Performance Inference of Building Spatial Design Modification Techniques

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Introduction

In present day, the built environment is responsible for 40% of global resource and energy use. Hence, to save costs and the environment, it is worthwhile to optimize building spatial designs with respect to material use and energy. The impact on a design's performance is high in the conceptual design phase, but few tools are available to support optimization in this phase.

This poster presents a method to determine a modification technique that is likely to improve the performance(s) of a conceptual building spatial design. As such it can support users and optimization processes to find new and improved building spatial designs in the conceptual design phase.

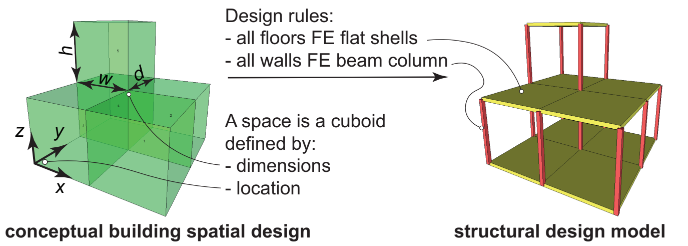

Figure 1: A conceptual building spatial design (left) is here defined by cuboid spaces in an orthogonal grid. Design rules are applied on a spatial design to generate domain specific models, e.g. a structural model (right).

Method

The proposed method consists of three parts: (1) define modification techniques; (2) apply modification techniques, and label results with possibly relevant data and/or characteristics; (3) draw inference from the labelled data.

1. Modification Techniques. From experience in the field, typical modifications to a building spatial design can be defined. When the number of spaces and the building volume are fixed, such modifications can be: Remove spaces and split others based on their performance and then rescale the design; Or, cut-off a part of the design and extrude it at the cutting plane. These examples are illustrated in figure 2.

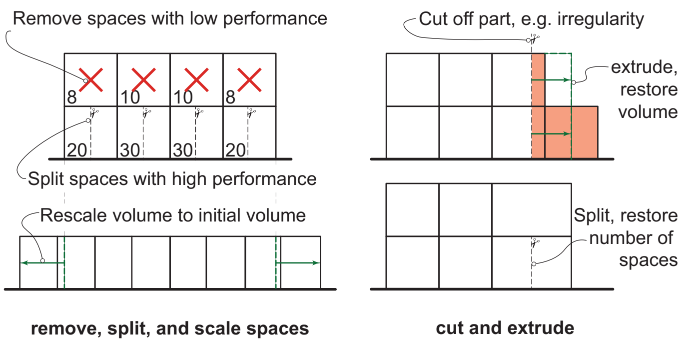

Figure 2: Possible modification techniques for building spatial designs.

2. Apply and label. A sample of building spatial designs is subjected to each modification technique. For each design and for each modification, the change in performance is measured and labelled with the name of the modification technique that caused it. Additionally, labels that characterize the building spatial design or its domain specific models are defined as well. Examples of these additional labels are: aspect ratios of dimensions, minimal and maximal performance values, or number of floors.

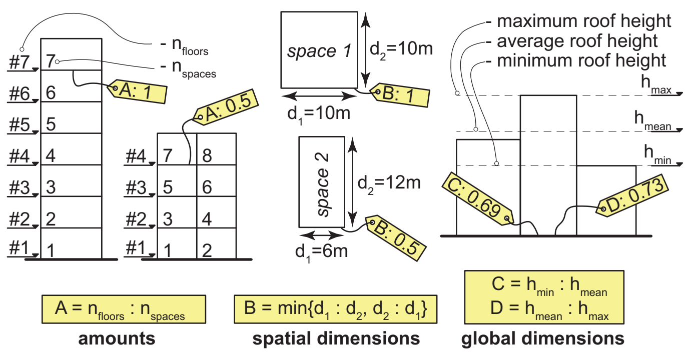

Figure 3: Labels can be given to either the whole building spatial design or sub-parts thereof, e.g. a space.

3. Inference. As inference entails a likelihood, it is inherently a statistical phenomenon and thus the dataset should be considerably large. Once such a data set is obtained, drawing inference can be achieved in several ways: Cluster results based on performance change; Statistic analysis; Or, via machine learning. A typical results is shown in figure 4.

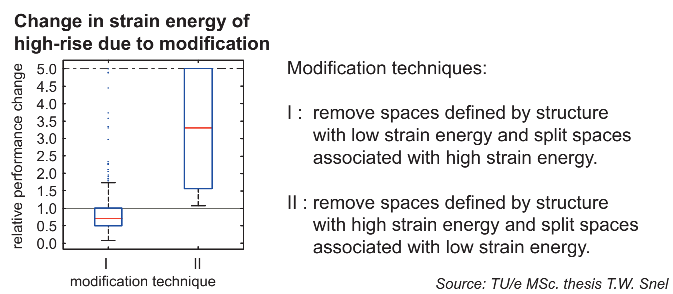

Figure 4: Inference: To improve the stiffness of a high-rise design, remove spaces that are defined by structure with low strain energy.

Conclusion and Outlook

So far, research on the presented method has lead to, among others, the following practical conclusions: Spaces defined by structure with low strain energy are best removed, to improve structural stiffness; Protrusive parts in a spatial design are best removed, to reduce heating/cooling loads; These results are well explainable from an expert's point of view, which validates the method. Based on these promising results the following directions for future work are formulated: Define more modification techniques; Apply machine learning; Increase data set; And, identify new relevant labels.

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