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Rethinking of Architectural design using Computational Approach

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Abstract - "Rethinking Architectural Design with Computational Methods" explores the computational evolution of architectural practice. This article traces historical changes and highlights key moments and achievements that shaped computing integration. It demonstrates the role of algorithms in generating and optimizing architectural information by delving into algorithm design. The integration of digital tools and fabrication techniques is demonstrated by discussing parametric design and the ability to create architectural solutions. This article explores the new potential of computational design and embeds it in a case study project of computational design. Challenges and future directions addressing ethical issues and expectations for change in human-machine interactions in architecture are identified. This research introduces architectural theory regarding the relationship between computers and the built environment.

Key Words: Architectural design, Computational methods, Algorithm, parametric design, Generative design

1.INTRODUCTION

Computational Design signifies the fusion of computational prowess and design methodologies through systematic logical sequences. Traditionally, architects relied on experience and intuition for design innovation, but contemporary technology has revolutionized this approach. The design journey is now empowered by computational capabilities, yielding more efficient and optimized solutions. The emphasis isn't merely on documenting the final design output; instead, Computational Design focuses on the transformative steps leading to that culmination. While computation might seem unfamiliar to those outside computer science, it defies a fixed definition, often characterized as a mathematical yet non-numerical process. Simply put, computation involves the transformation of sequences guided by precise rules and logical procedures.

2.1 History

The initial phase of computer integration in architecture, known as the 2D drafting era, began with Ivan Sutherland's development of Sketchpad in 1963. Sketchpad first supported 2D drafting before developing to accommodate 3D models, which signaled the beginning of 3D design's commercial use. IBM and General Motors then released DAC-1, a tool for drawing automotive models. The 1980s saw the release of AutoCAD, a well-known 2D drafting program that gave architects sophisticated tools and an intuitive user interface to improve accuracy and productivity while creating large-scale drawings. (Bhattacherjee, n.d.)

The next stage, which we'll refer to as the 3D modeling era, is all about creating 3D models and working on projects. Based on James Joseph Sylvester's 18th-century matrix theory, applications like Rhinoceros and Cobalt were first released in the 1980s. A new era in architecture was brought about using 3D modeling by architects such as Frank Gehry and Greg Lynn to handle complex geometry.

The third phase is the development of Building Information Modelling (BIM), which dates back to the 1970s and was codified in a paper by Simon Ruffle in the middle of the 1980s. As 3D models contained large amounts of information and allowed for a variety of calculations, BIM software was developed. In the middle of the 1970s, Charles M. Eastman invented innovative products like AEC CAD. Well-known BIM programs like Tekla Structures, Autodesk Revit, and ArchiCAD improved project and risk management by streamlining BIM processes. Notable constructions that demonstrate the impact of BIM on project visualization and execution efficiency are the Nanjing International Youth Cultural Centre and Lè Architecture. (Bhattacherjee, n.d.)

Computational Design, an algorithm-based methodology that is transforming architecture, is introduced in the fourth era. Improved form understanding helps designers explore options and come up with the best solutions. The development of computational design led to the creation of parametric architecture, generative design, geometric rationalization, form finding, and programmatic analysis. Its extensive acceptance was aided by David Rutten's Grasshopper, a visual programming application featuring Python and C# coding capabilities. Parametric architecture has also become more popular because to Cobalt, Dynamo, and FreeCAD. Computational design encompasses digital fabrication and robotics in construction. Its impact may be seen in architectural wonders like the Heydar Aliyev Center, the Guangzhou Opera House, and "Grotto II" by Benjamin Dillenburger and Michael Hansmeyer. (Bhattacherjee, n.d.)

In the fifth era, Machine Learning, an extension of computational design, employs algorithms, pattern recognition, neural networks, and artificial intelligence. Operating through stages of training, analysis, and applications, machine learning enables computers to design solutions based on input, leveraging experience and statistical models to yield productive data for users.

2.2 Parametric Design

The design methodology known as parametric design, or parametricism, is defined by the use of programming languages to manipulate parameters. This style, which defines the essence of parametric design, treats a model's geometric features as variable variables and was pioneered by visionary architects like Frank Gehry, Zaha Hadid, and Patrik Schumacher. It's important to make clear that, despite sporadic misconceptions, parametric design is not an architectural style in and of itself, even though its frequent use in buildings featuring free-form and dynamic geometries may imply otherwise. Combining parametric design with generative design tools allows for a wide range of creative possibilities and the production of many design iterations based on predefined parameters. (Hnin, 2022)

Fig -1: Astana Expo - 2017 Future Energy (*Astana EXPO – 2017 Future Energy – Zaha Hadid Architects*, n.d.)

2.2 Algorithmic Design

Algorithmic design, which uses algorithms to produce design concepts, differs from parametric design, which is molded by the parameters in a model. Algorithms, which dictate the creation of designs, are rules ordered logically in contrast to parameters, which represent modifiable current situations. The shapes of algorithmic design are not static; in a matter of minutes, a multitude of iterations are revealed, demonstrating their dynamic and iterative character. Algorithmic design stands out for its ability to generate ideas quickly and creatively, which opens up a wide range of possibilities in a short amount of time. (Hnin, 2022)

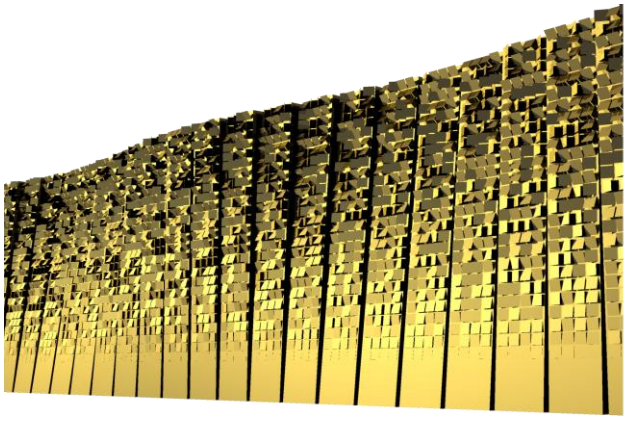

Fig -2:Nolan Building in Melbourne Project by Alexander Knox (*ADA*, n.d.)

2.3 Generative Design

Generative design often collaborates seamlessly with either parametric or algorithmic approaches, or a combination of both. Although there has been some terminological confusion, the term "generative" accurately describes its function as the creative engine underlying design output. More specifically, generative design is inextricably linked to both parametric and algorithmic design approaches. The skillful application of parameters and algorithms in algorithmic design to produce design iterations within predetermined limitations is the cause.

The Evolution-based Generative Design system pushes creativity even beyond. By adapting designs to their surroundings, this progressive approach evolves designs, reflecting the ideas of natural selection within a creative framework. (Hnin, 2022)

Fig -3 The Mushrooms of Seville (Sawantt, 2022)

3. CONCLUSIONS

In conclusion, the terrain of architectural innovation has been reshaped by the incorporation of computer techniques such as parametric, generative, and algorithmic design. With the aid of these instruments, architects can go beyond conventional limits and promote a dynamic interaction between technological accuracy and human creativity. Architecture is entering a new era of unprecedented possibilities thanks to the combination of the systematic logic of algorithmic design, the iterative exploration of generative design, and the flexibility of parametric design. In addition to improving design efficiency, this symbiotic interaction between human intuition and computational capabilities produces visually appealing, sustainable, and adaptable buildings. The combination of creativity and technology in architectural design offers a future where buildings are not only static objects but rather dynamic, responsive reflections of our changing wants and goals as we travel through this transforming journey.

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