C04

Integrating Digital Design and Additive Manufacturing through BIM-Based Decision Support and Digital Twin Methods

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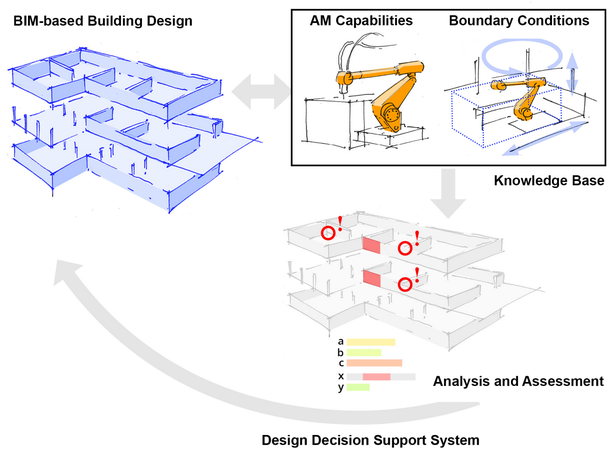
Summary

The project will contribute to closing the gap between digital design and additive manufacturing. The conceived Design Decision Support System (DDSS) will enable the identification of components suitable for AM technology, founded on a formal AM knowledge base. Methods will be developed for generating Fabrication Information Models (FIM) from Building Information Models (BIM). These methods will be based on graph theory and algorithmic geometry. By incorporating manufacturing information from robots and sensors, methods for creating digital twin representations reflecting as-built geometry and properties are developed. The approaches are based on the concept of multi-LOD BIM ensuring the consistency between multiple levels of detail.

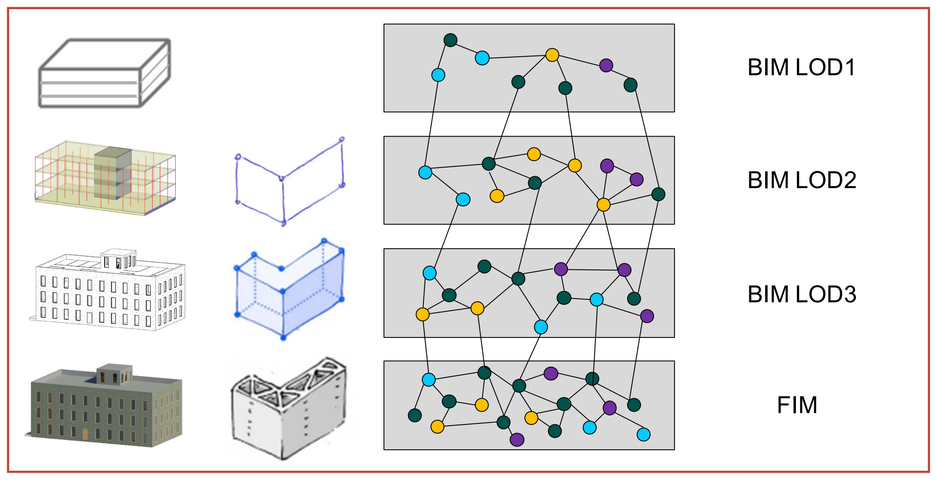
Research Questions

To close the gap between digital design and additive manufacturing, the following questions are tackled:

- How can a knowledge-driven systems support architects and engineers to select suitable AM methods?
- How can the concept of multi-LOD BIM be extended to support Fabrication Information Models that contain detailed information about AM processes?
- How can Fabrication Information Models be automatically derived from BIM models?
- How can a digital twin representation for AM components be designed to integrate information from various sensors to provide detailed as-built models?



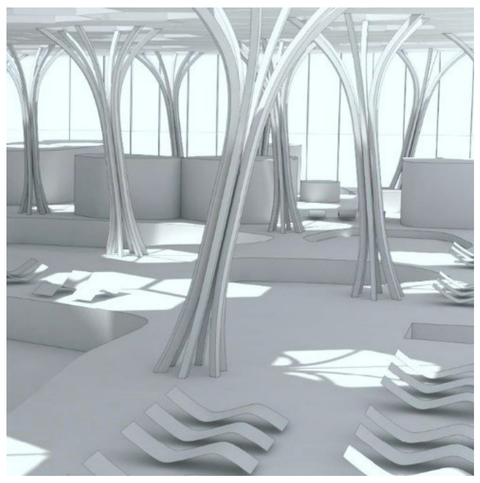
The proposed Design Decision Support System (DDSS) is founded on a knowledge base formalising the capabilities and boundary conditions of individual AM processes.



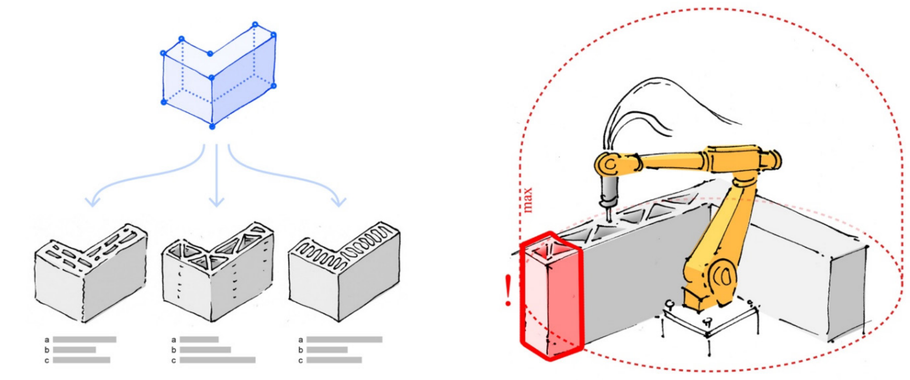
Multi-LOD BIM models allow for an adequate level of detail corresponding to the design progress. The project will investigate how FIM can be integrated and automatically derived from a detailed BIM model.

Methods

- Development of a multi-scale geometric model for AM in construction (with C01).
- Combination of B-Rep and V-Rep as well as semantic modelling for multi-LOD BIM.
- Combination of graph transformation with algorithmic geometry for automated FIM derivation.
- DDSS: Knowledge representation based on graph theory and ontological descriptions.
- Usability experiments with potential users for validating the DDSS methodology.



The conceived design decision support system will support architects and engineers in choosing suitable AM processes for realising organic building designs.



Right: Usage of FIM for steering the manufacturing process.
Left: Different variants of FIM for one BIM element.

Preliminary Work

- Long track record in BIM research, both on the fundamental and on the application level. Long list of joint projects.
- Extensive background in design decision support for early design phases (Petzold).
- Introduction of multi-LOD BIM methods for tunnels and buildings (Borrmann).
- Extensive experience in knowledge representation, graph rewriting, procedural geometry and parametric modeling.

The internal structure of a concrete component produced by AM (Chair of Timber Structures and Building Construction, TUM)