

Using Digital Methodologies In Design Optimization

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Introduction

Today, the architecture industry faces many challenges that revolve around occupant comfort, cost-effectiveness, and energy saving. Computational optimization is essential since it solves contemporary architectural challenges. Architects utilize biologically inspired techniques, Artificial Neural Networks, swarm intelligence, and evolutionary algorithms to discover high-performing design solutions. The influence of optimization techniques is more on engineering design than in architecture professions despite its core role in architectural research. Architects rarely use the optimization method since the architectural design is associated with time complexity and intensity. The field of mathematical optimization is more vigorous than the general optimization method, according to ADO evaluation. Nevertheless, contemporary researchers in architecture use problems of quantitative benchmarks to test optimization techniques. Complex design problems require specific optimization methods to be solved. However, the application of optimal design solutions among practitioners is hard due to various available barriers. The use of computer science in architecture, especially in design optimization, has elevated most optimal design problems through the development of robust optimization and user-friendly tools and software. Energy and cost-effective, comfortable as well as safe buildings are the main focus of design optimization in real life. The paper aims to explore the use of digitalized methodologies in architecture design optimization. The essay centres on major types of digital design optimization, digital technology in designing, and computerized approaches used to generate designs.

Types Of Digital Design Optimization

Genetic Algorithm Method: It is a powerful method for building and architecture design when associated parameters are incorporated. The designs of algorithms-based parametric are efficient when utilized to construct geometry models since the adjustment of the geometry parameter is easy; hence, it is possible to have a tailor-made design. Genetic reproduction and genetic evolution principles form the basis of a search method, such as the genetic algorithm, to optimize geometry designs. Additionally, it is possible to [optimize geometric design parameters](#) through the use of various tools, such as an integrated design. A binary genotype or string encoded from design variables is a representation of design due to geometry modelling and evolutionary search algorithm tools like a Generative Component. The use of natural selection, mutation, and crossover is common in design alternatives. The tool enables design optimization to be executed using any geometry

parameters and a combination of parametric graph variables. A user-defined geometry attribute is an example of a fitness score used to evaluate a design solution. During the evaluation, every new design has one fitness score. A subsequent design solution occurs if more solutions are selected (Gololov, I. and Yezioro, A., 2007). Hence, natural selection emulation leads to optimized generation. Ultimately, the practical design of a sports stadium and the simple case have been possible via the use of an integrated tool in the genetic algorithm method.

Non-Linear And Linear Design Methods: Examination of two or more design processes is critical during architectural design. Initially, before the intervention of computer science in architecture, great human labour, as well as time, was mandatory to successfully evaluate each design alternative. There are two major changes in design as a result of the introduction of computer-oriented design. The first change is the capability of architects to deform and handle forms of architecture. The new change reduced the time to create design alternatives. Limited time is required to replicate and produce physical model³⁰, 3-D virtual, and alternative from a 2-D drawing. The second method is where the alternative designs are generated through the use of computer processing power (Januszkiewicz, K., & Banachowicz, M, 2013). The degree and type of deformation in the generated alternatives are controlled by the designer. Consequently, the development of various designs is possible, and specific alternatives can be produced at undesignated stages.

Digital Tools Used In 3-D Design Optimization

Modelling And Drafting Software: There are two types of software that cover most of the tools architects use that are featured in this category. The first software is the drafting software. It is mainly used in the development of 2-D documentation and designs since its 3-D modelling capability is limited. The 2-D designs still serve as the major method of communication that the architects and structural engineers use. The 3-D modules contained in the software majorly offer orthogonal modelling options that are based on polygon meshes and solid modelling, hence only presenting limited options for free-form design. Vectorworks, Arc+, Datacad, Microstation and Autocad are the leading software programs. Also, several other applications are available but have a limited presence in the market. The other type of software is modelling software. It is designed for architectural use, such as model production, presentation, modelling, and design. In some instances, it is a limited animated software version. 3D VIZ, which is a limited version of 3ds Max, is among this category's commercial software (Aly, M. and Nassar, K, 2013).

Parametric Software Programs For Architects: The introduction of the first parametric applications happened in the 1980s. The effort, by this time, to develop an application that uses computer-based generation of the plan of a project to solve the "problem of space allocation" had been reduced. The development of programs that are human-machine interactive in which a designer uses a computer program referred to as a design companion to develop a design instead of using a drawing board was the main focus of the initial parametric applications. The approach was used to develop applications that were mostly 2-D, and the number of entities that could be handled was limited. Therefore, it was

necessary to employ a combination of methods. Hence, the suggestion to use the combination of an evaluation method and the generative method was made in 1987. The second generation of parametric software for architectural use was developed in the 1990s. The software provides the solution for both 2-D documentation and 3-D modelling. The sections and plans are derived from a similar 3-D model in the software. Tool for documentation, such as text or dimensioning, is included in the software. The full integration of the technique of free-form design is not yet in this software, hence presenting a limitation regarding the formal expression of the design. Some of the leading software here are Revit, Architectural Desktop and Archicad. A parametric software called Generative Components, which has the definition of complex constraints capability, is currently under development at Bentley.

Modelling Software Originally Designed For Other Professions: Architects use a majority of modelling software that was originally developed for use in other fields, such as industrial/mechanical and animation design. The software is mainly used in the average architectural company for representation and modelling, either for its final product representation or as a component of the design process. Free-form elements manufacturing and design are also important. Complex form manipulation and creation can be done by the use of software programs created for mechanical and industrial design. Also, the programs can export directly to RP and CNC machines and contain necessary modules for real material performance calculation. The leading programs here are Form Z, CATIA and SoftImage, among others (Arvin, S. A., & House, D. H, 2012).

Computer-Based Generative Design Methods

The ability of computer-aided designs to generate buildings from data was expected to replace conventional designs in the early days. Therefore, some of the developed generative systems aimed to utilize the processing powers of a computer in spatial design completion to overcome limitations that occur when designers process the information of models and designs. Moreover, computer-aided designs assist in the modelling of building plan layouts through the use of less comprehensive approaches.

Cellular Automata: Cellular Automata (CA) is one of the earliest tools used in computer form generation. It mainly began as software that simulates 2-D growth and is based on Von Neumann's 1940s theories about self-replicating forms. The adoption of CA in architecture is done in various ways, such as the use of CA to predict or simulate the cities' growth and the development of complex formal expressions. CA is capable of creating conceptual forms that are highly complex and, hence, can be used for inspiration in the finding process of an architectural form. For instance, the CA-based algorithm can be used in the generation of building façade patterns.

Automated Floor Plan Generation/Space Allocation: Various principles can be used in automated space allocation and floor plan generation. Using the programmatic information in generating a building plan was the main focus of the earlier approaches. The majority of the approaches centred on

2-dimension plan generation, but some used excluded planes (2.5-dimension). The above-mentioned approach demonstrates the generation of floor plan ability through the production of prototype tools, but neither has much commercial application in building plan generation nor substantial influence on architectural practices due to various reasons (Januszkiewicz, K., & Banachowicz, M, 2013). First is the complexity of the problem. Space allocation has little programmatic demands that architects take into consideration during the generation of a plan. The second reason is the singularity of each building. Each project requires new definitions of rules since the program for every building is unique. Finally, it requires three dimensions, which are complicated and difficult to solve.

Conclusion

The introduction of the computer in architecture has a wider scope of influence. One of the disciplines that has a wider application is design optimization through the use of digital methodologies. The use of digital methodologies optimization and simulation in the design process has enhanced the position of architects in the building discipline. The simulation process in the design process enables the architects to solve problems during the process. The tools or technologies do not automate the process completely but are useful in design evaluation and generation. The designers use the approaches in subjective and quantitative judgments as well as in maintaining control where appropriate. The continuous progress in the use of digital methodologies in design optimization is made possible by the production of appropriate software for the various approaches.

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