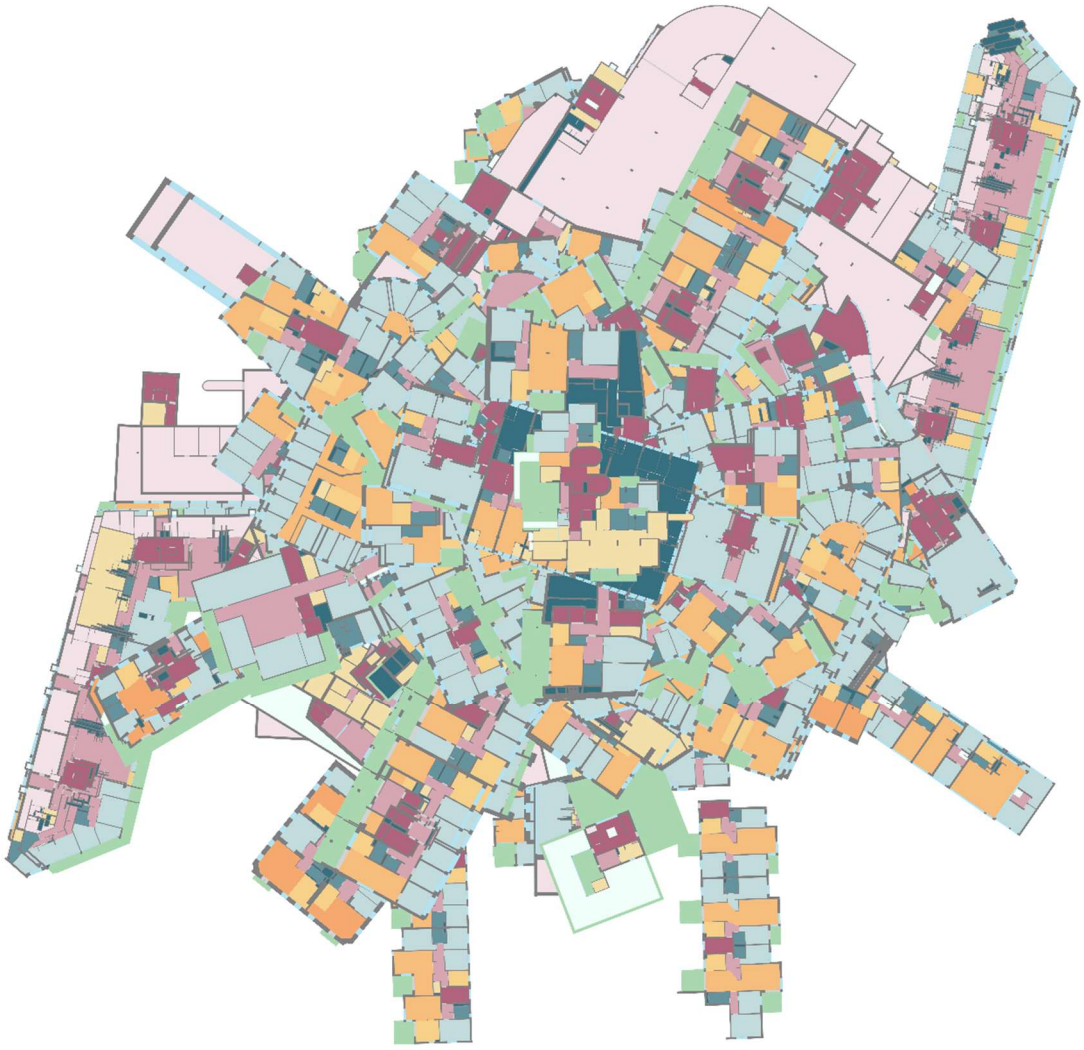
visual comfort l(AI)outs

A framework for daylight and view guidance during the early layout design process

MASTER THESIS



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A framework for daylight and view guidance during the early layout design process

Building Technology Graduation Project
MSc in architecture, Urbanism and Building Sciences

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10 Reflection

The goal of this master's thesis was to explore the applicability of an ML process within an architectural design process. The resulting ML process framework came from researching the available dataset and testing how it could be used in a design process. Through this process, I developed my own ML process framework and evaluation system to support designers in the early design phases when making performance-based decisions. The final goal was to take the first step to apply an ML tool into the predesign phase while testing the visual comfort performance indicators against guidelines. This chapter covers a reflection on the master thesis process in two parts: the graduation process and the social impact of the master thesis.

Graduation process

How is your graduation topic positioned in the master track building technology?

The Building Technology Master track is part of the Master Architecture, Urbanism and Building Sciences (MSc AUBS). It covers topics that cover the bridge between architectural design and engineering and focuses on innovation within these two fields. The master tracks consist of five chairs that relate to different parts of the environment design field. The master's program has an interdisciplinary focus with freedom for students to explore other directions and topics within the Building Technology field. Building Technology focuses on multidisciplinary problems that require innovative solutions by integrating design and technical disciplines.

This thesis, "visual comfort l(AI)outs", relates to two chairs within Building Technology. Firstly, the Design Informatics direction focuses on generating a machine learning tool to find the interior layout parameters that affect the daylight and view and to find the optimal layouts based on this. Secondly, Climate Design is integrated to create visually comfortable residential layouts. Combining the two fields allows me to explore a design topic through fundamental and new arising topics within the built environment. Additionally, connecting these two fields broadens the possibilities of optimising everyday design tasks through Artificial Intelligence. With this workflow, AI can contribute to efficiently assisting designers and engineers in the early decision-making stage of residential layout exploration.

How are research and design related?

The complicated relationship between research and design has been essential to this graduation process. Where I tried to push the decision-making process during a design towards based on knowledge within the field and earlier done research. The moment when the performance indicator evaluation happens in a design process is a critical difference between a typical design approach and my study's approach. Traditional design processes often analyse the performance indications at the end of the design process, leading to decisions that are only possible within the limited boundaries left at the project's later stages. With this design framework, the performance indicators are tested at the beginning stage of a design when the boundary conditions are still wide and open. This method encourages creativity and imaginative problem-solving, allowing for more flexible solutions to unanticipated challenges.

The research observed that the orientation of rooms is only sometimes chosen wisely within the existing dwelling dataset, potentially leading to more energy consumption and less comfortable living spaces for occupants. My framework integrates research findings for optimal room orientations into the design process. By recognising opportunities for improving visual comfort from the start of a project, the design process is led toward better performance from the beginning of the project.

What value did your approach and methodology bring to your thesis?

The method used for this research has several strengths and weaknesses. Weaknesses can be recognised by the model training's trial-and-error approach, which came together with my limited expertise in the machine learning domain. Strengths can be found in the scientific method in analysing the data and the helicopter view approach while creating the framework.

A weakness in the used method is that training an ML learning model is a trial-and-error process, resulting in a time-consuming task to fine-tune and train the models. Additionally, using deep learning models results in untransparent correlations that the model discovers during the training but are not accessible to understand fully. Because of this, the trial-and-error method is needed to train a model and reflect on the effect of the adjusted parameter. Additionally, my lack of in-depth knowledge and experience in machine learning hindered my ability to understand and address arising challenges during the model training fully.

The thorough examination of data and the ability to spot opportunities within the data while methodically removing noise are distinguishing strengths of the research technique used in this study. This careful data analysis methodology ensured that the research findings were robust and highly valuable. The investigation obtained vital information that might have remained concealed by closely going through the data. Another strength is the approach to examining the implementation of an ML model within the broader context of the built environment from a helicopter perspective. This overall perspective enabled a thorough evaluation of the ML model's effectiveness in real-world circumstances. Instead of focusing primarily on technical elements, the study included how the model may be realistically incorporated into architectural design.

What moral or ethical issues did you encounter during the process?

Ethical issues were critical in developing the research approach throughout the machine learning process. The dataset includes human-generated and human-selected data, inevitably leading to biases within the ML model. To achieve fair and equal outcomes, it was critical to address these biases before training the model.

Furthermore, the dataset's anonymity provided a difficulty, reducing the amount of information accessible for the study. Notably, the dataset did not include real environmental obstacles of the structures and natural objects, which was done to protect residents' privacy. To overcome this issue, I proposed an approach that uses simulation results to replicate real-world environmental obstructions, allowing the expression of potential obstacles while maintaining privacy. These ethical issues emphasised the importance of a balanced strategy that protects privacy while pursuing complete and fair research results.

Social impact

To what extent are the results applicable in practice?

The framework created as part of this research has potential for practical applications. The framework makes machine learning more accessible to professionals within the architectural field by streamlining its incorporation into the architectural design process. The framework's processing element generates a user-friendly structure for designers, and its simplicity of use suggests that architects might quickly adopt it as a tool to optimise building layouts for visual comfort during the early phases of a design.

To what extent is the projected innovative?

In the current built environment industry, collaboration between designers and AI for design guidance still needs to be improved. My framework makes a step further towards closing this gap. Applying my design framework can encourage designers to interact with AI and utilise its potential to improve design results.

How does the project contribute to sustainable development?

The ISO-15392 (2019) describes that standard sustainability involves three mutually interrelated aspects: environmental, economic, and social. This study can potentially contribute to sustainable development by directly or indirectly touching all three elements. Improving the daylight quality of a room tackles the environmental aspect indirectly. Applying the ML framework to design apartment layouts optimised for daylight and view quality can reduce energy consumption in buildings since good daylight performance results in lower electricity demand, which increases the sustainability of a building.

This research touches on all three aspects of sustainable design: people, planet, and profit. This research takes a crucial step toward decreasing our environmental impact by having the potential to reduce energy consumption in buildings. Additionally, incorporating excellent visual comfort and scenic views into apartment designs increases property prices, which benefits both property developers and homeowners.

Improved visual comfort in houses can significantly enhance inhabitants' well-being and general health, eventually leading to a higher quality of life. This aspect places the people at the heart of the building while designing for them. Daylight can have a significant impact on the social well-being of residents. Adequate natural light increases the comfort of the space and can improve mood, reduce stress, and promote the overall health and productivity of occupants. Natural lighting and view to the exterior can also create a sense of connection to the outdoors and promote a sense of community within a building. Furthermore, a lack of natural lighting can make a space feel cramped and uninviting and contribute to feelings of isolation and depression. Architects must consider the social impact of daylight and view when designing apartment buildings, mainly since people spend most of their time indoors.

How does the project affect architecture/the built environment?

This framework could lead to a completely different way of working for architects because they could get direct feedback on their layout design concerning visual comfort. In this way, designers can consider building performances from the beginning of the design process so that design choices will be made differently. Additionally, facilitating designers with a tool tackles the economic aspect because the designers will have fewer repetitive tasks. Designers can focus on the more creative tasks of a design when they have fewer repetitive tasks.