CERIS Civil Engineering Research and Innovation for Sustainability

URBE – URBE represents the built environment

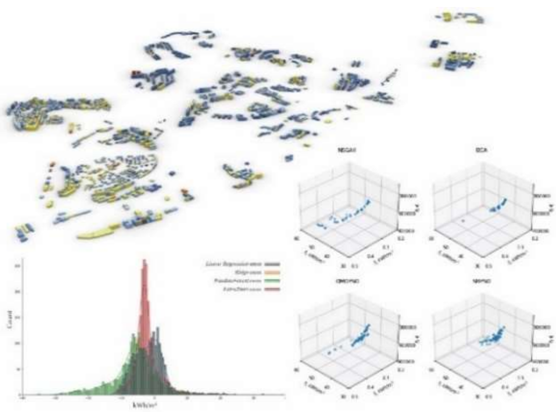
Summary

While the capacity of worldwide urban areas reaches its limit, urban growth is steadily increasing. At the present rate, it is estimated that the population in urban areas will have increased from 55% to 60% by 2030. This leads to two major challenges: (1) development and improvement of urban areas with a growing scarcity of land and (2) addressing sustainability and climate goals. To tackle these challenges, recent practices resort to simulation-based approaches to test planning and design solutions when it is not possible to test them empirically. These approaches can help practitioners with their decisions by extrapolating data from simulations and understanding how these decisions affect the urban metabolism of a city. Particularly, simulation approaches can help reducing the built environment's energy consumption, assessing renewable energy potentials, and improving an area's mobility. However, most tools are significantly time-consuming, require appropriate descriptions of simulation inputs, and post-processing of the respective outputs. The description of these inputs is laborious and requires expertise, and inappropriate processing of outputs can mislead their interpretation. To tackle these problems, this work explores how to automatically generate design and planning optimization workflows for the built environment. By integrating algorithmic design, simulation, machine learning, and optimization techniques in a single framework, this research aims to facilitate and speed up decision-making processes for urban and architectural practices. This will allow practitioners to explore solutions with more confidence and less effort, which contributes to more sustainable cities.

Algorithmic design is described as a design system in which an algorithm generates geometry based on specific variables and relationships. Its scalability allows the automatic generation of design solutions and its portability enables the integration of simulation tools and post-processing of results. This mechanizes most steps typical of analysis processes. With both model and simulations automated, the potential to integrate optimization processes emerges. Optimization searches for the most efficient solutions within the bounds defined by specified parameters and objectives. When dealing with complex systems, such as the built environment, practitioners typically address multiple conflicting objectives, which increases the complexity of the problem. Moreover, most objectives of building performance optimization are outputs yielded from significantly time-consuming simulation tools. Because of this, building optimization is often rendered unfeasible or performed incompletely without guaranteeing optimum results. By integrating machine learning techniques in this automated algorithmic design, simulation, and optimization framework it is possible to considerably speed up optimization processes, and automate them in easy-to-grasp interfaces. With this we can easily represent and optimize proposed solutions for an area's built environment, thus providing an answer for the described problems. This framework will be developed over multiple case studies for different optimization and analysis goals in the building and urban scope such as thermal and daylighting performances, and Life-Cycle analysis.

Keywords

Building performance simulation, building optimization, surrogate model, algorithmic design.



Urban Building Energy use, surrogate model, and Optimization algorithms compared.

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