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Inverse Modeling of Climate Adaptive Building Shells

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Subject

As opposed to traditional building shells, climate adaptive building shells (CABS) do have the ability to repeatedly and reversibly change their properties and behavior over time. Because of this adaptivity, CABS act as climate mediators, negotiating between occupants' performance requirements and impacts from the ambient environment.

Figure 1: Ideas for CABS concepts are often inspired by nature

Successful design and operation of CABS is a challenging task. CABS are inherently complex systems, consisting of interrelated dynamic components that are working across various physical domains. These components together have to resolve trade-offs between competitive performance objectives. Developments in CABS are typically driven by fragmented advances in science and technology. The true potential of making building envelopes adaptive is however still unknown. In this research, a so-called inverse modeling approach (IMA) is proposed to be able to explore the full option space with the aim of deriving the optimal dynamic properties of a building shell.

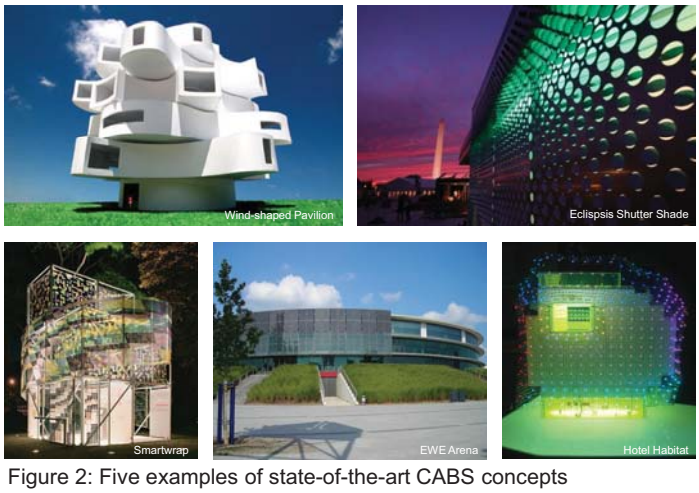

Figure 2: Five examples of state-of-the-art CABS concepts

Goal

The ultimate goal of this project is to develop building shell concepts with controllable thermophysical and optical properties that can adapt to changes in the internal and external environment. The intended concepts aim to improve indoor environmental quality in terms of thermal and visual comfort levels, while at the same time providing a substantial reduction in the energy demand for heating, cooling, ventilation and lighting.

Methodology

Work in this project concentrates on research, design and validation of IMA-prototypes by making advanced use of building performance simulation. To this end, the building shell is initially conceived as a bounded subset of undefined solutions, characterized by controllable, variable values for its thermophysical and optical properties.

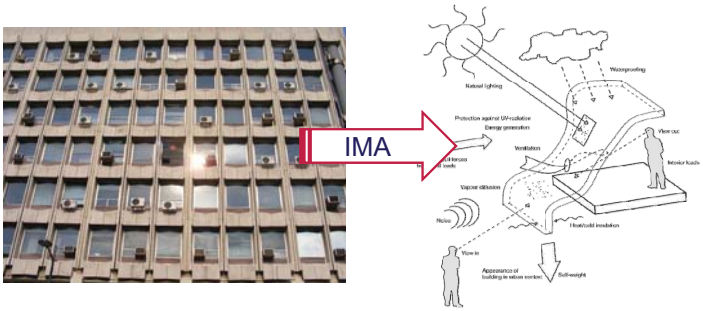

Figure 3: Graphical representation of the goal in IMA

The desired adaptive behavior over time will be determined via a predictive control strategy. Out of multiple possible scenarios of façade adaptation, the best option for a predicted time period is selected. This process is based on a multi-objective optimization problem that addresses the trade-offs between energy demand and both thermal and visual comfort, by searching for the most robust solution.

Expected results

The result of IMA will be a descriptive set of optimal dynamic values for thermophysical and optical properties in a given context. After being translated into building shell concepts, future R&D paths will be outlined that can help to achieve this goal.