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

Master's Thesis Topic

Modeling and Simulation of Robotic In-Situ Concreting Using Behavior Trees

With construction robotics becoming more prevalent, there is a need to model existing construction methods in a way that can be robotically executed. Current research focuses largely on masonry, prefabricated concrete or steel, or timber construction, omitting one of the most common methods: in-situ concreting. Behavior Trees (BTs) are a promising control architecture for this purpose. BTs are known as a modular, reactive and flexible framework for task planning and execution. BTs are increasingly used in robotics and therefore have a strong integration with robotic control systems such as the Robot Operating System (ROS). This thesis proposes to investigate how behavior trees can be used to simulate in-situ concreting a way that supports both ROS-based simulation and potential robotic execution.

Problem Statement

- Robotic execution introduces additional considerations such as battery limitations, communication, and system monitoring.
- Construction sites are inherently complex and dynamic environments, meaning that robots should have adaptive capabilities.
- Traditional methods such as Gantt charts or finite state machines have difficulty representing dynamic changes or uncertainties.
- There are often complex interdependencies between (sub-)tasks or even multiple robots that need to be modeled.

Preliminary Research Questions

1. How can in-situ concreting workflows be represented as behavior trees to capture task sequences, dependencies, and uncertainties of a construction site?
2. What are the differences with other models such as hierarchical finite state machines when considering e.g., adaptability and modularity?
3. To what extent can behavior trees handle dynamic execution scenarios, such as delays, resource constraints, or robot failures, in simulation and ROS?
4. How can behavior trees be integrated with ROS to bridge simulation and possible real-world execution?

Related Works

- https://doi.org/10.48550/arXiv.1709.00084
- https://doi.org/10.48550/arXiv.1701.03573
- https://doi.org/10.35490/EC3.2025.360
- https://doi.org/10.1109/TASE.2025.3579720
- https://doi.org/10.1109/CoDIT62066.2024.10708285

Requirements and Eligibility

Students applying for this topic should have a decent understanding of , as well as fundamental coding skills. Successful participation (i.e.,grades better than 2.3) in the modules *Professional Software Development/Engineering* and *Software Lab* are expected.

Contact
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