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تحسين الأداء البيئي والتصميمي لواجهة المباني باستخدام " الذكاء الاصطناعي"

Improving the Environmental and Design Performance of Building Facades using "Artificial Intelligence"

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***Abstract*: The construction sector has changed thanks to the use of artificial intelligence (AI) in architectural design. To investigate abstract conceptual concepts and produce an infinite number of design ideas based on mathematically determined criteria, AI offers a wide variety of computational methodologies. An exploratory examination of the development of AI in architectural design is presented in this paper. The study emphasizes this technology's potential, constraints, and prospects for architectural design. Since its inception as a tool for functional optimization, (AI) Artificial Intelligence has evolved into an unmatched source of design inspiration. The mechanism technology is needed to deliver the best lighting possible, depending on the design requirements. The following steps are taken during the design process: design concept, modeling and pattern development, application and implementation of the parameters "sun path, solar radiation, bulb temperature, and daylight," evaluation and simulation with the aid of the simulation program "grasshopper/ladybug-honeybee," and lastly, conclusion. Finally, it is suggested to engage in digital fabrication and materialization. The suggested design, which was implemented in the "Epic complex" structure, improved the facade's environmental and design performance by minimizing solar radiation on exposed facades and improving eye comfort by cutting back on glare from sunlight. This was done without altering the building's existing facade design. The authors stress the necessity of a well-rounded strategy, nevertheless, to guarantee that AI-generated designs are human-centric, environmentally conscious, and culturally aware. According to the study's findings, AI can enrich and inspire architectural design, but it must be used ethically and responsibly to prevent harming human creativity and design ethics.**

***Keywords:* Artificial Intelligence, Parametric Design, Algorithmic Design, Computer-Aided Design, Computational Design.**

1-Introduction

Since the dawn of time, man has been enhancing the environment. A home "shelter" was chosen for a number of reasons, including geographic, protective, and climatic factors. The geographical and climatic characteristics of the place of habitation both mirrored the characteristics of the dwelling. Housing and other structures are built to provide protection from unfavourable environmental factors. Given this, every single primitive home that has ever been discovered was either made by nature or by man using natural resources. Man is one of the primary factors in the creation of anthropomorphic space.

Building materials and engineering devices are being used to construct residential, domestic, and commercial structures according to the functional requirements of the space. With the advancement of architectural design, particularly advances in computer-aided design, funds for project implementation and building construction are regularly replenished.

The process of designing architectural spaces and forms can be made simpler thanks to contemporary, cutting-edge computer-aided design tools. The focus of interest is on computational technologies and the ways in which nature and technology interact. This necessitates the creation of cutting-edge instruments, processes, and materials, which the current architecture and design reflects.

Algorithmic design uses a structured and rational framework consisting of rules and programs to generate architectural outputs that include computational complexity. This approach enables architects and designers to systematically rationalize, analyse and iterate their designs, following a well-defined methodology.

The demands and preferences of the building's users as well as the larger cultural, historical, and environmental context in which the structure will be located should be taken into account by architects in order to resolve the conflict between aesthetics and function in architectural design. This entails taking into account the regional cultural norms and current architectural styles in addition to the specific physical features of the location. For instance, a structure intended to serve as a school should include both utilitarian elements like classrooms and offices as well as aesthetic elements that improve the learning environment, including natural light and open spaces. By taking into account these elements, architects may create structures that are both

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aesthetically beautiful and useful, as well as sensitive to their surrounds and context.

The Sydney Opera House in Sydney, Australia, is a wonderful illustration of design that encompasses both aesthetics and purpose (Fig. 1). The Sydney Opera House, one of the most recognized structures in the world, was created by Danish architect Jorn Utzon and finished in 1973. A great illustration of how form and purpose may coexist in one architectural design is the Sydney Opera House. The structure's unusual sail-like design is visually arresting, and it has come to represent Sydney and Australia. The structure is also extremely practical, offering a cutting-edge performing arts complex with numerous theatres, practice spaces, and other amenities.

Fig. 1: Sydney Opera House has highly functional areas and a sturdy structural structure, while also expressing a superb set of design aesthetics in order, shapes, and rhythms. [1]

Frank Gehry's design for the Guggenheim Bilbao Museum was one of the first instances of using digital technology to support architectural design creativity. Gehry's architecture is characterized by the building's characteristic curved surfaces and flowing lines, which provided a substantial challenge for conventional architectural design techniques. Gehry used digital technologies to overcome this difficulty. He made use of the fighter jet design computer-aided design (CAD) application CATIA, which was created for the aerospace industry. Gehry was able to envisage and actualize the many curved surfaces of his design using CATIA, producing a 3D model that could be used to direct the building's construction (Fig. 2). Hundreds of individual steel members make up the steel frame for the Guggenheim Bilbao Museum. Each of these members was created using CATIA, which made it possible to precisely manage each one's size, shape, and location. This ensured that the frame was completed before building began. Gehry was able to complete his ambitious design for the Guggenheim Bilbao Museum because to the early embrace of digital technology, pushing the frontiers of architectural design and producing a truly iconic structure.

analytical process and generation of creative ideas by the architect. This experience highlights the potential of (AI) Artificial Intelligence in providing a tool that helps informing knowledgeable decisions within a limited time during the design phase.

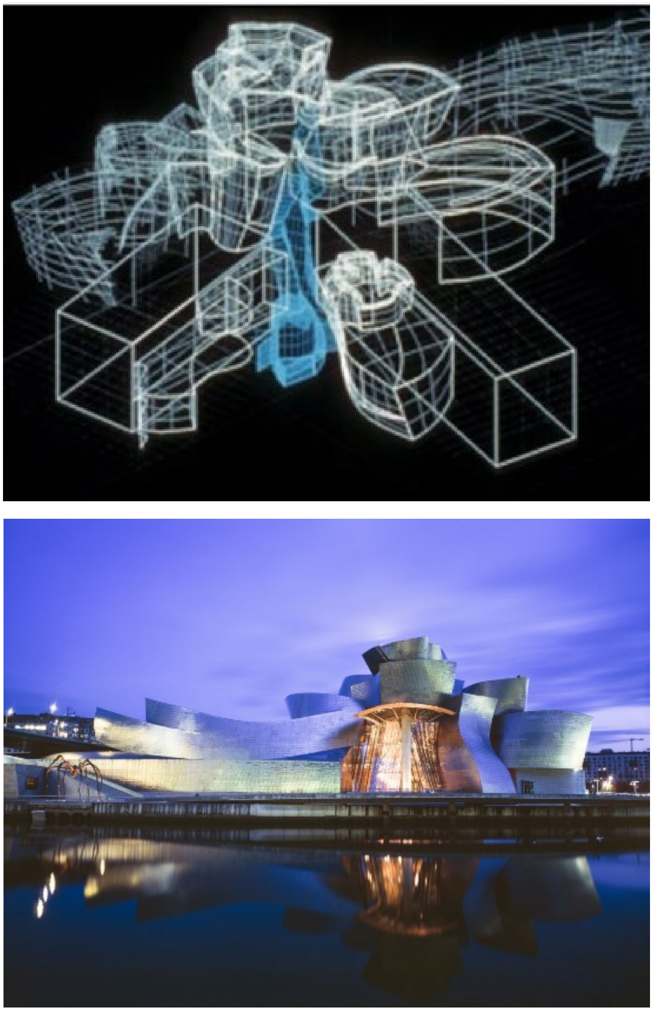

Fig. 2: The scale model of the Guggenheim Bilbao Museum is seen on the l eft. (Right) CATIA vector illustration of the museum's form. [2]

The incorporation of (AI) Aartificial Intelligence into the architectural field, according to Chaillou [9], did not occur as a sudden upheaval but rather as a logical progression and accumulation of earlier conceptions that incorporated similar technologies. Modularity, computational design, parametric design, and (AI) Artificial Intelligence are the four major phases of the historical evolution of (AI) Artificial Intelligence use in architecture (Fig. 3). Modularity involves using standardized, interchangeable parts in design to allow for flexibility and adaptability in construction. Computers are used in computational design to assist in the design process, enabling more accurate and complicated designs. Algorithms and variables are used in parametric design to produce design possibilities depending on predetermined criteria. By utilizing cutting-edge machine learning algorithms to aid in the design process and produce ever more intricate and optimal designs, (AI) Artificial Intelligence extends these ideas even farther.

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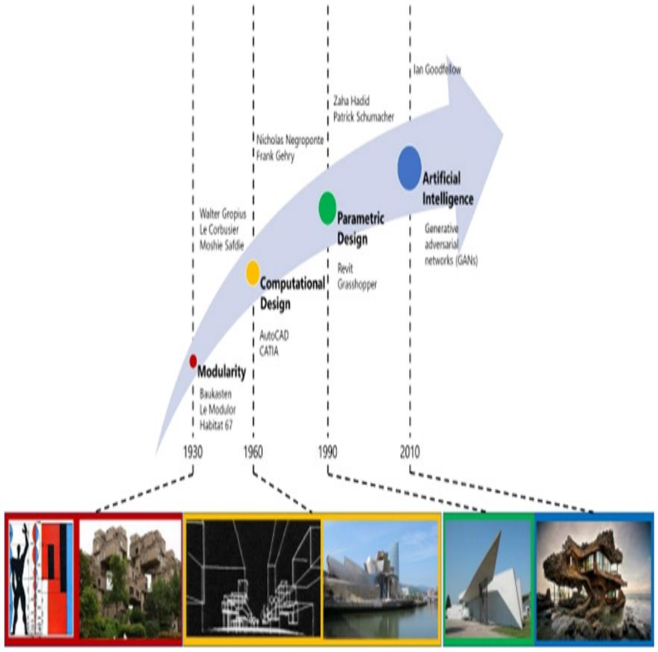

Fig. 3 : Evolution of AI predecessors in impacting architectural theories a nd practices. Images from left to right: Le Modulor concept by Le Corbu sier [3], Habitat 67 by Moshie Safdie [4], URBAN 5 by Negroponte [5], G uggenheim Museum Bilbao Museum by Frank Gehry [6], Vitra Fire Stat ion by Zaha Hadid [7], and GAN generated architecture by Midjourney [8]. Illustration by authors based on a historical analysis by [9].

Designers must use computer-aided tools to construct models and assi st them in visualizing concepts using parametric design software in or der to improve architectural design performance and incorporate new technology, which enables them to establish correlations between various design model characteristics. This form of design requires and aids in the creation of advanced interactive tools that let designers exp lore and optimize a large number of options while spending the least a mount of time possible accomplishing these goals. A sun-tracking facade system was developed as a result of the design challenge, environmental concern, and a personal interest in researching building s that forego conventional design practices in order to boost their energy efficiency [10]. In Egypt, the design of the building envelope h as a historic element; the building envelope or skin becomes principall y accountable for regulating the climate and occupant comfort ins ide the building. Consequently, the idea of adaptive building skin eme rged. An envelope that can alter its features and flexibly control the various building envelope parameters is referred to as an adaptive building skin [11]. A variety of methods, such as movement or chemical alteration in building materials, can bring about change[2].

To enhance building efficiency and encourage interior thermal comfot , there is growing interest in replacing static building facades with dynamic building facades. New strategies, techniques, materials, and concepts must be created in order for the hyper-cell process to act as a dynamic, responsive building skin that is adaptable and sensitive. This idea's main goal is to outfit buildings with components and systems that can constantly adapt to user needs and weather variations [13].

The original version also includes developing an intrinsically variable component that is defined by a set of surface attributes. Each instance is parametrically tailored to its unique placement on the host's surface, or "parametric pattern," in order to ensure total compatibility. The parametric pattern design technique is transformed into a powerful expression register via parametrism. The crucial change from adaptive compensation to amplifying disparities marked the beginning of the "parametric patterning." A data set that can result in extreme pattern differentiation is basic surface variance. As a result, the principal surface distinction is increased and strengthened considerably [

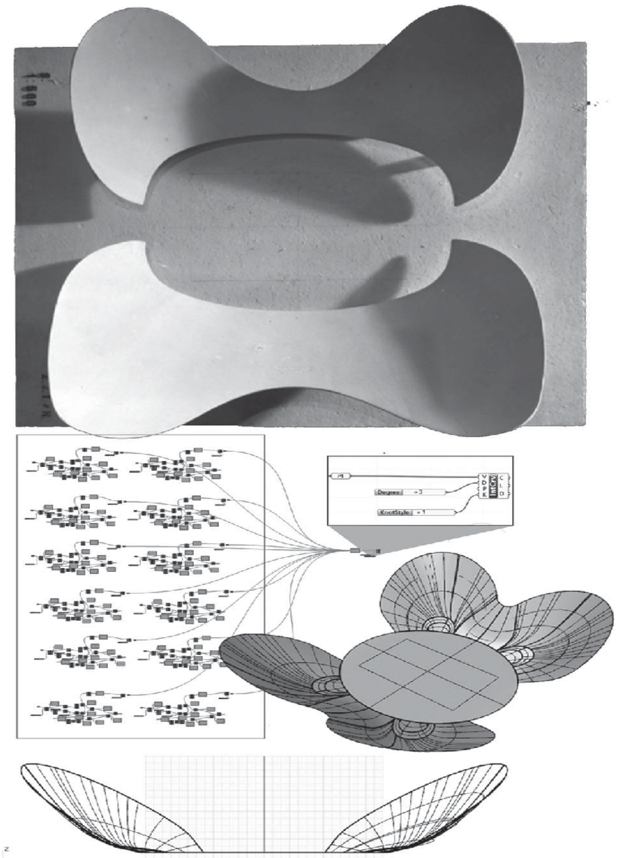

Fig. 4: Luigi Moretti's plans for the stadium Model, [19]

The primary concern of this research is how parametric methods are used to create hyper-cell patterns in order to improve buildings by providing appropriate external solar radiation and sunshine. There is no established method for producing They are still quite new to the area of architecture and these dynamic patterns. Conceptually, the designer can find the best performing answers to design problems for a cutting-edge design that matches the Egyptian identity through the use of parametric tools that permit various geometries, optimization techniques, and simulation software.

The objective of this study is to develop a framework for a design approach for parametric hyper-cell systems that may generate dynamic patterns that are adaptable. This adaptable prototype "parametric hyper-cell" is created with prefabricated parts and innovations from unconventional and

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experimental procedures. It has components that can take information from the outside world and reformulate it to create an enhanced and adaptable response.

According to the research hypothesis, logic can offer creative and practical solutions to several environmental and design issues in many nations, and its use can change façade designs, which can make a building a popular destination for tourists. The research methodology uses two prototypes made to match a case study for which the project chose "Epic Complex New Capital," a building used for administration in the center of Cairo, Egypt's New Administrative Capital. To examine and simulate the proposed supercell and test this hypothesis, the building is examined and compared to two other administrative buildings nearby

2. literature review

2.1. Appearance of the Parametric Term

As seen in (Fig. 5), the term "parameter" was first used in mathematics to describe a collection of numbers used to explain functionalities in addition to many unrelated variables known as "parameters" [15]. Midway through the 20th century, the vocabulary of algorithms and the expression parameters and variables were adopted into the field of computer science. The first-time loops were utilized was during the "coding" process, this helped create a system that could integrate two characteristics, such dimensions and tolerances, to build components. This is a theoretical method of describing how dimensions and viewpoints are combined to describe a shape [16]. The Italian architect Luigi Moretti introduced loops into architecture in the 1940s, claiming that shapes are defined by a combination of proportions and viewpoints. Moretti demonstrated how the patterns of his sports stadium, as shown in (Fig. 4), were the product of nineteen criteria for viewing angles and concrete price at the 1960 exhibition "Parametric Architecture" at the 20th Milan Triennale. [17].

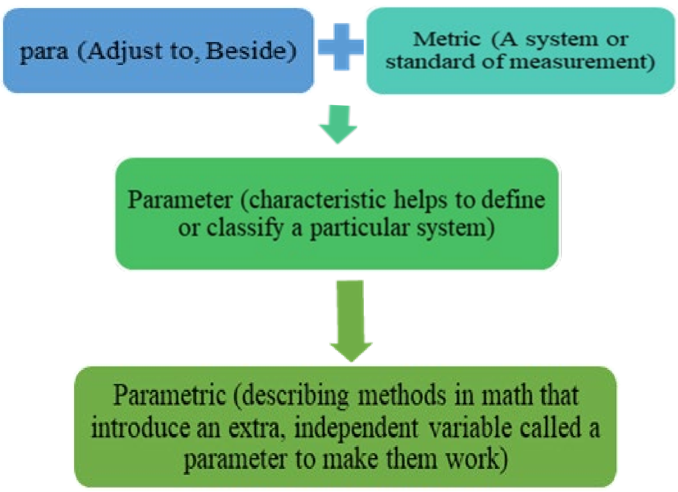

Fig.5: Definition of parametric

A set of parametric equations that are solved using digital computers a re used to develop a 3D form for an architectural structure. Generally s peaking, parametric thinking refers to complicated systems that combi ne algorithms with parametric equations, or "parametric design."

2.2. Strategies of Parametric Designs

The three steps of the Parametric Design Strategies process are experimentation, analysis, and implementation (Fig. 6). By demonstr ating a freehand drawing movement to depict the numerous phases o f the modeling process, the analysis step is made easier. In order to cr eate the parametric model, both processes rely on the visual progra mming languages "Rhino/Grasshopper," which have grown in popula rity among design groups (Fig.7). A virtual review is conducted at the experimental level using simulation tools and algorithms that u tilize parametric models (Ladybug and Honeybee) [18].

2.3. Parametric – Modelling

Information is gathered, data is processed, and outputs are produced via a collection of tasks. As seen in (Fig. 8), a component typically accepts some data from one or more sources and outputs the information.

The original version also includes developing an intrinsically variable component that is defined by a set of surface attributes. Each instance is parametrically tailored to its unique placement on the host's surface, or "parametric pattern," in order to ensure total compatibility. The parametric pattern design technique is transformed into a powerful expression register via parametrism. The crucial change from adaptive compensation to amplifying disparities marked the beginning of the "parametric patterning." A data set that can result in extreme pattern differentiation is basic surface variance. As a result, the principal surface distinction is increased and strengthened considerably [14].

2.3.1. Main Parametric Modelling Generation Tools

It is necessary to convert design data into values that can be recognized by algorithms, including Booleans, strings, and numerical information. The makers of design algorithms must also provide a variety of data kinds [20]. As shown in (Fig. 9), there are three sorts of parametric modeling tools.

Algorithms for the sketching by numbers tool begin with arithmetic and numbers. As shown in (Fig. 10), some components can offer one or more numerical values, a range of numbers, a domain-specific series of integers and/or an undetermined value.

The basic building blocks for creating geometries in parametric model ing are points and point grids. As seen in (Fig. 11), they could represe nt the beginnings of curves, the centers of circles, and the beginnings of planes.

Math operations like preparations and functions may be carried out in Grasshopper (Math > Script), as seen in (Fig.12), and are simple to produce numerical sequences for.

Fig. 6: Parametric Design Process

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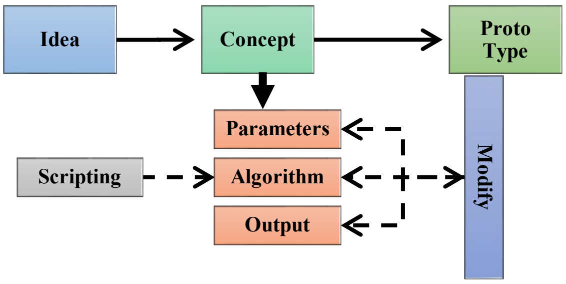


Fig. 7: Diagram Illustrating the first and second steps of Parametric Design

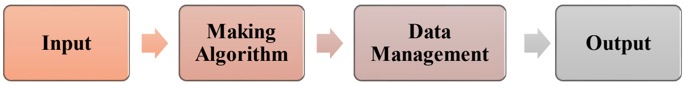


Fig. 8: Parametric Modelling basics

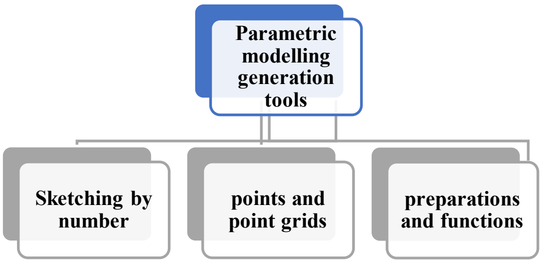


Fig. 9: Diagram for the Parametric Modelling Tools

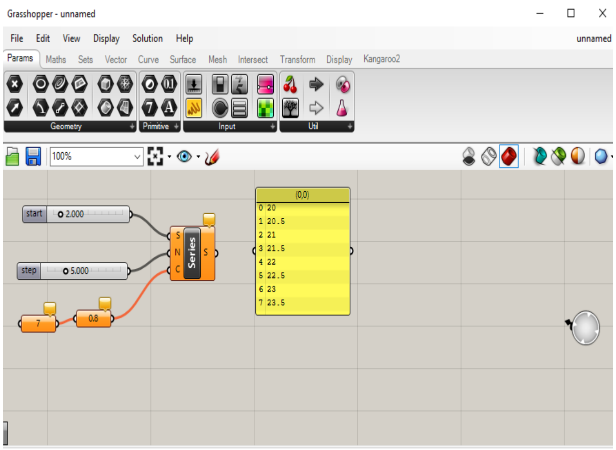


Fig. 10: The quantity of values required for the series to produce a pattern

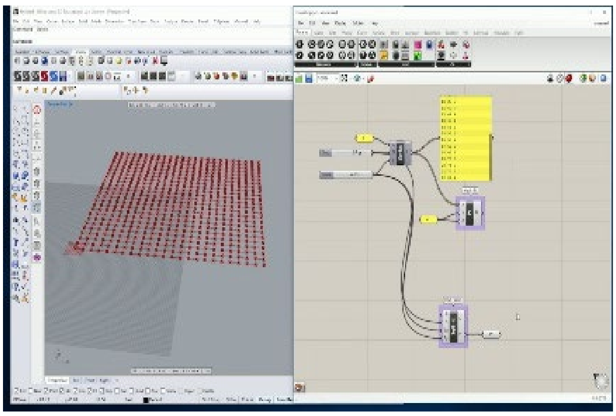
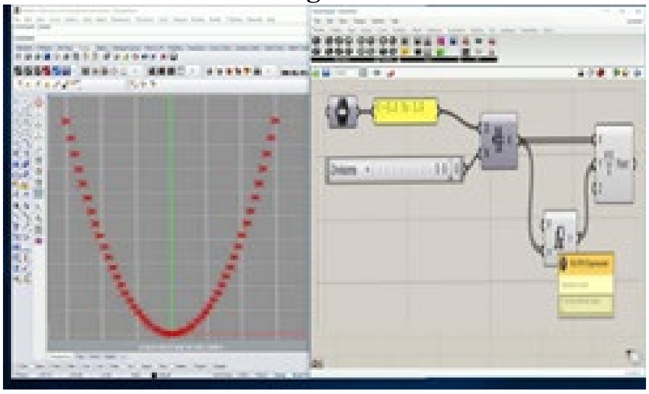


Fig. 11: Generating a grid of points by and to generate geometries

Fig. 12: Mathematical graph of all x values of the function from -3 to 3 f(x) = x2

In order to submit the hyper-cell mechanism, the research will address several parametric patterns for adaptive constructing skin patterns.

2.4. Parametric Design Patterns



Patterns are commonly used in design, featuring interior, exteriors of buildings, urban, and natural features. The patterns produced by interactions between several systems occur at a variety of dimensional levels; the many forms of parametric patterns are displayed in (Fig. 13).

2.4.1. Parametric Modular Static Patterns

The act of repeatedly replicating an element is known as repetition. Tilling is the partial overlap of planar objects across an area in mathematics. Subdivision is the process of breaking up a surface into smaller pieces by cutting or tracing lines, and then dividing the result into random tiles [21].

Branching is a fractal-like, self-repeating structure found in nature, such as tree branches. Weaving is a simple process that involves weaving two threads—the weft and the warp—at right angles to one another to make cloth [22].

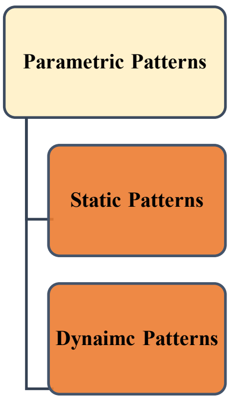


Fig. 13: Parametric Pattern Types

2.4.2. Dynamic parametric patterns

Moving and rotation are examples of simple transformations that are combined to produce more complex motion [23].

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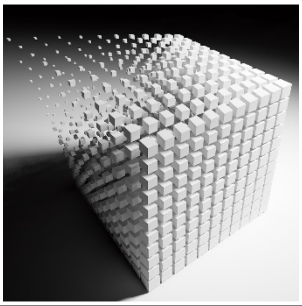
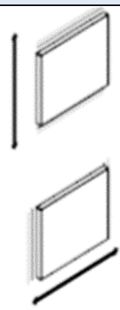
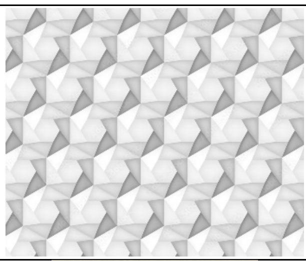
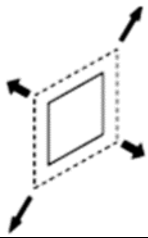
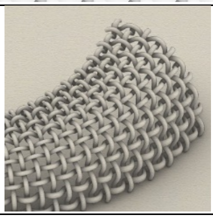
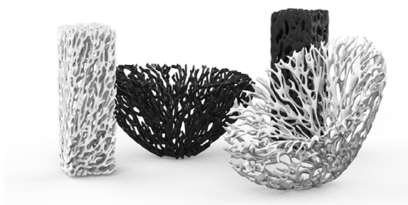
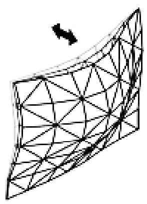
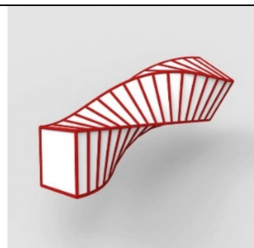
Table 1: Parametric Pattern Types				
Static parametric		**Dynamic parametric**		
Repetition		**Basic change**	**Move**	
Subdivision			**Rotate**	
Tilling			**Scale**	
Weaving		**complex change**	**Folding**	
Branching			**Balloon**	
			Twisting	

Fig.15. Parametric definitions for the first pattern created using Grasshopper

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We will address the application of this strategy by building a parametric hyper-cell prototype after identifying the first part of the curriculum was devoted to theoretical research. The main objective of this design is to produce a dynamic pattern system that is flexible and may be applied to any building, old or new, in order to improve the effectiveness of the building facade design. Where the study was created using testing and experimental techniques, followed by an outcomes analysis. The design process was carried out in accordance with the design framework matrix's rules, starting with the design idea and ending with experimentation and simulation. Using the "Rhino/grasshopper" program, which has the capability to achieve the goal of designing a flexible, variable, and appropriate cell in the process of changing parameters to reach the best design, the linguistic and biomimicry systems were combined to create a parametric hyper cell that suits the conditions of the building under study to use this system on one of its facades. Two cell alternatives were developed; the first is a proposal to cover longitudinal regions, and the second is for large areas. These alternatives were designed to match the façade module of the structure chosen for the study and to evaluate the mechanism and its efficacy. To verify correct application and performance, the evaluation process is then carried out using simulation programs.

3.1. Modelling and Creating the Pattern

The two concepts were designed using the "Rhino/Grasshopper" program. Each unit's interactive movement was activated using scripting as illustrated in (Fig. 14, 16), starting with a simple geometric shape (Polygon) and breaking it up into sections to generate its final shape. Following the application of the hyper cells and their integration with the building facade model that was created, the parametric definition modelling for the parametric pattern design was then completed.

3.1.1. First – Proposal

Starting with a polygon with four segments radius of 1 m, the pattern unit based on the drawing by numbers and the point grid is built to create the entire pattern on the façade of the existing building as shown in (Fig. 15). Using the dynamic pattern complicated transformation "folding," the first proposal hyper-cell's motion of vertical expansion and contraction across the axis is shown in (Table 3 left).

3.1.2. Second – Proposal

To create the full design on the present building's exterior, as seen in (Fig. 17), a rectangle of 2*2.6 m must first be created. According to (Table 2 right), the motion of the second suggestion is a dynamic pattern complicated transformation "folding" that causes hyper-cells to expand and contract horizontally through the axis.

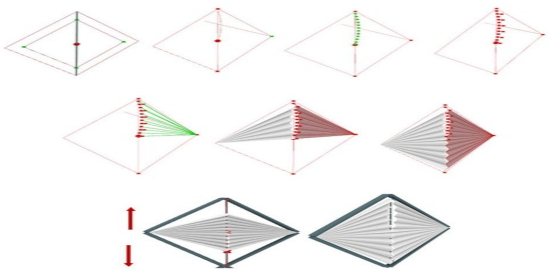
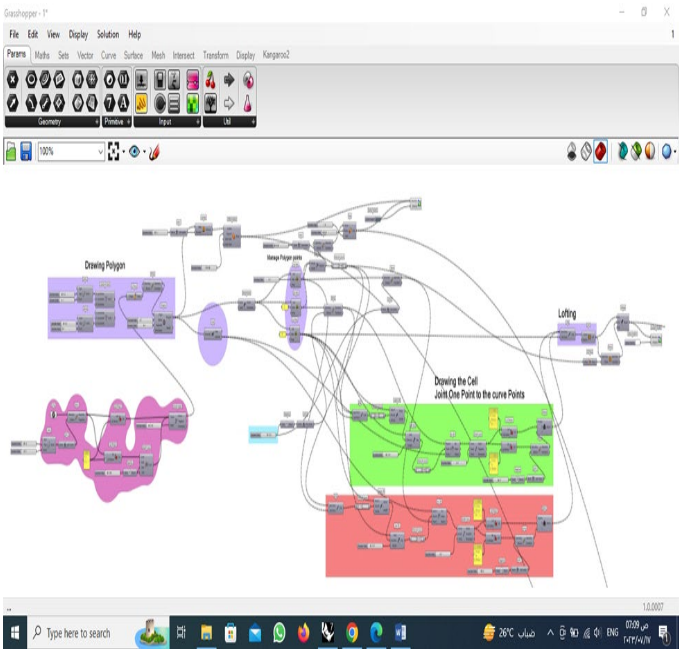


Fig. 14: The First Proposal's "steps" in the Design Process.



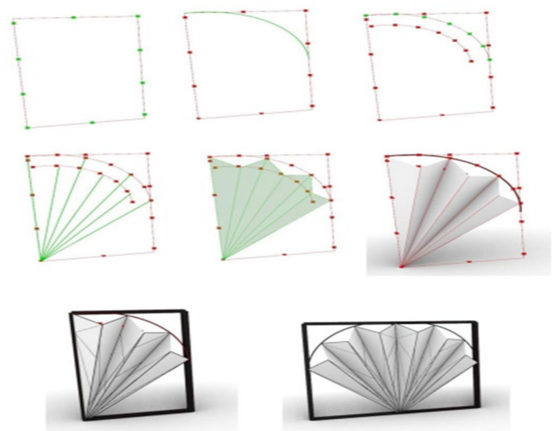


Fig.16: The Second Proposal's "steps" for the Design Process

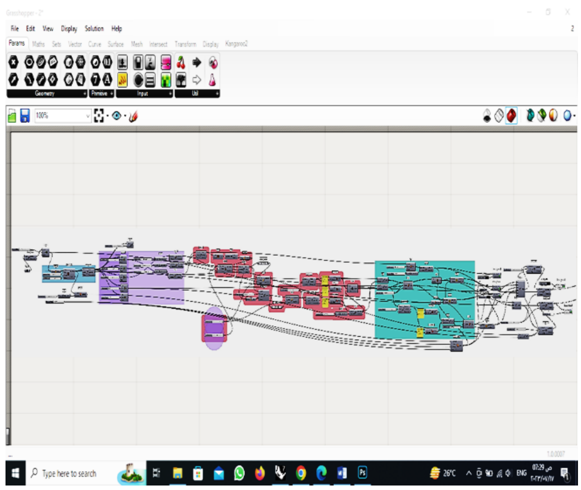


Fig.17: Parametric Definitions for Grasshopper software's second Pattern Design.

3. Material and methods

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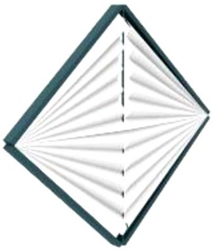
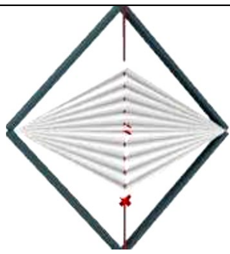
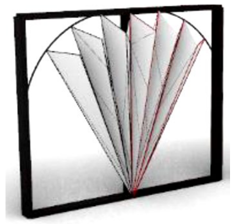
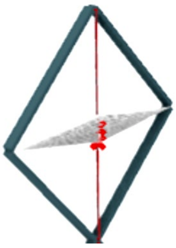
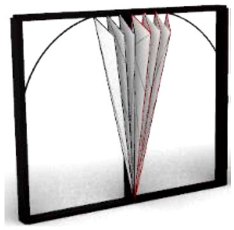
Table 2. The Two Hyper-cells' Movement

	1st suggestion	2 nd suggestion
Shut down		
Semi-opened		
opened		

3.2. Application and Implementation

The project chosen to implement and evaluate the hyper-cell designs is the "Epic, and Complex New Capital" Administrative Building, which is located in the heart of Cairo, Egypt's new administrative capital. After building the structural model as depicted in (Fig. 18, 19), it is important to recognize the path of the sun as an attractive point that generates pattern motions depending on its location as a "Rhino/grasshopper/ladybug" in parametric programs. Setting the parameters for designing an adaptable pattern based on daylight involves doing this in the first stage.

As indicated in (Fig. 20), The first concept was compatible with the cells on the south and west sides of the glass wall on levels two through six, whereas the second idea was compatible with level six thanks to the "Rhino/grasshopper" scheme

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Fig.18: (a) Building address [24]

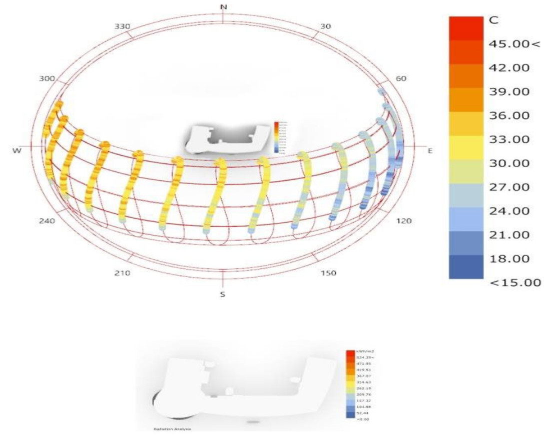

Fig. 18: (b) Sun's route in the area

Fig. 19: The Existing Building façade 3D Model

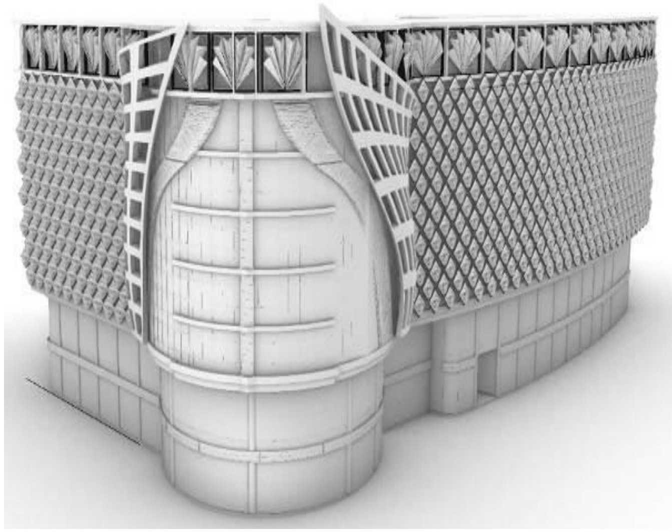

Fig. 20: The Application of the Hyper-cell Proposal

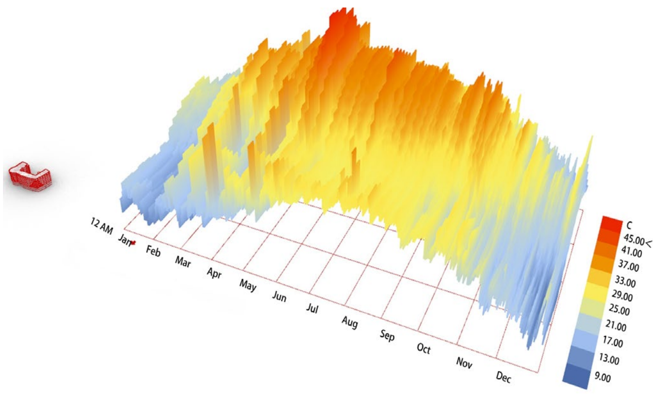

Fig. 21: (a) Monthly Dry Bulb Temperature

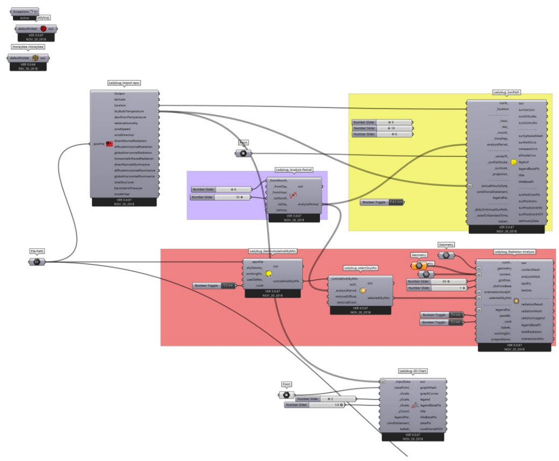

Fig.21: (b) Simulation definition

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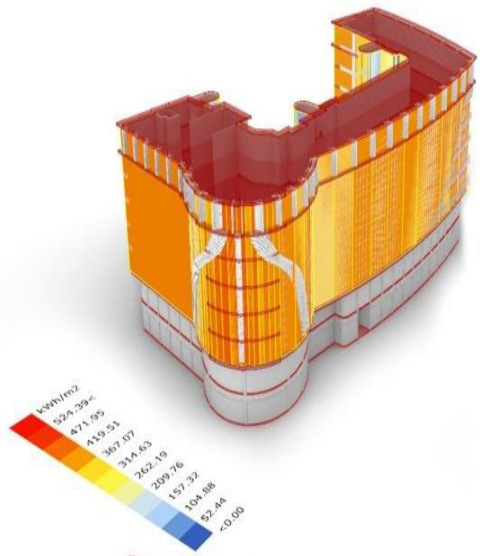
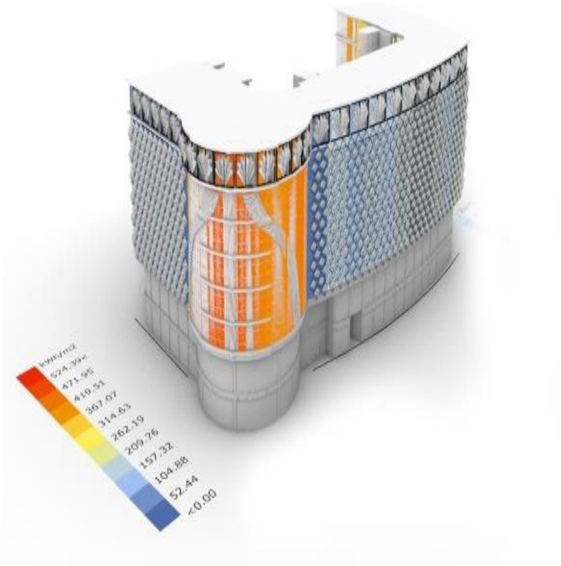
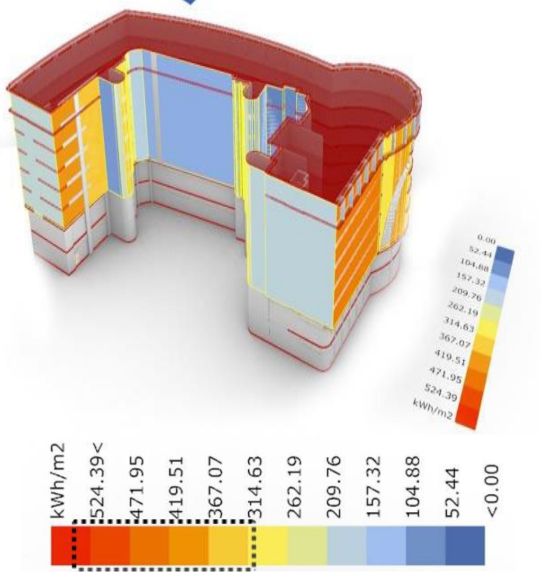
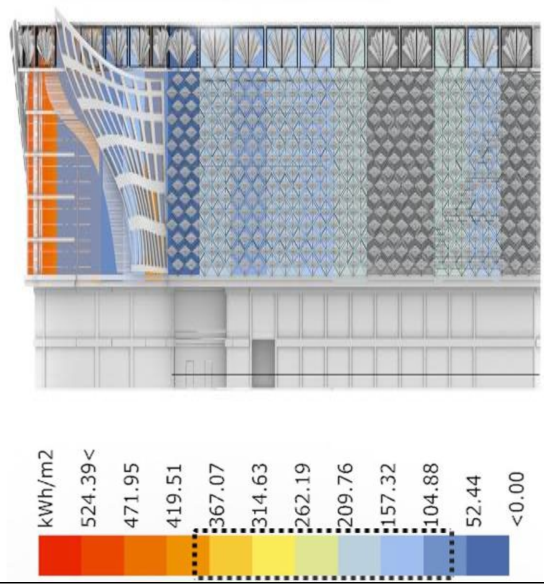
Table 3: Sunlight Simulation and Solar Radiation

"Ladybug/Grasshopper" simulation of solar radiation (Ladybug Analysis Period from month 6 – 10)	
Existing	**Following the use of Parametric Hyper-cell**
	
	

4. Results and Discussion

4.1. Results

The site analysis stage follows the completion of the design, modelling, and application processes. In order to increase building efficiency, achieve internal visual and thermal comfort, reduce the amount of solar radiation emitted by the direct sunlight-exposed façade, this phase identifies the facades that need to be redesigned by the use of parametric hyper-cells and their distribution. The outcomes are then examined both internally and publicly by comparing the building's state before and after the application. The simulations use the computer programs "Energy-Plus" and "Radiance," which communicate with

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plug-ins for "Rhino/Grasshopper/Ladybug and Honeybee" via software (.epw files). Temperatures rise the most throughout the summer, from June to the end of September, as seen in (Fig. 21). These months see average highs of between 36 and 42°C.

The most direct sunlight hits the southern facade, which causes glare and a bad visual environment inside. As shown in (Table 3), the hyper-cells were applied to the study's façade. simulating solar radiation on the surfaces. Before and after applying the hyper-cells using grasshopper/honeybee as shown in (Table 3), A building administration (5.2 mL, 3.7 m W) room with a southern façade was used for the daylight simulation.

4.2. Discussion

The significant evolutionary change in architecture and design, from the perspective of architectural design, is parametric. Modern computer technology and artificial intelligence have led to a variety of fundamentally innovative approaches to overall compositional and parametric design. As a result, a sophisticated system of historically evolved human knowledge and the inherent qualities of place is used to integrate architectural traditions with digital technology.

The intersection of multidisciplinary sciences, such as economics, biology, psychology, and mathematics. —leads to the synthesis of natural morphogenesis and novel parametric modelling. They enable the investigation of parametricism about one another and are effectively incorporated into sophisticated computer design.

Thus, the ideological quintessence, determined by human thought and cognitive activity, surrounds the mathematical algorithms of parametricism. The computer replicates the mathematical procedure by comparing the data in its "memory" with the parameters established by the person and interacting with the rules of several sciences Such intelligence can calculate the engineering and technical upkeep of the proposed object, minimizing them, the influence of seasonal weather conditions on the building, particularly its optimal orientation with regard to the sun and its outgoing interactions with its surroundings.

As a result, utilizing cross-disciplinary sciences, computer modelling, and artificial intelligence, it is now feasible to create architectural "plots" based on multifunctionality and multifactor. A spatial representation of the item, surface, or plane that will continue to function in the "digital environment" is created by the architect. The person's intention is communicated to the computer in the transformed parameters. The outcome is a revolutionary tandem for the depiction of the mental process and spatial surroundings that is the result of the "man-computer" creative cooperation. The process of designing is becoming simpler. Surfaces that are complex and multidimensional can be altered indefinitely to get perfect technical and economic indicator projects [25].

Today's artificial intelligence in computers is becoming more like a human partner [26], and parametricism integrates many methods. There are entirely new trends in architecture and design, including bionics, digital baroque and morphogenesis, parametric ornament, morpho-ecological design, and parametric urbanism, which can create a harmonious environment.

5. Conclusions

By observing the sun and using it as a magnet that affects the movement of the pattern and the comfort of the space's occupants, the current study aims to construct and produce parametric hyper-cell patterns to alter the design and find the relationship between the sun and the pattern's movement. Through the use of adaptable patterns, it is possible to change the illumination, distribution, glare, and directivity of light by adjusting the distances between the pattern's surfaces.

The pattern can be created using linguistic, biomimicry, or both methodologies, and it can be formalized in accordance with the design concept. Focused transformation uses three fundamental transitions: motion, rotation, and scale. These transitions, which are depicted as sophisticated geometric changes, when paired produce more complex actions like folding, twisting, ballooning, deflating, and inflating.

The mechanism technology is needed to deliver the best illumination possible, depending on the design requirements. The following steps are taken during the design process: design concept, modelling and pattern development, application and implementation of the parameters "sun path, solar radiation, bulb temperature, and daylight," evaluation and simulation with the aid of the simulation program "Grasshopper/ladybug-honeybee," and lastly, conclusion. Finally, it is suggested to engage in digital manufacturing and materialization.

The proposed design, used in the "Epic complex" building, raised the facade's efficiency in terms of design and the environment, lowering glare from direct sunshine and minimizing solar radiation on exposed surfaces to provide eye comfort. This was done without altering the building's existing facade des

6. References

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©Tanta University, Faculty of Engineering
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[1] Deezen, Sydney Opera House concert hall reopens after extensive renovation, Dezeen. (2022). https://www.dezeen.com/2022/09/02/sydney-opera-house-concert-hallrenovation/.

[2] Marcos Martínez, How do you build a Guggenheim museum? - Ferrovial's blog, Ferrovial. (2017). https://blog.ferrovial.com/en/2017/10/guggenheim-museumconstruction/.

[3] Forgemind ArchiMedia, Corbusier Modulor color.jpg, 2010. https://www.flickr.com/photos/eager/5031911411/.

[4] Wladyslaw, Deutsch: Montreal: Habitat67, 2008. https://commons.wikimedia.org/wiki/File:Montreal_-_QC_-_Habitat67.jpg.

[5] E. Pertigkiozoglou, 1973: Nicholas Negroponte and Architecture Machine Group MIT, Medium. (2020). https://eliza-pert.medium.com/1973-a1b835e87d1c.

[6] Samuel Medina, Gallery of Paul Goldberger: "Frank Gehry Really Doesn't Want To Be Remembered as Somebody Who Just Did a Few Iconic Buildings" - 8, ArchDaily. (2015).

https://www.archdaily.com/778151/paul-goldberger-frank-gehry-really-doesntwant-to-be-remembered-as-somebody-who-jus t-did-a-few-iconicbuildings/565f0003e58ece20b4000229-paul-goldberger-frank-gehry-really-doesntwant-to-be-remembered-as-somebody-who-just-did-a-few-iconic-buildings-photo.

[7] Z. Hadid, Marsupium, Vitra Fire Stationlabel QS:Lit,"Vitra Fire Station", 1993. https://commons.wikimedia.org/wiki/File:Vitra_Campus_-_Hadid_Fire_Station_-_full_view,_blue_sky.jpg.

[8] Sunena V Maju, Midjourney: in the middle of the universe and multiverse of AI imagination, (2022). https://www.stirworld.com/see-features-midjourney-in-themiddle-of-the-universe-and-multiverse-of-ai-imagination.

[9] S. Chaillou, The Advent of Architectural AI, Medium. (2020. https://towardsdatascience.com/the-advent-of-architectural-ai-706046960140.

[10] M. Tashakori, "Design of a computer controlled sun-tracking façade model," The Pennsylvania State University, 2014.

[11] F. Z. Çağlar and G. Z. Gedik, "A new design proposal for perforated solar screens and optimization in terms of solar control," Civil Engineering and Architecture, vol. 9, no. 7, pp. 2416–2426, 2021, Doi: 10.13189/cea.2021.090727.

[12] H. MODIN, "Adaptive Building Envelopes.," Chalmers University, Goteborg, Sweden, 2014.

[13] H. S. M. Shahin, "Adaptive building envelopes of multistory buildings as an example of high-performance building skins," Alexandria Eng. J., vol. 58, no. 1, pp. 345– 352, 2019, Doi: 10.1016/j.aej.2018.11.013.

[14] P. Schumacher, "Parametricism: A new global style for architecture and urban design," Archit. Des., vol. 79, no. 4, pp. 14–23, 2009, doi: 10.1002/ad.912.

[15] C. Stover and E. W. Weisstein, "Parametric Equations," MathWorld--A Wolfram Web Resource. (Accessed Jun. 02, 2022). https://mathworld.wolfram.com/ParametricEquations.html

[16] M. Lane, "Recovering Ada: Finding our way home through sensuous correspondence," Eur. Grad. Sch., 2015.

[17] R. Scheeren and D. L. Costa, "The Parametricism manifest: prospects about a „new global style" for architectural design and urban planning," V!Rus, vol. 11, no. December 2015, 2015.

[18] N. Gu, R. Yu, and P. A. Behbahani, "Parametric Design: Theoretical Development and Algorithmic Foundation for Design Generation in Architecture," Handb. Math. Arts Sci. Springer Int. Publ. Cham, pp. 1–22, 2018.

[19] G. Gallo and G. Pellitteri, "History to Parametric Architecture," Learn. Prototype. Adapt. Short Pap. Proc. 23rd Int. Conf.

Compute. Archit. Des. Res. Asia 2018, no. May, pp. 1–6, 2018, doi: 10.13140/RG.2.2.28349.15842.

[20] Z. KHABAZI, "Generative Algorithms - Weaving," Morphogenesis, 2013, Doi: 10.1007/978-1-4614-3858-8_ 100399.

[21] W. Jabi, Parametric design for architecture. Hachette, UK: Laurence King Publishing, 2013.

[22] S. Hanafin, S. Datta, and B. Rolfe, "Tree façades: Generative modelling with an axial branch rewriting system," Circuit Bending, Break. Mending - Proc. 16th Int. Conf. Compute. Archit. Des. Res. Asia, CAADRIA 2011, pp. 175–184, 2011.

[23] J. Moloney, "Movement at the periphery," in Designing Kinetics for Architectural Facades, Taylor & F., New York, USA: Routledge, 2011, pp. 3–11.

[24] "Google maps location," Google maps.

https://www.google.com/maps/place/Epic+Complex/@30.0286114,31.674242,779/data=!3m2!1e3!4b1!4m5!3m4!1s0x14584 16ed03de1ef:0x59aa36c2c904d1d!8m2!3d30.0286114!4d31.6764307.

[25] Lihobabin, K.A., Shevnina, A.P., Pomorov, S.B.: Parametricheskaya metodologiya v rabote architecture, Vestnik AltGTU im. I.I. Polzunova 1–2, 223–226 (2015)

[26] Shapoval, A.V.: O vliyanii iskusstvennogo intellekta na sovremennuyu industrialnuyu kulturu, Vestnik KGU im. N.A. Nekrasova 4, 230–232 (2009).