Parametric Thinking for Designing structures in Contemporary Architecture

Nadine Al-Bqour

Abstract— This review highlights Parametric thinking for designing architectural structures in contemporary architecture. It first explains the reasons for the emergence of the parametric design and its uses, and clearly defines its extension from algorithms. This review explains the evolution for the types of parametric design over time, and then explains parametric design systems and how they work. The review also focuses on the types of parametric design and explains it through global case studies. Moreover, it highlights the limitations faced by the parametric design of architectural structures and some of the misconceptions that have been projected onto the parametric design. Finally, it summarizes the future of parametric design in contemporary architecture.

Index Terms— Parametric design, Parametric structures, Parametric design thinking, Mathematics in Architecture, Parametric systems, Differentiation patterns in parametric design structures, Contemporary architecture, Performative Parametric Structures.

1 Introduction

Contemporary architecture is in constant search for different and new structures due to the capabilities of the contemporary design process. As the technological development has provided innovative ways to deal with the design process with the end of the era of manual painting [1]. Moreover, in the search for a suitable form of buildings, architects have always been trying to treat the appearance of their work as a personal signature in the structures they design. The contemporary technological development opens these architects` new horizons in design as the available capabilities make the architect cooperation with the computer possible in terms of researching the appropriate structural model for the cases of specific buildings while maintaining their personal signature in designs [2]. Although the computer is unable to understand aesthetics, it is able to perform millions of calculations per second and visualize results faster [3]. Computer systems have emerged as a cornerstone of architectural design during the past decades, on the occasion of the emergence of a new field of study dealing with the perception of design and arithmetic in the practice of contemporary architectural design. Whereas, computer systems represent the starting point for parametric structures [4].

The production of parametric structures relies on parametric tools which in turn are mainly based on algorithms of computer systems, thus providing increased mathematical control over design engineering during design activity. Its adaptability and responsiveness to changing design standards and requirements make parametric structures particularly useful for exploring design in the complex and dynamic design settings of contemporary architecture [5]. The contemporary architectural design revolves around the use of modeling through computer systems resulting from technological advances to generate new parametric structures. The generation of parametric structures through the use of modeling as a tool complements the designer's capabilities in visualizing architectural structures [6]. Recently, the modeling of parametric structures has been used extensively in the contemporary architectural design process. This modeling gained great acceptance as a generative method for new parametric structures. However, the immediate use of modeling parametric structures has led to an increased and superficial application for the principles of modeling parametric structures. Therefore, it is necessary to reformulate this topic. Also, the capabilities and limitations of modeling structures should be illustrated in contemporary architectural design [7].

To this end, this paper discusses new parametric structures sy tems from the perspective of exploring parametric design by providing some global examples for their applications. Also, this paper examines some of the limitations of parametric structure systems, especially with regard to their role in contemporary architectural design, flexibility, and complexity. Also, its principles and statement of its various patterns through many examples and ending with the future of its application in architecture.

2 The Emergence of Parametric Design Thinking

Recently, there is a need to quickly explore unexpected design solutions that respond to goals such as aesthetics, performance, project requirements, site, and building constraints or new demand for digital manufacturing in contemporary architecture. This recently led to the start of so-called parametric design as targets are converted into design parameters. In contemporary practice, parametric systems rely mainly on algorithm symbols that allow expressions of procedures to solve design problems [8]. The application of parametric structure design facilitates the process of exploiting computational techniques to integrate performance evaluation of specific design requirements with optimization techniques to create and test different design solutions automatically without having to redraw each solution as in the traditional method of the architectural design process. Then, based on the optimization criteria, the optimal solutions are chosen nearby, and the bad solutions are eliminated [9].

The design of parametric structures is an emerging research problem in the field of contemporary architectural design. However, discussions about the creative process in designing parametric structures are limited. Moreover, despite the 57 years since the parametric design was in place, we still do not know what the parametric design thinking is. Is it a simple tool, useful in some kind of architectural improvement, or is it a method that helps

architects develop unexpected solutions [10]. More recently in architecture, the need for rapid automatic exploration of design solutions that respond to complex design requirements using computing techniques has triggered the so-called design of parametric structures. It provides a performance-based design process for integrating performance appraisal of specific design requirements with optimization techniques to choose near-perfect solutions and neglecting bad solutions in the early design stages that influence model creation [9].

3 The Parametric Design Thinking

Emphasis was placed on aspects of Parametric Design Thinking (PDT) from practice. It describes the components of the PDT Knowledge Model, the design method and the information processing model that is critical to effective search and cooperation for solutions to architectural problems as it combines the latest technology in practice and research with parametric architectural structures [11]. Besides being another tool for modeling complex shapes, Parametric Design appears as a unique and distinctive model of architectural design. Both research and practical application in parametric design influence the emergence of parametric design theories that are currently undergoing paraphrasing and epistemic shift. In parallel, the development of existing tools and practices for parametric design began to influence the forms of PDT [12]. The distinction between practice and research in architecture is often unclear, and routinely, the construction activity is research in itself [13]. By working in this context, this review will highlight the forms of parametric design thinking and their contributions to contemporary architectural knowledge whether in research or in practice.

4 Evolution of Use of the Mathmatics in Creating Parametric Structures

To understand the process of modeling parametric structures by using computer modeling, it is necessary to focus on mathematical language as it is a source of inspiration for creating three-dimensional spatial forms in art and architecture. Thus, an analysis of the various examples represents the relationships between the formation of parametric structures and the rules of mathematics. It is evident in different time frames, different patterns, and different approaches to thinking about and creating art and architecture. The starting point for this analysis is the symbolic golden ratio of Vitruvius and its effect on the principles of the formation of parametric structures [6]. Starting the creative process in the visual arts, consciously or unconsciously, solid, logical, and measurable methods are used. In architecture, the primary means of formation are the geometrical characteristics of shape, divisions, rhythm, symmetry, the symmetry of axes, hierarchies, proportions, and finally color and texture [14].

The creation of an Architectural Parametric Structure relates to the incorporation of these elements. Thus, at this stage of the creative process, we have to deal with such criteria that create functional dependencies once they are interconnected. The development of the capabilities of mathematics and modern algorithms in the field of generating new parametric structures led to the use of mathematical language as an inspiration for creating three-dimensional spatial forms in art and new parametric structures in architecture. Currently, the possibilities of art and architectural ideas gained by contemporary mathematics, algorithms and mathematical methods open up a new way of thinking about the relationship between mathematics and computational systems in generating new parametric structures [15]. An analysis of the various examples where mathematical achievements inspire art and the architecture shows the relationships between the formation of spatial shapes, parametric structures, and the rules of mathematics. The development of this effect is evident in the different timeframes, as it shows different methods in ancient architecture to contemporary architecture [6].

4.1 The Golden Ratio

The symbolic starting point for this analysis is the golden ratio and its effect on the principles of spatial formation because the Vitruv formula is still present in contemporary graphic design [16]. It is not known exactly why this the ratio was considered a law of beauty, but it can be said that it can be considered the symbolic beginning of parametric thinking in architecture design. The value of the golden ratio, which affected various areas of spatial formation and was noticeable for more than 2,400 years [6]. The main meaning of parametric architectural structures is to identify aspects that affect the model using numerical values and establish relationships between them using mathematical functions. From a mathematical point of view, the golden ratio is a very simple record of the relationship between the dimensions of building elements [17].

4.2 Paper Geometry

The influence of mathematics on the design of 3D spatial shapes in applied art and parametric structures in architecture can also be seen in the oriental art of Japanese origami folding paper and its derivatives [18]. Origami, as an example of an algorithm's paper architecture, can be a strong base point in the experiment using a new paradigm as the design process begins. Creating a small and compact case-making casing in order to find the intended shape is an essential aspect of the artist or architect's conceptual work [19]. This raises the question, if it is possible to create the spatial form of paper, can it also be formed as a building? Inspiration for both origami and kirigami can be found in applied art, such as fashion, furniture, accessories, and even in the architecture itself [6].

4.3 Fractels in Nature

The next step in the review is the fractal issue. Symbolically related to the evolution of mathematical inspirations in architectural design, it advertises a deeper level of sophistication in the algorithmic record of engineering, also a strong starting point for parametrization [20]. Fractals are part of nature, can be represented by mathematical algorithms, and serve as an inspiration for nintuitive geometry in spatial forms and interesting parametric structures. By developing the mathematical capabilities of modern technologies, fractals can be considered inspired by nature's algo-

rithms for a complex language of mathematics. This gives new insight to artists and architects to get inspiration from the surrounding nature [21]. The question of fractals creates a link in the mathematical development between the simple record of engineering and the architectural design of parametric structures. Fractals are geometric figures that are already found in nature. Also, we can find examples in oriental culture and art, for example, in cupboards. We can also find fractals in various shapes. In Tokyo, for example, simple fractal engineering is inspired by the Kisho Kurokawa design of Nakajin Capsule Tower and the apartment building [6].

4.4 Parametric Design Structures

Recently, it must be taken into account the current technological potential, the computing power of modern computers and the strong links between mathematics and algorithms with architectural design [6]. In this way, by observing evolutionary contemporary design, by searching for the existence of mathematics in creating spatial shapes in the idea of architectural parametric structures [22]. It can be said that contemporary architecture is increasingly drawn from technological capabilities. As a result, the way of thinking about the mathematical approaches to contemporary architectural design has changed. Parametric structures in architecture provide a way to think about constructing a building, which, according to specific restrictions, guarantees the greatest number of parameters that the designer is interested in [6].

The design of architectural parametric structures stems from mathematical design, in order to find functional dependencies between individual elements in both space and structures, which is the most important step in the parametric approach [23]. It is possible to measure the aspects that affect the realization of the project by using numerical values as indicators of performance. The project may be designed, and mathematics is the tool that will enable it to be improved. Thus, parametric architecture is a decisive leap in the use of mathematical symbols, because from that moment on, in addition to influencing shape, we are able to essentially interfere with the work of the building. The idea of designing a parametric structure, through its functional use, goes far beyond art and architecture. One example is the Parametric plaster project by Jake Eiffel from Victoria University in Wellington. 3D printers designed by Eiffel produced lighter and more flexible plaster. In architecture, thanks to the use of advanced technology, a variety of shapes created mainly can be found. One example is Absolute Towers, a project designed by Mad Architects. The trend that combines applied mathematics, art, architecture, and other forms of creativity has many advantages and gives us a wide range of possibilities. These possibilities include the effort to achieve optimal shapes, the extinction of nonfunctional shapes, the full use of technological advances, and innovative methods of parametric structures while opening the mind to a new way of design. Given the definition of architecture cited by Le Corbusier in the introduction to this section of the review, it is certain that Parametric thinking is able to provide all aspects that influence good contemporary architectural design. Parametric design systems must be well acquainted for optimal use in contemporary architecture [6].

5 Parametric Design Systems

Parametric systems rely mainly on the principles of the algorithm. Therefore, it is necessary first to discuss the role of algorithms and algorithmic thinking in the architectural design of parametric structures, in order to be able to discuss parametric systems [5]. An algorithm is a limited set of instructions that aims to achieve a clearly defined purpose in a limited number of steps. The algorithm takes one or a set of values as inputs, performs a series of computational steps that transform the inputs, and finally produces one or a set of values as outputs [24]. The power of the algorithms lies in the ability to solve a wide range of computational problems including but not limited to sorting and searching, data structure operations, merging problems, numerical problems including random number generation, and computational engineering [25].

Algorithms can create design entities and mathematically manipulate them such as the geometry, design variables, data structures containing digital or engineering entities, mathematical expressions, and logical operations [5]. This level of design control in the 3D modeling environment allows designers (or developers in this case) to expand functionality or evaluate specific cases and respond appropriately. Therefore, the algorithm can effectively deal with design intricacies that exceed shape with great precision and translate them into architectural properties represented by parametric structures in contemporary architecture [26].

Parametric design is a subcategory of algorithm design, and it relies strictly on algorithm architecture (Dino, 2012). Mathematically, there is no difference between algorithms and parametric systems. Algorithms work by default on parameters, and the main component of the parametric system is the algorithm itself, which is called a schema or definition [27]. However, parametric systems differ from the algorithmic design and emphasize the explicit and direct treatment of parameter values in order to effect a change in the design artifact. This simple difference between purely algorithmic design versus parametric design is only evident during the design process, where parameter values are changed by the designer in order to process design engineering in search of the optimal design solution [28]. The parametric system consists of a set of highly specialized tools that cover the entire workflow from input engineering to manufacturing data and can also be modified or replaced individually without affecting the functionality of the system as a whole [5].

Parametric approaches are a generator in Parametric design. Parametric design systems distinguish themselves from other generative systems in the way that they allow a gradual control of the model during the design process, which proves to be especially useful during design exploration [29]. Their responsiveness and ability to adapt to both internal and external stimuli, which are the dynamics of the creative the design process and other contextual circumstances, make these systems an appropriate strategy during design in complex design settings. Moreover, parameter parametric processing has special value in performance-based design processes, which facilitates the rapid cycle of performance analysis and design grouping as an integrated process [5].

5.1 Parameter Based-Design

Parametric (algorithmic) design allows procedures to be clarified to solve both well-defined problems with a clear goal, and unspecified complex problems that contain many practical solutions where it can be considered a categorical approach appropriate for the design problems, which is most representative of the creative design process for parametric structures [5]. Design problems do not provide the best single solution, but a category of satisfactory solutions. Therefore, the designer needs to be able to define, redefine and change the design problem in the light of the solution as he navigates the design space between possible solutions for the design problems [9].

5.2 The Performative Parametric Structures

The emergence of computer-aided design tools in architecture has led to a new aesthetic understanding that is freed from Euclidean geometry, and the enthusiasm for unrestricted experience on a design space of flexible dimensions [10]. The design of the parametric structures must be driven primarily by the aesthetic and plastic senses of the designer. Also, a much broader set of external factors must be addressed during design where performance is the driving force behind the shape since architecture should perform rather than just a shape in multiple fields [5]. In the process of designing performance parameters, the difference in design space is facilitated by the parameter groups, and convergence is made on the basis of the performance idealism for selecting the best parameter set [11]. The designer needs to describe and solve each parameter set before exploring the model. The principles of applied design can be incorporated either early in the design process where key design concepts and engineering are developed, or later during detailed design where the performance of parameter systems is improving [30].

Aviva Stadium in Dublin, Ireland and the Kilden Center for the Performing Arts in Kristiansand, Norway is the ideal works of this approach in selecting the best parametric group during the design process as a performative approach. Aviva Stadium (Dublin, Ireland) is a sports stadium designed by Bobolos and engineered by Puro Happol [5]. Through this approach to the design process, the architects eventually led to the overall appearance and cladding of the building, and the engineers led the sizing and structural determination of the members [31] On the architectural side, some explorations were made in response to certain criteria such as the beautification of the building. On the engineering side was the roof truss structure and cladding system designed as a rain screen consisting of interlocking louvers. The facade of the Kilden Center for the Performing Arts in Kristiansand, Norway is another modern example of designing contemporary architectural parametric structures. The facade is a huge curved wall that separates the lobby from the outside. The wooden facade intersects with the front facade, it intersects with a vertical glass facade and steel facades in the interior and exterior parts. Facade geometry is a compact surface that extends between a straight top and a curved lower edge [5].

6 Differentation Patterns in the Parametric Structures

Differentiation thinking has become a distinction within a Parametric style an important means of design in contemporary architectural design [32]. Differentiation thinking can be defined as a type of parametric version scheme that characterizes the formal design style in response to functional and contextual environmental goals and constraints. As defined above, architectural design differentiation planning is a unique strategy for PDT [33].

The following case studies are the basis for choosing the specific differentiation pattern in parametric design structures. The structure, tectonic model, and embodiment types allowed the design and embodiment of complex shapes by designing a specific differentiation style as a means of parametric architectural design for structures. In addition to functional goals, each architectural project offers forms a distinction and performance behavior. In each of the case studies represented.

6.1 Differentiation a gradient geometric pattern as a modified medium for various functions - The Broad Museum

It is located in Los Angeles and established in 2015. The Digital Design Process Model was an Engineering Form, the architectural model of tectonic arrangement was the structure - shape – material, differentiation pattern was a gradient mesh from a specific surface, and the architectural design medium was modified medium for various jobs [11]. In the recently built spacious museum in California, the museum's interior exhibition space is provided with a continuous solar modulation and control system. In the case of this building, this is a fixed system. This is called a "veil" by architects, and this continuous normative rhombic pattern covers the outer wall and ceiling of the museum. The grid continuity is distinguished in engineering to control the lighting of skylights in the ceiling [34]. Moreover, the function of wall surfaces is modified locally for architectural purposes such as opening the entrance area in order to provide external exposure to the glass wall and general areas of the building. The large grammatical distance on the second floor of the facade adjusts the light at the point where the infantry reaches the exhibition levels in the building [11].

6.2 Differentiation of a structural mesh as a medium of an ecological responsive skin - Louis Vuitton Store

It is in Macau, established in 2007 by Zaha Hadid Architects. The Process Model of Digital Design was a Performance-based Ecological model, the architectural Model of Tectonic Order was Structure-Material-Form, the differentiation Pattern: Gradient packing of circular elements, and the architectural Design Medium: Structural mesh medium of responsive skin. The experimental design of the Louis Vuitton store in Macau, offers some additional characteristics of differentiation in the parametric design. As with the wide museum, the Zaha Hadid design of Louis Vuitton is a protective mesh structure for the building's exterior skin. A typical structure, in this case, is a network structure of a differentiation system of elements. The purpose of the functional behavior in this pilot project was to provide an environmentally responsive differential. Within the thick structural wall of evolutionary elements, it is possible to adjust and control direct solar penetration, as well as control the view and provide the introduction of other elements such as signs, outdoor lighting, etc. In this

experimental design, the wall structure became the structural support for the roof element. Thus, the leather is effective as well as an environmentally responsive design system in the parametric design of this project [11].

6.3 Differentiation of expanded aluminum metal screen as a medium of modulation – Messe Basel New Hall

Established in 2013, The process Model of Digital Design was material Formation Model, the architectural Model of Tectonic Order was Material-Structure-Form, the differentiation the pattern was Expanded metal aluminum mesh, and the architectural Design Medium was the Modulation medium for program and function. In the design and construction of the new Bern Messe hall for 2013, by Swiss architects, Herzog de Meuron [35]. and expanded aluminum metal mesh screen provides similar functionality to the top two levels of exhibition halls within this building. The building, whose job it is to provide three new independent halls for Berne Messe is treated as three overlapping buildings. The metal mesh screen is distinguished in shape by bending and folding the screen structure in a process similar to the "expanded metal" well known in the building. This much larger mesh is leather that can be treated as a stepped surface and can be differentially modified, thus providing a distinct architectural form and display capabilities for each of the three halls [11].

6.4 Differentiation as a medium of experimental structural design – Venice Architecture Biennale

Established in 2016 by Philippe Block, the process Model of Digital Design was the performance-based structural design model, the architectural Model of Tectonic Order was Material-Structure-Form, the differentiation Pattern was Differentiation of form in bending, and the architectural Design Medium: Medium of structural form-finding [11]. Led by Philip Block at ETH Zurich, the BRG Block Research Group has become renowned for its experimental structural design using modular design as the basis for a new a design approach that goes beyond the typical and computational methods of building types. He takes advantage of his method of creating the standard structural form through digital parametric processes and performance models of structural design [36]. Parametric models generated by algorithm scripts can create designs by changing geometrically related parameters according to specific structural forces and design material properties in different contextual circumstances. This is achieved through digital simulation and physical experimentation of experimental models. This is followed by a lot of groundbreaking works by parametric structural designers such as Gaudi, Frei Otto, and in the case of the study below, the shell structures of Felix Candela and Heinz Isler [37].

This exhibition at the 2016 Venice Biennale, shows an example of the contemporary experimental cellar structure that replaces traditional building materials and traditional methods in basements of new materials manufacturing techniques and techniques. The project demonstrates how new generative structural processes to find form and methods of improvement can generate the geometry of the compression basements absorbed by tension bonds. After historical precedents, these basements show a new approach to parametric design in the design and construction of cabinets that provide structural weight and environmental impact and can be created with 3D printing technology [11].

6.5 Differentiation as a medium of multi-functional performative design – Chaise Lounge

It was established in 2008 - 2010 by Neri Oxman (Mediated Matter Group at MIT) in Collaboration with Craig Carter, the process Model of Digital Design was the Performance based generation, the architectural Model of Tectonic Order was Digital Material-Structure- Form, the Differentiation Pattern was Voronoi Differentiation and the architectural Design The medium was Medium of 'multi-functional performative design' of Variable Properties Design (VPD) of the structural surface pattern. It is inspired by Neri Oxman at the Massachusetts Institute of Technology and its research group (Medmed Matter / Media Lab) from nature where models are generated through growth processes, topological release and changing properties of materials in the behavior of natural systems. The term "materials environment" coined by Neri Oxman seeks to integrate form, material, and structure by integrating search strategies for algorithms and inventing manufacturing techniques for 3D manufacturing techniques. Design is an example of replacing the traditional information flow from a model-structure material- to-material-structure-model that incorporates a new manufacturing technique called "Variable Properties Design (VPD)." VPD is a design model, methodology, and technical framework through which material assembly is modeled, simulated, and fabricated with different parametric properties. Designed to accommodate multiple and constantly diversifying functional limitations [11].

This approach can be considered as a unique mathematical model for parametric design. A unique thought process in which the invention of a new tool or technique. In this design, differentiation is achieved by differentiating between Voronoi which provides a multi-functional performance design approach to the structural surface pattern. This is accomplished through VPD. That is, the 3D printing process is guided by the distinctive performance characteristics of digital materials. This is evidenced by the design of the continuous skeleton area of the shell structure (black), the support structure (gray) and the rest supports and smoothness (white) in the areas of physical stress [11]

6.6 Differentiation as a design medium of structural sectioning materialized by fabrication techniques – Metropol Parasol Seville

It is located in Spain, established in (2011) by Mayere Hermann and Arup Engineering, the Process Model of Digital Design was the Performance-based Model, the architectural Model of Tectonic Order was Form-Fabrication-Structural-Material, the Differentiation Pattern was the Force Form Differentiation and the architectural Design Medium was Medium of structural sectioning, materialized by a form-force pattern and a parametric fabrication the technique [38]. Metropol Parasol designed by Jurgen Mayere Hermann and Arup Engineering. It is the name of a partially covered multi-functional urban plaza in Seville, Spain. The design provides three functional vertical areas, which are elevated apron; Ground level for archaeological findings. The optically dominant key element of the tall wooden grid structure. The canopy, which is a shading element on an urban level, as well as a detailed viewing platform, is raised on six large mushroom columns or vertical structures [39]. The structural shape of the parasol mesh is affected by structural forces, program requirements, and environmen-

tal conditions. The material of the structural system is formulated after the choice of the manufacturing technique. Finally, the shape and dimensions of the structural division have been informed of the structural strength characteristics represented by a structural model differentiating the pattern of the strength field. Urban sized canopy is designed as a wooden mesh structure implemented by parametric manufacturing technology to create an organically flowing shape in response to structural load. The diversity of structural sections is designed with a pattern of differentiation of strengths [11].

7 Limitations and Misconceptions on Parametric Structural Design Systems

Recently, there is a lot of attention directed toward the design of parametric structures. This is mainly due to the newly emerging visual parametric modeling tools, which mask the algorithmic complexity of parametric models behind the visual programming interface, thereby reducing the technical skills needed to use computation and contribute to its widespread adoption in architectural design [40]. However, the unjustified and superficial application of the principles of standards poses a threat to its proper use as a design tool. Therefore, it is necessary to discuss some of the misconceptions and flaws of parametric modeling [5].

7.1 Parametric design equals complex engineering

There is a misconception that designing parametric structures is the only way to generate complex engineering. Indeed, complex architecture was present even before calculation was an applied field in architectural design, as can be seen in the works of Frei Otto, Jorn Utzon, Pier Luigi Nervi, Felix Candela, Anton Gaudi, and others [5]. Each of these architects has found innovative techniques to deal with the complexities of free engineering in their work. Hanging chain models and plaster cut agglutination, for example, were physical explorers of Antonio Gaudi during the process of finding the shape. As expected, this process was neither smooth nor effective. The results of these standard models must undergo significant changes as they are transported to the physical structure [41].

Therefore, only the expertise and skills of the architect have been relied upon to negotiate a system based on the abstraction of models and true construction. Another similar example is the Sydney Opera House by Jorn Utzon, a competition project that won first prize in 1957 and opened in 1973. Today the building is considered a masterpiece of many architects and engineers. However, the design exploration process sparked a great deal of controversy during its construction period [42]. The architecture of the roof structure was originally indeterminate and was initially considered impractical. During the next five years of concept design, engineers and architects had to rationalize the roof into a buildable form that allowed the use of individual concrete formwork and thus one curvature during the construction process. Moreover, its design and construction took sixteen years and exceeded the budget almost fourteen times. The design of such complex and non-standard geometric shapes seeks parametric approaches and can be efficiently handled using high-level engineering handling using parameters and algorithms. The calculation can eliminate the need for physical modeling or trial and error strategies to optimize a model, increase the efficiency of design and synthesis analysis while increasing the accuracy of form and detail [5].

7.2 Design of parametric structures does not offer unlimited flexibility

As discussed above, designing parametric structures requires a certain level of flexibility for change and the ability to reformulate a design problem. As a result, the flexibility of parametric modeling is a result, limited to the parameters that it describes internally. There is a need to reconfigure the parameter model over and over as the project topology changes [43].

7.3 The design of parametric structures does not reduce the complexity of the design

Complexity is perhaps one of the central terms describing contemporary design problems in architecture. The increasing complexity of design in architecture is due not only to external stimuli such as increased building performance requirements, new building jobs, user requirements, urban settings, spatial configurations, integrated design processes, etc., but also due to the new official interest in free form engineering and mathematical and engineering concepts [44]. The need to address and address an increasing number of concerns in an integrated manner provides increased levels of sophistication in architecture. The parametric design claims to be able to help the designer make complex decisions with more confidence compared to the traditional case [45].

While providing the designer with a set of tools to expand his cognitive and operational capabilities in complex design settings, parametric modeling poses new challenges in the practical use of this new medium and some of the consequences of computing. The design of the parametric structure requires strong technical knowledge of mathematics [5]. Although the technical requirements have already been met for their effective use in architectural design of parametric structures, the potential of parametric generating systems has not been explored in detail in architectural design. Parametric design tools emphasize the diversity of design strategies, rather than providing the designer with a comprehensive framework of concrete techniques or methods. Computational design capabilities to change the way we design, rather than simply increasing or replacing human designers also apply to parametric obstetric systems as well [46].

8 Future of Designing Parametric Structures

In the future, the development of parametric design systems will undoubtedly occupy the mathematical design agenda in both theory and practice, as new paradigms link parametric methods and architecture making work. In a time of rapid technological change, architects can regain control of such new computational strategies by positioning themselves in a constructive position, so that they are able to effectively integrate them into their design processes [47].

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