Chair of Computing in Civil and Building Engineering
TUM School of Engineering and Design
Technical University of Munich

Master Thesis Proposal

Automated Extraction of Reusable Design Components using Artificial Intelligence

Background

Designers generate vast amounts of data across disciplines, stored in Common Data Environments (CDEs) and project repositories. These include 2D/3D CAD drawings, BIM models, and associated metadata. Despite this wealth of information, design teams often recreate components from scratch due to a lack of a structured component library or due to difficulties finding the right component, e.g., reusable design elements such as blocks, families, parametric objects, or grouped assemblies commonly used in CAD and BIM environments (Jang and Lee 2024; Cao et al. 2022).

Leveraging Artificial Intelligence (AI) to automatically identify, extract, and recommend reusable design components from past projects presents a significant opportunity. As the architecture, engineering, and construction (AEC) industry moves towards more data-driven and sustainable workflows, there is increasing demand for intelligent tools that promote design reuse and standardization. By analyzing patterns and relationships within design components together with contextual metadata (Langenhan et al. 2013), AI systems can surface relevant components at the right time, promoting standardization, reducing redundancy, and accelerating design cycles (Li et al. 2020). Over time, such systems should be able to learn from user behavior and improve their recommendations, enabling more informed and sustainable design decisions (Du et al. 2025).

This master thesis will be conducted in cooperation with Bentley Systems and co-supervised by an employee.

Objectives

The student shall investigate and develop methods for automatically identifying and recommending reusable design components from past projects. The system should:

- Analyze geometry and semantics from BIM models to detect reusable components.
- Leverage AI/ML techniques to cluster and classify reusable components
- Provide contextual recommendations to designers during the design process.
- (optional) Continuously refine recommendations based on feedback and evolving design practices.

Expected Outcomes

- **Scientific master thesis** with comprehensive analysis of both unsupervised and supervised artificial intelligence and machine learning techniques to extract design components from native design files.
- **Working prototype** capable of
    - identifying and extracting design components from a sample of native design files and
    - recommending relevant components during the design process.
- **Evaluation of output quality** and accuracy against manually created components.

Prerequisites

- Programming skills in Python or similar languages.
- Basic understanding of AI/ML concepts (e.g., supervised vs unsupervised learning).
- Familiarity with BIM/CAD data formats and modelling is a plus.

Supervisors

- Stefan Fuchs, Chair of Computing in Civil and Building Engineering, stefan.m.fuchs@tum.de
- Georgios Pavlidis, Product Management Group, Bentley Systems, georgios.pavlidis@bentley.com

References

Cao, Jianpeng, David F. Bucher, Daniel M. Hall, and Mike Eggers. 2022. “A Graph-Based Approach for Module Library Development in Industrialized Construction.” *Computers in Industry* 139 (103659): 103659.

Du, Changyu, Zihan Deng, Stavros Nousias, and André Borrmann. 2025. “Predictive Modeling: BIM Command Recommendation Based on Large-Scale Usage Logs.” *Advanced Engineering Informatics* 68 (103574): 103574.

Jang, Suhyung, and Ghang Lee. 2024. “BIM Library Transplant: Bridging Human Expertise and Artificial Intelligence for Customized Design Detailing.” *Journal of Computing in Civil Engineering* 38 (2). https://doi.org/10.1061/jccee5.cpeng-5680.

Langenhan, Christoph, Markus Weber, Marcus Liwicki, Frank Petzold, and Andreas Dengel. 2013. “Graph-Based Retrieval of Building Information Models for Supporting the Early Design Stages.” *Advanced Engineering Informatics* 27 (4): 413–26.

Li, Nanxing, Qian Li, Yu-Shen Liu, Wenlong Lu, and Wanqi Wang. 2020. “BIMSeek++: Retrieving BIM Components Using Similarity Measurement of Attributes.” *Computers in Industry* 116 (103186): 103186.