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Chair of Computational Modeling and Simulation

Logic Representation and Reasoning for Automated Building Design Adaptation toward Code Compliance

Topic Description

In architectural design and construction, one of the significant hurdles is ensuring compliance with a diverse set of building codes and location-based standards. These mandatory regulations, crucial for safety, sustainability, and functionality, often necessitate rigorous adaptation of building designs. Traditionally, these adaptations are made by designers through manual reviews and are based on their expertise and experiential tacit knowledge, making the process iterative and labor-intensive. This thesis explores an innovative pathway beyond these conventional methods, proposing an automated, logic-based approach integrated within the design process. The primary goal is to streamline and rationalize design logics to enable efficient and intuitive representation of design decisions and intents, bridging the creative aspects of design with stringent regulatory compliance requirements. This approach leverages advanced techniques in logic representation, reasoning, and rule-based systems within the context of Building Information Modeling (BIM) environments to automate design adaptations, ensuring they meet code compliance efficiently.

Method Description

This research centers on embedding sophisticated logic representation and reasoning into the BIM framework, automating design adaptation to ensure regulatory compliance. The methodology intertwines logic reasoning with creative design thinking, promoting a symbiosis between technological innovation and architectural creativity for enhanced design and compliance processes.
The thesis involves creating an intelligent, rule-based system to articulate and manage design intents in architectural projects. This system will translate design principles into a structured logic representation, forming a dynamic, context-sensitive framework that can adapt designs intelligently and autonomously within the BIM authoring tools. This integration aims to establish a foundation for automated design checks and adjustments during the design stages, significantly streamlining the design process.

Keywords

Building Information Modeling, Design Process Logics & Design Thinking, Logic Reasoning, Rule-Based Systems, Co-Creation

Main Tasks

The thesis will encompass the following key tasks:

- Comprehensive literature review to understand the current landscape and methodologies employed in Rule-Based Systems, Design Thinking, and Parametric Design, mainly focusing on the representation and reasoning of design logic in initial design phases.
- Identification and formalization of rules derived from prevalent design intents and logics in architectural practice.
- Development of an rule-based system/approach integrated within a BIM environment, capable of representing, reasoning, and applying the codified design intents.
- Practical application and testing of the system using real-world design scenarios, followed by assessing its performance and utility in actual design contexts.
- Evaluation of the system's effectiveness, informed by expert feedback and comparative analysis with traditional design adaptation methods (optional).

Implementation Basics

The practical aspect of the research requires:

- Experience in initial phases of architectural & structural design and familiarity with common design processes and challenges.
- A solid grounding in programming, with expertise in languages commonly used in rule-based system development (e.g., Python, C#) and interest in learning logic programming languages (e.g., *Prolog* or Drools) is advantageous.
- Proficiency in parametric modeling software (ideally *Dynamo for Revit* or *Grasshopper*);

Prospective Outcomes

The successful completion of this thesis is expected to yield the following outcomes:

- An advanced system/approach capable of representing and adapting building designs in terms of 'geometry and semantics', guided by encoded design principles and design logics.
- A methodology that enhances efficiency, accuracy, and consistency in achieving code compliance in architectural design, potentially reducing the time and resources currently required for manual adaptations.
- Contributions to academic and professional discourse on automated design processes, particularly concerning integrating logical reasoning and rule-based systems in BIM.

Supervision

Supervisors:

Jiabin Wu - Chair for Computational Modeling and Simulation (www.cee.ed.tum.de/cms)
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Supervision mode:

- Submission of an exposé, a kick-off meeting, and weekly progress exchange in Microsoft Teams;
- Intermediate thesis meeting, closing meeting before the final presentation.

Selected References

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