Master Thesis

Exploring link prediction on BIM graphs using graph neural networks

The fragmented nature of the construction industry necessitates close collaboration among design disciplines and requires extensive data exchange. Despite advances in BIM technology, teams still rely on a sequential file-based process for design exchange, resulting in issues of data loss, cumbersome coordination, and multiple design iterations. To address these challenges, a graph-based approach has been proposed to compile and link building information on the cloud to facilitate intelligent applications, termed Cloud-based BIM (CBIM) [1].
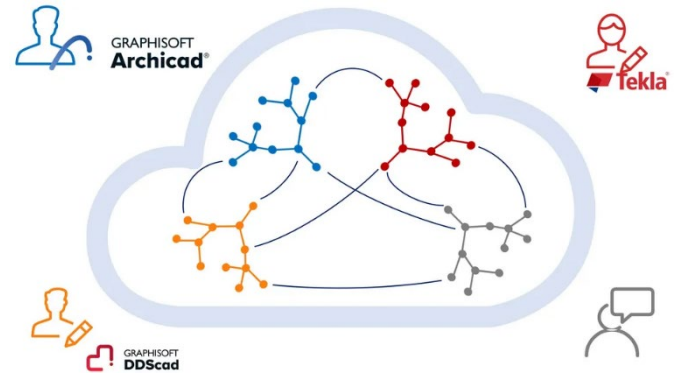

Figure 1 Representing and linking multi-disciplinary BIM graphs.

The core concept of CBIM is to establish interdisciplinary relationships to link individual BIM sub-graphs and form the meta-graph. The linked subgraphs serve as a foundation for supporting many intelligent design collaboration functions such as change propagation and consistency maintenance [2]. Existing studies have explored using a rule-based approach to generate relationships between objects across disciplines by geometry computation [3]. However, the exploration of using more advanced techniques, specifically graph neural networks, for predicting links on BIM graphs is still lacking.

This master's thesis topic aims to fill in this gap by conducting an exploratory experiment. Specifically, the student will conduct the following tasks:

- **Literature Review**: Conduct a comprehensive review of the concept of using linked graphs to enable intelligent applications in design and construction and the development of GNNs in the general computer science domain

- **Relationship class selection**: Review the literature and select the relationship classes that are practical in facilitating intelligent design applications and reasonable to be instantiated by a learning-based method

- **Learning-based method development**: Design a GNN-based approach of link prediction on BIM graphs

- **Experiment implementation**: This will include a dataset construction, and implement the GNN experiment. The dataset construction will need a collection of paired BIM models, compile BIM models as graphs, and label the across-domain relationships. The graph compilation tools can be provided.

The following skills are required:

- Motivation and interests are the most important. Desires to explore how to conduct research

- Basic programming skills in Python

- Basic understanding of machine learning

- Nice to have: experience in PyTorch, PyG, DGL, or any other deep-learning library

Supervisor

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References

[1] Sacks, R., Wang, Z., Ouyang, B., Utkucu, D. and Chen, S., 2022. Toward artificially intelligent cloud-based building information modelling for collaborative multidisciplinary design. *Advanced engineering informatics*, *53*, p.101711.

[2] Wang, Z., Ouyang, B. and Sacks, R., 2023. Graph-based inter-domain consistency maintenance for BIM models. Automation in construction, 154, p.104979.

[3] Ouyang, B., Wang, Z. and Sacks, R., 2023. Semantic enrichment of object associations across federated BIM semantic graphs in a common data environment. In *ECPPM 2022-eWork and eBusiness in Architecture, Engineering and Construction 2022* (pp. 591-598). CRC Press.