Development of an AI-based surrogate model to select optimal building envelope retrofit solutions considering heat waves in the Netherlands

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Reflection

Graduation Process

In my graduation project, I addressed a significant challenge within the built environment by leveraging innovative technologies, including artificial intelligence. The project evaluated optimal, future-proof retrofit strategies by analysing key factors such as occupant comfort, energy efficiency, cost-effectiveness, and environmental sustainability. The methodology used integrates façade, climate, and computational design, creating a cohesive approach. This interdisciplinary strategy is fundamental to the Building Technology Graduation Studio, where connecting knowledge from diverse fields is essential for developing innovative solutions that yield positive societal and environmental impacts.

The primary goal of my thesis was to develop an AI-based surrogate model for selecting optimal building envelope retrofit solutions, specifically designed to address heat waves in the Netherlands. This goal was successfully met, despite the considerable challenges posed by the project's ambitious scope and tight time constraints. Indeed, the research considered multiple complex topics, including building envelope design, future weather predictions, building energy simulation models, and artificial intelligence.

It is important to note that within the research context, the project introduces two main innovations. Firstly, the simulation process and selection of optimal retrofit scenarios incorporate future heat wave predictions, an aspect not considered in the reviewed papers. Specifically, the time horizons considered are 2050 and 2100. This approach aims to ensure the future-proofing and enhance the sustainability of the built environment. Secondly, unlike the existing literature reviewed, this project explores both the potential and limitations of using a Multi-Task Learning model within this research context.

Although this project may seem technical, it demonstrates a strong correlation between research and design. Initially, the investigation into common retrofit strategies for the considered building archetype was translated into specific technical design details for each refurbishment intervention. Moreover, following the selection of the thermal properties for optimal retrofit solutions, these properties were interpreted into necessary design interventions across the four envelope parameters: roof, ground floor, façade, and windows.

I started this journey with no prior knowledge of machine learning, driven purely by my keen interest in the field. The learning curve was steep, and the guidance from my professors were essential in managing complexity with ease. They helped me gain a thorough understanding of the subject matter and provided critical support throughout the project. During the thesis process, I often found myself overly focused on minor details. However, the feedback from my mentors was crucial in learning to maintain an overall perspective on the project and to keep the ultimate objective in sight. This project taught me how to manage a complex challenge by breaking it down into manageable themes and studying them with the appropriate depth, while also making critical connections between different areas.

The success of my research approach can largely be attributed to the expert guidance I received for each topic addressed within the project. I was supported by a team of experts, including university professors, PhD researchers, and specialists from Arup, the company with which I collaborated. This continuous support and the extensive feedback I received were crucial in applying the correct methodologies to all studied topics.

This experience has been profoundly educational, not only in terms of technical knowledge and skills but also in project management and prioritization. It has prepared me to tackle future challenges with a balanced approach and a strategic mindset.

Societal impact

Sustainability in its various forms has always been a central topic in the development of this project. The overarching goal was to contribute to the decarbonization of our society, particularly by reducing the environmental impact of the built environment. Moreover, the project aimed to ensure sustainable and future-proof development. In pursuit of this goal, it considered the resilience of buildings to heat waves and investigated retrofit options that used materials with low embodied carbon.

The primary stakeholders of the project are housing corporations, which are responsible for the housing conditions of many low-income families. The project thus assists these corporations in deciding the best retrofit interventions to implement, simplifying a process that benefits a large percentage of inhabitants and the building stock. By improving the living conditions of these families, the project enhances their quality of life and, consequently, their physical and mental health. Simultaneously, it reduces the energy consumed by the built environment and decreases the amount of greenhouse gases emitted.

Transferability

Another important aspect to address is the transferability of knowledge within the framework. While the research primarily uses Python for analysis, the reliance on multiple separate tools reduces the framework's efficiency and fluidity. Developing an integrated data platform could improve interoperability and streamline the process. Moreover, the framework should be designed to communicate not only with specific target users but also with non-experts. Enhancing this aspect would broaden the applicability of the research and facilitate the collection of external feedback for further refinement.

In addition to this, the framework is specifically designed to assist clients in selecting retrofit solutions that best meet their needs. While the approach is adaptable to various user preferences, it is tailored specifically for terraced houses owners. Therefore, if a client needs to retrofit a different type of building, this research may not provide the most suitable retrofit scenario. Moreover, if the user desires to precisely adjust design parameters, significant modifications to the framework would be required.