

Consistency analysis of models used in a beer brewery digital twin

The goal of this assignment is to develop an approach and corresponding tooling for analyzing consistency among cross-domain multi-tool models. For testing the approach and the developed tool, we will use the digital twin of a beer brewery, which was developed as part of another Master assignment and an ongoing PhD project.

Assignment

This assignment has 3 primary aspects:

- **Model dependency representation:** This is about representing models and their dependencies using a graph structure. Various graph-based knowledge representation techniques exist [4][5]. Here the research challenge is to identify an appropriate graph structure that not only is suitable for this case-study but also can be extended/reused in different contexts.
- **Inconsistency analysis and detection:** Here we want to process the previously mentioned graph structure to identify inconsistencies among dependent models. Defining rules for identifying inconsistency is an established method and there are several works on that including [6]. Here the research challenge is to investigate what other methods exist and if one of them is appropriate for this case-study. If not, develop another way for defining rules to detect inconsistencies.
- **Reporting:** A user friendly and intuitive (possibly web based) user interface is necessary to make the above mentioned functionalities accessible to the intended users.

Reading materials

- Digital twin of a micro-brewery was developed by Ander Lee [3].
- Mohammad Ibrahim [2] has developed a tool that can read and store structural information from block-based models into a graph database.
- Torres et al. [1] published a systematic literature review where they presented various inconsistency types.
- There are several works including [4][5][6] for graph-based information representation, inconsistency detection.
- The list of literature here should work as a starting point and more related work needs to be found.

Student Profile

Besides high motivation, dedication and clear communication, we expect a student to have the following skills,

- Ability to research current literature
- Willingness to learn whatever is necessary for this assignment
- Good programming skills (preferably in Java or Python)
- Ability to review existing works and translate necessary parts to code
- Proactive, take ownership of Master assignment

References

- [1] Torres, W., van den Brand, M. G. J., Serebrenik, A. (2020). A systematic literature review of cross-domain model consistency checking by model management tools. *Software and Systems Modeling*, 1–20. <https://doi.org/10.1007/s10270-020-00834-1>
- [2] Ibrahim, M. (2023). A Graph Database Design for Multi-Domain Model Management. EngD Thesis Technische Universiteit Eindhoven. <https://research.tue.nl/en/publications/a-graph-database-design-for-multi-domain-model-management>
- [3] Investigating frameworks for integration and orchestration: a case study on a microbrewery digital twin. Lee, A. (Author). MSc Thesis. <https://research.tue.nl/en/studentTheses/investigating-frameworks-for-integration-and-orchestration>
- [4] Feldmann, S., Wimmer, M., Kernschmidt, K., & Vogel-Heuser, B. (2016). A comprehensive approach for managing inter-model inconsistencies in automated production systems engineering. *IEEE International Conference on Automation Science and Engineering, 2016-November*, 1120–1127. <https://doi.org/10.1109/COASE.2016.7743530>
- [5] Purohit, S., Van, N., & Chin, G. (2021). Semantic Property Graph for Scalable Knowledge Graph Analytics. *2021 IEEE International Conference on Big Data (Big Data)*, 2672–2677. <https://doi.org/10.1109/BigData52589.2021.9671547>
- [6] Liu, WenQian, Steve Easterbrook, and John Mylopoulos. "Rule-based detection of inconsistency in UML models." Workshop on Consistency Problems in UML-Based Software Development. Vol. 5. 2002. <http://www.cs.utoronto.ca/~sme/papers/2002/uml02wl.18.pdf>