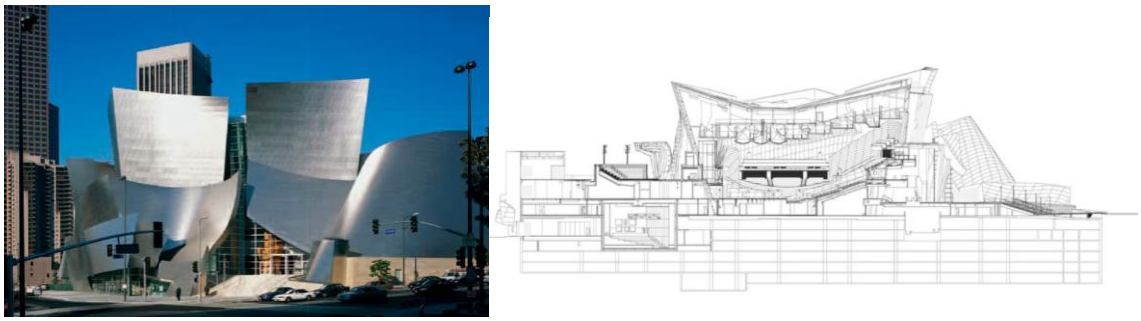


Figure 3. Frank Gehry - Walt Disney Concert Hall Parametric Design and Detailed Solutions (Url 1)

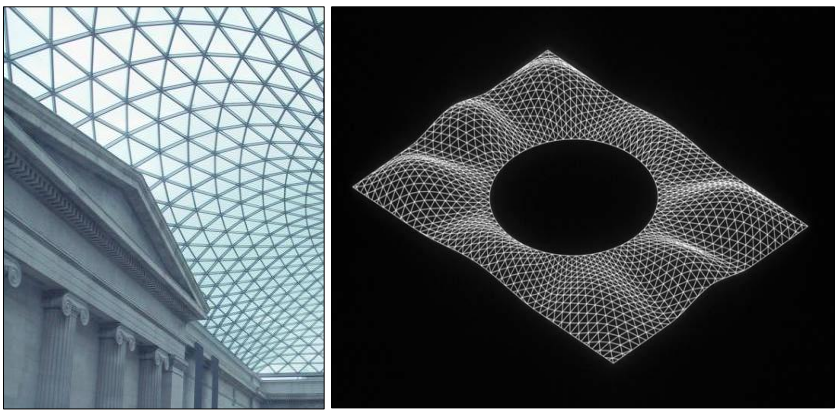


Figure 4. Norman Foster - The Roof Over the Courtyard of the British Museum and Its Parametric Modeling (Woodbury, 2005)

The computer, one of the digital systems heavily used in parametric design, has taken its place in every aspect of today's society, which demands diversity and speed. The importance of the computer, which is used in every process from the design to the production of a product today, should not be overlooked (Baykara, 2011). According to Leach, the computer is a powerful tool for creating designs, and the success of the resulting product is directly proportional to the architect's mastery of the computer tool (Leach, 2019). In this regard, considering that parametric design is a computer-aided design (CAD) tool, architects need to strengthen their relationship with computer systems in order to create effective designs.

Parametric design is a system that allows design to be created within a computer-generated system by entering different parametric values. Although it is generally used for form generation, it is also used in detail solutions and structural designs (Figures 5 and 6) (Baykara, 2011). Within this system, parameters are interconnected in a complex manner, so changing a single parameter causes the entire design to change. For this reason, the designer must be aware of the complex connections that the parameter has within the design process and its effect on the design process.

Figure 5. Frei Otto – Munich Olympic Stadium and Supporting Structure Details (Url 2)

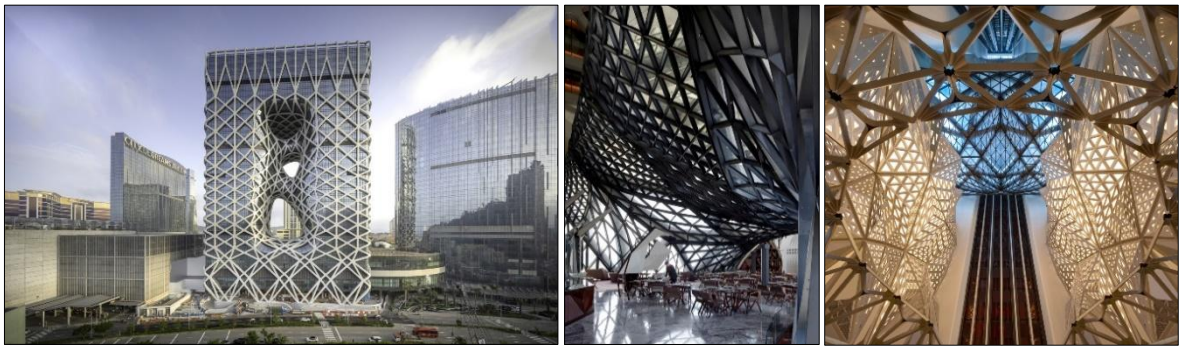


Figure 6. Zaha Hadid Architects – Morpheus Hotel ve Envelope Details (Url 3)

2.1. Advantages and Disadvantages of Parametric Design

Parametric design is a design system that facilitates the designer's ability to express their ideas more quickly and through a variety of alternatives. Although it offers significant advantages to the designer, it is possible that the desired results may not be achieved due to systemic limitations or the user's hardware limitations. This section aims to examine the advantages and disadvantages of parametric design.

2.1.1 Advantages of Parametric Design

Parametric design is a digitally supported design method that enables complex designs to be solved through different parameters. This method has many advantages for designers. The main ones are that it speeds up the design process and offers various design alternatives. Other advantages are as follows:

• Able to create design alternatives by establishing the right relationships between decisions made during the design process,
• Accelerating the design process, paving the way for different designs (Baykara, 2011),
• Giving the designer control over the parameters used in the design,
• Enabling new ideas and solutions through the products created,
• Creating model integrity by combining design and analysis,
• Enabling the production of complex forms by visually presenting the designed product (Şekerci, 2020),
• Enabling the design of complex and organically shaped products.

2.1.2. Disadvantages of Parametric Design

Parametric design, while facilitating the design of organically shaped products, also has some negative characteristics. Some of these characteristics are as follows:

• Design flaws that negatively impact the functionality of organic-shaped product packaging can be observed (Şekerci, 2020).
• Designers lacking sufficient expertise may produce designs that are lacking in detail and superficial.
• Although this method allows for many designs, some emotional approaches cannot be systematized (Şekerci, 2020),
• Due to being a current method, many problems arise in the field of education and training,
• There may be difficulties in finding technologically equipped instructors.

2.2. The Use of Parametric Design in Architecture and Digital Tools

Although studies on the parametric design process date back to the 1800s, the introduction of parametric design into the field of architecture, driven by developments in mathematics and physics, was made possible by the creation of “Sketchpad” in 1963, the first two-dimensional modeling tool (Figure 7) (Davis, 2013).

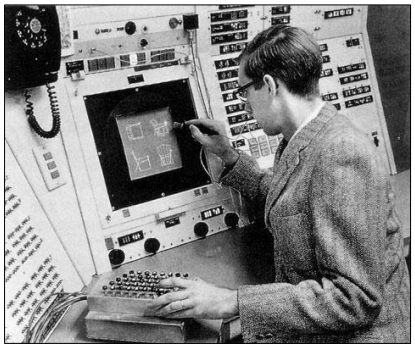


Figure 7. Ivan Shutterland ve Sketchpad 1962 (Url 4)

This program, developed by Ivan Shutherland, is open to change, offers the possibility of development, and provides more accurate and faster results than traditional drawings. It pioneered the development of such software and hardware, paving the way for three-dimensional programs. Later, modeling tools used for specific purposes and methods were made available to users (Şekerci, 2020).

As the process progressed, developments in the field of design and architecture led to an increase in the number of available programming options. The rise in computer ownership in the 1980s ensured that these options reached a wide user base. By the 21st century, parametric design, complex structural models, and advanced construction techniques have emerged as fundamental components of architecture (Jabi, 2013).

The use of computers and software in architecture is divided into two categories: production and design. In the former, computers are used to produce a pre-designed form, while in the latter, computers are involved in the design process (Yüksekkaya, 2020). Although the involvement of computers in the design process offers certain advantages, the work ultimately depends on the designer's perceptual and cognitive abilities. Designers must interpret and use existing digital capabilities in line with their own aesthetic values. The quality of the resulting design varies depending on the potential use of parametric design tools. As technology advances and different design ideas emerge every day, software has begun to be produced specifically for designers and architects. Some of these software programs are Generative Components, Digital Project (CATIA), and Grasshopper.

2.2.1. Generative Components Software

Generative Components is a parametric CAD software designed by Dr. Robert Aish (Day, 2005). Launched in 2003, this software was widely used in large-scale projects, particularly in London and its surroundings, by 2005. In 2007, it was made available free of charge to designers. Generative Components is a parametric design tool that offers potential solutions within the framework of design rules and provides support in implementing these solutions (Hensel, 2006). This software, which has a strong presence in academic environments and advanced design offices, brings variable and fluid parametric modeling capabilities to the field of architecture. Designers can design complex forms and systems by establishing relationships between the rules and models they define. This software, with its special definitions, provides users with a flexible working space through design, as it allows them to design objects on demand, manage them, and control them. It has also been created with a simple programming language so that it can be used interactively with software such as AutoCAD and Rhino (Kızılkaya, 2011). This software is mainly used by engineers and designers, especially in building design. It is also used extensively in modeling natural structures (Figure 8).

Figure 8. Lagoon Business Center – A Perspective Created with Generative Components (Url 5)

2.2.2. Digital Project Yazılımı (CATIA)

Digital Project is a computer-aided parametric design software developed by Gehry Technologies. Although initially running on high-performance computers, advances in technology have made it accessible to many computer users. As a result of this development, parametric design tools have become widespread, been adopted in the industry, and accelerated construction development times (Yu, 2009). This software allows for the creation of design elements such as objects, as well as the calculation of estimated costs and material usage. The software allows users to model within complex configurations and is highly suitable for detailed design. (Figure 9) This makes it possible to perform calculations and analyses on the model created. It can also work online with software such as AutoCAD and 3ds Max.

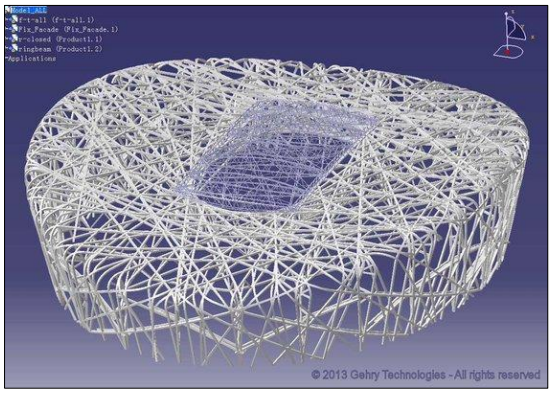


Figure 9. Beijing Stadium – Parametric Model Created in Digital Project (Url 6)

2.2.3. Grasshopper Software

Grasshopper (Figure 10) is a parametric design software developed by David Rutten that works in conjunction with the Rhinoceros 3D modeling program. The biggest advantage of this software is that even users with minimal programming experience can explore the relationships between design elements thanks to its simple interface. It is also preferred by many Rhinoceros users because it is free. Grasshopper, a newer software compared to other parametric design software, has become widely used today. Grasshopper, which works in conjunction with Rhinoceros, can be compared to Generative Components due to its similar features.

Figure 10. Aviva Stadium – Design Created with Grasshopper (Url 7)

3. FUTURISM AND FUTURISTIC ARCHITECTURE

Futurism (Futureism); derived from the Latin words “futura” and “futur,” its Turkish equivalent is “Realizm.” It rejects conventional thinking and traditional perspectives, particularly exerting its influence between 1909 and 1920. It is an art and social movement that originated in Italy and later spread to other countries (Nef, 2019).

At the core of Futurism lies the pursuit of freedom, abandoning the traditional in favor of the new and exciting. The term Futurism was first coined in 1909 by Italian artist Filippo Tomasso Marinetti in the Futurist Manifesto published in the Paris newspaper Le Figaro, which laid out the main principles of the movement. The manifesto stated that art must be integrated with the movement and technology of the future. Thanks to this published article, Marinetti found many supporters and ensured the spread of this movement. This manifesto also attracted the attention of architects (Başaran, 2007). Although Futurism emerged as an art movement in Italy in the fields of painting, literature, and sculpture, it presents itself as a discipline that examines and explores everything related to the future from sociological, psychological, economic, and technological perspectives (Akbulut, 2019). In this sense, futurist works can take on highly abstract forms. With the development of technology and the emergence of modern cities, it has also begun to manifest itself in the fields of architecture and design. However, it is observed that architecture has moved away from abstract concepts. This is because functionality plays a major role in the design of buildings (Sarıgül, 2008).

The fundamental aims of the Futurism movement are to completely reject traditional aesthetic values, to argue that the future of the world lies in modernity, to modernize countries, and to establish the concepts of "Urbanized Civilization" and "Mechanization" as fundamental principles in social life (Phaidon, 1999). Futurism, in its most basic sense, is the design of a positive future, and a futurist can be defined as the designer of a positive future. The main goal of futurism is to create a sustainable future. At this point, futurists are individuals who develop a positive, innovative, and useful vision first for themselves and then for all of humanity, who are aware that they must be designers of the future, not observers of it (Akbulut, 2019).

As a result, Futurism, which embraced the speed and dynamism brought about by mechanization and leaped toward the future, influenced many artists in a short period of time. However, due to its lack of a solid foundation and its disregard for detail, Futurism ultimately lost its momentum with the death of Boccioni, who was trained by Marinetti, and the end of World War I. However, we can still see the influence of Futurism today through works that have survived to the present day and designers who have embraced this perspective.

Futuristic architecture presents itself as a design language that utilizes curved forms and lines alongside simple, clean, and straight lines. Dynamic and curved forms ensure the continuity of structures while also emphasizing boundlessness (Akbulut, 2019). The main characteristics of futuristic architecture are fluidity, mobility, and dynamism in design. (Figure 11) Designs that were primarily geometric shapes before the futuristic movement have gained a different meaning with futurism through the use of different angles, oval lines, and elements such as domes. Evolving in a different direction with the advancement of technology, futuristic architecture attracts attention with details such as curved lines, creative forms, glass elevators, metal materials, and the use of mechanical elements (Conrads, 1991).

Figure 11. Futurist Architect Sant'Elia - A Perspective from Citta Nuova (Url 8)

Designers embracing futuristic architecture created unusual, imaginative, and previously unseen structures rather than designing buildings with functional forms, symmetrical lines, and primary geometric shapes. This movement, which has different interpretations, has developed within the framework of the following four characteristics: mobility, technology, natural materials, and science (Atak, 2019).

Mobility is one of the most fundamental characteristics of futurist architecture. Designs created before the futurist movement featured simple, flat, and clean lines with primary geometric forms. With futurism, sharp or oval lines combined with different angles and dome-like forms began to be widely used. This supports the idea that designs can be limitless.

With the development of technology in the 20th century, futurist architecture sought to embrace these changes. Machines and mechanics came to the fore in futurist architecture, with sharp lines and metal materials used in various forms of staircases and glass elevators. The aim was to create technological and aesthetic innovation. The structural elements used in futuristic architecture were created by drawing inspiration from the natural environment. Every element we see around us has structural potential for futuristic architecture. One of the goals of futuristic architecture is to reflect the natural environment in buildings and designs.

Science enables us to examine our surroundings by looking at the world from different perspectives through research and thinking. In futuristic architecture, it is necessary to embrace and examine the environment in order to create a new design. For this reason, science is an indispensable element of futuristic architecture.

One of the first representatives of the Futurist movement, Italian Futurist architect Antonia Sant'Elia, defines the city as a screen on which the dynamism of Futurism is realized in his work titled "La Citta Nuova (The New City)." Sant'Elia's concept of the "city" was like a rapidly developing machine. In this city, buildings would not be constructed to last for long; each new generation would build new structures according to their own vision. In this way, architecture would not be tied to the past but would constantly look to the future. He also included his ideas and projects on modernity in this work. In this vein, he became one of the idols of futurist architecture as the designer of modern cities and futuristic structures, drawing power from technology in the 20th century. Throughout his architectural career, he published numerous articles and produced many architectural works. (Figure 12) However, he lost his life during World War I before he could realize the projects and ideas he had developed

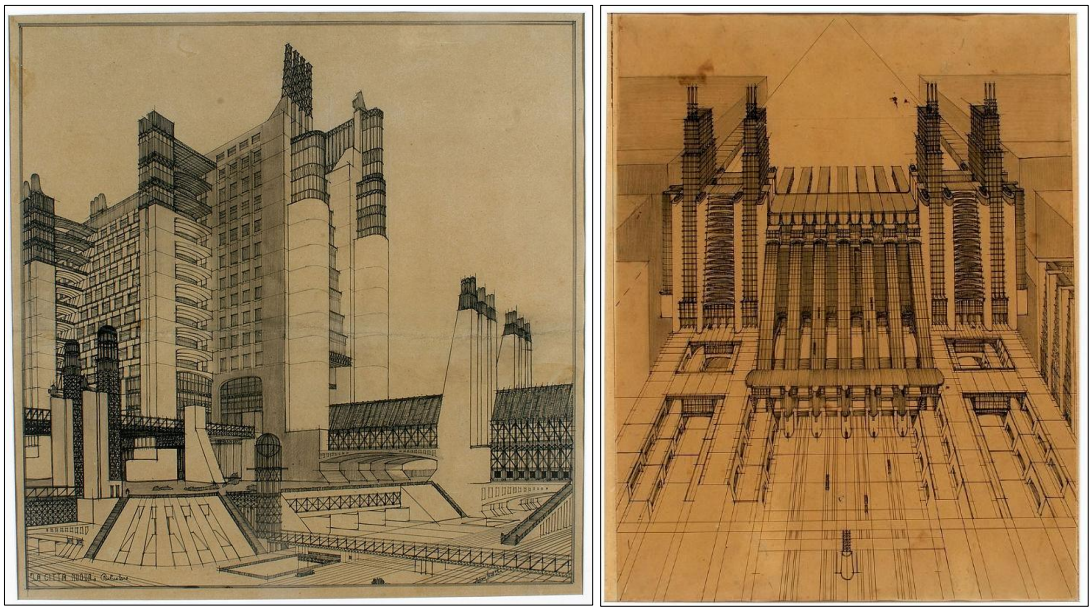


Figure 12. The Studies of Futurist Architect Sant'Elia (Url 9)

3.1. Examples of Futuristic Architecture

Futurist architects preferred to design more impressive city skylines rather than planning future housing in detail. These designs were not intended to meet specific needs, but rather to offer ideas and predictions about the possible appearance of future cities. A common feature of these ideas was their vertical development. Accordingly, multi-story building clusters were designed, and cities grew vertically rather than horizontally. Futurist projects are considered an expression of the excitement that comes with technology rather than designs made with attention to detail. This is because many details were not worked out in these designs, and many possible situations were overlooked. This is why almost none of the futurist architects' designs were ever built. However, their ideas inspired many people and influenced the periods that followed. Today, traces of futurist architecture can be seen in our city skylines and many buildings (Yaşar, 2019). This section will examine examples of buildings designed under the influence of futurism.

3.1.1. Guggenheim Bilbao Museum (Frank Gehry, 1997)

Located in the city of Bilbao, Spain, the Guggenheim Bilbao Museum (Figure 13), designed by Frank Gehry in 1997, is one of the most important designs of deconstructivist and futuristic architecture. In addition to its content, the building also attracts attention with its unique architectural features.

Figure 13. Frank Gehry – Guggenheim Bilbao Museum (Url 10)

Frank Gehry sought to reflect all the possibilities of technology in his architectural designs. Through Gehry Technologies, his own in-house technological research company, Gehry has succeeded in bringing to life many designs that could be described as beyond imagination, using the full capabilities of CAD software. The Guggenheim Bilbao Museum is one such design. The sloping surfaces, made of titanium, limestone, and glass, form the structure's shape. This can also be seen as a reflection of futuristic architecture. The curved surfaces were designed on a computer and then implemented. These surfaces were produced using parametric design software called CATIA. The curved titanium surfaces play an important role in controlling the daylight and airflow entering the building, as well as providing an aesthetic appearance. These features make the deconstructivist and futuristic characteristics of the building more pronounced. (Figure 14).

Figure 14. Guggenheim Bilbao Museum Construction Envelope Detail (Url 10)

3.1.2. Galaxy Soho (Zaha Hadid, 2012)

Located in Beijing, the capital of China, Galaxy Soho (Figure 15), designed by renowned architect Zaha Hadid in 2012, is a complex that has become an integral part of the city, featuring office, retail, and entertainment spaces.

Figure 15. Zaha Hadid – Galaxy Soho (Url 11)

Designed with infinite curvature logic, the structure consists of five fluid and continuous masses connected by bridges, drawing attention with its curved and organic forms. The masses harmonize with each other from all directions and ensure fluidity. The courtyards between the masses reflect traditional Chinese architecture. The masses in the structure are not composed of solid blocks; instead, a fluid transition is provided between them. The level differences within the design are important for users to perceive the continuity of the curved lines. The fluid bridges and corridors of the structure, along with its formal characteristics, reflect futuristic traces. (Figure 16).

Figure 16. Blocks Connected by Bridges (Url 11)

4. PARAMETRİC DESİGN AND FUTURİSM

Today's technological developments, with new technologies emerging every day, present us with a situation that is endless and impossible to keep up with. At this point, the question of how the development of brand new digital tools surrounding us in the field of architectural design is taking place is a subject of great interest. Parametric design software is one of the most important examples of the use of technology in architecture. Deconstructivist and futurist architectural experiences present themselves as areas where all the possibilities of technological developments in this regard can be utilised. When viewed in the context of historical proximity and its relationship with technology, Futurism and parametric design software appear as two closely related concepts. Although the Futurist perspective dates back further, developments in the field of parametric design have enabled the characteristics of Futurism to be presented in a more striking manner.

Although Futurism emerged as an artistic and cultural movement in Italy, architecture has generally remained in the background. This is because developments in architecture have been much slower compared to other art forms. Artists who embraced Futurism wanted to imagine cities of the future, exciting, mechanised and fast-paced, while architecture inevitably lagged behind this thinking (Garcia, 2019). Today, our world and societies are changing very rapidly, and our needs are constantly changing. At this point, parametric design is a response to our changing needs today and in the future. With the emergence of deconstructivism, parametric design, which has grown in popularity, is a design method frequently used in architecture alongside futurism (Schumacher 2008). Boccioni, one of Marinetti's students who pioneered futurism, argued that the speed of change in life meant that architecture also had a transient nature and was an area open to innovation. The field of architecture emerged as an important point in the subsequent development of futurism, which lost its significance in the art world with the deaths of the artists who embraced it within a short period of time (Garcia, 2019).

Parametric design can be defined as a digital technology that reflects new ways of thinking, provides diversity, and enables implementation. These technologies are an indispensable requirement for bringing architectural designs (Figure 17) containing different geometric shapes and complex drawings to life (Schumaer, 2004). Parametric design tools are digital software programmes coded on the basis of parameters. Their ability to allow continuous updates based on parameters makes them a major reason for preference, particularly for designers who embrace the Deconstructivism and Futurism movements.

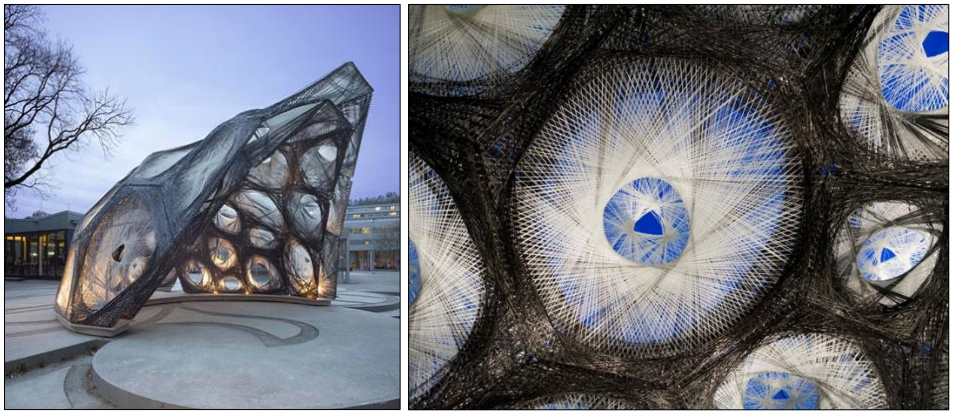


Figure 17. Achim Mendes - ICD/ITKE Research Pavilion (2013-2014) (Url 12)

Until recently, creating a new architectural form that had not been tried before was considered quite difficult. For this reason, the fact that architecture cannot keep pace with the speed of life is a bitter reality. Looking at formal diversity throughout history, the absence of various geometries, previously untried angles, curved and dynamic forms found in Deconstructivism and Futurism reflects the importance of parametric design in architecture. Futurism and parametric design converge on many common concepts and ideas, referring to the past. Both concepts embrace centuries of architectural knowledge, arguing that new forms must meet new needs in step with the pace of societal change, and that curved geometries and different angles must be effective in architecture. Mobility and dynamism are indispensable characteristics for these two concepts (Conrads, 1991).

Marchi has defined futuristic architecture as 'unrealistic.' Consequently, the primary reason none of Sant'Elia's designs, one of the first futurist architects, were ever built was the lack of sufficient technological infrastructure to realise these projects. This situation also applies to Iraqi-born British architect Zaha Hadid. Hadid's designs could not be realised until the 'Vitra Fire Station,' the first parametric architectural project to become a reality (Figure 18) (Woods, 2008).

Figure 18. Zaha Hadid – Vitra Fire Station (1989-1993) (Url 13)

The concepts of Parametric Design and Futurism have given rise to a new architecture that symbolises speed and technology in their respective eras. At the same time, the qualities of projects, linked to the needs of the societies in which they are located, appear before us as a symbol of constant change (Jencks and Kropf 1997). Finally, it is a fact that futuristic architects and parametric design have brought new ideas to the world of architecture. Thanks to these concepts, a large proportion of visionary projects have had the opportunity to come to life.

4.1. Examples of Futuristic Architecture Designed with Parametric Software

Futuristic architecture presents itself as a design concept that utilises curved forms and lines at different angles, rather than architectural designs that employ primary geometric shapes. At this point, the following examples of futuristic architecture will be examined, indicating why they were selected:

Hangzhou Olympic Stadium

• It is one of the strongest examples of parametric software optimising structure-facade integration.

Nordpark Cable Railway

• It was selected because it is an example that enables parametric adaptation to different topographies.

• It demonstrates the parametric reproducibility of the same design language in different locations.

4.1.1. Hangzhou Olympic Stadium (NBBJ, 2011-2018)

Located in Houngzau, China, the stadium (Figure 19), constructed between 2011 and 2018, was designed by NBNJ as an 80,000-seat sports complex (Url 14). In terms of combining form generation with different functions, it stands out as an important example of parametric control of the process.

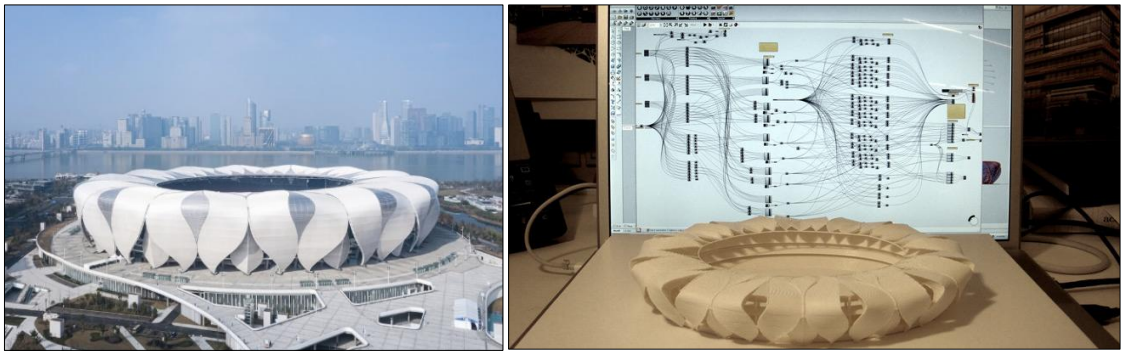


Figure 19. NBBJ – Hangzou Olympic Stadium and Parametric Modelling (Url 14)

The stadium, designed using different parametric software (Grasshopper and Kangaroo) in conjunction, was designed by working on the same model for both the architectural and structural systems. In addition to the structural system, the qualities and performance of the façade elements were also designed in a controlled manner using parametric software. Thus, formal problems on inclined surfaces were resolved. The surfaces were divided into sections, and the most suitable geometric forms were selected. The parametric modelling of these façade sections, which are interrelated, ensured the integrity of the façade (Figure 20) (Oktan and Vural 2017).

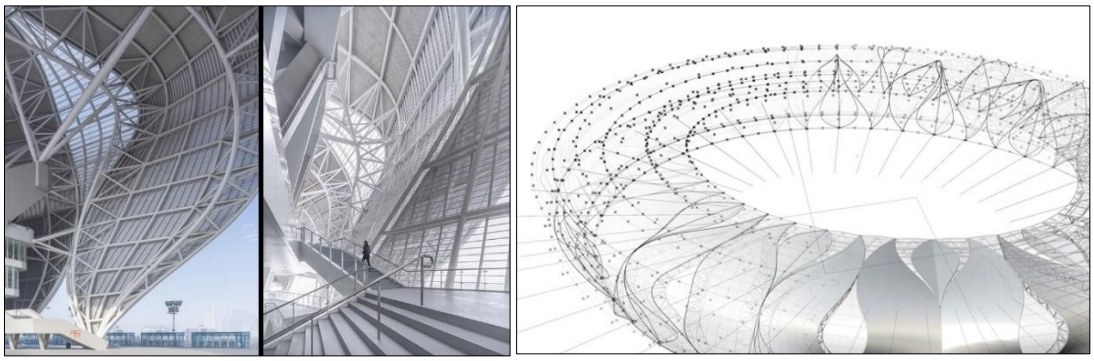


Figure 20. Hangzou Olympic Stadium Structure Detail (Url 14)

4.1.2. Nordpark Cable Railway (Zaha Hadid, 2004-2007)

The project designed by Zaha Hadid in Innsbruck, Austria, constructed between 2004 and 2007 (Figure 21), consists of four stations (Url 15). An important element in parametric design, it is a significant example of how similar design ideas can be adapted to different locations in terms of the design's ability to adapt to different environmental conditions. This adaptation was achieved by modifying the parameters used in the design.

Figure 21. Zaha Hadid - Nordpark Cable Railway (Url 15)

The structures, designed according to the terrain conditions at different elevations, were constructed by placing organic roof structures on concrete bases. The forms and soft lines of the shells are reminiscent of the movement of glaciers native to the area. (Figure 22) The stations built as part of the project incorporate parameters that are compatible with the topography in which they are located. The reason for the curved form of the shell design is that it allows different parameters to come together under the same design language (Sudaş, 2014).

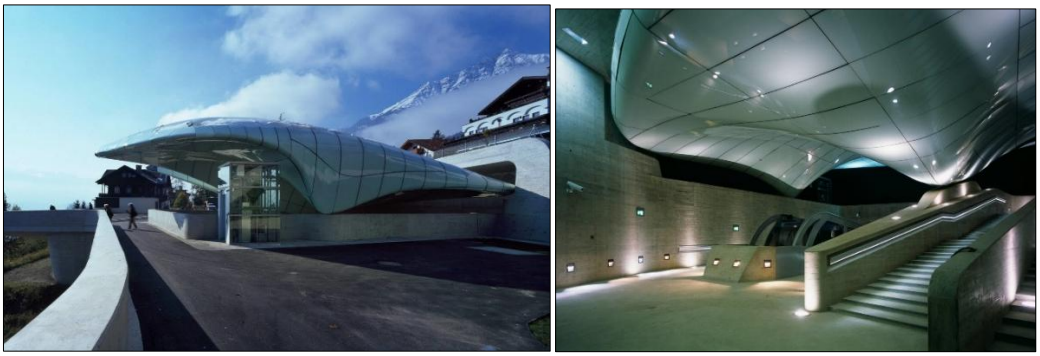


Figure 22. Nordpark Cable Railway Different Stations (url 15)

5. FINDINGS AND DISCUSSION

Analyses have shown that parametric design tools facilitate the modelling of curved, organic, and dynamic surfaces. The formal characteristics of structures designed using software such as Grasshopper, CATIA, and Generative Components are particularly compatible with the principles of fluidity and mobility in futuristic architecture. The rapid calculation models provided by this software have facilitated the generation of alternative design proposals.

Analyses show that futurist architecture has historically treated technology as a conceptual ideal, while parametric design has made these ideals technically feasible in contemporary design practice. When comparing the unbuilt projects of early futurist architects such as Sant'Elia with structures designed today by Zaha Hadid, Gehry, and Menges, it has been found that parametric tools play a decisive role in form generation, structural analysis, and material performance analysis.

• **Hangzhou Olympic Stadium:** Grasshopper and Kangaroo software guided both aesthetic and structural decisions throughout the design process, and the parametric model optimised the compatibility of the steel space frame with the curved shell.

• **Nordpark Cable Railway:** Maintaining a similar design language across different topographical conditions was made possible through parametric control; shell geometries were recalculated parametrically, with wind loads and slope angles used as input parameters.

Research findings indicate that both approaches focus on dynamism, movement, fluidity, and innovation. While futurism highlights the speed of the future and mechanised life as an artistic vision, parametric design forms the technical infrastructure of this vision. The management of parameters enables the digital realisation of the ‘fluid and boundless space’ envisioned by futurist architecture.

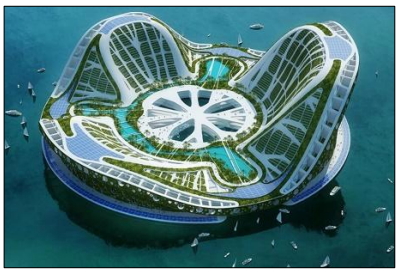
Although there are criticisms in the literature that futuristic designs neglect functionality, parametric design is seen to facilitate the integration of functional requirements into form. Parametric modelling offers balanced solutions by relating functional data such as structural load distribution, solar gain ratios, and circulation decisions to geometric behaviour.

While Sant'Elia and early futurist projects could not be built due to the technological limitations of the time, today's digital production tools facilitate the implementation of these designs from both a geometric and structural perspective. Thanks to computer-aided analysis and BIM integration, the architectural vision of the future has become more realistic and feasible.

6. CONCLUSION

Thanks to parametric design software, it has become possible to design and implement fluid, continuous, and curved forms, moving beyond traditional design methods. Undoubtedly, parametric design software has made the greatest contribution to the realisation of structures designed within the scope of futuristic architecture. In this regard, parametric design methods offer significant benefits in the design and implementation of curved forms and structures. From the past to the present, many futuristic structures have been designed using parametric design software. While some of these designs have been implemented and brought to life, others have remained only at the project stage, and some have been halted and cancelled during the construction process for various reasons. To give an example, the Cybertecture Egg, designed by James Law and located in Mumbai, India, was designed as a conceptual office building for the future. The project, which was planned with a parametric design shell combining different materials and systems, remained at the project stage because it did not meet today's conditions. Similarly, the Lillypad, designed by Vincent Callebout, was conceived as a solution to problems that will arise in the future due to rising sea levels and has not been implemented today. Another example, India Tower, was cancelled and never realised due to a dispute that arose between the local government and the construction company after construction had begun (Table 1).

Table 1. Built and Unbuilt Futuristic Structures

BUİLT STRUCTURES		NOT BUİLT STRUCTURES	
Building and Architect	Location	Building and Architect	Location
Soumaya Museum (Fernando Romero Enterpise)	Mexico (Meksika)	Cybertecture Egg (James Law)	Mumbai (Hindistan)
 (Url 16)		 (Url 17)	
Cayan Tower (SOM)	Dubai (BAE)	India Tower (OMA)	Mumbai (Hindistan)
 (Url 18)		 (Url 19)	
The Yas Hotel (Asimptote Architecture)	Abu Dhabi (BAE)	Lilypad (Vincent Callebout)	- -
 (Url 20)		 (Url 21)	
Metropol Parasol (Jürgen Mayer)	Sevilla (İspanya)	Putrajaya Waterfront (Studio Nıcoletti Associati)	Kuala Lumpur (Malezya)
 (Url 22)		 (Url 23)	

As a result of technological developments, architecture has also undergone significant changes. Alongside architecture that has historically been confined to primary geometric forms and certain structures, a new form of architecture has emerged, consisting of curved forms and structures. At this point, the importance of parametric design software that has entered our lives is enormous. They contribute greatly to the realisation of designs that were previously undesigned and unimplementable. There are many

commonalities between the parametric design process and movements that embrace a futuristic mindset and design approach, such as futurism. The most fundamental commonality between the two concepts is the necessity of abandoning the conventional and creating designs that utilise technology and possess different forms and angles. Parametric design software plays a major role in bringing the designs required by futuristic architecture to life. When viewed in the context of their relationship with technology, Futurism and parametric design software emerge as two closely related concepts. Although the futuristic perspective has older roots, developments in parametric design have enabled the characteristics of futurism to be presented in a more striking manner.

This study has revealed that parametric design and futuristic architecture converge on a common conceptual ground, that technological developments have strengthened this convergence, and that they offer new possibilities for contemporary design production processes. According to the results obtained:

Answers to the Hypotheses

• Hipotez 1 is confirmed. Parametric design software enables the application of curved, dynamic and complex geometries specific to futuristic architecture.

• Hipotez 2 is confirmed. Parametric tools provide a strong technical infrastructure in terms of structural calculation, material compatibility, and form optimisation for transforming futuristic design principles into physical structures.

• Hipotez 3 is confirmed. There is a common system of thought based on movement, fluidity, dynamism, and transformation between the two approaches.

Answers to Research Questions

1. Parametric design makes the dynamic forms of futuristic architecture technically producible.
2. The form understanding envisaged by the futurist movement is reinterpreted using parametric software and transferred into physical reality.
3. The development of digital tools has accelerated the realisation of futuristic forms, making the design process more rational and optimisable.

This study is one of the first analytical frameworks to comprehensively address the relationship between parametric design and futurism from technical, conceptual, and formal perspectives. It fills a gap in the literature by explaining the impact of current digital techniques on the production of futuristic forms. The sample structure analysis provides an interdisciplinary model by concretising the theoretical discussion. This comprehensive approach provides a critical framework for understanding the architectural design approach of the future.

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