New Paradigms of 21st Century Architecture Production: Parametric and Digital Architecture

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ABSTRACT

Over time, architectural styles undergo evolution and fluctuation in popularity, with distinct historical periods marked by specific styles. Architectural styles are characterized by salient features that render a building or structure notable and historically identifiable. These styles typically fall within a subset of visual arts styles and are often closely connected to their broader artistic contemporaries. This thesis seeks to investigate the potential of achieving various objectives through a comprehensive comprehension of parametric architecture. Furthermore, the primary aim of this study is to ascertain if parametric design, or Parametricism, constitutes a novel style for the current era or if it is merely a design approach. The research problem explored herein concerns the ambiguity surrounding the concept or style of parametricism in terms of its formal characteristics, owing to the rapid adoption of parametric design. Through an in-depth literature review, this paper delineates the historical connotations and benchmarks of style, architectural styles, and Parametricism across various dimensions. The scope of this study is confined to unearthing the precise definition of architectural style within the literature and ascertaining the position of Parametricism (parametric architecture) within the architectural styles of the 21st century.

Keywords: Architecture, Architectural Styles, Design, Parametricism.

ÖZ

Zaman içinde, mimari tarzlar evrim geçirir ve popülerlikleri dalgalanır, belirli tarzlarla işaretlenmiş farklı tarihi dönemler bulunur. Mimarlık tarzları, bir binayı veya yapının dikkate değer ve tarihsel olarak tanımlanabilir kılan belirgin özelliklerle karakterizedir. Bu tarzlar genellikle görsel sanat tarzlarının bir alt kümesine düşer ve genellikle daha geniş sanatsal çağdaşlarına yakından bağlıdır. Bu makale, parametrik mimarinin kapsamlı bir anlayışı aracılığıyla çeşitli amaçların elde edilebilme potansiyelini araştırmayı amaçlamaktadır. Ayrıca pratik mimarlık bağlamını incelemeyi amaçlayarak parametrik alanın daha derinlemesine değerlendirmeler sunmayı hedeflemektedir. Ayrıca bu çalışmanın temel amacı, parametrik tasarımın veya parametrizmin, mevcut çağ için yeni bir tarzı mı yoksa sadece bir tasarım yaklaşımını mı oluşturduğunu belirlemektir. Bu araştırmada incelenen araştırma sorunu, parametrik tasarımın hızlı kabulü nedeniyle formal özellikleri açısından parametrizm kavramı veya tarzı etrafındaki belirsizlikle ilgilidir. Bu araştırma, kapsamlı bir literatür taraması ve örnek olay analizi yoluyla tarzın, mimari tarzların ve parametrizmin tarihsel anlamlarını ve ölçütlerini çeşitli boyutlarda belirler. Bu çalışmanın kapsamı, literatür içinde mimari tarzın kesin tanımını ortaya çıkarmaya ve parametrizmin (parametrik mimarlık) 21. yüzyılın mimari tarzları içindeki konumunu belirlemeye sınırlanmıştır.

Anahtar Kelimeler: Mimarlık, Mimari Stiller, Tasarım, Parametriklik.

DEDICATION

To My Family

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I wish to extend my heartfelt gratitude to my mentor, Associate Professor Dr. KOKAN GRCHEV, for his unwavering guidance and consistent input throughout the duration of this project.

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Chapter 1

INTRODUCTION

Over the past two decades, there has been a profound shift in architectural design and production. Prior to the 1990s, architects primarily utilized analog tools, including freehand sketches, physical models, drafting boards, and manual rendering methods. The inception of the Paperless Studio in 1992 at Columbia University, which employed computers for the design, representation, and realization of architectural concepts, has now become the standard practice in the field.

Never before in human history has there been such rapid advancement in architectural design as witnessed at the outset of the 21st century. With the continuous emergence of novel technologies and their swift integration into design professions, one can only speculate about the future landscape of our built environment in the coming decades.

Research into the role of Parametrics typically encompasses two primary areas: one focusing on the digital domain influenced by technological progress, and the other delving into methodological concerns associated with design practices. At a broad level, the key question is how to incorporate digital technology into design methodologies. A more targeted inquiry might consider the degree to which parametric design provides a methodological perspective. However, these questions remain expansive, leading to numerous 'why' and 'how' inquiries that highlight the ambiguity surrounding the parametric sphere.

While the genesis of parametric design can be traced back merely fifteen years, the inclination towards such methodologies in architecture has deeper roots, reaching back to the initial endeavors in computerized design simulation. Computers, like any digital instrument, offer two primary areas of exploration: theoretical foundations and practical outcomes. In the practical realm, emphasis has predominantly been on the utility of computer software as an asset to the design procedure. Consequently, the focus shifted towards the refinement and progression of these systems. As noted by Robert Woodbury, the inaugural computer-aided design system, developed by Ivan Sutherland for his 1963 PhD thesis on Sketchpad5, was inherently parametric.

Sutherland's platform pioneered the introduction of a principle that later became integral to numerous parametric systems: the notion of 'constraint'. Typically, a constraint delineates a relationship among two or more entities. For instance, it may ensure that a set of lines remains parallel or perpendicular, or it might specify a relationship within an object, such as the diameter or area. Within the design process, constraints are typically categorized into geometric and physical constraints (Zarei, Y. 2012). The advancement of these constraints significantly augmented many computer platforms. Optimal outcomes are achieved when architects harmoniously merge reverence for traditional methods with adept mastery of contemporary techniques (Zarei, Y. 2012).

1.1 Problem Statement

This study aims to provide a clearer understanding of applied architecture by offering in-depth insights into the Digital and Parametric domains and critically analyzing the role of communication in parametric architecture. The growing popularity of parametric methodologies is driven by their ability to generate complex,

unconventional forms with intricate geometries and advanced technical nuances. At the same time, these designs are recognized for their innovativeness and distinct communicative potential. While extensive research exists on parametric design in general, a detailed examination of parametric design practices and their outcomes remains limited. This study addresses this gap by investigating both the generative principles of parametric design and the ways in which communication occurs within parametric architecture, thus contributing to the broader discourse on its methodological and practical significance.

1.2 Aims and Objectives

The primary aim of this research is to explore how parametric design can enhance nonverbal communication in architectural design paradigms. By doing so, it seeks to bridge the gap between computational design processes and the expressive potential of architecture.

To achieve this aim, the study will focus on the following specific objectives:

- To analyze the generative processes of parametric design that facilitate the creation of complex forms and patterns.
- To investigate the integration of computational tools in the design process and their role in shaping parametric architecture.
- To evaluate the communicative potential of parametric forms by examining their spatial and perceptual impact.
- To critically assess case studies of parametric architecture to determine its influence on contemporary architectural discourse.
- To ensure a realistic perspective, this research exclusively examines real building cases rather than conceptual designs, grounding its conclusions in practical, built examples.

1.3 Research Question

In the realm of architectural discourse, a profound question emerges:

- **Could Parametric Architecture be considered the epochal style of this era, or does it falter in the face of traditional design methodologies?**

This broad inquiry leads us into an expansive exploration of the defining characteristics of our era, from digitalization and computational design tools to a focus on personalization, optimization, and sustainability, all encapsulated within the sphere of parametric architecture. Yet, the question remains whether this style truly embodies the zeitgeist of our time or if it is merely a manifestation of technological advancement, devoid of a humanistic touch and wider accessibility.

Further delving into the intricacies of this debate, one might pose an additional question:

- **To what extent does Parametricism offer a distinctive architectural standpoint?**

This question prompts a comprehensive examination of how Parametricism contributes to the architectural narrative. It allows us to scrutinize its formal expressiveness and adaptability, its role in optimization and interdisciplinary integration, but also critically examine its limitations in terms of accessibility, human-centric design, and constructability. These queries serve to anchor a multifaceted exploration into the inherent value, challenges, and potential of Parametricism in the architectural landscape of this era."

1.4 Objectives of the Study

The preliminary aim of this research is to investigate how nonverbal communication can be proposed in architectural design paradigm through parametric design. Thus, the research objectives are:

- To understand the complex processes of parametric designs in which forms and patterns can be produced.
- To examine that how computational tools can be embedded to imagine such generating of forms and patterns.

1.5 Scope of the Study

Given the expansive nature of digital and parametric architecture, this research deliberately narrows its focus to the study of Parametric Architecture as a design methodology and potential architectural style. The research does not cover all aspects of computational design but specifically examines the origins of Parametricism, its defining characteristics, and key case studies. By doing so, the study aims to provide a critical analysis of parametric architecture's theoretical foundations and practical applications while acknowledging its limitations in terms of accessibility, constructability, and human-centric design.

1.6 Method of the Study

Since the key objectives of this research are:

- A comprehensive understanding of Parametric architecture (Parametricism)
- Investigating recent understandings of architectural styles in 21st century and the position of Parametricism between the styles.

The following methods are used to gain the objectives of the research

1.6.1 Intensive Descriptive Approach

The descriptive approach, often termed "disinterested", primarily focuses on accumulating knowledge regarding the subject of investigation without intending to alter it. The objective is to discern the current or historical state of affairs. While this approach may gather opinions on the existing situation's desirability, it does not engage

in devising improvements. When a study is ideographic, encompassing only a single case or a limited number, its methodology may not vastly differ from a routine endeavor to understand an unfamiliar object in daily life. Due to the novelty of the subject under study, outlining all the investigation's stages precisely might be challenging. Determining the necessary data to collect may become apparent only after preliminary analysis. Consequently, flexibility in adjusting the research strategy is essential as deeper insights emerge. This adaptability is characteristic of what is frequently termed an "iterative" method. The typical initial step involves examining the subject from various perspectives, either through the lenses of different established disciplines or from assorted practical viewpoints. Revisiting these perspectives enhances comprehension, as initial observations can inform subsequent analyses. This procedure can be likened to a narrowing spiral progressively approaching its objective.

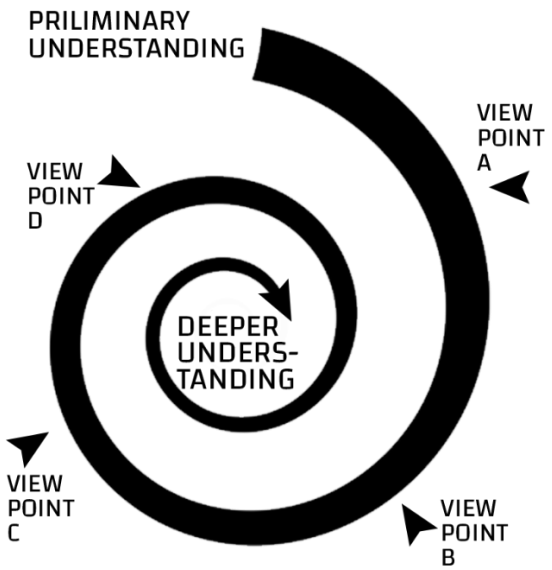


Figure 1: Illustrates Intensive Descriptive Approach, Redrawn Based on Pentti Routio's Explanation by the Author.

As the examination progresses, the most insightful perspectives for the research become evident, clarifying the researcher's comprehension of the subject. From this

juncture, it becomes essential to gather only empirical data pertinent to the central question, optimizing the volume of material requiring analysis. The iterative cycle continues until either a satisfactory conclusion is attained or available resources are depleted.

1.6.2 Critical Review of Literature

Based on this, on one hand a critical review of literature conducted to understand both Parametricism. It studies the origins of parametric design and Parametricism in architecture and the phases of Parametricism, then studying the preliminary attempt of this “style”, so to understand the being of parametric design in the field of architecture theory and practice.

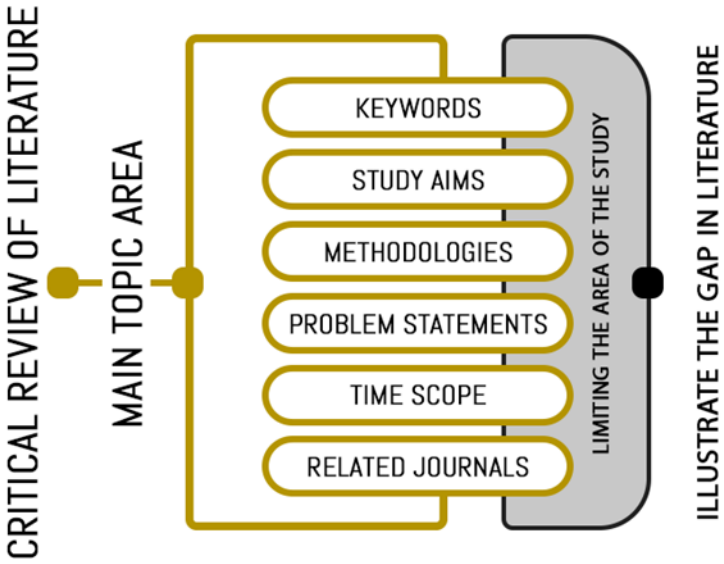


Figure 2: Application of Critical Review of Literature in this Study, by the Author

1.6.3 Comparative Historical Research

Comparative historical research is a method of social science that examines historical events in order to create explanations that are valid beyond a particular time and place, either by direct comparison to other historical events, theory building, or reference to the present day.

So this method applies to investigate the recent understandings of architectural styles in 21st century in general and specifically to clarify the possibility of considering parametric architecture as a style or not.

1.6.4 Case Study Analysis

On the other hand, an evaluation which derived from both literature survey and comparative historical research is developed to evaluate Parametricism conducted to several parametrically designed case studies which purely symbolize the style and fulfill the selection criteria's. Which investigate that context of practical architecture for offering profounder reviews into the parametric realm.

1.7 Contribution to Knowledge

This research contributes to the ongoing discourse on architectural styles by critically examining Parametricism as a theoretical and practical movement. The study aims to provide a structured framework for evaluating the communicative potential of parametric architecture, addressing both its aesthetic and functional implications. Furthermore, it offers a critical perspective on whether Parametricism represents a paradigm shift comparable to historical architectural styles or remains an advanced design tool devoid of stylistic autonomy. By doing so, the research helps clarify the broader significance of digital and parametric methodologies in contemporary architecture.

1.8 Research Structure

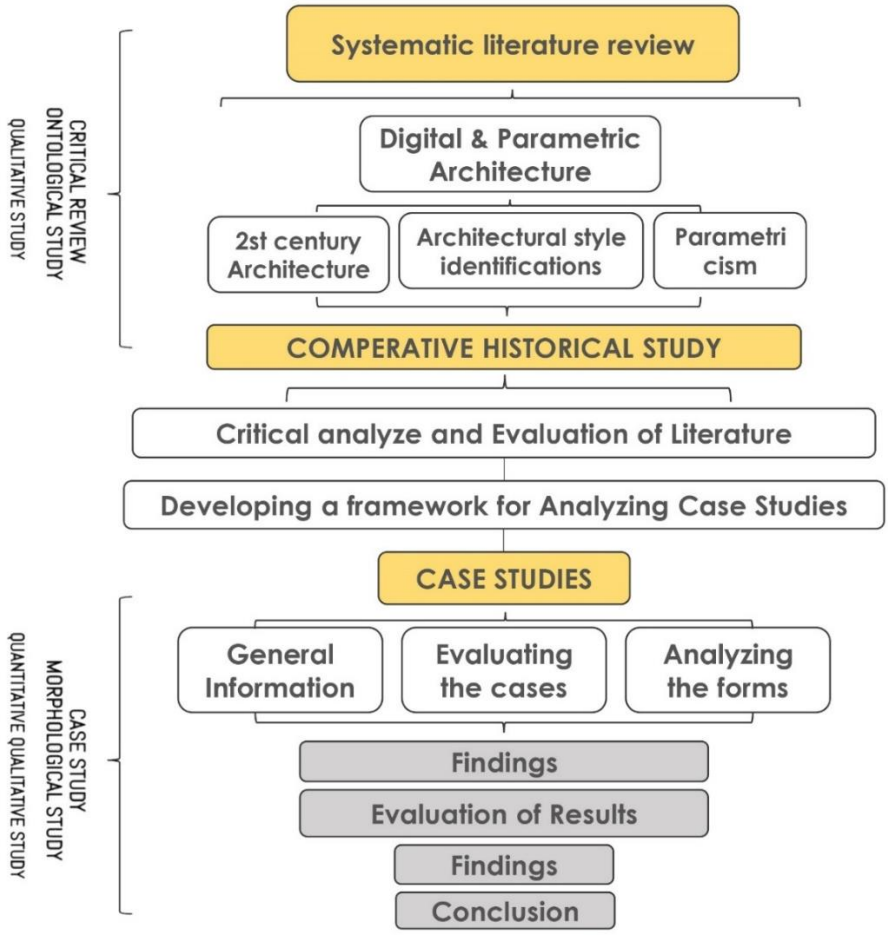


Figure 3: Adopted Research Methodology

Chapter 2

21ST CENTURY NEEDS ITS OWN PARADIGM SHIFT IN ARCHITECTURE

The complexity of architectural design encompasses interdisciplinary considerations, prompting architects to constantly seek innovative approaches to navigate challenges and foster creativity (Kowaltowski et al. 2010; Zhou 2012). Addressing various design prerequisites demands a process enhanced by computational thinking (Abdullah and Kamara 2013; Botchway et al. 2015).

Prominent architectural firms such as ZAHA Hadid Architects, Gehry Partners, Bjarke Ingels Group, Foster + Partners, and UN Studio employ state-of-the-art design methodologies via sophisticated computer applications. These tools not only facilitate limitless conceptualizations but also expand the scope of potential design solutions (Goldberg 2007; Ceccato 2009; Tyrnauer 2010; Platt 2014). They employ these systems beyond mere drafting, embracing organic, non-Euclidian, and intricate form-finding mechanisms (Piedmont-Palladino 2007; Ceccato 2009; Chang 2015).

Kolarevic advocates for architects evolving into "Information Master Builders." Referring to William Mitchell, the renowned MIT digital expert, he underscores the intrinsic link between the instruments employed by architects and the resultant architecture. By examining the history of architecture, Kolarevic identifies a direct correlation between conventional tools such as the T-square, compass, and pencil, and

the rectilinear structures produced. Moreover, he attributes the prevalence of contemporary "blob" designs in various products and architectural practices to available software tools and their applications (Kolarevic, B. 2004).

2.1 Digital Transformation

Digital transformation has a pervasive global influence, reshaping methods of work, communication, and relationship-building. This cultural shift towards digitization fosters collaboration and innovation, which can significantly enhance productivity and efficiency. Though the term 'digital transformation' might not be widely recognized among architects and professionals in the built environment, evidence suggests that the architectural and design sector predominantly welcomes the prospects introduced by this change. Digital transformation emphasizes the revisioning of uniting people, data, and processes to offer value to customers, ensuring an edge in an increasingly digital-centric market. It enables the conceptualization and creation of previously unattainable architectural designs, propelling urban areas to tackle challenges related to urbanization and sustainability. As noted by Satya Nadella, CEO of Microsoft, "Every company is essentially a software entity. Adopting a digital mindset is imperative. It's not merely about integrating a singular software solution but about envisioning the company's trajectory in the digital realm." Research indicates that many architectural practices leverage digital tools to center clients in the design process. Digital transformation transcends mere technological adoption—it represents a profound cultural shift, underpinned and advanced by technology. The overarching aspiration of this transformation is to enhance building and place quality while elevating client outcomes. The architectural and design community is actively digitalizing their fields and the broader construction domain. This is evident in innovative design methods, novel building structures, utilization of advanced

materials, and the adoption of collaborative digital work methodologies. A joint survey by RIBA and Microsoft reveals that nearly 90% of respondents believe that digital tools are revolutionizing their current work practices. Rather than being a fixed endpoint, digital transformation embodies a perpetual evolution and rejuvenation. Visionaries at the helm of this transformation anticipate future advancements and modalities even before transitioning entirely to new operational methods. For instance, numerous architects transitioned from CAD to BIM, but rather than halting there, forefront innovators are delving into immersive visualization technologies building upon the BIM framework. This engenders a sustained innovation culture, where novel ideas are integrated into daily organizational functions, with dedicated resources, time, and budget. So, what drives the adoption of digital transformation? The essence lies in the efficiency and innovation digital technologies bring to projects.

2.2 Digital Architecture

Over the past fifteen years, digital media has been employed in various capacities within architecture, significantly impacting construction and design. Initially, digital media served merely as a representational tool. However, as digital technology advanced, it provided architecture with an innovative instrument for conceptual design (Schnabel, M.A).

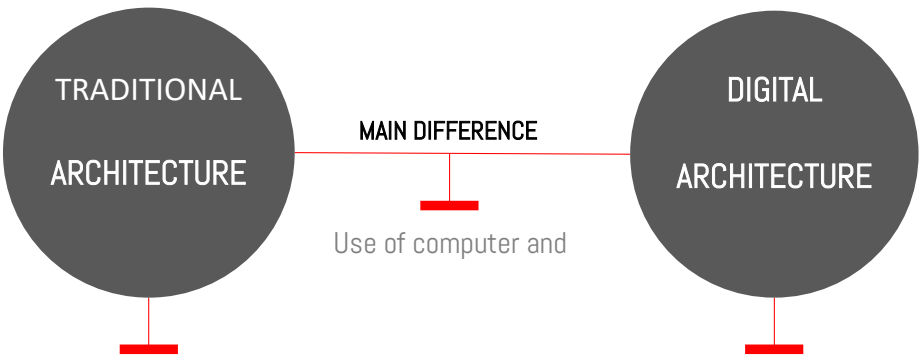


Figure 4: Digital Architecture Versus Traditional Architecture

Architectural design was influenced not only by the capabilities of digital technology but also by concepts from diverse fields. Previously elusive mathematical and geometrical algorithms, forms, and structures have become discernible and spatially intelligible for architects, rendering them applicable. This new methodology incorporated computational concepts such as topological space (topological architectures), isomorphic surfaces (isomorphic architectures), motion kinematics and dynamics (animate architectures), keyshape animation (metamorphic architectures), parametric design (parametric architectures), genetic algorithms (evolutionary architectures), and fractal geometry (fractal architecture) as outlined by Kolarevic (Kolarevic, 2003). In the era of digital parametric non-standard architecture, mathematics and geometry are pivotal to the architectural design process. These elements play a crucial role from the inception to the manufacturing of architectural components (Milena, S., & Ognen, M. 2010). Contemporary computational technology offers an array of tools for the design, analysis, simulation, and fabrication of intricate architectural forms. Today's preeminent architects and prominent architectural institutions employ diverse software packages and digital methodologies, ushering in a novel aesthetic in digital architecture. Concurrently, these advancements bring forth new challenges tied to mathematical and geometrical disciplines (Stavric M., & Marina 2011).

2.3 Architecture in the Digital Age

Architectural design transcends merely problem-solving; it encompasses redefining design challenges and seeking superior solutions (Yu et al. 2013). Regardless of computer assistance, the design process encompasses both routine and non-routine activities. In the past decade, investigations into the architectural design process, informed by digital technologies, have enhanced comprehension of design as a

procedure, notably in routine design. More recently, this has extended to supporting creativity in non-routine tasks (Gero 1990; Gero and Maher 2013). The digital domain has empowered designers to grapple with intricate geometries and vast data sets, thereby delving into an entirely new design realm reliant on computational methods. As posited by Woodbury (2010), parametric instruments facilitate the formation, administration, and structure of intricate digital design models. Modifying an object's parameters can yield an expansive array of outcomes (Kolarevic 2004). The fabrication sector has recently seen the emergence of advanced 3D parametric modeling tools. Coupled with new software and techniques for CAM modeling and computer numerically controlled (CNC) fabrication, these innovations simplify building and subsystem modeling. Consequently, renowned international architectural firms are ardently exploring the capabilities of digital technology (Feng 2013; Jester 2014; Oxman 2008).

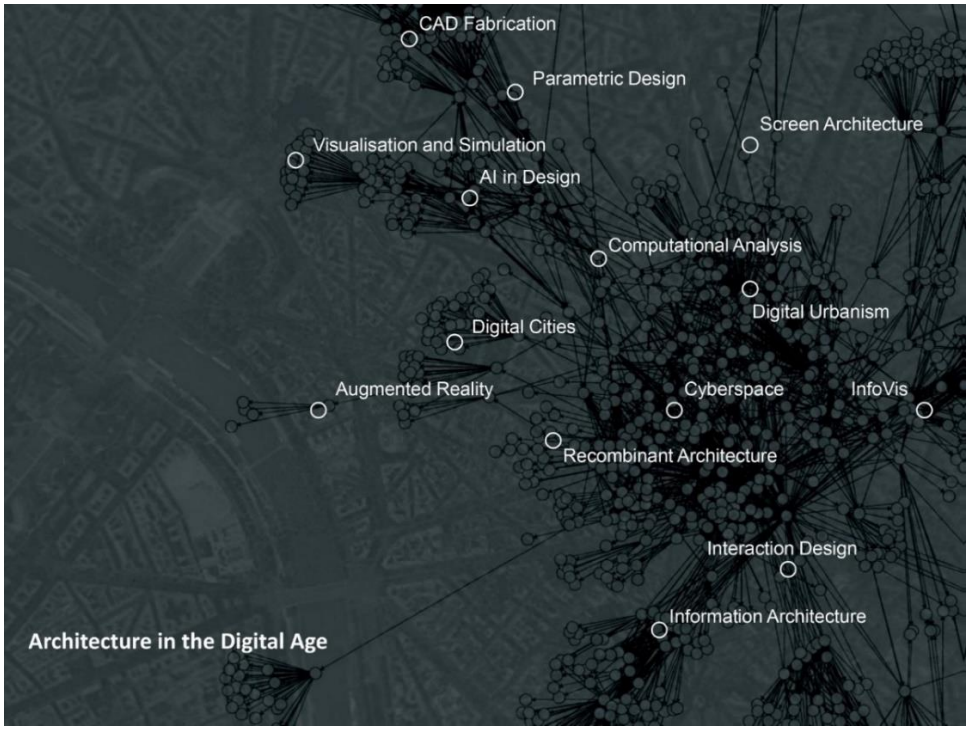


Figure 5: Architecture in the Digital Age

Architecture in the digital age for nowadays includes many sections in which these sections are developing and growing in a fast way, and other sections are added to them gradually. Some of the main important and used sections of architecture in digital technology are the following:

- CAD fabrication
- Parametric design
- Screen architecture
- Visualization and simulation
- AI in design
- Computational analysis
- Digital cities
- Digital urbanism
- Augmented reality
- Cyberspace
- Info Vis
- Recombination Architecture
- Interaction Design
- Information architecture

2.4 Categories of Digital Technologies for Architectural Design

- **Advanced modeling**

  Although some modeling tools are not driven by computation, it remains essential to mention those that empower architects to depict intricate geometries with unparalleled precision and adaptability. Through programming methodologies, many of these tools can have their functionalities expanded into the parametric and algorithmic arenas.

- **Computational design - software**

  By integrating computational abilities with representational features, computational design methods become instrumental in adopting parametric and algorithmic design techniques. Two predominant trends exist at present: visual programming languages, such as Grasshopper, and text programming languages, like Python. This section predominantly concentrates on visual programming tools (and their plug-ins) that bolster representational systems for computational design.

- **Computational design - programming languages**

  Although programming represents a more abstract facet of computational design, it offers enhanced control and potential for implementing such methods. Typically, programming pairs with established modeling tools to readily leverage modeling and visualization capacities. In advanced scenarios, a standalone application might be developed from the ground up.

- **Performative analysis**

  Digital scrutiny of digital models introduces an avenue to sidestep costly physical examinations. Presently, there's an expansive array of engineering analysis software (CAE) at one's disposal, aiding designers in collaborating and honing their designs. There's a pronounced inclination towards software solutions that feed directly into algorithmic design, though some established packages remain indispensable.

- **Digital fabrication**

  The appeal of these instruments stems from the capacity to harness data embedded in digital models to directly instruct CNC fabrication devices. Such tools make feasible the tangible production of intricate geometries or adaptable components.

Consistently, there's heightened attention towards solutions that synergistically function alongside computational design models.

- **Robotics**

  Simulating the motion of a robotic arm stands as a central component when orchestrating the digital fabrication procedure with these machines. Such software can also reverse engineer operations to ascertain the optimal movement trajectories for various robotic components, factoring in diverse constraints.

Chapter 3

IDENTIFICATIONS OF ARCHITECTURAL STYLE IN 21st CENTURY

3.1 Historical Meaning and Standards of Architectural Styles

3.1.1 Research on Style

Architectural styles are distinguished by features that render a building or structure historically or notably identifiable. They form a subset of styles in visual arts and often align with broader contemporary artistic movements. Key elements of a style may encompass form, construction methodology, materials, and regional characteristics. Architectural works typically fit within a style chronology that evolves over time, reflecting shifts in fashion, beliefs, religions, technology, materials, or emerging ideas that pave the way for novel styles (Retrieved January 2020). The term "style," derived from the Latin 'Stilus' through Old French, originally pertained to writing or its method. By the eighteenth century, the term began to allude to specialized construction or production (Johnson, 1994). The conception of style and its utilization across various disciplines and studies varies widely. A comprehensive review of all literature on the subject would be extensive for a single dissertation, let alone a lone chapter. Nonetheless, exploring definitions and descriptions relevant to architectural design can aid in understanding our interpretation of style.

3.1.2 Dictionary Definitions on Style

The term "style" embodies a multifaceted concept, and dictionary definitions alone might not fully encapsulate its depth. However, these foundational definitions can clarify the term in general and in relation to this research. Koenen & Drewes (1976) categorize the concept of style into four distinct meanings: 1) style as an expression mode in writing, 2) as a generalized expression form associated with specific art schools or periods, 3) as a habitual method, and 4) as a chronological system, such as the Gregorian or Julian chronology. Cayne (1991) characterizes style as: a) a unique way of executing or articulating something, b) the signature character of specific schools, art types, or individual works, c) the manner of expressing literary or musical content, and d) a chosen manner or tone in speech or rhetoric. Notably, even the definitions from just these two sources underscore the diversity in how "style" is defined across disciplines. Despite some descriptions being less pertinent to this research, numerous definitions remain, adding layers of complexity.

3.1.3 Value of Style

Architectural design prominently incorporates recurring organizational patterns, or architectural styles, such as generic system organizations like dataflow or layers and specific structures like the OSI communication stack or the MVC user interface paradigm. Utilizing architectural styles methodically offers several advantages. Firstly, it fosters design reuse by enabling the redeployment of proven solutions to fresh challenges. Secondly, it can enhance code reuse, given the consistent aspects of a style often align with shared implementations. Thirdly, a system's organization is more comprehensible if standardized structures are employed. For instance, describing a system as "client-server" instantly provides a clear idea of its components and their interconnections. Fourthly, adherence to standardized styles enhances interoperability,

as seen with CORBA object-oriented architecture [Cor91] and event-based tool integration [Ger89]. Fifthly, architectural styles, by narrowing the design scope, can often facilitate style-specific analyses, allowing for assessments like schedulability or deadlock-freedom in pipe-filter systems. Lastly, it's generally feasible to offer style-specific visualizations, enabling graphical and textual representations aligned with engineers' domain-specific perceptions. However, the application of architectural styles remains largely inconsistent. It's challenging to precisely identify what design aspects a style should define, compare styles by their characteristics, correlate systems based on varied styles, develop universal tools for leveraging style, choose fitting styles for a particular problem, or merge multiple styles into a new one. Clearly, there's a need for a more structured foundation to understand and utilize architectural style. This paper will briefly introduce and juxtapose three methodologies to establish such a foundation.

3.1.4 Basic Properties of Style

Before delving into the various methodologies, it's pivotal to underscore four key facets of architectural styles that any conceptual framework should incorporate:

- Architectural styles introduce a lexicon of design constituents, including component and connector types such as pipes, filters, clients, servers, parsers, databases, and more.
- They set forth configuration guidelines or topological stipulations that dictate the allowable compositions of these constituents. For instance, certain guidelines might bar cycles in a specific pipe-filter style, mandate that a client-server structure adheres to an n-to-one relationship, or delineate a distinct compositional sequence like a pipelined breakdown of a compiler.

- They offer a semantic interpretation, ensuring that compositions of design elements, appropriately restricted by the configuration guidelines, possess defined significances.
- They detail analyses applicable to systems formulated in that style. Such analyses might encompass schedulability evaluation for a style focused on real-time processing [Ves94] or deadlock identification in client-server message transmission [JC94]. Notably, code generation emerges as a specific yet crucial analysis subset, with many styles facilitating application development, such as parser generators, or endorsing code reuse for certain communal utilities, for instance, user interface infrastructures and communication facilitation among distributed operations.

3.1.5 Three Views of Architectural Style

Considering the above, we can discern three interpretative perspectives on style:

- Style as Language: Here, a design's stylistic vocabulary is represented as a series of grammatical constructs. Configuration guidelines emerge as either context-free or context-sensitive grammar rules. Standard techniques can assign semantic interpretations to languages. Analyses are primarily those feasible on architectural "programs", which involve compliance verification of grammatical guidelines, flow assessment, compilation, and more. This perspective resonates with the idea of interpreting a style as denotational semantics for architectural diagrams (Abowd, Allen, & Garlan, 1993).
- Style as a System of Types: In this perspective, the architectural lexicon is represented as a set of types. A pipe-filter style might, for instance, define filter and pipe categories. Within an object-oriented framework, hierarchical definitions become feasible, with "filter" being a subclass of a broader

"component" category, and "pipeline-stage" being a subset of "filter". Similarly, a "pipe" might emerge as a subset of a universal "connector". Type constraints can be preserved as datatype invariants, operationally actualized within the code modifying these type instances. The type system can be utilized for analysis, enabling type verification and other architectural transformations contingent on the specific types (Garlan, Allen & Ockerbloom, 1994).

- Style as a Theory: From this vantage point, a style is delineated as an ensemble of axioms and inferential guidelines. Vocabulary is indirectly represented via the logical attributes of elements. Configuration stipulations and semantics are detailed as additional axioms. Analytical pursuits entail proving a novel theorem, subsequently extending the style's theoretical framework. This methodology is exemplified in Moriconi's work (Moriconi, 1994; Moriconi, 1995).

3.1.6 Architectural Style

An architectural style is characterized by distinctive features that make a building or structure notable or historically identifiable (Agathos et al., 2022). Generally, considered a subclass of visual arts style, architectural styles encompass elements such as form, construction methods, materials, and regional characteristics (Booth, 1989). These styles often reflect evolving trends, beliefs, and technological advancements (Kubler, 2008). The term "style," derived from the Latin "Stilus" via Old French, initially referred to a manner of writing (Crystal, 2005). By the 18th century, it had come to denote a mode of skilled construction or production (Johnson, 1994). The concept of style has di-verse applications across disciplines, making a comprehensive review challenging (Pashler et al., 2008). However, understanding the various definitions and descriptions related to architectural design is crucial for

conceptualizing style in this field. Histori-cally, architectural style has fluctuated in its legitimacy and usage (Kornberger et al., 2011). For example, before 1750, architecture adhered to established principles, allow-ing architects to exercise creativity within recognized rules (Collins, 1965). The aware-ness of architectural styles, such as Classical or Gothic, developed long after the struc-tures were built (Crook, 1987). As Davis (1986) noted, style is not inherent in the material but must be interpreted and documented. Peter Collins (1998) further elaborated on the historical consciousness of style, particularly during the period between 1750 and the early 20th century, when the focus shifted from defining style to selecting the appropriate style for different building types. Architectural education during this period emphasized that style should authentically reflect the building's purpose and was considered the "poetry of architecture" (Collins, 1998). In modern times, architectural style is often viewed through the lens of abstraction and categorization of design elements (Fielding, 2000). This approach to style, particularly in software architecture, emphasizes the functional and non-functional properties of architectural elements (Xu et al., 2006; Di Nitto & Ros-enblum, 1999; Shaw, 1990). Styles are used as mechanisms for defining the common characteristics of architectures, abstracting the interactions of components by focusing on essential patterns and constraints (Garlan, 1993; Garlan et al., 1995; Shaw & Clem-ents, 1997). This approach allows for flexibility and innovation in design while main-taining coherence and consistency across different projects (Perry & Wolf, 1992; Abowd et al., 1995). However, the notion of style as a set of constraints rather than a personal-ized design process has led to debates within the architectural community (Loerke, 2000). Recent critiques of modern architectural practices highlight concerns about the loss of identity and coherence in contemporary designs. Curl (2018) discussed the rise of architectural barbarism, emphasizing the disconnect

between modern architecture and its historical roots. Similarly, Mitrović (2022, 2023) explored the philosophical un-derpinnings of architectural principles in the context of fraud and obfuscation, ques-tioning the authenticity and integrity of current architectural trends. In this regard, he argued that Deconstructivists share problematic assumptions with other movements like phenomenology, including an anti-visual stance, an overemphasis on language, and a tendency to attribute architectural creativity to collective cultural influences ra-ther than individual agency. Buchanan (2012) and Al-Sabouni (2016) addressed the broader cultural and social implications of architectural styles, arguing for a return to designs that reflect cultural identity and historical continuity. The confused state of architectural research, as high-lighted by Buday (2017), and the persistence of outdated architectural norms, discussed by Dickinson (2018), further underscored the challenges faced by contemporary archi-tects. Mehaffy (2020) and Silber (2007) criticized the aesthetic failures of modern archi-tecture, advocating for a return to principles that prioritize functionality and human-centered design. In summary, architectural style is a complex and multifaceted concept that encompasses both historical traditions and modern innovations. The ongoing de-bates within the field reflect a broader struggle to balance the demands of innovation with the need for continuity and coherence in design

The discourse on architectural style has regained its validity. Historically, the notion of style was employed, among other ways, to characterize an architect's oeuvre in terms of caliber and technique. "Prior to 1750, architectural endeavors were largely about adhering to entrenched principles, allowing architects to harness their creative prowess while conforming to recognized guidelines" (Collins, 1965). This raises intriguing queries: were ancient Greek architects aware that they were crafting in the classical style? Did Gothic cathedral architects recognize their adherence to the Gothic

style? These terminologies emerged significantly after the creation of the structures they describe, a sentiment echoed by Davis, who posited:

> "Style is not in the material, the matter of artifacts or works of art. Style must be discovered and written up by someone". (Davis, 1986)

Peter Collins (1965) chronicled the evolution of style consciousness. From 1750 to the early twentieth century, the central question wasn't the nature of style but the appropriate style for a specific building type. Blondel, during his architectural instruction post-1750, imparted to his disciples that architectural style epitomized the authentic essence, selected based on a building's intended function, and was perceived as architectural poetry (Collins, 1965). The prevalent design approach involved emulating antecedent styles, yielding structures reflecting Greek, Renaissance, or Baroque influences (Watkin, 1980). Case in point, Gottfried Semper (1803-1879), a predominant German architect of his era, predominantly crafted in Renaissance or Baroque styles.

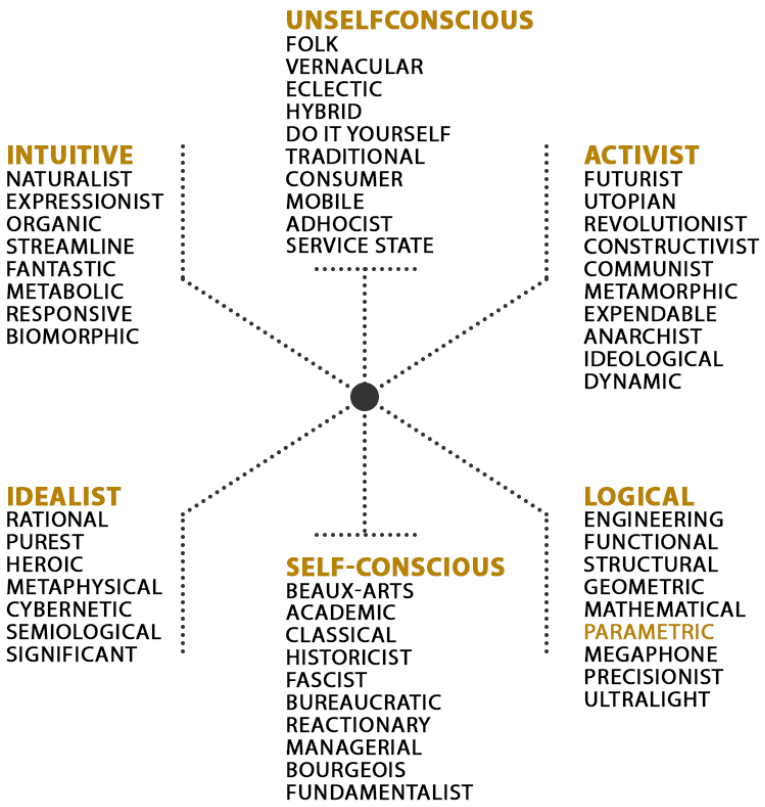


Figure 6: Jenks Structural Diagram 1920–2000, Semantic Space of Six Polaritiesre, Redrawn by the Author

3.2 Scholars' Explanations of Architectural Styles

An architectural style represents a set of specific constraints that determine the roles and characteristics of architectural elements, as well as their permitted relationships within a conforming architecture. Because an architecture comprises both functional and non-functional aspects, directly comparing various architectures—whether they are for different system types or the same system in varying environments—can be challenging. Styles serve as a tool to categorize architectures and define their shared characteristics, according to Di Nitto and Rosenblum (1999). They abstract the interactions of components, concentrating on the core interaction patterns while omitting the incidental architectural details (Shaw, 1990). Perry and Wolf (1992) describe an architectural style as an abstraction drawn from different specific architectures, potentially emphasizing particular aspects. Such a style focuses on

pivotal decisions about the architectural elements and underscores key constraints related to the elements and their associations. In this context, styles may prioritize connectors or specific facets of component interfaces. Conversely, works by Garlan and Shaw (1993), Garlan et al. (1995), and Shaw and Clements (1997) define style in relation to patterns of interaction among distinct component types. Precisely, an architectural style prescribes the vocabulary of components and connectors usable within that style, along with rules about their combination (Garlan, D., 1993). This narrow perspective on architectural styles originates from their interpretation of software architecture. Viewing architecture as a formalized description, not an operational system, leads to abstractions rooted only in common patterns of graphical representations. Abowd et al. further specify that architectural styles are defined by conventions interpreting a certain category of architectural descriptions (Abowd, G. D., Allen, R., & Garlan, D. 1995). Architectures can be characterized as manifestations of specific styles (Di Nitto, E., & Rosenblum, D. 1999). Since architectural styles might cater to various software architecture facets, one architecture might encompass several styles. Additionally, combining multiple foundational styles can result in a unified hybrid style. While some architectural styles are presented as universal solutions, Shaw (1995) asserts that designers should opt for a style that aligns with the specific problem at hand. Unfortunately, the term "style," denoting a set of constraints, can be misleading. This interpretation contrasts with the traditional meaning of style, which would accentuate a design's individuality. Loerke critiqued the emphasis on personal stylistic preferences in professional architecture. He instead characterized styles from a historical perspective, where factors like material availability, local culture, or the influence of rulers shaped architectural styles, rather than the designer's vision. Loerke identified the actual origin of style in traditional architecture as the

constraints imposed on a design. Therefore, using the term "architectural style" simplifies conveying shared constraints' attributes, rather than signaling a personalized design approach (Wilson, F., et al. 1990).

3.3 21st Century Reconsiderations of Architectural Styles

As the world transitioned into the 21st century, the field of architecture witnessed a profound transformation, influenced significantly by the advent of information technology and a globalized perspective on design. This era marked a departure from traditional paradigms, ushering in an age where the reconsideration and reinterpretation of architectural styles became a focal point for innovation and creativity. Lehr (2008) identifies this trend as a reflection of the industry's response to the dynamic changes in soci-etal needs, technological advancements, and environmental concerns. This period of architectural evolution is characterized by a multifaceted approach toward design, where architects and designers ventured beyond the confines of conventional styles to explore the integration of historic elements with modern aesthetics and functionality. Luu et al. (2014) highlight the inclination towards modernizing and updating older styles, which was not merely an act of revival but an endeavor to make these styles pertinent to contemporary societal demands. This approach led to the creation of hybrid styles, which melded the essence of different eras and cultures into a cohesive design language, resonating with today's diverse global landscape. Among the various styles that emerged during this period, parametricism stands out as a distinct movement that epitomizes the twenty-first century's architectural ideology. Defined by Patrik Schu-macher and exemplified through the works of Zaha Hadid Architects (ZHA), paramet-ricism is not just a style but a methodology that leverages computational design tools to generate fluid, dynamic forms, and spatial arrangements. This style is characterized by its

adaptability, precision, and the ability to create complex, integrated systems that respond to environmental, social, and economic parameters. Parametricism's significance lies in its innovative use of technology to redefine the boundaries of architectural de-sign, making it a pivotal example of how the discipline has evolved in response to the IT revolution. This movement also aligns with the industry's growing emphasis on sus-tainability, as parametric tools allow for the optimization of materials and energy use, thus contributing to the development of more sustainable design solutions. In comparison to other twenty-first-century styles, parametricism can be seen as a forerunner in the adoption of advanced digital technologies, setting a benchmark for how architects can harness computational methods to enhance design efficiency and effectiveness. While other styles may draw from historical or cultural influences to inform their aes-thetic and functional aspects, parametricism's foundation in algorithmic processes and data-driven design represents a paradigm shift towards an architecture that is inherent-ly responsive to its context and capable of addressing the complex challenges of the modern world. Moreover, the exploration of traditional or indigenous styles, as noted by Salman (2018), further underscores the architectural community's interest in creating spaces that are not only innovative but also culturally sensitive and inclusive. This endeavor to blend the old with the new, the traditional with the cutting-edge, reflects a broader ambition within the field to conceive buildings and spaces that are both func-tional and aesthetically pleasing while also being mindful of their environmental impact and cultural significance.

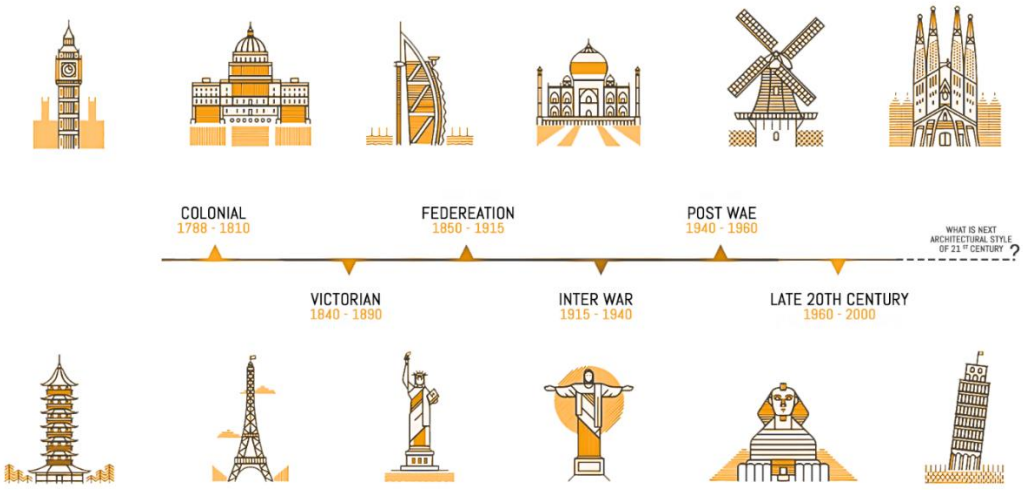


Figure 7: Notable Architectural Styles Grouped by Historical Period, by the Author

3.4 Styles and Parametricism

As it's illustrated in the table below in which Schumacher attempts to categorize Parametricism as an epochal style of the century, and considering as a competitive style which replace Modernism and considers Deconstractivism and Postmodernism were Traditional styles which Parametricism puts a turning point. Parametricism is a style within contemporary avant-garde architecture, promoted as a successor to post-modern architecture and modern architecture. The term was coined in 2008 by Patrik Schumacher, an architectural partner of Zaha Hadid (1950-2016). Parametricism has its origin in parametric design, which is based on the constraints in a parametric equation. Parametricism relies on programs, algorithms, and computers to manipulate equations for design purposes (Schumacher, P. 2011)

Table 1: Classification of Style According to Patrick Schumacher (redrawn Based by the Author on Schumacher, the Autopoiesis of Architecture: A New Framework for Architecture p. 253).

Styles	Epochal Style	Subsidiary Style	Transitional Style
Passive Style	Gothic		
Active Style	Renaissance	Mannerism	
	Baroque	Rococo	
Active Reflective Style	Neo-Classicism		
	Historicism	Neo-Gothic	
		Neo-Renaissance	
		Neo-Baroque	
		Eclecticism	
			Art Nouveau
			Expressionism
	Modernism	Neue Sachlichkeit	
		Organicism	
		Rationalism	
		Brutalism	
		Metabolism	
		High-Tech	
			Postmodernism
			Deconstructivism

Chapter 4

PARAMETRICISM AND PARAMETRIC ARCHITECTURE

4.1 Origins of Parametric Term

A parameter (from the Ancient Greek παρά, para: "beside", "subsidiary"; and μέτρον, metron: "measure"), generally, is any characteristic that can help in defining or classifying a particular system (meaning an event, project, object, situation, etc.). A parameter serves as a vital component of a system, instrumental in characterizing the system or assessing its performance, condition, or status. Within disciplines such as mathematics, computer science, engineering, statistics, logic, and linguistics, the term "parameter" carries specific meanings. Within these fields, it is essential to differentiate between the use of "parameter" and related terms like argument, property, axiom, variable function, and attribute. Parametricism emerges as a contemporary avant-garde architectural style, positioned as the successor to post-modern and modern architecture. Patrik Schumacher, a collaborator of Zaha Hadid (1950-2016), introduced the term in 2008. Originating from parametric design, parametricism depends on parametric equation constraints. It employs programs, algorithms, and computers for design equation manipulations. Elements of Parametricism have found applications in urban, architectural, and furniture design. Advocates argue that a defining feature of Parametricism is the parametric variability and mutual adaptability of all design components. Schumacher describes Parametricism as an Autopoiesis, a self-referential system where altering one

component impacts all others. The style eschews both sheer repetition and stark differentiation, emphasizing correlation and distinction. Its objective is to enhance spatial complexity while preserving clarity, enabling architecture to mirror the intricacies of the contemporary global network society. Empowered by innovative technology, designers are now focusing on forms shaped by discernible systems. This data-driven, parametric approach responds to two decades of digital projects, often pursued for their novelty. (Beorkrem, C. 2017).

4.2 History of Parametricism

This section explains the roots and antiquity of parametricism in architecture and provides meanings and sympathies with parametricism as a recent term in this field. Later, it discusses numerous scholars' clarifications and identifications of parametricism, finalizing by interpretation of styles and parametricism and ending with heuristics in parametricism. One of the initial efforts to use parametric equations originated in Robert Hook's hanging chain model, which Antonio Gaudi then established in his ideas (Lachauer, 2015). It is problematic to distinguish if Gaudi was straight-wedged by the diverse investigators and mathematicians who had previously applied parametric formulas to illustrate geometry. (Rippmann, M. 2016). Mark Burry, the contemporary authorized architect of Gaudi's Sagrada Familia, utters that there is for all aims and objectives none composed by Gaudi himself about the motivations, conjectures, and repetition that pushed him to spread the limitations (Davis, 2013).

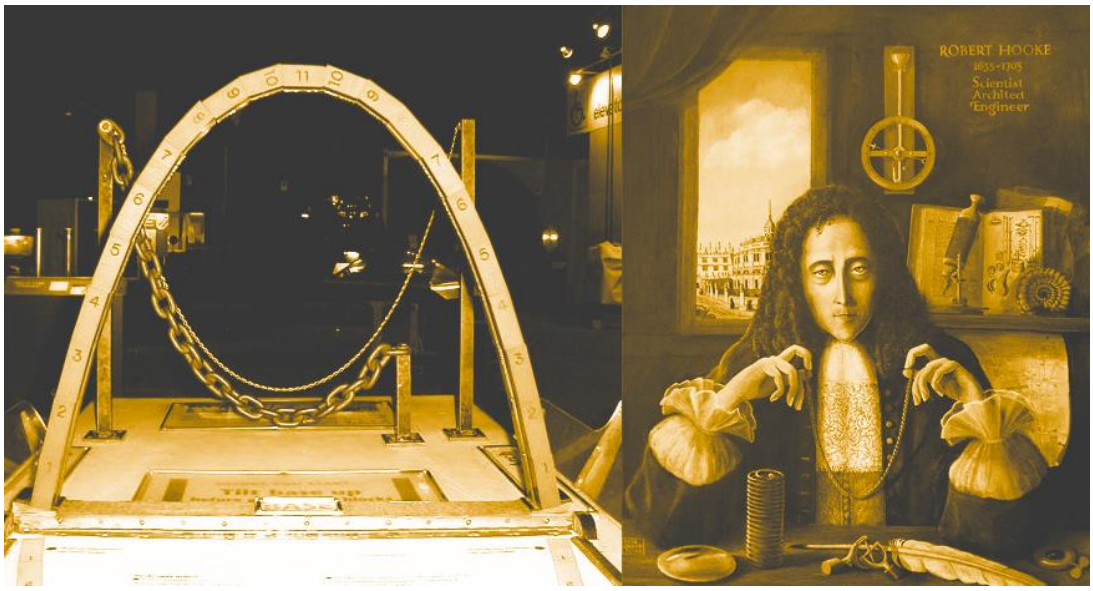


Figure 8: Robert Hook's Hanging Chain Mode is Refined by the Author

Compared to the earlier parametric formula applications by researchers, Gaudi's advanced implementation of the hanging chain model demonstrates its parametric implications (Gürsel Dino, İ. 2012). He innovated a method to derive the shape of a catenary curve based on gravitational pull-on strings, eliminating countless manual computations (Lauriola, D. 2017).


Figure 9: Antoni Gaudí Catenary Model Inverted and Diagram of Cables, and Weights, by the Author.

In the 20th century, before Zaha Hadid's partner Patrik Schumacher conceptual-ized Parametricism, one of the first individuals to talk about architectural parameters was

Luigi Moretti (Gallo & Pellitteri, 2018). In 1958, he created the National Institute for Mathematical and Operative Research for Urbanism (IRMOU), where he researched and tried to progress parametric architecture (Moretti, 1958). In one of his works of lit-erature, in 1940, he decided that 'The functional parameters are accurately registered and recognized as the foundation for the expressive game of an architect" (Moretti, 1958). After twenty years, Moretti shared this with the world in his exhibition of "Para-metric Architecture and Mathematical and Operational Research in Town-planning: 12th Triennial Exhibition, Milan, Arts' Palace, September-October 1960" (Figure 9). Greg Lynn, Jesse Reiser, Lars Spuybroek, and Kas Oosterhuis were parametric architecture's primary experts (Bredella, N. 2022. In contemporary studies of Parametricism in architecture, researchers focused on bridging the gap between theoretical constructs and practical applications. Hazbei and Cucuzzella (2023) examined the contextual challenges faced by parametric architecture, emphasizing the need for a comprehensive understanding of contextual integration within design processes. Biçer and Erdinç (2023) explored the journey from conceptual paper designs to tangible parametric structures, highlighting the transformative power of parametric design in translating abstract ideas into physical reality. Lucente and Canestrino (2023) analyzed Luigi Moretti’s pioneering contributions to parametric theory, exploring the discrepancies between theoretical aspirations and actual implementation in Moretti's projects. Nasir and Kamal (2023) examined parametric architecture’s role in contemporary building design, advocating for a holistic consideration that encompassed social, environmental, and functional aspects. Hegazy and Saleh (2023) in-vestigated the intersection of artificial intelligence and parametric design, discussing how AI could enhance parametric exploration and generate innovative design solutions beyond human imagination. Saltykov and Gnetova (2023)

examined the application of parametric methods in designing children's supplementary education facilities, high-lighting how parametric design could create dynamic, adaptable spaces responsive to educational needs. Maleckas (2024) addressed the integration of cultural heritage identity codes into parametric design, proposing theoretical models that combined traditional architectural elements with modern parametric techniques. Gaha (2023) investigated the potential of parametric design in shaping new city identities through innovative materials and environmental applications. Lee et al. (2023) explored the rationalization of free-form architecture using generative and parametric designs, presenting methodologies to streamline complex geometric forms into feasible construction plans. Di Paola and Mercurio (2023) conducted parametric experiments to push the boundaries of architectural form and function, encouraging architects to explore uncharted territories in spatial and structural innovation. Bianconi and Filippucci (2023) revisited Moretti’s views on digital representation in architecture, illustrating how parametric tools could transform perception and interaction with architectural spaces. Bell (2023) focused on the underlying principles and thought processes that drove parametric thinking rather than the visible outcomes. Yussuf et al. (2024) discussed procedural approaches in parametric design, emphasizing step-by-step methodologies guiding architects from conceptualization to realization. Chen et al. (2023) explored the use of para-metric shape grammars in architectural design, using a district of "Three Lanes and Seven Alleys" in Fuzhou City as a case study. MALLASI (2023) proposed a pixel-based design approach for patterning dynamic façades, leveraging parametric thinking to create responsive and visually engaging building exteriors.



Figure 10: A Model of a Stadium by Luigi Moretti. Exhibited at the 1960 Parametric Architecture Exhibition at the Twelfth Milan Triennial. the Stadium Derives From a Parametric Model, Retrived by the Author.

4.3 Bibliometric Analysis

This section reports the results of a bibliometric analysis that explores the evolution, popularity, and scholarly attention given to parametricism and parametric architecture, utilizing data gathered from approximately 1000 literature sources in the Web of Science database. VOSviewer software was employed to analyze these sources, providing insights into the trends and patterns within the field. The study's bibliometric analysis begins with an examination of the number of publications over the years. The data reveals a gradual increase in interest and scholarly output concerning parametricism and parametric architecture since the early 2000s. The initial years saw a very low number of publications, with very few papers per year from 2000 to 2008. However, a noticeable rise began in 2009, with the number of publications growing significantly, reaching a peak in 2013 and another one in 2019 with 120 publications. This upward trend underscores the growing recognition and relevance of parametricism within architectural discourse.

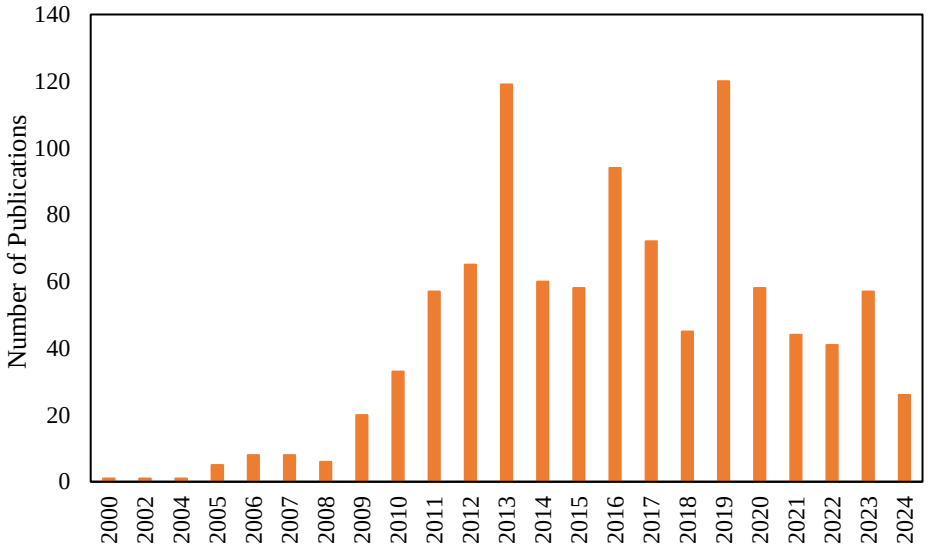


Figure 11: Number of Publications on Parametricism and Parametric Architecture in the Literature Over the Past Years.

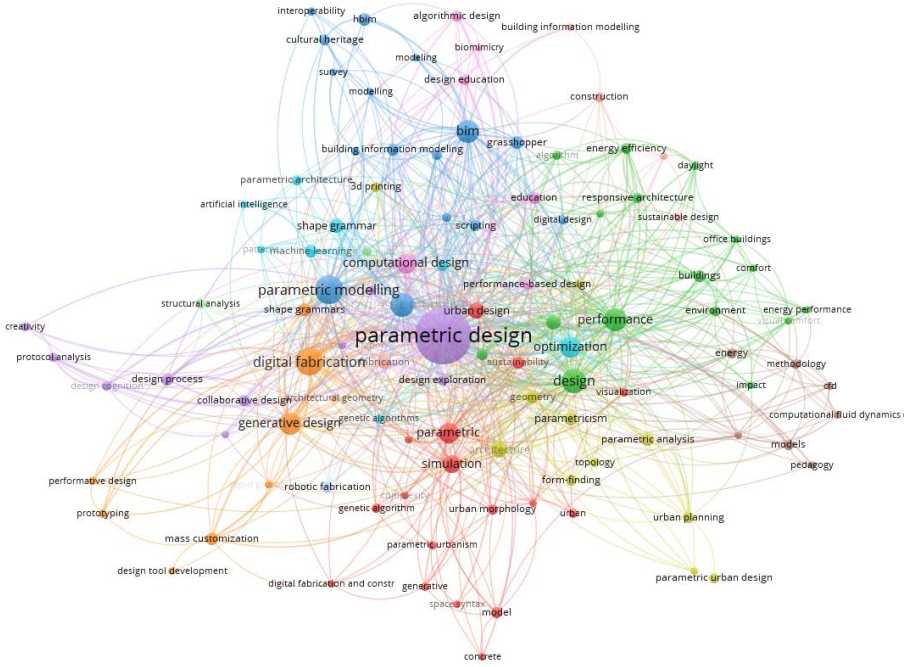


Figure 12: Keywords Co-Occurrence on Parametricism and Parametric Architecture in the Literature.

Further analysis of keyword co-occurrence highlights the central themes and areas of focus within the literature on parametricism. The visualization reveals that "parametric design" is the most prominent keyword, closely followed by "parametric modeling"

and "design". This indicates that the core interest of the scholarly community lies in the methodologies and technical aspects of parametricism. The dense interconnections between these keywords suggest a well-developed and interlinked body of research, emphasizing the methodological innovation that parametricism represents. In terms of publication sources, shows that the "International Journal of Architectural Computing" is the leading journal in publishing research on parametricism, followed by the "Nexus Network Journal" and the "Architectural Science Review". This distribution of sources reflects the interdisciplinary nature of parametricism combining both computational design and architectural theory. Additionally, the frequent appearance of the "Education and Research in Computer Aided Architectural Design in Europe (eCAADe)" conference indicates the significant role of academic conferences in disseminating research findings in this field. The geographical distribution of contributions (Figure 14) reveals that the United States leads in scholarly output on parametricism, followed by Italy, Australia, China, and England. This international spread indicates a global interest in the subject, with substantial contributions from both Western and Eastern countries. The dominance of the United States may be attributed to its robust academic infrastructure and its early adoption of computational design techniques.

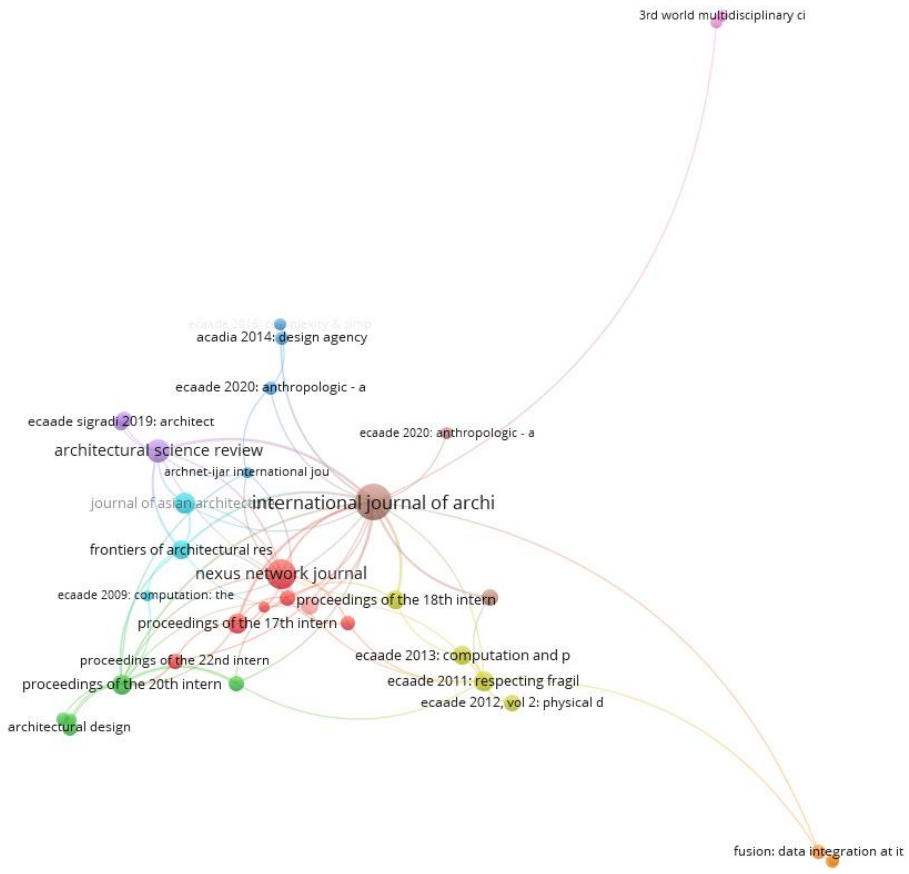


Figure 13: Literature Sources with the Highest Number of Publications on Parametricism and Parametric Architecture.

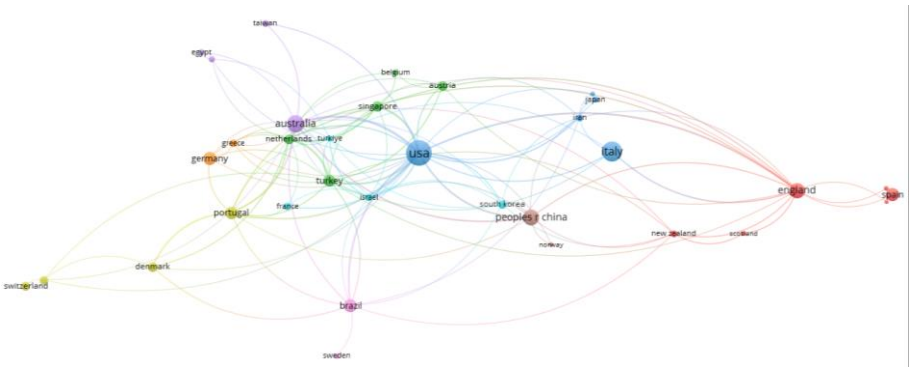


Figure 14: Countries with the Heights Number of Contributions to Parametricism and Parametric Architecture.

Untimely, this bibliometric analysis highlights a broader impact and integration of parametricism within the architectural community. The steady increase in publications, especially after 2008 when the term was coined, suggests that

parametricism has moved from a niche methodology to a mainstream architectural approach. This transition is further evidenced by the widespread use of related keywords and the diversity of publication sources, which indicate that parametricism is being explored from multiple perspectives and disciplines.

4.4 Parametricism: Between Style and Method

Styles serve as the aesthetic representations of specific time periods (Bayard, 2012). They can be likened to the descriptors of buildings. The "Dictionary of Architecture and Construction" defines architectural style as the categorization of design products that possess common attributes, such as similarities in general appearance and in the arrangement of design elements, crafted during a distinct time frame and within a particular geographical area (Harris, 2006). Conversely, another dictionary portrays styles as elements that evolve over time, incorporating shifts in materials, building technology, and theoretical concepts (Ambrose et al., 2007). The concept of Parametricism should be explored in conjunction with these definitions and its associated architectural milieu.

To critically evaluate the Parametricism concept, it is imperative to understand the architectural context that gave rise to it. Between the era when Modernism was recognized as a style and the introduction of the Parametricism concept, significant technological advancements were witnessed. Parametric design mirrors the advancements in digital technology within architecture. It has influenced architecture in terms of design methodology, tools, fabrication techniques, and the relationship between form, space, and structure. This era of transformation has catalyzed the formation of new theories. Even though roughly a century has transpired since the inception of Modernism, the modernist

Considering the digital design epoch (inclusive of CAD software and the like) as a "transitional phase," the parametric design phase emerges as an era wherein digital design and its associated tools are seamlessly integrated into architecture, becoming as commonplace as pen and paper. Under such conditions, it is anticipated that a novel architectural style would be birthed from the digital revolution, analogous to how Modernism arose from the Industrial Revolution and the advent of mechanization. It was Patrik Schumacher who proposed the pioneering concept of this potential new style, naming it "Parametricism," and heralding it as the next monumental style succeeding Modernism (Oktan & Serbulent, 2017).

4.5 Phases of Parametricism in Architecture

4.5.1 Proto Parametricism (1952-1992)

Throughout his professional journey, Frei Otto dedicated himself to the exploration of lightweight, tensile structures, employing form-finding physical models that achieved analog "material computation." Such endeavors are now recognized as precursors to Parametricism. His iconic design of the Olympic Stadium in Munich, constructed for the 1972 Summer Olympics, stands as a testament to pioneering lightweight tent construction. This project was realized in collaboration with the architect Günther Behnisch.

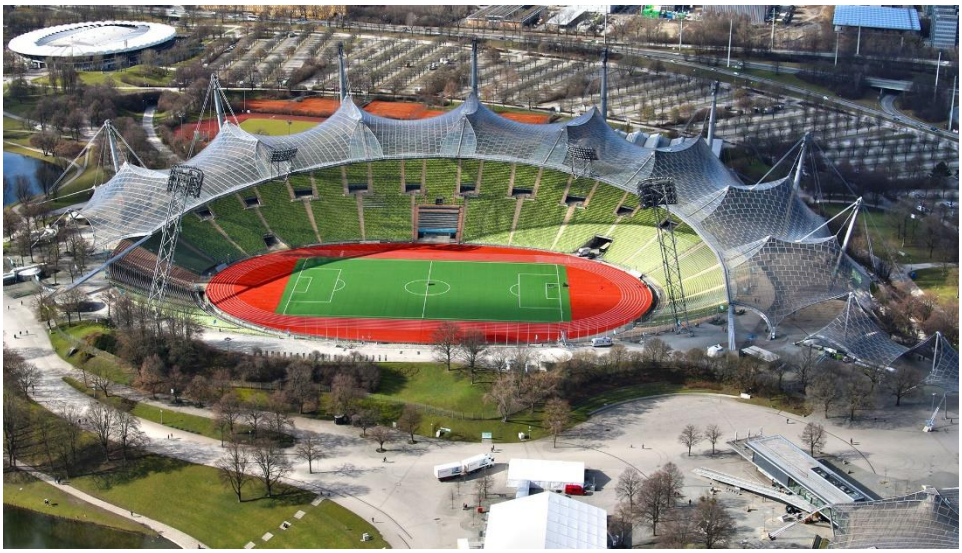


Figure 15: Munich Olympic Stadium (Frei Otto and Günther Behnisch, 1972)

4.5.2 Early Parametricism (1993-2008)

In the evolution towards Parametricism, initial built projects between 1993 and 2008 aspired to refine and advance manufacturing and construction methodologies, thus enhancing the architectural discipline's ability to manifest intricate digital designs into tangible material constructs. A pioneering example is the Water Pavilion (1993-1997), conceived by Lars Spuybroek (NOX) and Kas Oosterhuis (ONL). This structure was the first to marry continuous geometry with an array of sensors inside, forging an interactive milieu—often termed responsive architecture—wherein light and sound could be modulated by visitors. Esteemed architecture critic Charles Jencks lauded it as "yet to be surpassed" in his publication, "The New Paradigm of Architecture" (Jencks, 2002).



Figure 16**.** The Water Pavilion (Lars Spuybroek, 1993-1997)

Kas Oosterhuis' Saltwater Pavilion, a project envisaged entirely in a three-dimensional computer model, won multiple awards and nominations in the late 1990s. Oosterhuis stated, "The delineation of the form is embedded in the digital genes of the design, which form the crux of its existence. This primordial concept serves as the genetic fulcrum for all ensuing development stages. The domination of platonic volumes and rudimentary geometries like cubes, spheres, cylinders, and cones no longer holds sway as architecture's foundational elements."

A critically acclaimed project from this period is the Yokohama International Passenger Terminal (1995-2002) by Foreign Office Architects (FOA), led by Farshid Moussavi and Alejandro Zaera-Polo. It received accolades for its revolutionary architectural approach and its emphasis on social consciousness. The venture made significant strides both in form and in societal impact, embellishing a pivotal communal urban expanse (FOA, 2014).



Figure 17: Yokohama International Passenger Terminal (Foreign Office Architects, 1995-2002)

Another prominent early project was orchestrated by Greg Lynn (FORM), Douglas Garofalo (Garofalo Architects), and Michael McInturf (Michael McInturf Architects) in 1999, using vector-based animation software. This innovative design added a 1500-seat sanctuary atop a refurbished laundry factory, marking its transformation into the New York Presbyterian Church in Queens.



Figure 18: New York Presbyterian Church in Queens, New York (1999)

Among the epoch's standout constructions is the Phaeno Science Center in Wolfsburg, Germany, orchestrated by Zaha Hadid Architects starting in 2000. Inaugurated in 2005, it's hailed as a mesmerizing architectural masterpiece that reshapes our visions of the future. It clinched the 2006 RIBA European Award and the 2006 Institution of Structural Engineers Award for Arts, Leisure, and Entertainment Structures (RIBA, 2006).

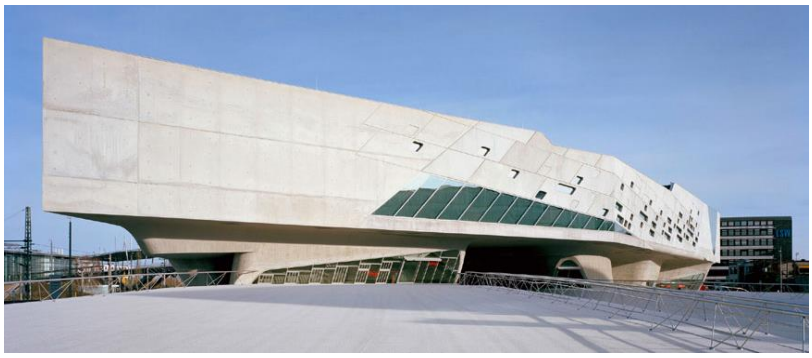


Figure 19: Phaeno Science Center (Zaha Hadid Architects, 2000-2005)

An ensuing exemplar is the 22-story 0-14 tower in Dubai, UAE (2007), conceived by Reiser + Umemoto. Its structural shell boasts a distinctive lace-like facade tailored for modulated light and perspectives. The meter-wide gap between the shell and primary enclosure fosters natural ventilation, cooling the glass facade. This design is an early representation of the environmental advantages stemming from the adaptive principles of Parametricism. The edifice's load-bearing concrete shell obviates the need for internal pillars and load-bearing partitions (Reiser, n.d.). The Giant Interactive Group Corporate Headquarters, envisioned by Morphosis Architects between 2005 and 2006 and realized between 2009 and 2010, emerges as a testament to organic development from intricacy. The campus encapsulates a plethora of functionalities within a seamless undulating plane, which rises and sinks into the ground, sculpting a novel artificial landscape (Jain, R. 2020).

4.5.3 Parametricism 1.0 (2009-2014)

There has been a notable worldwide shift in avant-garde architecture recently, suggesting the emergence of a distinct style known as Parametricism. This style has its origins in digital animation techniques and has been further refined through advanced parametric design systems and scripting methods. Developed over the past 15 years, Parametricism now dominates the realm of avant-garde architecture. This style marks the end of an interim period of ambiguity that followed the crisis of modernism, characterized by fleeting movements such as Postmodernism, Deconstructivism, and Minimalism (Schumacher, 2008).

Significant architectural projects embodying the Parametricism style were executed after the 2008 global financial crisis. Notable among these is Coop Himmelb(l)au's Dalian International Conference Center in Dalian, Liaoning, China, finalized in 2012. This structure has become a distinguishing landmark and stands as the focal point of the rising Central Business District in Dalian, introducing a parametric design adjacent to the Bay of Korea. The building's exterior presents a dynamic and fluid vector field that aligns the penetration of natural light with the spatial organization within (ZHA, 2014).



Figure 20: Dalian International Conference Center (Coop Himmelb, 2008-2012)

The most expansive among these projects is the Dongdaemun Design Plaza in Seoul, South Korea, conceptualized by Zaha Hadid Architects in collaboration with Samoo. This development contributed to Seoul's recognition as the World Design Capital in 2010. The construction employed cutting-edge fabrication techniques, specifically in the crafting of "45,000 aluminum panels of varying sizes and curvatures." The facade, characterized by the designers as "a field of pixilation and perforation patterns," transitions from a solid structure during the day to a vibrant light display at night.

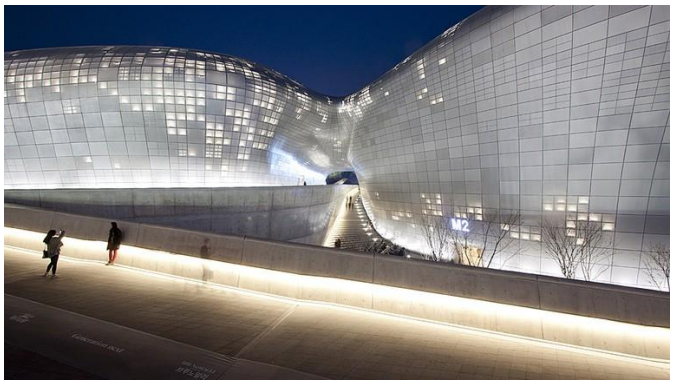


Figure 21: Dongdaemun Design Plaza at Night (Zaha Hadid Architects, 2009-2014)

4.5.4 Parametricism 2.0 (2015 - present)

During a 2014 discussion between Michael Hansmeyer and Patrik Schumacher of ZHA, held as part of "The New How" lecture series at Princeton University School of Architecture, Schumacher introduced the concept of "Parametricism 2.0". This term denotes an advanced and fully evolved version of Parametricism, integrating impactful parameters (Garcia, 2014). Schumacher stressed that with two decades of accumulated expertise, Parametricism is poised to become mainstream, addressing the comprehensive range of societal architectural needs, from structural articulation to environmental compatibility (Garcia, 2014).

Projects currently being designed under the Parametricism 2.0 framework include Google's California Headquarters by Bjarke Ingels (BIG) and Thomas Heatherwick (Heatherwick Studio), the Beijing New Airport Terminal Building by Zaha Hadid Architects, which is anticipated to be the world's largest airport terminal, and the Harbin Cultural Center in Harbin, Heilongjiang, China by MAD Studio.



Figure 22: Beijing New Airport Terminal Building in Beijing China by Zaha Hadid Architects



Figure 23: Harbin Cultural Center in Harbin, Heilongjiang, China by MAD Studio



Figure 24: Harbin Cultural Center in Harbin, Heilongjiang, China by MAD Studio

4.6 Subsidiary and Transitional Styles in Parametricism

4.6.1 Foldism

The primary subsidiary style is underpinned by a straightforward concept heavily fortified by scientific and engineering principles. Fordism emphasizes creating intricacies without incorporating a multitude of elements. Designers leverage the same plane to articulate various architectural interconnections and characteristics inherent in their designs. Such an approach engenders fluid spaces that seamlessly adapt to both their external context and internal prerequisites. This technique was manifest in several designs by Zaha Hadid Architects during the early adoption of Parametricism, as illustrated in the subsequent figures.

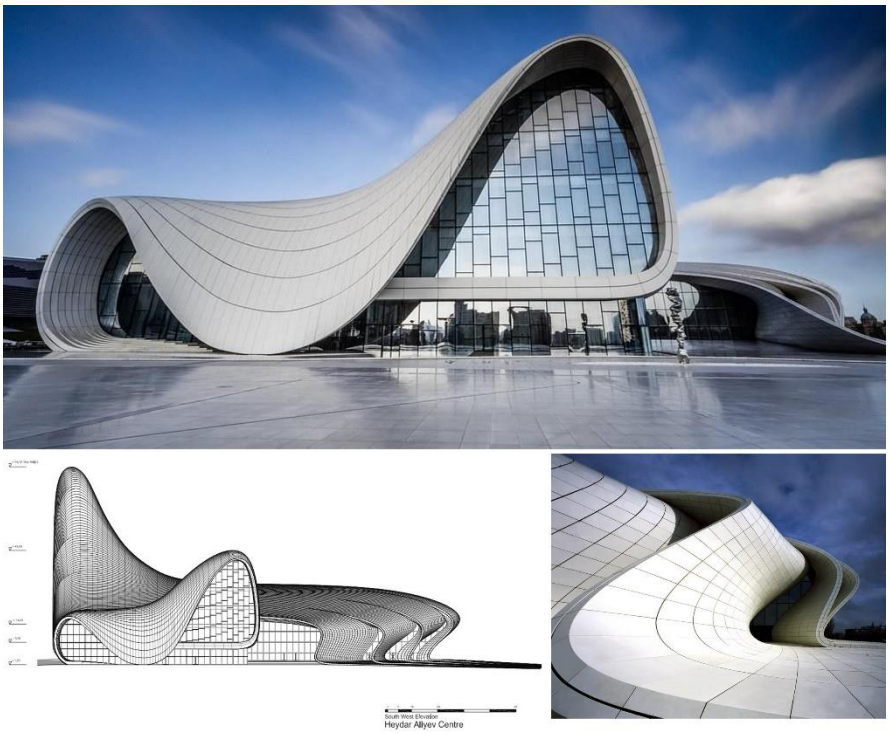


Figure 25: The Heydar Aliyev Center, Baku, Azerbaijan Designed by Zaha Hadid

Blobism is the fusion of Blob into volume. It delivers new level of complexity against the existing urban landscape. The terms "blob architecture," "Blobism," and "Blobismus" describe an architectural movement characterized by organic, amoeba-like building forms (Curl & Wilson, 2015). While the phrase "blob architecture" gained traction in the mid-1990s, "Blobitecture" first appeared in print in William Safire's 2002 New York Times Magazine column titled "Defenestration" (Safire, W. 2002). Despite its initially pejorative connotation, the term persisted and is now commonly used to denote structures with curved and rounded forms. Czech-British architect Jan Kaplický introduced the term "blob" in reference to the "Blob Office Building" in London in 1986, characterized by its organic, aerodynamic shape coupled with advanced technological and energy-efficient features. The phrase "blob architecture" was popularized by architect Greg Lynn in 1995 during his digital design experiments using metaball graphical software (Schumacher, P. 2010). This software, alongside others, paved the way for architects and designers to craft unique forms.

Such designs, despite their organic appearance, are intrinsically tied to computer-aided design programs. These forms arise from algorithmic manipulations on computer modeling platforms. Other essential digital tools include nonuniform rational B-splines (NURB), freeform surfaces, and the digitalization of sculpted forms through methods similar to computed tomography (Waters, J. K. 2003).



Figure 26: Sage Gateshead is a Music Education and Concert Centre, the South Bank of the River Tyne in Gateshead. By Foster and Partners, 2004.



Figure 27: Galaxy SOHO is an Urban Complex Building Located in Beijing, China. Built Between 2009 And 2012, It is The First of Two Buildings Designed by Iraqi-British Architect Zaha Hadis in Which Directly Reflecting the Blobism in Parametric Architecture

4.6.2 Swarmism

At the core of parametric design lies the principle of associative modeling, emphasizing the interconnectedness of geometric shapes across all design components. These interdependencies demand a designer's innovative prowess. But these are not mere geometric fits; they can be strategically chosen. The design emphasizes the relations sustained among the composition's elements. The parametric design model is envisioned as a nexus of relationships or dependencies. The unique feature of parametric design is its topology, not its temporary specific shape. Such flexibility benefits continuous design modifications during the process and promotes the generation of alternatives. The parametric model can be seen as a foundational building blueprint for producing diverse versions that can coexist. Repetition gives way to mass customization, allowing for versioning even within one building design.

For instance, façade components might populate a volume's surface with varying curvature. These components are designed to auto-fit to surfaces, each adopting a custom-fit shape based on the foundational blueprint, leading to continuously varied arrays of elements. This differentiation impacts both the individual form of the elements and their orientation and distribution density.

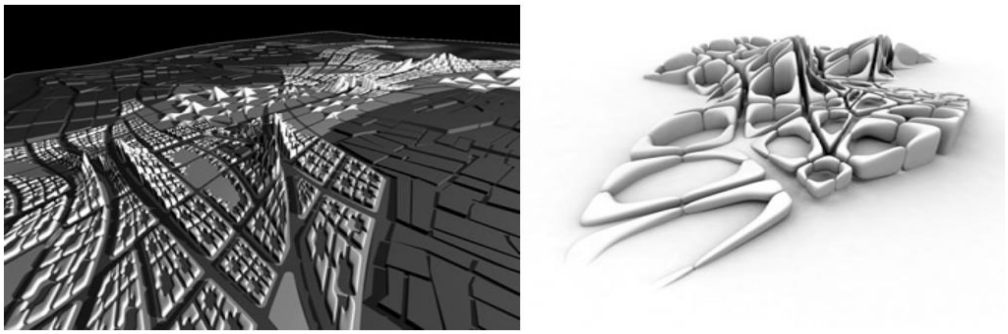


Figure 28: Zaha Hadid Architects, Kartal-Pendik Masterplan, Istanbul, 2007

4.6.3 Tectonism

Tectonism emphasizes the advanced elevation of engineering and fabrication-centric form-finding and optimization processes. Nonetheless, it doesn't signify a divergence from Parametricism. In fact, tectonism represents the most predominant and promising sub-style within the overarching and historical style of Parametricism. Looking back, one can differentiate tectonism from earlier stages of Parametricism, such as Foldism and Blobism. Even though these antecedent sub-styles continue to be practiced, they coexisted during the Modernism period just as the initial white Bauhaus style existed alongside subsequent Unlike these antecedent sub-styles, tectonism incorporates a range of technical rationalities, ensuring heightened efficiency and morphological rigor. Moreover, it retains ample design flexibility to tackle programmatic and situational requirements. Given that the principles of tectonism are inherently diverse and open-ended, this added rigor is complemented by enhanced tectonic diversity, thus

providing a fresh array of morphological physiognomies. Such an approach equips designers with the ability to bestow a distinct, identifiable character to specific projects. In comparison to Foldism or Blobism, tectonism offers a broader spectrum of expressive diversity without veering towards capricious form generation.

While the primary design objective continues to be Parametricism’s aim for adaptive versatility and intricacy, tectonism approaches these goals with an expanded array of parametric influencers and boundaries. These influencers stem from advanced computational engineering strategies, now accessible to architects during preliminary design phases through structural form-finding instruments like RhinoVAULT (suited for intricate compression-only shells) and physics mechanisms like 'kangaroo' for 'grasshopper' (to simulate shell or tensile structures). Furthermore, analytical utilities such as Principle Stress Lines analysis in ‘Karamba’ can be transformed into generative tools. There are also optimization instruments like structural topology optimization (for instance, found in ‘millipede’). Numerous fabrication and material-centric geometric boundaries can be incorporated into generative design methodologies, which can then navigate the unique solution space defined by these limitations. Within ZHA CODE, extensive efforts are being made to create custom tools tailored for specific fabrication constraints.

Tectonism introduces innovative technical rationalities and new articulatory depths, evolving from pioneering endeavors to conceive and employ novel forms of robotic fabrication, inclusive of diverse robotic 3D printing techniques. It's crucial to acknowledge that, akin to prior phases in Parametricism's evolution, tectonism is already being implemented across various design fields, with architecture remaining its primary domain.

In Figure 29, the design leverages the immense geometric intricacy and precision enabled by cutting-edge 3D-printing technologies. This design was conceived through several consecutive optimization strategies: After establishing the exterior edge line, the surface was formed using mesh relaxation with Kangaroo. This surface then served as the foundation for a structural topology optimization, resulting in a reinforcement pattern through iterative subtraction. Subsequently, this pattern underwent two gradient geometric alterations: initially modulating the surface's depth and then augmenting the perforation amidst the emerging ribbing network's lines (Fig. 29).



Figure 29: ACADIA 3D Printed Chair, ZHA CODE, Printed by Stratasys, Presented at ACADIA 2014

Figure 30 presents a self-supporting, multi-panel shell employing curved-crease folding to produce curved surfaces crafted from sheet materials. This fabrication process encompasses robotic cutting, scoring, and folding of 1.5 mm aluminum sheets. These manipulated components are subsequently bolted to construct a complex double-curved shell, which emerges from the pattern without necessitating a mold (Fig. 30).



Figure 30: ARUM, Zaha Hadid Architects/ZH CODE, with Buro Happold and Robofold, Venice Biennale 2012

Similarly, as demonstrated in Figure 31, Felix Candela's Capilla San Vicente de Paul in Mexico City is composed of three Hyperbolic Paraboloids whose apexes converge high above ground level. This version adopts an interrupted symmetry as opposed to Candela's sleek shell. Here, the shell is layered in a grid pattern, where the mesh design aligns with the primary stress lines determined using the structural analysis software, 'Karamba' (Fig. 31).

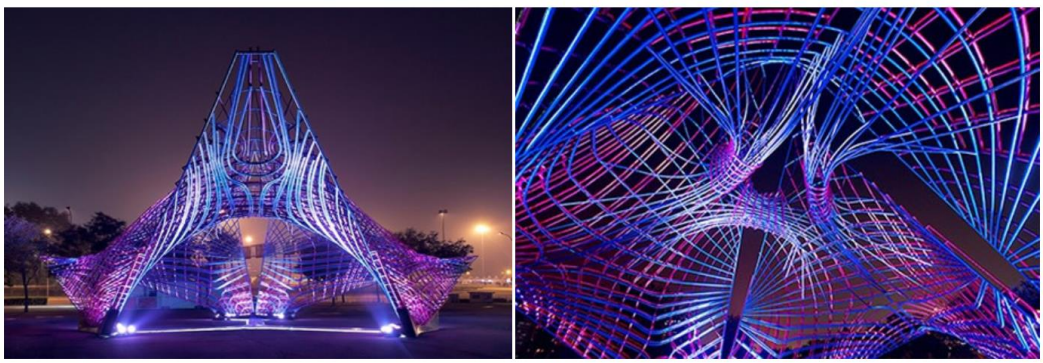


Figure 31: Candela Revisited, ZHA CODE with Bollinger-Grohmann, Beijing International Architecture Biennale 2013

4.7 Expanded Role of the Architect in Parametric Architecture

Recent applications of parametric designs in architecture underscore the exploration and challenges presented by the parametric-enabled approach, prompting a re-evaluation of conventional architectural practices. Historically, architects relied solely on traditional tools. Although theoretical frameworks and sketches remain vital, there is an undeniable transition to digital platforms, as outlined by Chokhachian and Atun (2014) and Jester (2014). Numerous Late Modernist architects employ digital parametric tools to uphold a modernist aesthetic, diligently probing the capacities of these refined instruments. More than a mere stylistic product, many designs are intricate topographical models that, in a pre-digital era, posed challenges both in representation and fabrication, incorporating extensive parameterization levels.

The allure of parametric processes lies in their potential to achieve heightened complexities. While some might misconstrue parametric design as a sign of architectural indolence, mastering such designs, though accessible at the onset, proves challenging. The current trend in parametric design emphasizes integrating BIM-authoring tools with conceptual design, analysis, and simulation mechanisms. This raises the question of the architect's precise role throughout these design stages. Unquestionably, architects did not influence the inception of these digital tools but have assimilated and utilized them, as noted by Abdelmohsen (2008), Chokhachian and Atun (2014), Kolarevic (2004), and Rybczynski (2013). In this light, the parametric paradigm cautions that architects' failure to adapt might lead to their roles becoming increasingly peripheral.

With the integration of parametric models, computers transcend mere digital drafting, actively assisting architects in design exploration and decision-making. Consequently,

the architect's role is evolving and undergoing redefinition. Architects now navigate a transformative phase, broadening their expertise spectrum, delineating knowledge-building and representation mechanisms, identifying problem-solving resources, and overseeing data exchange methods within this newly defined paradigm. Simultaneously, they continue to uphold the architect's traditional responsibilities.

This expanded role, although demanding, remains crucial. While computers can aid designers, it is essential that they recognize the broader context. Architects incorporating computer assistance should be mindful that these tools do not supplant fundamental design principles. Instead, computers facilitate design exploration in novel ways, receiving significant endorsement from the architectural community.

However, it's imperative to note that this digital parametric approach does not render the designer redundant. Instead, it allows the designer to delegate specific tasks to the computer, effectively integrating human intelligence with computational capabilities. Nevertheless, mastering this technology should not detract from the architect's inherent artistic nature. The primary objective remains to envision beyond the tool itself. Through their work, architects aim to comprehend the cultural, societal, historical, and temporal dimensions, with their designs echoing societal values, beliefs, and emotions, as discussed by Abdelmohsen (2008), Chokhachian and Atun (2014), and Dino (2012).

4.8 Parametric Design Thinking

Parametric design thinking has emerged as a significant theoretical subject, irrespective of specific styles or design tools, becoming a crucial paradigm of digital design (Oxman and Gu, 2013). As new languages and tools arise, compared to traditional parametric models, it is imperative to develop and examine a generic formulation of a Parametric Design Schema as a holistic theoretical framework for supporting design endeavors. Karle & Kelly (2011) characterize this process as one

that integrates tangible and intangible systems into a design proposition, divorced from the specificity of digital tools. It emphasizes commencing the design process with parameters, rather than starting with preconceived or established design solutions. Far from being just another digital method, parametric design thinking encompasses a deeper comprehension of parametric structures of design knowledge, which can be encapsulated and depicted as generic parametric schema. The prevalence of design patterns in specific areas is an occurrence noted by numerous scholars in both conventional architectural design (Alexander et al., 1977) and in parametric design (Woodbury et al., 2007). Brett Steele posits that parametric design knowledge embodies a design thinking model that melds topological patterns with generic typologies. This intellectual capacity is referred to as the "serial".

4.9 Heuristics in Parametricism

Heuristic are principles that guide the design process. So they give an operational definition of Parametricism. The formulation of these principles is based on observations. So by looking at what we and a lot of other architects have done for the last ten to fifteen years, what students are doing globally, and I analyzing what general features and values these efforts share. And “heuristics” means rules/guidelines of how to progress a project, what to avoid in order not to fall back into old ways, to have a clear demarcation against older styles, and how to approach the project and advance it via specific design steps. So in order to set up a clear research hypothesis, you need to clearly negate some ways of working (Schumacher P. 2012).

4.9.1 Formal Heuristics

The functional heuristics of Parametricism include both Negative Principles and Positive Principles that have evolved since the mid-1990s across many projects worldwide, and that together constitute unifying heuristics. The Negative Principles

include the avoidance of functional stereotypes (i.e. prescriptive program typologies), and the avoidance of segregative functional zoning (i.e. impermeable separation spaces according to single function allocation). The Positive Principles include the networking of parametric activity/event scenarios, and the communication of all spaces, activities and events (Schumacher, P. 2012).

4.9.2 Functional Heuristics

Similar to the Functional heuristics, there are unified Formal heuristics distinguishing Parametricism from other styles of architecture. The Negative Principles include the avoidance of rigid forms that lack malleability; the avoidance of simple repetition that lacks variety; and the avoidance of collage of isolated and unrelated elements that result in a lack of order. The Positive Principles include the intelligent information-rich deformation of soft forms; differentiation of all systems through gradients, thresholds and singularities; and interdependent correlation of all systems (Schumacher, P. 2012).

4.10 Critical Comparison of Parametricism

This section intends to provide critiques of parametricism and compare it against another alternative with the ultimate aim of highlighting directions for which parametricism can be further improved and rendered. Parametricism and Parametric Architecture/Design represent a pivotal moment in the evolution of architectural theory and practice, highlighting a shift towards the integration of computational algorithms and digital fabrication techniques in the design process. The distinction between these concepts, as outlined in Table 2, offers a foundation for understanding their specific applications, methodologies, and implications within and beyond the architectural domain. Parametricism, characterized by its broad theoretical framework, signifies a movement that transcends traditional architectural boundaries, advocating

for a design philosophy that leverages algorithmic processes and digital technologies to foster innovation and complexity in architectural forms. This movement, propelled by figures like Patrik Schumacher, aims to redefine architectural aesthetics, functionality, and the very process of design through the utilization of parametric modeling tools and computational strategies. In contrast, Parametric Architecture narrows this broad vision to the specifics of architectural practice, focusing on the use of parametric design principles to craft buildings and spaces that respond to a myriad of parameters and constraints through sophisticated computational models. Parametric Design, meanwhile, extends the reach of these principles across various design disciplines, emphasizing the role of algorithms and parameters in shaping the built environment, irrespective of the scale or context. The discussion around Parametricism, while enriched by its innovative approach to design and architecture, is not without its critics, Table 3. One of the primary concerns raised against Parametricism relates to its design flexibility. Critics argue that an over-reliance on complex computational algorithms and the preoccupation with generating avant-garde forms can sometimes limit designers' ability to respond to the unique needs of a project or to adapt their designs to evolving requirements. This critique points to a potential rigidity within Parametricism, suggesting that despite its technological sophistication, it may lack the practical adaptability necessary in the ever-changing landscape of architectural design. Furthermore, the critique underscores the importance of maintaining a balance between innovation and pragmatism, urging designers to ensure that their reliance on parametric tools enhances rather than constrains their creative and responsive capacities.

Table 2: Comparative Assessment of Parametricism, Parametric Architecture, and Parametric Design (Assasi, 2019).

Aspect	Parametricism	Parametric Architecture	Parametric Design
Definition	A theoretical framework that defines a specific architectural style embracing parametric modeling and computational design.	The application of parametric design principles, specifically within the architectural field, to create forms and designs controlled by parameters and algorithms.	A broad methodological approach utilizing variables and parameters to build and modify digital models, applicable across various design disciplines beyond architecture.
Key Features	Emphasis on algorithmic design processes. Non-linear geometries. Differentiation and variation. Adaptive responsiveness. Digital fabrication. Dynamic formalism. Interdisciplinary collaboration.	Use of digital fabrication technology. Integration of programming languages. Application of parametric modeling approaches for architectural solutions.	Scripting and algorithm writing. Design experimentation and refinement. Cross-disciplinary application (product, industrial, urban planning design).
Focus	Defines a style and movement within architecture and beyond, characterized by the use of parametric modeling tools.	Focuses on the specific application of parametric design concepts to create innovative architectural solutions.	Emphasizes the process of design through the manipulation of parameters applicable in a wide range of design fields.
Technological Integration	Utilizes advanced computational tools and algorithms for creating complex, adaptive designs.	Involves the creation of architectural forms using specific parametric modeling software like Grasshopper for Rhino or Dynamo for Autodesk Revit.	Involves the use of computational tools to explore design possibilities, optimize performance, and generate complex forms across different design areas.
Scope	A broader design movement that impacts architecture and other design fields.	Specifically tailored to the architectural domain, with a focus on creating personalized and inventive designs.	A versatile and methodological approach that transcends architecture, being applicable in product, industrial, and urban design.
Origins and Proponents	Popularized by Patrik Schumacher, emphasizing a new architectural movement via computational design.	Recognized within architectural practice for its innovative approach to design and fabrication.	Broadly applicable across design disciplines, not limited to or defined by a specific movement or style.

Cultural sensitivity emerges as another significant critique of Parametricism. Observers have noted that parametric designs can sometimes appear disconnected from the cultural, historical, and environmental contexts within which they are placed.

The global application of parametric principles, without adequate consideration for local nuances, can lead to an architecture that feels alien or inappropriate to its surroundings. This critique emphasizes the need for parametricism to integrate cultural empathy and contextual awareness into its design process, ensuring that buildings not only showcase technological prowess but also resonate with the local identity and heritage. The human scale and accessibility of parametric designs have also been called into question. The pursuit of grandiose, sweeping forms characteristic of Parametricism can result in spaces that, while visually striking, may feel overwhelming or impersonal to users. This critique highlights the necessity of prioritizing human comfort, scale, and interaction within the design process, advocating for an architecture that, despite its computational origins, remains deeply human-centric. Economic accessibility presents another hurdle for Parametricism. The specialized knowledge and technology required for parametric design can render it an expensive approach, potentially confining its application to projects with substantial budgets. This limitation raises concerns regarding the inclusivity of Parametricism and its capacity to address a broader spectrum of architectural challenges beyond the realm of elite, high-profile developments. Finally, engagement with criticism is a crucial facet of the discourse surrounding Parametricism. Some critics have observed a tendency within the parametric design community to overlook or dismiss critical feedback, particularly concerning the livability, practicality, and social implications of parametric designs. This reluctance to engage with critique not only stifles dialogue but also impedes the evolution of Parametricism into a more adaptable, contextually aware, and human-centered design philosophy.

Table 3: A Brief Critical Comparison of Parametricism.

Aspect	Critique of Parametricism	Key Benefits of Alternative
Design Flexibility	Over-reliance on complex algorithms can limit spontaneity and adaptability in design.	Allows for adaptable designs that can evolve over time with changing user needs.
Sustainability	Highly complex designs can detract from environmental goals.	Emphasizes efficiency and sustainability through designs inspired by nature, potentially reducing environmental impact.
Cultural Sensitivity	Designs may lack context, failing to integrate or respect local culture and heritage.	Incorporates local materials, techniques, and forms, enhancing cultural relevance and community acceptance.
Human Scale	Some parametric designs can feel alienating or impersonal due to their scale and form.	Prioritizes human needs, comfort, and scale, making spaces more accessible and enjoyable.
Economic Accessibility	The cost and complexity of parametric designs can limit their accessibility to high-budget projects.	Focuses on affordable, low-tech solutions that promote sustainability without the need for expensive technology.
Criticism Engagement	Limited engagement with critical feedback regarding the practicality and livability of designs.	Engages community members and stakeholders in the design process, ensuring that projects meet actual needs and preferences.
Realism and Feasibility	Assumes perfect ease in designing intricate forms with CAD, overlooking software limitations and the rough discretization of surfaces. This idealization can lead to unfeasible designs due to the practical challenges of construction and material suitability.	Prioritizes designs that are realistic and feasible within current construction techniques and materials, ensuring that projects are not only innovative but also practical and executable within reasonable budgets, thus bridging the gap between concept and reality.

4.11 Influence of Parametric Architecture on Architectural Sustainability

Parametric architecture, as an architectural style, is intrinsically versatile and adaptable, qualities that position it at the forefront of sustainable architectural practices. It provides architects with the computational tools to model, manipulate, and optimize design variables, thereby tailoring architectural responses to both local environmental conditions and material efficiencies. Consequently, parametricism is not just a stylistic evolution, but a crucial pathway to more environmentally attuned and sustainable architecture" (Kolarevic & Malkawi, 2005; Menges & Ahlquist, 2011).

4.11.1 Energy Efficiency through Form Optimization

Parametricism, as an architectural style, is intrinsically versatile and adaptable, qualities that position it at the forefront of sustainable architectural practices. It provides architects with the computational tools to model, manipulate, and optimize design variables, thereby tailoring architectural responses to both local environmental conditions and material efficiencies. Consequently, parametricism is not just a stylistic evolution, but a crucial pathway to more environmentally attuned and sustainable architecture" (Kolarevic & Malkawi, 2005; Menges & Ahlquist, 2011).

4.11.2 Material Efficiency

Parametricism, with its ability to manipulate design parameters, opens up vast opportunities for architects to delve into a broad spectrum of design solutions and material efficiencies that were hitherto challenging to realize. Through parametric adjustments, architects have the capability to fine-tune designs to align with specific material requirements, thereby minimizing wastage during the construction phase. This precision in material usage and reduction in waste not only lowers the environmental impact but also has economic benefits. Furthermore, parametricism fosters the optimization of structural performance, leading to designs that fulfill their intended function with minimal material usage. This enhances the material efficiency of the building and promotes a more sustainable approach to construction and design" (Kilian, 2006; Beorkrem, 2012).

4.11.3 Adaptability and Longevity

The inherent flexibility of parametric design bestows upon structures the capacity to adapt over time, thereby extending their functional lifespan. Buildings conceived through parametric design principles exhibit an inherent capacity for modification to meet evolving user needs or accommodate changing environmental conditions. This

potential for adaptability reduces the need for energy-intensive practices such as demolition and new construction. By facilitating design longevity and flexibility, parametricism plays a significant role in enhancing the sustainability of the built environment (Kolarevic, 2003; Jabi, 2013).

4.11.4 Responsive Urban Design

In the context of urban design, parametric tools can be harnessed to foster more sustainable cities. By simulating diverse urban parameters—population density, green space distribution, and transportation infrastructure, to name a few—urban planners can utilize these tools to enhance walkability, promote efficient transport, and ultimately, reduce urban carbon footprints (Batty, 2008; Duarte, 2011).

Nevertheless, while the potential of parametricism to augment sustainability is substantial, it is critical to acknowledge that the tools themselves are not autonomous agents of sustainable outcomes. Rather, their effective use is contingent upon the architects and planners who wield them. It is the deliberate alignment of parametricism with sustainability principles that ensures this potent design methodology truly contributes to a more sustainable architectural and urban future (Picon, 2010).

4.11.5 Parametric Architecture's Varied Impact on Sustainability

On the other hand, it is essential to recognize that the sustainability of parametric design outcomes is not solely determined by the tools themselves but by how they are applied. Parametric design methodologies offer architects the tools to create buildings that are not only architecturally expressive but also environmentally responsive. The precise manipulation of design parameters enables the optimization of natural light, thermal comfort, and energy efficiency, contributing positively to a building's sustainability credentials. Moreover, the ability to simulate environmental conditions and predict performance outcomes allows for more informed decisions that align with

sustainable design principles. However, the application of parametricism is not without its criticisms. For instance, it is argued that the emphasis on complex forms and innovative facades can sometimes overshadow the fundamental goals of sustainability. High-profile projects by renowned architects have sparked debate over whether the aesthetic qualities of parametric designs come at the expense of practical, sustainable solutions. These concerns underline the importance of grounding parametric design in a sustainability-first approach, where environmental considerations are integral to the design process rather than secondary considerations. Furthermore, the material choices and construction techniques associated with parametric designs can have significant environmental impacts. While parametric tools enable the optimization of material usage and structural efficiency, the actual construction processes involved in realizing intricate designs can be resource-intensive. Therefore, a critical assessment of the entire lifecycle of parametrically designed buildings is necessary to fully understand their sustainability impact. Parametricism also holds the potential to revolutionize urban design, offering scalable solutions that can enhance the sustainability of cities. Through the strategic planning of urban spaces, transportation systems, and green infrastructure, parametric tools can support the development of more sustainable urban environments. However, this potential is contingent upon a holistic application that considers social, economic, and environmental sustainability dimensions. In addressing the critique of parametricism's impact on sustainability, it is clear that the discipline is at a crossroads. The path forward requires a conscientious application of parametric tools, where sustainability is not an afterthought but a fundamental design criterion. By embracing this challenge, architects and designers can leverage the full potential of parametricism to contribute to a more sustainable and environmentally responsible built environment.

4.12 Findings and Remarks

According to the study conducted above, we can come up with some findings through the critical review of the literature regarding styles and parametricism

- There are new considerations for the architectural style of the 21st century. The trend toward Reconsidering Architectural Styles reflects a desire to find new and creative ways to design buildings and spaces that are both functional and aesthetically pleasing.

Table 4: Content Analysis of the Existing Sources According to the Process Development of Parametricism, by the Author.

Authors	Year	Explanation
Sutherland	1963	The first use of parametric design concepts through a graphic user interface system occurred in Sutherland's Ph.D. research, which allowed him to draw with the computer and apply changes parametrically at the same time (Fernández-Álvarez, Á. J. 2020, June).
Morretti	1971	Parametric Architecture is the examination of how the dimensions of a design are interconnected and dependent on specific parameters. (Caetano, I., Santos, L., & Leitão, A. 2020).
Kalay	1989	When parameters are altered, the geometric relationships determined by computation are automatically adjusted. (Caetano, I., Santos, L., & Leitão, A. 2020).
Schumacher	2008	The concept of "Parametricism" as a design style was first introduced in the "Parametricism Manifesto" and further explored in subsequent papers and a book titled "The Autopoiesis of Architecture" in 2011. The author outlined certain principles, known as "Dogmas," that must be adhered to in order to create a parametric design, as well as other principles, referred to as "Taboos," that should be avoided. (Schumacher, P. 2008).
Woodbury	2011	The process of investigating the links between geometric concepts is known as parametric design (Woodbury, R. 2010).
Frazer	2016	Parametric architecture is evolving and re-positioning itself as a dynamic process that takes into account the latest technologies, as well as environmental and societal considerations. (Frazer, J. 2016).

Oxman	2017	Parametric design is considered a novel approach to design thinking. It brings innovative ideas and shifts the focus from typological thinking to topological design thinking in the creative design process, which is considered a significant transformation in the way of design thinking (Oxman, R. 2017).

- Parametricism has Subsidiary and transitional styles. It is not uncommon for architectural styles to evolve and incorporate elements from other styles. In the case of parametric architecture According to the study, Parametricism is a style followed by several subsidiary styles and one transitional style as shown in the table below.
- Parametricism is the epochal active reflective style of the era, followed by three subsidiary styles within the upgraded Parametricism which are Blobism, Foldism, and Swarmizm. Finally, a Transitional Style named Tectonism.

Table 5: Active Reflective Styles of Parametricism Drawn by the Author.

Styles	Epochal Style	Subsidiary Style	Transitional Style
Active reflective Style	PARAMETRICISM	BLOBISM	
		FLODISM	
		SWARMIZM	
			TECTONISM

- As with many epochal styles, Parametricism has its Heuristics. Throughout the study, it's confirmed that Parametricism is using certain principles called heuristics to gain specific design outcomes. The Heuristics are divided into two groups which are Formal Heuristics and Functional Heuristics, each group includes both Negative Principles and Positive Principles that have evolved since the mid-1990s across many projects worldwide

Chapter 5

ANALYSIS AND INVESTIGATION OF THE CASE STUDIES

5.1 Conceptual Framework for Analyzing Case Studies Within Parametric Architecture

This chapter focuses on developing a conceptual framework to understand and analyze parametrically designed buildings and projects within architecture. This frame work is a two -dimensional analysis which are Architectural style and Parametric Architecture Design consideration.

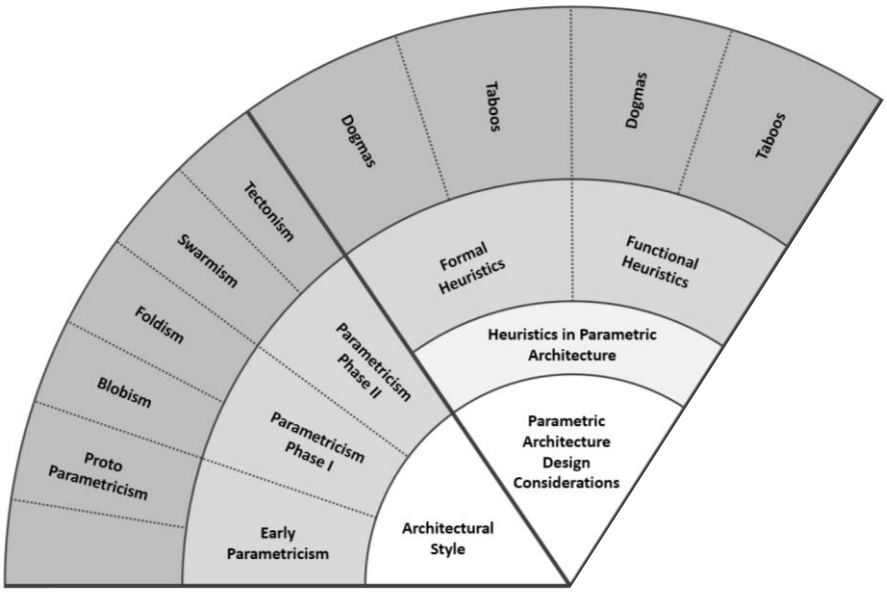


Figure 32: Conceptual Framework for Understanding Analyzing Parametrically Desdigned Bildings and Projects (Author)

5.2 Method of Analysis

A. In the context of my thesis, during the assessment stage, a comprehensive evaluation is conducted for each individual building case, focusing on various critical factors. This holistic evaluation encompasses a range of aspects, beginning with the gathering of general information about the building, including its name, year of construction, and intended function. Additionally, the geographical location is pinpointed to consider regional influences and environmental factors. Any awards or recognitions received by the building are noted to gauge its outstanding features and contributions. The primary architectural facade or main view is carefully described to capture the essence of the building's external appearance. Architectural plans, including floor plans and site layouts, are scrutinized to understand the spatial organization, while elevations provide insights into the building's aesthetic qualities and design elements. These factors collectively provide a comprehensive understanding of each building case, which is instrumental in making informed decisions regarding preservation, renovation, and architectural documentation, aligning with the objectives of my thesis.

Table 6: General Information Collected

General Information	Building Name	
	Year	
	Function	
	Location	
	Awards	
	Main view	
	Plans	
	Elevations	

B. In the context of my thesis, the analysis of architectural style is a pivotal component, encompassing a comprehensive evaluation of the overall information related to the case study. This entails an exploration of the general architectural style, which serves as the foundational framework for the subsequent phases of the style. The architectural style under consideration in this study follows a chronological progression through various phases, namely Proto Parametricism (1952-1992), Early Parametricism (1993-2008), Parametricism 1.0 (2009-2014), and Parametricism 2.0 (2015 - present). Additionally, the study acknowledges subsidiary and transitional styles within the broader context of Parametricism. These subsidiary styles include Foldism, Blobism, Swarmism, and Tectonism, each of which represents distinctive expressions and adaptations within the realm of Parametricism, contributing to the richness and diversity of contemporary architectural discourse. The examination of these style phases and their associated subsidiaries is central to the thesis's objectives, aiming to provide a nuanced understanding of architectural evolution and innovation within the context of Parametricism.

Table 7: Analysis of Architectural Styles

Analysis of Architectural Style	Overall information about the case		
	General architectural style		
	Phases of the style	Proto Parametricism (1952-1992)	
		Early Parametricism (1993-2008)	
		Parametricism 1.0 (2009-2014)	
		Parametricism 2.0 (2015 - present)	
	Subsidiary and transitional style in Parametricism	None	
		Foldism	
		Blobism	
		Swarmism	
		Tectonism	

5.3 Criteria for the Selection of Cases

Since the emergence of parametric architecture many buildings are categorized under this style internationally. In this study a very limited selection is to be used to be analyzed and investigated according to the scope of the study starting with their architectural style and defining their architectural characteristics.

The criteria for selecting the cases are:

- 01 | The buildings purely symbolize the Style
- 02 | According to different levels of Parametricism development throughout the time
- 03 | The most identical & attractive buildings comparing with others
- 04 | The most innovative buildings according to its time.
- 05 | The buildings which may became a part of the city heritage
- 06 | Chose buildings of different architects
- 07 | Buildings which highly communicate with the surroundings and users

5.4 Analysis of the Case Studies

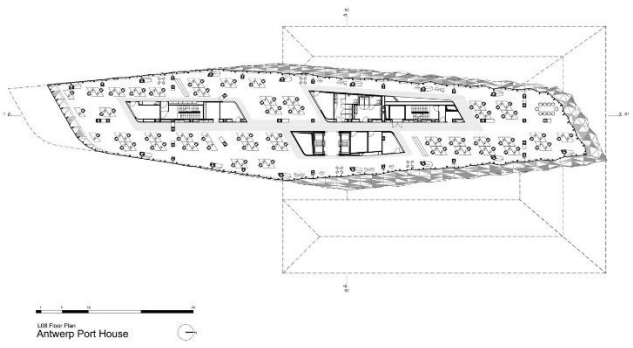
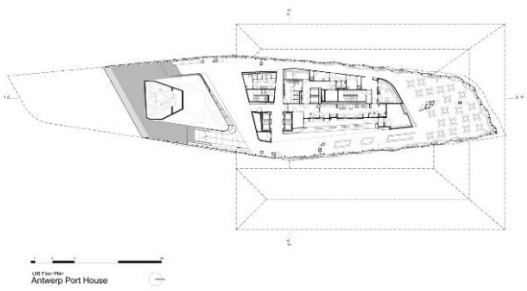
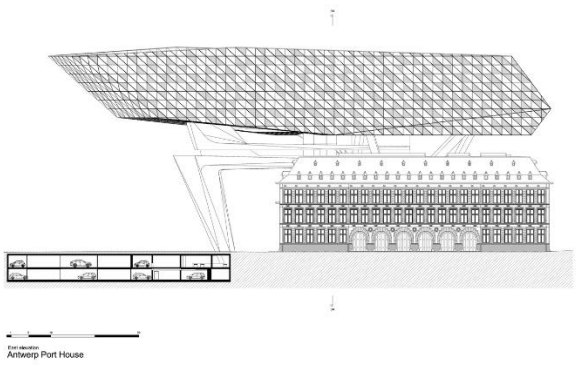
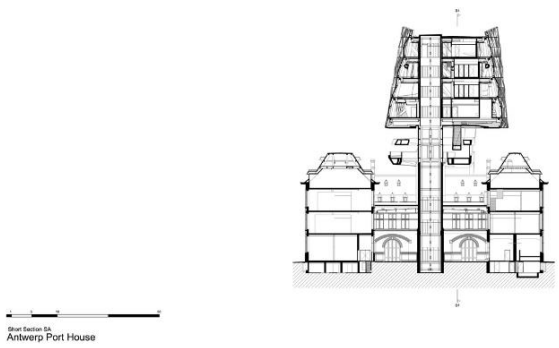
According to the criteria's mentioned above several case studies from different architectural companies and different countries has been selected which are the following:

1. The Port House, Antwerp, Belgium
2. Harbin Opera House Harbin, china
3. KAFD Grand Mosque, Riyadh, Saudi Arabia
4. Guangzhou Opera House, China
5. KAPSARC - King Abdullah Petroleum Studies and Research Center , Saudi Arabia
6. Vessel Public Landmark, China

7. Soumaya Museum, Mexico City, Mexico
8. Galaxy SOHO

The selected cases will pass through intensive analysis according to the tables shown in section 5.2 method of analysis. Meanwhile the analysis will be gathered in one table and explained in detail in findings.

Table 8: The Port House, Antwerp, Belgium

General Information		
	Case No. 01	
	Building Name	**The Port House**
	Year	2016
	Area	12800 m²
	Function	Port House
	Location	Antwerp, Belgium
	Design Firm	Zaha Hadid Architects
	Awards	MIPIM Awards 2018
	Main view	
		
	Plans	
		
	Sections and Elevations	
		

analysis of Architectural Style

Overall Information About the case			▪ The new Port House in Antwerp repurposes, renovates and extends a derelict fire station into a new headquarters for the port. ▪ Bringing together the port's 500 staff that previously worked in separate buildings around the city. ▪ Working with Origin, leading heritage consultants in the restoration of historic monuments, ZHA's studies of the site's history and heritage are the foundations of the design which ○ Firstly emphasizes the north-south site axis parallel with the Kattendijkdok linking the city center to the port. ○ Secondly, due to its location surrounded by water, the building's four elevations are considered of equal importance with no principal facade. ZHA's design is an elevated extension, rather than a neighboring volume which would have concealed at least one of the existing facades.
Architectural Style			
Phases of the style	Proto Parametricism (1952-1992)		
	Early Parametricism (1993-2008)		
	Parametricism 1.0 (2009-2014)		
	Parametricism 2.0 (2015 - present)	■	The construction year is 2016, its considered second phase of Parametricism in which started from 2015 till now.
Subsidiary and transitional style in Parametricism	None		
	Foldism	■	▪ **Algorithm-Driven Forms:** Parametric tectonics utilize algorithms to generate designs. ▪ **Fluid Structures:** The style encourages seamless, flowing structural forms. ▪ **Complexity and Detail:** It allows for intricate, detailed architectural features. ▪ **Adaptive Design:** Parametric tectonics can adapt to site-specific requirements.
	Blobism		
	Swarmism		
	Tectonism		

Table 9: Harbin Opera House Harbin, China

General Information

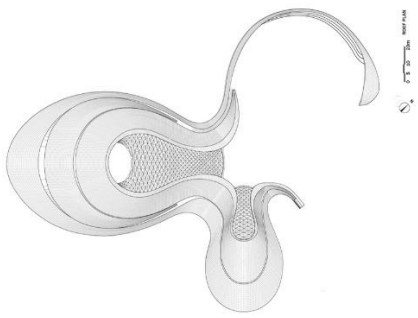
Case No. 02	
Building Name	**Harbin Opera House**
Year	2015
Area	850000 ft²
Function	Opera House
Location	Harbin, China
Design Firm	MAD Architects
Awards	MIPIM Awards 2018

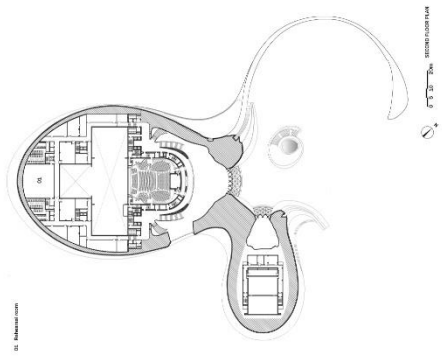
Main view



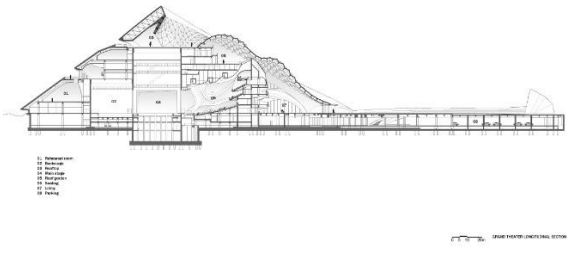


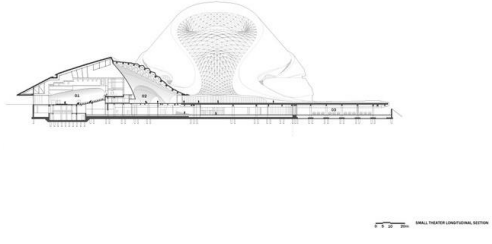
Plans





Elevations

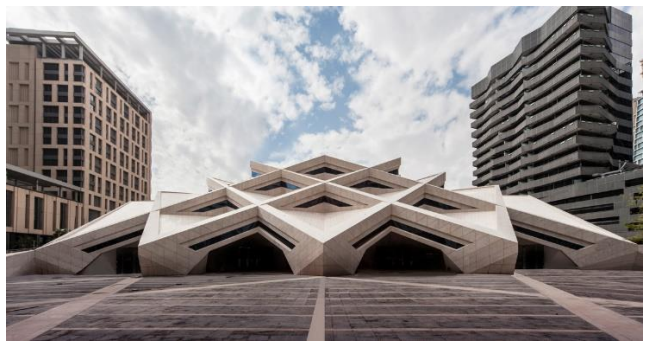
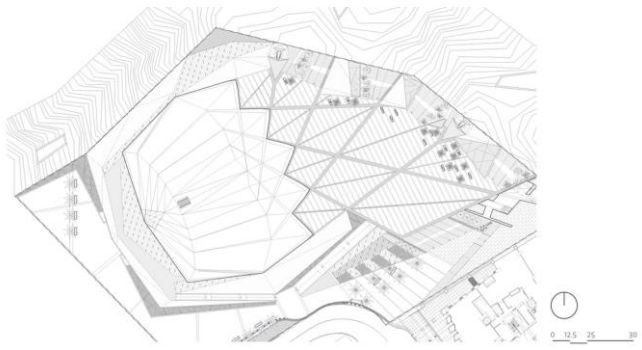
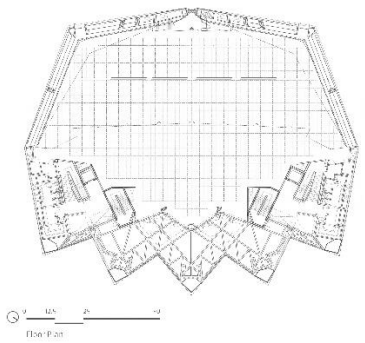
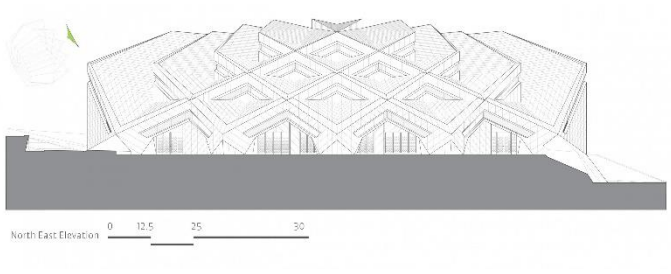
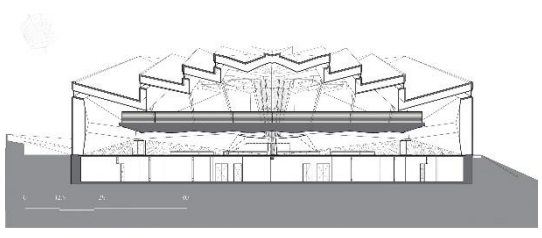




Analysis of Architectural Style

Overall Information About the case			▪ This project is an excellent example of an architectural response to the spirit of place, nature, and local culture. ▪ The Harbin Opera House's design is inspired by the region's extreme winter climate and frigid, snowy landscape. It is set within the wetlands of Harbin and responds to the sinuous landscape of the surrounding nature, appearing as if it's been sculpturally carved from a snowdrift. ▪ The building features two concert halls: the grand theatre, which can seat approximately 1,600 guests, and a smaller theatre to accommodate an intimate audience of 400. ▪ Its flowing forms and spaces are an embodiment of Ma Yansong's "Shanshui City" design philosophy, which translates as 'Mountain-Water City', integrating nature and the urban environment. ▪ The façade and roofing comprise white aluminium panels, providing a reference to the snow-covered topography of Harbin.
Architectural Style			
Phases of the style	Proto Parametricism (1952-1992)		
	Early Parametricism (1993-2008)		
	Parametricism 1.0 (2009-2014)		
	Parametricism 2.0 (2015 - present)	■	The construction year is 2015, its considered second phase of Parametricism in which started from 2015 till now.
Subsidiary and transitional style in Parametricism	None		
	Foldism	■	▪ Creating complexity without use of multiple elements ▪ Complex shape ▪ Simple Elements ▪ Fluidity
	Blobism		
	Swarmism		
	Tectonism		

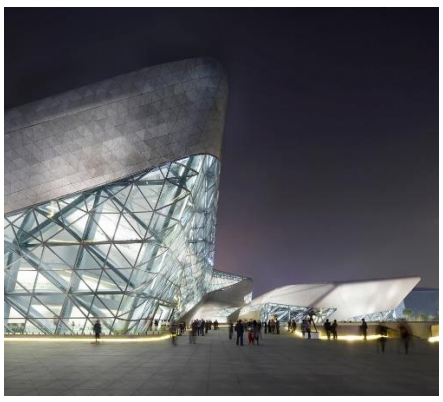
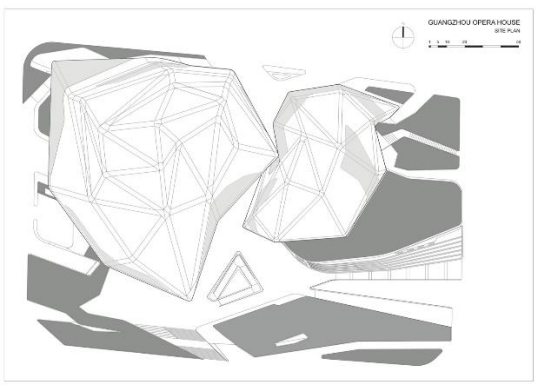
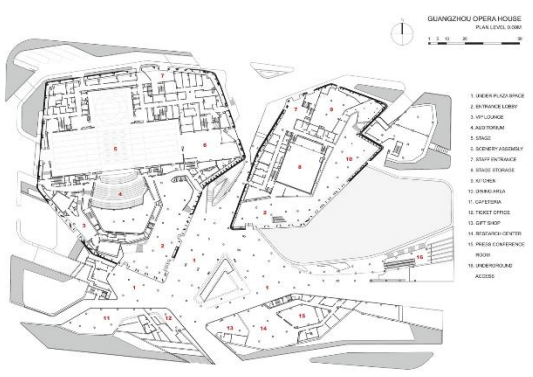
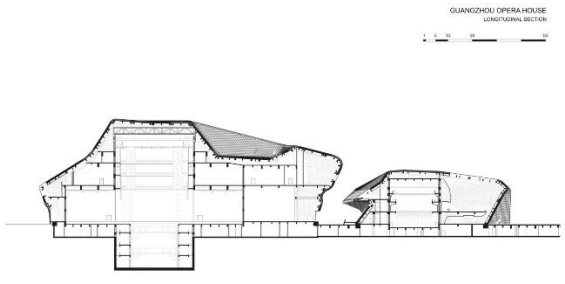
Table 10: KAFD Grand Mosque, Riyadh, Saudi Arabia

General Information		
	Case No. 03	
	Building Name	**KAFD Grand Mosque**
	Year	2017
	Area	10,760 m²
	Function	Mosque
	Location	Riyadh, Saudi Arabia
	Design Firm	Omrania and Associates
	Awards	2017 Finalist, religion - World Architecture Festival 2019 Nomination for Abdullatif Al Fozan Award for Mosque Architecture
	Main view	
		
	Plans	
		
	Elevations	
		

analysis of Architectural Style

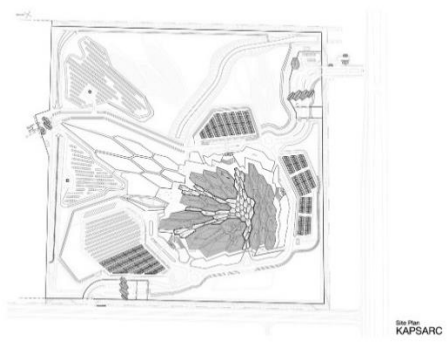
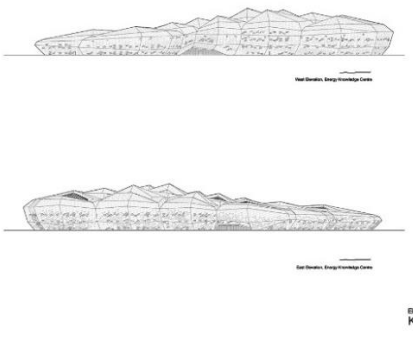
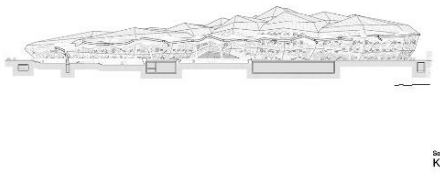
Overall Information About the case			▪ The Grand Mosque in the King Abdullah Financial District (KAFD) is a landmark project in Riyadh, Saudi Arabia. ▪ The Grand Mosque's design embodies a modern interpretation of traditional Islamic principles, art, and culture. It emphasizes a return to the essence of Islamic faith, focusing on the spirituality, simplicity, and sense of community. ▪ The exterior of the building is clad with a geometric pattern that is reflective of traditional Islamic art. ▪ The patterned façade filters the sunlight and creates a meditative play of light and shadow inside the mosque. ▪ One striking feature of the mosque is the minaret. Unlike traditional minarets, the one at the KAFD Grand Mosque is conceived as a vertical garden, bringing a fresh perspective to traditional Islamic architecture. ▪ The Grand Mosque has been designed with sustainability in mind, meeting LEED Silver standards.
Architectural style			
Phases of the style	Proto Parametricism (1952-1992)		
	Early Parametricism (1993-2008)		
	Parametricism 1.0 (2009-2014)		
	Parametricism 2.0 (2015 - present)	■	The construction year is 2017, its considered second phase of Parametricism in which started from 2015 till now.
Subsidiary and transitional style in Parametricism	None		
	Foldism		
	Blobism		
	Swarmism		
	Tectonism	■	▪ **Material Expression:** Tectonic architecture showcases construction materials honestly. ▪ **Structural Emphasis**: The design emphasizes structural elements and joints. ▪ **Form and Function Unity**: Form closely follows function, enhancing structural logic. ▪ **Craftsmanship Valorization**: It appreciates craftsmanship and construction details.

Table 11: Guangzhou Opera House, China

General Information		
	Case No. 04	
	Building Name	**Guangzhou Opera House**
	Year	2010
	Area	70000
	Function	Opera House
	Location	Guangzhou, China
	Design Firm	Zaha Hadid Architects
	Awards	RIBA Architecture Award and AR's Best Public Project Honor Award, 2022
	Main view	
		
	Plans	
		
	Elevations	
		

Analysis of Architectural Style	**Overall Information About the case**			▪ Architecture: The design mimics two pebbles on the bank of the Pearl River, representing a fusion of art, technology, and nature. ▪ Structure: The building consists of two structures, the 1,800-seat Grand Theatre and the 400-seat Multifunctional Hall. ▪ Materials: The design features a distinctive façade made from glass-fiber-reinforced gypsum. ▪ Interior: The interior creates a dramatic, multi-dimensional space with a folded, flowing design. ▪ Landscape Integration: The Opera House's design successfully integrates the urban environment with the natural landscape, linking the river's edge with the cultural district. ▪ Symbolism: The architecture of the building is symbolic of China's rapid modernization and its emerging influence in the fields of art and culture.
	General architectural style			
	Phases of the style	Proto Parametricism (1952-1992)		
		Early Parametricism (1993-2008)		
		Parametricism 1.0 (2009-2014)	■	The construction year is 2010, its considered first phase of Parametricism in which started from 2009 till 2014.
		Parametricism 2.0 (2015 - present)		
	Subsidiary and transitional style in Parametricism	None		
		Foldism	■	▪ **Algorithm-Driven Forms:** Parametric tectonics utilize algorithms to generate designs. ▪ **Fluid Structures:** The style encourages seamless, flowing structural forms. ▪ **Complexity and Detail:** It allows for intricate, detailed architectural features. ▪ **Adaptive Design:** Parametric tectonics can adapt to site-specific requirements.
		Blobism		
		Swarmism		
		Tectonism		

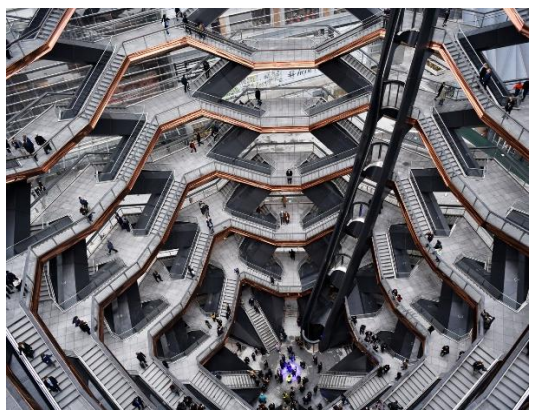
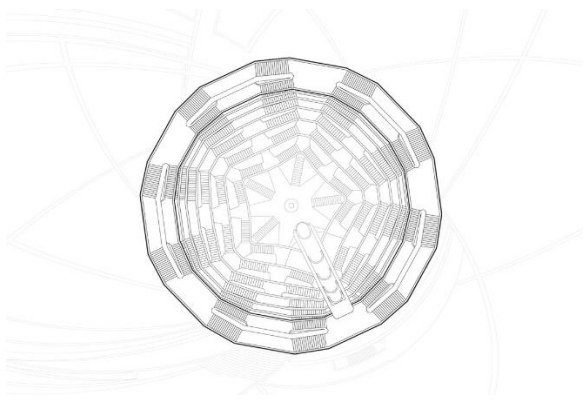
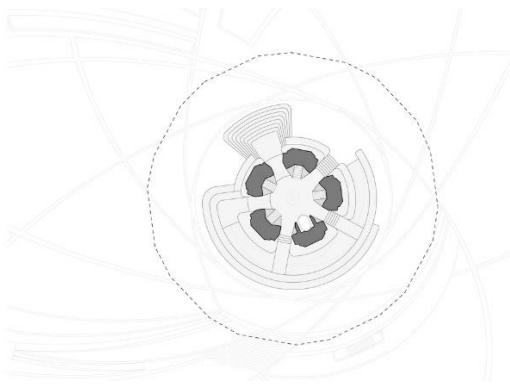
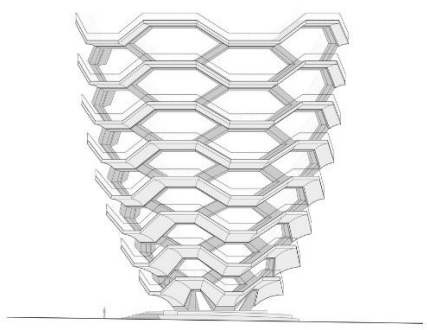
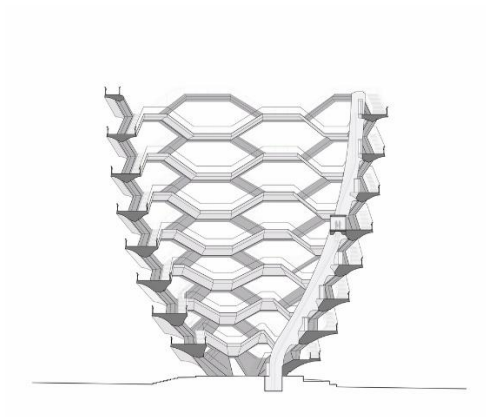
Table 12: KAPSARC - King Abdullah Petroleum Studies and Research Center, Saudi Arabia

General Information		
	Case No. 05	
	Building Name	**King Abdullah Petroleum Studies and Research Centre**
	Year	2017
	Area	70000 ft²
	Function	Research Centre
	Location	Riyadh, Saudi Arabia
	Design Firm	Zaha Hadid Architects
	Awards	LEED Platinum Certified, World Architecture Community Award Smart Building Award
	Main view	
		
	Plans	
		
	Elevations	
		

Analysis of Architectural Style

Overall Information About the case			▪ Concept: The design is inspired by cellular structures and crystalline forms, allowing for an organic, modular approach that creates a flexible and adaptable complex. ▪ Components: The research center is composed of five buildings: the Energy Knowledge Centre, the Energy Computer Centre, a Conference Centre with an exhibition hall and 300-seat auditorium, a Research Library, and a Musalla (prayer hall). ▪ Structure: The cellular structure forms hexagonal prismatic honeycomb shapes that contain courtyards, providing natural daylight and serving as environmental buffer zones. ▪ nterior: The interiors follow the concept of fluid connectivity and offer large, open-plan office areas, meeting spaces, and auditoriums. ▪ Landscape: The landscape design takes advantage of the local desert environment, with indigenous vegetation that requires little water. ▪ Cultural Context: Despite its futuristic design, the KAPSARC complex respects the local architectural traditions and responds to the harsh desert climate of its surroundings.
General architectural style			
Phases of the style	Proto Parametricism (1952-1992)		
	Early Parametricism (1993-2008)		
	Parametricism 1.0 (2009-2014)		
	Parametricism 2.0 (2015 - present)	■	The construction year is 2017, its considered second phase of Parametricism in which started from 2015 till now.
Subsidiary and transitional style in Parametricism	None		
	Foldism		
	Blobism		
	Swarmism		
	Tectonism	■	▪ **Material Expression:** Tectonic architecture showcases construction materials honestly. ▪ **Structural Emphasis**: The design emphasizes structural elements and joints. ▪ **Form and Function Unity**: Form closely follows function, enhancing structural logic. **Craftsmanship Valorization**: It appreciates craftsmanship and construction details.

Table 13: Vessel Public Landmark, China

General Information		
	Case No. 06	
	Building Name	**Vessel Public Landmark**
	Year	2019
	Area	2210 m²
	Function	Landmark & Monument
	Location	New York, United States
	Design Firm	Heatherwick Studio
	Awards	No famous architectural awards
	Main view	
		
	Plans	
		
	Elevations	
		

Analysis of Architectural Style

Overall Information About the case			▪ Function: It serves as an interactive landmark meant to be climbed and explored, adding a unique dimension to the public plaza. ▪ Structure: The Vessel consists of a network of staircases and platforms forming a 16-storey structure, standing 150 feet tall. ▪ Aesthetics: The design is reminiscent of an abstracted honeycomb, or a 'jungle gym' structure, made up of a series of interconnecting flights of stairs. ▪ Material: It's built with a structural painted steel frame, with its distinctive shiny exterior cladded in a polished copper-color steel skin. ▪ Staircases and Platforms: The structure includes 154 interconnecting flights of stairs, nearly 2,500 individual steps, and 80 landings offering remarkable views of the city, the river, and beyond. ▪ Symbolism: Vessel represents a commitment to public space within private development, functioning as a social landmark as much as a physical one. ▪ Public Interaction: It's accessible to the public, but due to its popularity, entry is managed through a ticketing system.
General architectural style			
Phases of the style	Proto Parametricism (1952-1992)		
	Early Parametricism (1993-2008)		
	Parametricism 1.0 (2009-2014)		
	Parametricism 2.0 (2015 - present)	■	The construction year is 2019, its considered second phase of Parametricism in which started from 2015 till now.
Subsidiary and transitional style in Parametricism	None		
	Foldism		
	Blobism		
	Swarmism		
	Tectonism	■	▪ **Material Expression:** Tectonic architecture showcases construction materials honestly. ▪ **Structural Emphasis**: The design emphasizes structural elements and joints. ▪ **Form and Function Unity**: Form closely follows function, enhancing structural logic. ▪ **Craftsmanship Valorization**: It appreciates craftsmanship and construction details.

Table 14: Soumaya Museum, Mexico City, Mexico

General Information

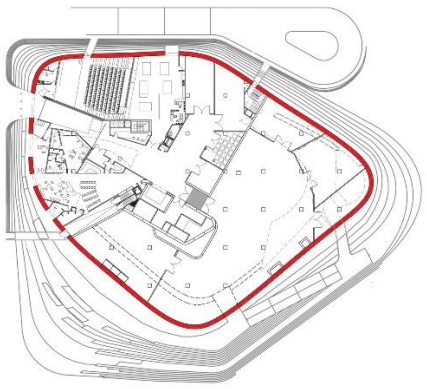
Case No. 07	
Building Name	**Soumaya Museum**
Year	2007
Area	64,583 ft²
Function	Museum
Location	Mexico City, Mexico
Design Firm	Fernando Romero
Awards	

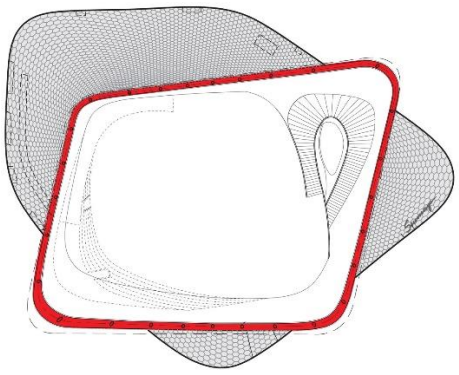
Main view



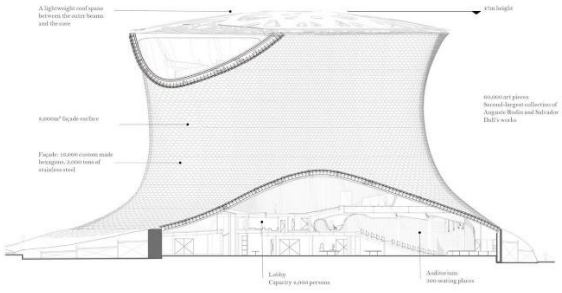


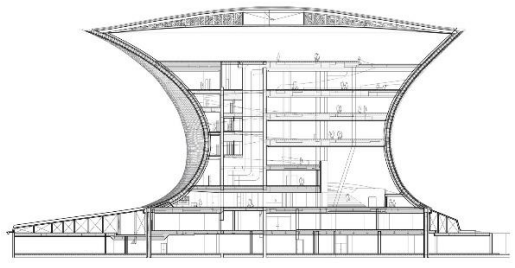
Plans





Elevations

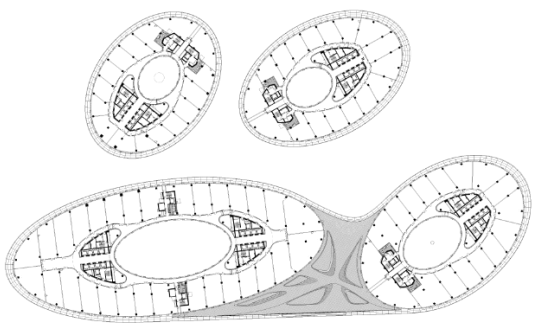
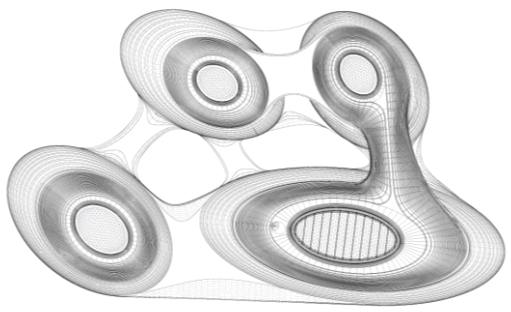
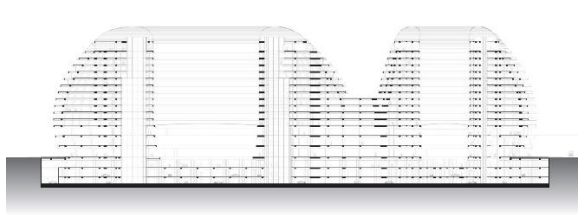
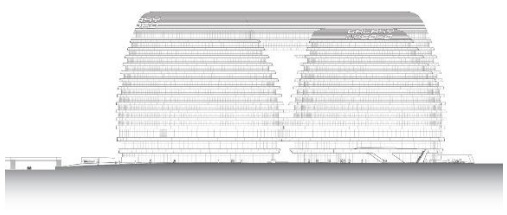




Analysis of Architectural Style

Overall Information About the case			▪ Design: The museum building is an architectural masterpiece designed by Fernando Romero, Carlos Slim's son-in-law, and is engineered by the world-renowned firm, Ove Arup and Partners. ▪ Construction: The building's construction took place from 2007 to 2011 and was financed entirely by Slim himself. ▪ Structure: The museum's structure is characterized by its unique and striking shape, which resembles a silvery cloud-like form. The building's exterior is covered in 16,000 hexagonal aluminum tiles, which contribute to its distinct appearance. ▪ Interior: The interior of the museum spans six floors and features a total of 60,000 square feet of exhibition space. Inside, visitors will find open, flowing spaces illuminated by natural light. ▪ Collection: The museum's collection includes more than 66,000 works from various periods, ranging from the 15th to the mid-20th century. It is especially known for its extensive collection of European painting and sculpture and Mexican art. ▪ Public Access: The Soumaya Museum is open to the public free of charge, fulfilling Carlos Slim's goal of making art and culture accessible to all.
General architectural style			
Phases of the style	Proto Parametricism (1952-1992)		
	Early Parametricism (1993-2008)	■	The construction year is 2007, it's considered early Parametricism.
	Parametricism 1.0 (2009-2014)		
	Parametricism 2.0 (2015 - present)		
Subsidiary and transitional style in Parametricism	None		
	Foldism	■	▪ **Complex Geometry**: Foldism embraces complex geometric forms that mimic the process of folding. The folded surfaces create a unique play of light and shadow and facilitate novel spatial experiences. ▪ **Structural Efficiency**: The fold, in essence, gives flat, two-dimensional surfaces three-dimensional strength and rigidity. This characteristic allows the creation of large spans and overhangs without excessive material use, contributing to structural efficiency. ▪ **Continuity**: Foldism often exhibits a continuous, seamless design where walls, roofs, and floors can merge into one unified structure. This results in fluid and dynamic spatial configurations, often blurring the distinction between interior and exterior spaces. ▪ **Algorithmic Design**: Foldism is closely tied to the use of parametric design tools and digital fabrication methods. Algorithms simulating the physics of folding allow architects to design and fabricate complex, folded geometries with a high degree of precision.
	Blobism		
	Swarmism		
	Tectonism		

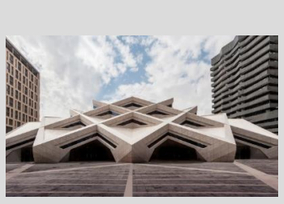
Table 15: Galaxy SOHO

General Information		
	Case No. 08	
	Building Name	**Galaxy SOHO**
	Year	2012
	Area	332857 m²
	Function	Mixed Use Architecture, Office Buildings, Shopping Centers
	Location	Beijing, China
	Design Firm	Zaha Hadid Architects
	Awards	Royal Institute of British Architects (RIBA).
	Main view	
		
	Plans	
		
	Elevations	
		

Analysis of Architectural Style

Overall Information About the case			▪ Design and Construction: Commissioned by SOHO China and completed in 2012, the project was designed by Zaha Hadid Architects. It represents one of Hadid's most innovative works, known for its futuristic and organic design. ▪ Structure: The Galaxy Soho consists of four domed structures, connected by bridges and platforms, creating a fluid and continuous space. The design avoids corners and straight lines, resulting in a seamless and curvilinear appearance. ▪ Function: The mixed-use development spans 330,000 square meters and includes office spaces, retail spaces, and entertainment facilities. The various functions are interconnected within the fluid design. ▪ Material: The building's exterior is made of aluminum and stone, while the interiors feature glass, terrazzo, stainless steel, and glass-reinforced gypsum. ▪ Integration: The building integrates well with its urban surroundings, with multiple access points connecting it to the surrounding streetscape and city.
General architectural style			
Phases of the style	Proto Parametricism (1952-1992)		
	Early Parametricism (1993-2008)		
	Parametricism 1.0 (2009-2014)	■	The construction year is 2012, its considered First phase of Parametricism in which started 2009-2014
	Parametricism 2.0 (2015 - present)		
Subsidiary and transitional style in Parametricism	None		
	Foldism		
	Blobism	■	▪ **Organic Forms**: Blobism, also known as Blob architecture, is characterized by organic, amoeba-like shapes that deviate from traditional geometric forms. ▪ **Digital Design**: The creation of these blob-like structures is made possible through the use of advanced computer-aided design (CAD) tools, which allows architects to manipulate and visualize complex forms with relative ease. ▪ **Fluidity**: In Blobism, there is a smooth, seamless fluidity between architectural elements such as walls, ceilings, and floors. This fluidity often extends to the building's exterior, creating an impression of a single, continuous form. ▪ **Flexibility:** Blobism is not restricted by traditional architectural rules and norms. This results in a high level of flexibility in form and function, allowing architects to create spaces that are both innovative and responsive to user needs.
	Swarmism		
	Tectonism		

Table 16: Summary of the Analysis

CASES	PROJECT NAME	YEAR	LOCATION	PERSPECTIVE VIEW	SUMMERY	PHASES OF THE STYLE	SUBSIDIARY AND TRANSITIONAL STYLE IN PARAMETRICISM
Case 01	The Port House,	2016	Belgium		Designed by Zaha Hadid Architects, repurposes a disused fire station as the new port headquarters. The design consolidates 00 staff and respects the site's history and geographical context. Utilizing an elevated extension rather than an adjacent structure, all four facades maintain equal significance, emphasizing its distinct waterside location.	Parametricism 2.0 (2015 - present)	Foldism
Case 02	Harbin Opera House	2015	China		Harbin Opera House, set within Harbin's wetlands, mirrors the region's snowy landscape with its sculptural design. Housing two concert halls, it accommodates 1,600 and 400 guests respectively. Its flowing architecture embodies Ma Yanshong's 'Mountain-Water City' philosophy, merging nature and urbanity. Its white aluminium façade echoes Harbin's snow-covered topography.	Parametricism 2.0 (2015 - present)	Foldism
Case 03	KAFD Grand Mosque	2017	Saudi Arabia		The Grand Mosque in Riyadh's blends traditional Islamic principles with modern design, emphasizing spirituality, simplicity, and community. The minaret, innovatively envisioned as a vertical garden, reinterprets traditional Islamic architecture. The building meets LEED Silver sustainability standards.	Parametricism 2.0 (2015 - present)	Tectonism
Case 04	Guangzhou Opera House	2010	China		Guangzhou Opera House, resembling two riverbank pebbles, symbolizes the fusion of art, technology, and nature. Comprising two structures, its distinctive glass-fiber-reinforced gypsum façade and dramatic interior design reflect China's modernization. It smoothly integrates with the surrounding urban landscape.	Parametricism 1.0 (2009-2014)	Foldism
Case 05	KAPSARC - King Abdullah Petroleum Studies and Research Center	2017	Saudi Arabia		The design (KAPSARC) draws inspiration from cellular structures and crystalline forms, resulting in an adaptable, modular complex. Comprising five buildings, its honeycomb structure optimizes natural light. The interiors embody fluid connectivity, while the landscape leverages the local desert environment.	Parametricism 2.0 (2015 - present)	Tectonism

Case 06	Vessel Public Landmark.	2019	China		The Vessel is an interactive, 16-story public landmark comprising a network of staircases and platforms, resembling an abstract honeycomb. Crafted from painted steel and a polished copper-color cladding, the structure includes over 2,500 steps and 80 landings offering stunning views. It symbolizes the commitment to public space within private development.	Parametricism 2.0 (2015 - present)	Tectonism
Case 07	Soumaya Museum	2011	Mexico		Designed by Fernando Romero, the Soumaya Museum features a unique, cloud-like structure. Its exterior, adorned with 16,000 hexagonal aluminum tiles, encapsulates six floors of flowing, naturally lit spaces. The design represents an architectural fusion of art, culture, and modern engineering.	Parametricism 1.0 (2009-2014)	Foldism
Case 08	Galaxy SOHO	2012	China		Galaxy SOHO, designed by Zaha Hadid, blends futuristic and fluid design, featuring four continuous, flowing volumes coalescing into an organic whole without sharp corners or abrupt transitions. Its interior spaces mirror this continuity, creating seamless transitions between sections.	Parametricism 1.0 (2009-2014)	Blobism

Chapter 6

FINDINGS AND REMARKS

Based on the comprehensive research carried out in this study, several key findings have emerged from the critical review of existing literature surrounding contemporary architectural styles and the influence of Parametricism.

The notion of architectural style is undergoing a significant shift in the 21st century. The trend towards a reconsideration of architectural styles highlights an urgent quest to discover innovative strategies that ensure buildings and spaces are not only functional but also visually appealing and responsive to their context. This represents a move away from standardization and towards a more nuanced understanding of the intricate relationship between form, function, context, and aesthetic sensibilities.

The advent of digital design tools and computational design methodologies has led to an architectural revolution, with Parametricism at the forefront. Parametric design offers architects a fresh palette of possibilities, enabling the creation of complex, dynamic forms that were previously unthinkable or impractical. This has expanded the boundaries of architectural style, allowing architects to explore novel expressions of form and space.

Parametricism has initiated a rethinking of traditional architectural principles. It emphasizes process over product, allowing design and fabrication to evolve

dynamically in response to a wide range of parameters. This stands in contrast to traditional architectural practices, which often prioritize the final design product.

Despite its potential, the widespread adoption of Parametricism remains limited due to several factors. These include the complexity of parametric design tools, the challenges associated with fabricating complex forms, and the need for a paradigm shift in architectural thinking and practice. Overcoming these challenges requires ongoing research and experimentation, as well as the development of new skills and competencies in the architectural profession.

The rapid technological advancements in fields like Artificial Intelligence, Machine Learning, and Big Data are poised to have profound implications on Parametricism and the wider architectural practice. These technologies offer new ways of manipulating and understanding complex datasets, potentially leading to even more sophisticated applications of parametric design.

Consequently, the future of architectural style, particularly in the context of Parametricism, appears exciting, albeit challenging. The constantly evolving technological landscape and the rising aspirations for more sustainable, resilient, and culturally responsive built environments necessitate a constant reassessment and adaptation of architectural styles. Parametricism, with its inherent flexibility and ability to respond to a multitude of factors, stands well-positioned to influence the evolution of architectural style in the 21st century.

Table 17: Content Analysis of the Existing Sources According to the Process Development of Parametricism, by the Author.

Authors	Year	Phase	Contribution	Explanation
Sutherland	1963	Graphic Interface.	Apply changes Parametrically With computer	The first use of parametric design concepts through a graphic user interface system occurred in Sutherland's Ph.D. research, which allowed him to draw with the computer and apply changes parametrically at the same time (Fernández-Álvarez, Á. J. 2020, June).
Morretti	1971	Interconnected Design.	Relationships between the dimensions	Parametric Architecture is the examination of how the dimensions of a design are interconnected and dependent on specific parameters. (Caetano, I., Santos, L., & Leitão, A. 2020).
Kalay	1989	Automated geometric computation	Computational Geometric relations	When parameters are altered, the geometric relationships determined by computation are automatically adjusted. (Caetano, I., Santos, L., & Leitão, A. 2020).
Schumacher	2008	Parametricism Manifesto	Certain Principles "Dogmas," and "Taboos,"	The concept of "Parametricism" as a design style was first introduced in the "Parametricism Manifesto" and further explored in subsequent papers and a book titled "The Autopoiesis of Architecture" in 2011. The author outlined certain principles, known as "Dogmas," that must be adhered to in order to create a parametric design, as well as other principles, referred to as "Taboos," that should be avoided. (Schumacher, P. 2008).
Woodbury	2011	Associative geometry.	Exploring connections of geometric concepts	The process of investigating the links between geometric concepts is known as parametric design (Woodbury, R. 2010).
Frazer	2016	Evolving process	Adapting itself with newest technology	Parametric architecture is evolving and re-positioning itself as a dynamic process that takes into account the latest technologies, as well as environmental and societal considerations. (Frazer, J. 2016).
Oxman	2017	New paradigm, topological thinking.	Paradigm of design thinking	Parametric design is considered a novel approach to design thinking. It brings innovative ideas and shifts the focus from typological thinking to topological design thinking in the creative design process, which is considered a significant transformation in the way of design thinking (Oxman, R. 2017).

In the complex tapestry of architectural styles, Parametricism has been identified as having several subsidiary styles and even one transitional style. This evolutionary development is not unusual, as architectural styles often undergo transformation and assimilation, adopting and adapting elements from other contemporaneous or

preceding styles. In the context of parametric architecture, this study illuminates that Parametricism is not a singular, monolithic style, but rather a nuanced, multifaceted design approach that encompasses several subsidiary styles and even incorporates a transitional style.

Our exploration establishes Parametricism as the epochal style of our era. This categorization recognizes its central position in the contemporary architectural discourse, highlighting it as a style that not only reflects the ethos of our times but also actively shapes our built environment and its future trajectory. As an epochal style, Parametricism forms the umbrella under which several subsidiary styles have emerged. These include Blobism, Foldism, and Swarmizm, each representing a unique interpretation and application of parametric design principles.

Blobism is characterized by its organic, fluid forms, made possible by the advanced computational tools at the disposal of today's architects. Foldism, on the other hand, is defined by its folded, angular structures, showcasing the mathematical precision achievable through parametric design.

Swarmizm introduces another facet of Parametricism, drawing inspiration from the emergent behavior of swarms in nature to create complex, adaptive architectural forms. This style demonstrates the potential for parametric design to capture the inherent complexity and dynamism of natural systems, translating these principles into architectural designs.

Beyond these subsidiary styles, the study has also identified a Transitional Style named Tectonism. Tectonism signifies a shift from the reliance on visual and formal attributes

towards an emphasis on structural logic and construction processes. It serves as a bridge, linking the realm of Parametricism with the broader field of architecture, facilitating a dialogue between the digital and the material, the theoretical and the practical.

Through this nuanced understanding, we can see that Parametricism is not just a style, but a complex design phenomenon that is shaping the architectural discourse in the 21st century. As we continue to unravel its intricacies, it is clear that the influence of Parametricism will be felt for years to come, shaping not only our architectural landscapes but also our understanding and interpretation of style itself".

Table 18: Active Reflective Styles of Parametricism Drawn by the Author.

Styles	Epochal Style	Subsidiary Style	Transitional Style
Active reflective Style	PARAMETRICISM	BLOBISM	
		FLODISM	
		SWARMIZM	
			TECTONISM

• As with many epochal styles, Parametricism has its Heuristics. Throughout the study, it's confirmed that Parametricism is using certain principles called heuristics to gain specific design outcomes. The Heuristics are divided into two groups which are Formal Heuristics and Functional Heuristics, each group includes both Negative Principles and Positive Principles that have evolved since the mid-1990s across many projects worldwide.

According to the study the answer to research questions is stated below;

The Question:

Could Parametric Architecture be considered the epochal style of this era, or does it falter in the face of traditional design methodologies?

The answer:

Parametric architecture, at its core, utilizes the power of computational design and algorithmic understandings to develop architectural forms. This style can adapt to changing environments and requirements, thus is often seen as an epochal style of this era. Let's take a look at some reasons for this assertion, and some counterarguments:

A. Alignment with the Digital Age:

Parametric architecture aligns perfectly with the digital age, with its heavy dependence on computational design tools. With the rise of digital technologies and their increasing prevalence in daily life, parametric architecture could be seen as the architectural manifestation of this shift.

B. Responds to Complex Requirements:

Parametric architecture allows architects to respond to complex design requirements and considerations. By defining certain parameters (such as the need for sunlight, wind flow, etc.), architects can generate designs that optimally meet these requirements. This is an embodiment of our era's focus on customization and personalization.

C. Sustainable Approach:

In a time where sustainability is an increasing concern, parametric design's ability to optimize resource use and performance aligns well with this priority. It can minimize waste and maximize efficiency, making it a potentially epochal architectural style.

D. Encourages Innovation:

The algorithmic, data-driven nature of parametric architecture pushes the boundaries of architectural form and aesthetics, enabling architects to innovate in ways not possible with traditional design methodologies.

However, there are some counterarguments to this notion:

A. Limited Accessibility:

Parametric design relies heavily on advanced software and computational knowledge, which may not be accessible or comprehensible to everyone. It could be argued that an epochal style should be one that can be adopted widely, and in this respect, parametric architecture might fall short.

B. Potential Lack of Human Touch:

Critics often argue that parametric architecture, being so heavily driven by algorithms and data, lacks the human touch. If the zeitgeist of an era includes a return to human-centric values and design, then parametric architecture may not be seen as its epochal style.

C. Overemphasis on Form:

There are concerns that parametric architecture can lead to an overemphasis on form over function, creating structures that are visually striking but may not fully meet user needs or integrate well with their surroundings.

In conclusion, whether parametric architecture is considered the epochal style of this era could depend on the balance between its potential for innovation, alignment with digital and sustainable trends, and the criticisms regarding its accessibility, humanistic qualities, and functional practicality.

The Question:

To what extent does Parametricism offer a distinctive architectural standpoint?

The answer:

Parametricism, an architectural style birthed from the digital age and computational design, indeed offers a distinctive standpoint in architecture. Let's discuss this by looking at several facets:

A. Formal Expressiveness:

Parametricism offers a unique standpoint in the freedom and complexity it introduces to architectural form. Traditional architectural styles are often constrained by regular and simplistic geometric forms, but parametricism can generate an infinite variety of complex and organic forms due to its algorithmic nature.

B. Adaptability:

Parametric design allows for easy modification of designs. Changes to parameters automatically translate into changes in the design, enabling a more adaptable design process. This is particularly useful in the context of evolving client needs, environmental considerations, or site-specific constraints.

C. Optimization:

Parametricism offers a standpoint where design can be optimized to a degree not feasible with traditional design methods. This can relate to optimizing for structural performance, energy efficiency, material utilization, and more, contributing to sustainable and efficient architecture.

D. Interdisciplinary Integration:

Parametricism encourages the integration of various domains, such as structural engineering, environmental science, and even social sciences, into the architectural design process. This can lead to more holistic and well-rounded design outcomes.

However, it's also important to note some limitations and criticisms:

A. Accessibility:

As mentioned before, parametric design requires sophisticated computational tools and specific knowledge, which can be a barrier for many architects, especially in parts of the world where such resources are not readily available.

B. Humanistic Design:

There is a criticism that parametricism can lead to an overemphasis on form and technology at the expense of human factors and contextual appropriateness. While parametric tools can indeed optimize for many factors, the subtleties of human experience and local context may not be as easily parameterized and quantified.

C. 3. Constructability:

While parametric design can produce fascinating and complex forms, the feasibility of constructing such designs can sometimes be challenging. This may result in cost overruns, construction difficulties, or the need to simplify the design.

In summary, parametricism offers a unique standpoint in architecture with its ability to create complex, adaptable, optimized, and interdisciplinary designs. However, its full potential is contingent on addressing issues around accessibility, the integration of human and contextual factors, and constructability.

Chapter 7

CONCLUSION

In conclusion, the central purpose of this research was to fill the knowledge gap surrounding the broad understanding of parametric design, particularly due to its swift adoption in contemporary architectural practice. The research directed its focus towards dissecting Parametric Architecture, often referred to as Parametricism, and scrutinizing the evolution of architectural styles in the 21st century, with an emphasis on the placement and influence of Parametricism within this panorama.

An in-depth descriptive methodology was utilized, primarily through a rigorous literature review, which served as the basis for the content analysis aimed at interpreting the gathered information. The study's scope was constrained to defining architectural style in the context of the existing literature, subsequently setting the stage for identifying Parametricism's role within the array of 21st-century architectural styles.

Parametricism can be seen as a robust advancement of Leon Battista Alberti's architectural principles, putting forth a ground-breaking concept laden with numerous historical references. However, the practical application of this concept has been impeded by various challenges, limiting its impact on the architecture industry and society at large, and consequently preventing it from being fully recognized and adopted as a "style". Instead, it remains largely a concept.

In spite of its inherent complexity and the potential it holds for diversity, parametric architecture has emerged as a global style, forming the bedrock of contemporary digital architecture. While there exist variations and different interpretations of parametric architecture, it has attained the status of an international style, given its widespread acceptance and application across different countries.

Looking ahead, future research could delve into numerous potential areas. These could include:

- Investigating the role that Parametricism will play in shaping the future of architectural practice, as the design industry navigates through an era marked by digital transformation.
- Exploring the intricate relationship between parametric design and emerging fabrication techniques, such as 3D printing, robotic construction, and advanced manufacturing, all of which hold great potential for revolutionizing the construction industry.
- Assessing the impact of Parametricism in the realm of public space design, with an aim to understand how these design approaches can foster more inclusive, adaptable, and responsive urban environments.

These are just some of the areas that warrant further investigation, as we strive to fully understand and actualize the potential of parametric design in shaping our built environment, and, by extension, our society. Given the rapidly evolving technological context, these and other areas of exploration are not only relevant, but crucial in charting the future course of architectural practice and pedagogy. As we move forward, it is paramount to remain critically engaged with the opportunities and challenges

presented by Parametricism and to foster a discourse that is both rigorous and open to innovation.

Finally, this study highlights the potential of Parametricism as the defining architectural style of the 21st century, demonstrating its capacity to respond dynamically to cultural, historical, and geographical complexities, as well as diverse user needs. The transition from sheer production quantity to meaningful, high-quality designs marks a pivotal shift in architectural discourse. By prioritizing values and thoughtful contributions, Parametricism can evolve beyond a design approach into a fully recognized style, shaping the future of architecture with its adaptability and contextual intelligence. As architects and designers, we must embrace this transition, ensuring that Parametricism's legacy is defined not just by innovation, but by the depth and impact of its architectural expressions.

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APPENDIX

- Gothic is noted for its verticality and light-filled spaces, characterized by features such as pointed arches, ribbed vaults, and flying buttresses. It originated in the High Middle Ages and is particularly associated with cathedral architecture, reflecting an aspiration towards the heavens and the divine.
- Renaissance is characterized by a rebirth of classical antiquity, emphasizing symmetry, proportion, and geometry in architecture, alongside a focus on humanism and realism in the visual arts. This period marked a departure from the more formulaic structures of the medieval period, favoring a return to the study of nature and classical forms.
- Mannerism is characterized by its artificial (as opposed to naturalistic) qualities, with an emphasis on elegance, elongated forms, and a lack of clear perspective.
- Baroque emerged after the Renaissance, known for its exuberance, grandeur, and drama, as well as its use of contrast, movement, vivid details, and deep color to achieve a sense of awe. Architecture and art from this period are characterized by their emotional intensity, opulent decorations, and dynamic scenes.
- Rococo is known for its decorative art and architecture that is elaborate, ornamental, and light-hearted, with themes often centered around love, classical myths, and nature.
- Neo-Classicism was a revival of the classical styles and spirit during the late 18th and early 19th centuries, emphasizing clarity, order, and symmetry. It was inspired by the art and culture of ancient Greece and Rome, and it was a reaction against the excesses of the Baroque and Rococo styles.

- Historicism represents the use of historical forms and decorative styles from different periods in history, often combined in a single building or artwork. It reflects a romantic fascination with the past and was particularly popular in the 19th and early 20th centuries, leading to the creation of eclectic architecture that borrows from various historical periods.
- Neo-Gothic revives medieval Gothic architecture with a romantic emphasis on individualism and detailed craftsmanship.
- Neo-Renaissance and Neo-Baroque represent a return to the principles and styles of the Renaissance and Baroque eras, respectively, emphasizing symmetry, proportion, and grandeur in the case of Neo-Renaissance, and dramatic effect, movement, and detailed ornamentation in Neo-Baroque.
- Eclecticism is an architectural style that combines elements from different historical styles and periods, aiming for harmony in diversity.
- Art Nouveau is distinguished by its use of long, sinuous, organic lines and was applied most notably to architecture, interior design, and decorative arts.
- Expressionism manifests through the depiction of subjective emotions and experiences over objective reality, often using bold colors and dynamic compositions.
- Modernism is a broad movement that emerged in the late 19th and early 20th centuries, advocating for new approaches to art, architecture, and literature. It rejects historical precedents and traditional styles, emphasizing innovation, functionality, and simplicity instead. In architecture, it is characterized by minimalism, the use of industrial materials, and the idea that form should follow function.

- Neue Sachlichkeit (New Objectivity) refers to a German movement in art, literature, and music of the 1920s that was characterized by a realistic style combined with a cynical, socially critical philosophical stance.
- Organicism celebrates harmony between human habitation and the natural world through design principles inspired by nature and organic forms.
- Rationalism in architecture emphasizes reason and order, favoring a reductionist approach and often employing geometric forms and the repetition of modular elements.
- Brutalism is known for its straightforward, honest approach to form and material, often using raw concrete or other materials in their natural, unfinished state.
- Metabolism is a post-war Japanese architectural movement that explores ideas of megastructures and prefabricated modular elements to accommodate growing populations and changing urban needs.
- High-tech architecture incorporates technology and industrial systems into building design, often showcasing structural elements, mechanical systems, and innovative materials.
- Postmodernism breaks away from modernist principles by embracing complexity and contradiction, often incorporating elements of historical styles in a new context or with a sense of irony.
- Parametricism represents a style within contemporary architecture and design characterized by the use of computer-aided design software to generate geometries based on algorithmic rules that relate to various parameters. This approach allows for complex, fluid forms and patterns that can adapt dynamically to their context and programmatic requirements.

- Blobism (also known as Blob architecture) is identified by its organic, amoeba-shaped forms that appear to be blob-like or droplet-like in shape. These forms are often created through digital design techniques, allowing for smooth, seamless surfaces and curvilinear shapes that challenge traditional architectural geometry and structure.
- Flodism could potentially refer to a design philosophy influenced by fluid dynamics and the aesthetics of fluid movement. If this is an intended style, it would likely emphasize seamless, flowing forms that mimic the properties and behavior of liquids. However, without more context or standard recognition of the term, it's difficult to provide a detailed description.
- Swarmism might involve design principles inspired by swarm intelligence observed in nature, such as in flocks of birds or schools of fish. This approach could utilize algorithms to simulate the decentralized, self-organized patterns of behavior found in nature, resulting in dynamic, adaptable design systems or structures that mimic these natural processes.
- Tectonism refers to an architectural style or approach that emphasizes the expression and exploration of construction and structure. It focuses on the articulation of tectonic elements and how parts of a building are assembled and connected. Designs in this style show the materials, structural logic, and craftsmanship, often revealing the construction process as an integral part of the aesthetic experience.