Master Thesis Defense Minh Nguyen

Date: Tuesday, 06.10.2020
Time: 10:00
Room: C125, Online

Title: Knowledge-Enabled Specification of Composable Robot Motion Control Architectures

Abstract:
Developing software for robotic applications requires knowledge of a large variety of domains, including perception, manipulation, control, and many others. Capturing this knowledge in concrete implementations then integrating them on a single physical platform is a complicated task. This challenge motivates the development of several Model-Driven Engineering (MDE) methods, which can represent knowledge in concepts closer to the respective domain concerns for easier understanding and validation. These methods also improve the automation of the development process via code generation or automatic constraint checking. Model-driven methods in robotics often target popular component-based frameworks like Orocos or Robot Operating System (ROS), which partially and informally deal with the complexity of robotic applications by breaking them into ``components'' and facilitating their runtime composition with some form of a communication middleware. Methods tailored towards modeling component-based software generally do not support specifying the behavior of individual components. Scioni et al. [1] propose a Domain-Specific Language (DSL) to tackle this issue, which we extend in this thesis into the algorithm and control domains.

We develop the Algorithm and Controller DSLs in the Meta Programming System (MPS) workbench, with a focus towards integrating controller models into a complete motion control scheme of a robot manipulator. To this end, we identify numerous constraints and implement their verification in model compositions for both languages through the different mechanisms available in MPS. We also develop code generation modules that transform models composed using the developed DSLs into concrete C implementations. We first evaluate the proposed languages by integrating the generated implementation of the recent ABAG control algorithm [2] into three simple motion control schemes and test on the Kinova Gen3 robot manipulator. Additionally, we devise two objective metrics to evaluate non-functional aspects of the languages, specifically the relevance of the identified constraints and the usability of the included textual editor for model compositions.

[1] Enea Scioni et al. “Hierarchical Hypergraphs for Knowledge-centric Robot Systems: a Composable Structural Meta Model and its Domain Specific Language NPC4”. eng. In: Journal of Software Engineering for Robotics (JOSER) 7 (Special Issue on Domain-Specific Languages and Models for Robotic Systems July 26, 2016), pp. 55–74. doi: 10.6092/JOSER_2016_07_01_P55.
[2] Antonio Franchi and Anthony Mallet. “Adaptive closed-loop speed control of BLDC motors with applications to multi-rotor aerial vehicles”. In: 2017 IEEE International Conference on Robotics and Automation (ICRA). IEEE, May 2017. doi: 10.1109/icra.2017.7989610.