

Interactive Design Optimization Of Architectural Layouts

Posted on September 17, 2018

Michalek and Papalambros's article talks about the design of architectural floors using an interactive method for incorporating human and mathematical optimization. Many design area involves constraints, preferences as well as subjective and quantifiable goals. Various subjective and aesthetic design aspects are overlooked in model optimization since they are hard to model with mathematics. However, architectural and product design requires the use of aesthetic and subjective aspects in designing floor plans. During optimization, there is a physical interaction between the building objects and the designer. The interaction is vital since the optimization representation can be changed through modification, deletion, and adding of the structural, constraints, and objective units. The designer easily refines the ill-defined designs encountered in the early design phase through the application of the mathematical optimization tool. Moreover, the exploration of design alternatives computationally and visually is highly utilized by the designers to sustain, compute and provide effective solutions.

Performative Computation-Aided Design Optimization

The authors of the article illustrate the use of performance-based [computational design approaches](#) in the generation, optimization, and simulation of architectural designs. The research examines various methods of design, such as the relationship between performance, building form and proprietary software used for parametric design. The article describes the present issues for form sketching. Architects have unprecedented freedom of fabricating and modelling forms due to extensive CAD/CAM technology development. Digital fabrication has intensified the disconnection between principles of "performance-driven design" and methods of "visual-driven from seeking." The research methodology used focuses on technical optimization and human optimization (performance was driven, and visual processes integration was driven). The two projects used to explain the concept are the Anthropometric Garments and the Scuta - Re: Skin. The Anthropometric Garments project introduces the students to the use of ergonomic analyses and anthropometry in observing and documenting the human body. The investigations drive from using performativity and visual data extracted from the human body. The "scuta" project investigates the relationship between visual-based and performance-based design. The research concludes that the relationship between performance, meaning, and form generates new design languages and methodologies.

Black-Box Optimisation Methods For Architectural Design

Exploration of automated design space depends on black-box optimization. The articles talk about the three types of black-spot optimization in architecture. The four performance designs with unique characteristics and complexity are the basis used for the comparison. The first black-spot optimization method is metaheuristics. It is a common approach among practitioners and researchers. Many architectural theorists utilize this theory in their writing. It is a popular method since it can be applied to multi-objective optimization and is easy to implement and use. Visual programming software such as Grasshopper™ easily implements genetic algorithms. The second type is direct search, which minimizes the possibility of constructing a model without an objective function. DIRECT is a common example of direct search that can be incorporated into Goat™. Nevertheless, the direct search method is outperformed when applied to mathematics test problems. The last method is the model-based optimization. It establishes the unknown fitness landscape through the use of interpolated functions. Also, the estimation of the design candidate's performance is done by a surrogate model. This approach is appropriate in the architecture design process because it is possible to estimate the performance of the whole design space and establish a good design candidate at the same time. (Nagy et al., 2017) The result indicates that the metaheuristics method is appropriate where there are thousands of design candidates, while model-based and direct search methods require few design candidates.

Heuristic Methods In Architectural Design Optimization

The focus of the authors in this article is on the illustration of methods of optimization and the roles they play in architectural production and design. The development of the optimization methods happened during the “New Monte Rosa Shelter” project's research phase to enable the design's adaptation for the specific constructive and environmental constraints of the site and cost minimization. Students developed the New Monte Rosa Shelter project for a high-altitude mountain shelter. The article explains that optimization was required to reduce cost and minimize weight as well as the material of the structure for construction and transportation reasons. The optimization of the wooden framework geometry was made possible by a series of genetic algorithm programs. The architects obtained surface information output from the combination of the programs to produce a digital toolset, which allowed for three-dimensional model output from the framing data. The optimization toolset enables easy manipulation of the architecture. The article centred on a single specific optimization tool that enabled the automatic filling of the wooden framework with different constructive systems and materials.

Nonlinear Shaping Architecture Designed With Using Evolutionary Structural Optimization Tool

The article explores the use of the Evolutionary Structural Optimization as a digital tool in architecture and structural designs. Nature provides structural designs and efficient engineering solutions in architecture. The connection between science and art is established if the structures and natural environment interact. Hence, it is a new concept that should be applied to architectural design. The utilization of finite elements, such as a framework for engineering purposes, was the primary reason for the development of the evolutionary structural and optimization tool. Extended, Bi-directional, and additive ESO are the incarnations resulting from the development of ESO. The paper also explains the use of digital tools in architectural and structural designs. The result indicates that a combination of economic and ecological efficiency, as well as sustainability, occurs when structural and architectural designs appreciate a new holistic integration. For instance, a highly energy-efficient building in Switzerland is known as Rolex Learning Center. The findings show that the integration of a multitude of parameters and structural optimization is the basis of an excellent optimized architectural design. Moreover, the paper assumes a correlation between design methods and processes in nature. Therefore, good revolutionary or architectural forms and space are not guaranteed by the architecture design and structural engineering but by the Evolutionary Structural Optimization tool. (Hillier & Hanson, 1984)

Using Evolutionary Computation To Explore Geometry And Topology Without Ground Structures

Peter Von B. explain the application of Evolutionary Computation (EC) in the exploration of topology and geometry without ground structures. Evolutionary Computation use in optimization and analysis of structural systems has increased over the past two decades. The EC methods include generic algorithms, evolutionary strategies, and simulated annealing, as well as other numerical methods based on stochastic methods. The methods are very computationally intensive, unlike deterministic methods. As the size of being analyzed increases, the burden of computation also increases. Direct computational methods such as linear programming are where ground structures were first applied. The article explains that avoiding the use of the ground structure as a common practice of coding the topology can reduce the computation level. The author further suggests that avoiding the use of ground structure can help in reaching several good solutions, as has been shown in comparative examples. Computational hindrance occurs when ground structures are used such that the computational intensity level needed for the Evolutionary Computation is impacted by chromosome (binary string length).

Structural Morphology And Self-Organization By STACH, EDGAR

Edgar's papers investigate a fundamental principle regarding the relationship between physical constraints and optimization logic. The goal of the research was to understand the process of optimization in nature through the evaluation of each process based on its scope, essential features, processes, principles, and processes. Topology and structural shape optimization are efficient and reliable methods of computational structural optimization. However, the two techniques are rarely used by the designers or architects. The practical application of the structural optimization theory in structural design is through the use of the principle of being lightweight in nature. Structural morphology occurs on micro, local, and global scales. The optimal layout is the essential constituent for the Performance-Based Optimization of Structure. The structure "layout" in this context refers to sizing, shape, and topology information of the materiality and structural component. It is possible to address a different problem at the same time using this optimization strategy. Structural morphology links architecture and civil engineering. The study of how structural behaviour relates to geometric is termed structural morphology. Independent and clear subsystem results when the form is decomposed through structural engineering as opposed to contemporary architecture. However, the new analysis tool enables architecture to deal with complex geometry and avoid system severing and isolating.

The Practical Optimization Of Complex Architectural Forms

The articles explain how complex architectural forms can be optimized practically by the use of digital methodologies. The shape of a building determines the internal conditions and the energy consumption. Production of designs with minimal consumption of energy has been attempted several times within a thermal simulation environment using computer-based optimization. The article explains that optimizing parameters, including glazing ratios and U-values, have been looked at in most of the studies. The article presents the optimizing methodology involving internal layout and building facades. Basic shape alteration can affect the performance of energy by up to 40 per cent. Optimization of form can be done by using genetic algorithms. Floor division into multiple spaces allows for the correct distribution of equipment in the building, artificial lighting, and occupancy.

References

Nagy, D., Lau, D., Locke, J., Stoddart, J., Villaggi, L., Wang, R., Zhao, D., & Benjamin, D. (2017). Project Discover: An application of generative design for architectural space planning. Proceedings of the Symposium on Simulation for Architecture and Urban Design.

<https://doi.org/10.22360/simaud.2017.simaud.007>

Hillier, B., & Hanson, J. (1984). The social logic of space. Cambridge University Press.

<https://doi.org/10.1017/CBO9780511597237>