A model driven method to optimize thermal comfort

Reshaping a hospital courtyard

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ABSTRACT

Human's general perception of an open space is influenced by architectonical, psychological but also physical factors. For this reason, it is important to consider environmental comfort as a crucial element when it comes to designing an urban outdoor space [1]. In this paper, we consider the following research questions: in a Mediterranean climate, is it possible to design an outdoor urban space that is thermally comfortable for a longer time-span, usable just as much as an indoor space? Our purpose is to identify the primary influencing factors that designers can modify in a built environment, and to provide guidelines to better understand the effect of alternative parameter settings on the microclimate. To this end, we propose an innovative two-phases design methodology: first, we use simulation to gather data on thermal comfort for selected configurations of parameters; next, we use these data to train a Machine Learning algorithm. The learned model (a decision tree) is used to support designers in optimal parameter settings.

CCS CONCEPTS

• Simulation Evaluation • Computers in other domain • Decision support systems

KEYWORDS

Decision Trees, Thermal comfort, simulation, decision support systems, data-driven design of urban spaces

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1 Thermal control of peculiar outdoor spaces

The goal of a well-designed outdoor space is to make people feel comfortable. Nevertheless, it is complex to obtain this result, due to the high number of influencing factors, and to the limited understanding of the mathematical relationships between design choices, external climatic factors, and the perceived (and ultimately user-dependent) thermal comfort.

2 Parameters for thermal comfort

Thermal comfort is defined as “That condition of mind which expresses satisfaction with the thermal environment” [2]. This definition is not easy to convert into physical parameters, as thermal comfort comprises climatic and behavioral aspects.

To match all these parameters together, an index was studied based on the equivalence of the dynamic physiological response predicted by a model of human thermoregulation. This index is called UTCI (Universal Thermal Climate Index) [3] and has been used to measure the best performance of our case study.

3 Definition of the workflow

The main contribution of the paper is the definition of a model-based workflow to support design decisions. The workflow was divided into 4 steps:

- contextual selection of the design analysis;
- selection of parameters, simulation experiments, gathering of experimental data for selected configurations;
- training of a machine learning algorithm to derive a general model (decision tree) to support design decisions;
- analysis of the results.

4 Conclusions

The purpose of this research was to provide architects with a methodology to support informed decision making that can be used from the conceptual until the construction phase. Using the proposed process, the architect is conscious of the benefits that every decision can bring to the thermal comfort and therefore to the general comfort of the users. We leave to future experiments the inclusion of additional parameters to obtain a more complete decision-support tool. For example, a different model of the building (e.g., completely enclosed courtyard or two sides opened courtyard), another microclimatic area or even another climatic zone.

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