PARAMETRIC DESIGN OPTIMIZATION FOR SOLAR SCREENS: AN APPROACH FOR BALANCING THERMAL AND DAYLIGHT PERFORMANCE FOR OFFICE BUILDINGS IN EGYPT

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Abstract

Architects used to be the chief builder that controls the whole design process starting from early design phases till the final end-product construction. By the time specialization and the use of mass-produced building components spread widely and dominate all industrial fields and architects became more separated from many key aspects of a building's production. New technologies, including digital generative design and digital fabrication systems can narrow the gap between architectural designs, associative engineering aspects and buildings construction and reintegrate them into a digitally collaborative cycle process where architects is the "chief builder" again. In this regard, parametric generative systems as well as optimization algorithms, have made a major shift in the design process from designing an 'object' to design the 'logic' of the object, considering parametric optimization approach as a generative-explorative tool.
On the other, hand building façade plays a significant role in architecture; it is not only a mean to express the design concepts but it is the main moderator between interior spaces and exterior environment. The increasing reliance of office buildings on air conditioning and artificial lighting systems indicates the failing role of the building facade to perform its function as a moderator. Within this context, ecological facades have proved their potentials for enhancing buildings' environmental performance.

The main aim of this research is to define the effectiveness of both parametric design and Genetic Algorithms approaches for assessing various solar screens' parameters and to optimize screen configurations that improve both indoor daylight quality and thermal performance while providing minimum energy consumption.

The research will discuss the issue through two main parts;
Firstly, a theoretical study, based on a comprehensive literature review, was addressed to; firstly, explore daylight and thermal performance fundamentals for office buildings as the main aspects affecting office building current energy raising demands, as well as presenting the building performance metrics, rating systems and simulation tools to establish the basic knowledge for this study. Secondly, investigate the ecological façade strategies and their effects on daylight, thermal and energy performance. This concludes with the integrated methodology that combines daylight and thermal performance for office buildings. Thirdly, investigate the

parametric design and optimization algorithms approaches for optimizing building designs to conclude with the parametric design and Genetic Algorithms (GAs) integrated methodologies as generative-analytical design methods for optimizing building designs.
Secondly, an empirical study, based on computer simulation, was conducted using combination between the two previous methodologies. Thus, the methodology integrated daylight and thermal simulation tools with paramedic modeling and GAs technique using DIVA, Grasshopper and Galapagos respectively. It was used to generate, evaluate and optimize a non-conventional daigrid-based solar screen different parameters; size, rotation angle, scale ratios and protrusion value, to balance indoor daylight and thermal performance within the minimum possible energy consumption. The simulation was conducted for a south-oriented side lit office space in Cairo, Egypt to optimize a diagrid-based solar screen various parameters; size, rotation angle, scale ratio, and protrusion value.

Thus, the thesis presented a comprehensive analysis for the effect of the proposed solar screen different parameters on both daylight and thermal performance for office buildings. It addressed evaluation criteria that could give an indication about cooling loads based on daylight simulation and hence daylighting optimum cases can be sorted regarding thermal and energy performance without calculating them. This research also conducted an analytical comparison between the GAs optimization and parametric simulation approach testing each approach's effectiveness and limitations in balancing daylight and thermal performance for the proposed solar screen. Finally, two parametric-based optimization method; Modified GAs and Adapted Parametric Algorithm, were suggested to overcome the previous limitations. They could help architects to efficiently optimize any non-conventional solar screen regarding specific performance target.

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