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From the Guest Editors of the Special Issue on Domain-Specific Languages and Models for Robotic Systems

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Introduction

This is the special issue on Domain-Specific Languages and Models for Robotics Systems. It comprises contributions that report on the use of domain-specific languages (DSLs) and models in robotics. A DSL is a programming or modeling language dedicated to a particular problem domain that offers specific notations and abstractions, which, at the same time, decrease the coding complexity and increase programmer productivity within that domain. Models offer a high-level way for domain users to specify the functionality of their system at the right level of abstraction. DSLs and models have historically been used for programming complex systems. They have however recently garnered interest as a separate field of study; this special issue investigates recent developments in DSLs and models for robotic systems. The special issue presents articles that report on the role of domain-specific languages and models in robotics, whose success is demonstrated by exploitable results (tools, systems, implications, etc.). The papers systematically describe their solution in terms of languages, models, and the underlying system architecture. Moreover, the papers address lessons learned about the use, benefits, and/or challenges of using DSLs or models in the robotics domain. All the papers not only explain their approach but also explain why a particular structure for the DSL or model has been chosen, why a particular structure for the DSL or model was proposed and used, and what are the benefits and implications of the proposed DSL or model. Therefore, all the papers provide additional value by reporting what has been done for what reasons based on which domain analysis resulting into which insights and enabling which step change. The special issue has been inspired by the topics of six years of the DSLRob workshop series (from 2010 to 2015) and is designed to serve as state-of-the-art reference for the body of knowledge available for DSLs in robotics. For more information, see the DSLRob workshop series web pages [1], [2], [3], [4], [5], [6] and the DSLRob open-access proceedings [7], [8], [9], [10], [11], [12].

Editorial – *Manuscript received July 19, 2016.*

Overview of Contributions

Stampfer, Lotz, Lutz, and Schlegel present the principles of the SmartMDSD Toolchain which is an integrated model-driven development environment for robotics software. It is based on a formalized software component model enforcing the principles of separation of concerns and separation of roles. The latter is key towards composition of complex robotic software systems out of reusable and configurable building blocks. They report on lessons learned out of six years of experience in developing tools, methods and DSLs for software development for robotics and conclude with a user study to assess the benefits of Model-Driven Software Development (MDSD) and their toolchain in particular. It is one of the rare examples of an integrated toolchain for MDSD in robotics.

Ziadi, Farges, Stinckwich, Ziane, Dhouib, Marmoiton, Morette, Novales, Kchir, and Patin present an integrated toolset that addresses variability issues in mobile robotics. This toolset relies on an ontology of mobile robotics and a DSL to describe robotic systems that are partly described. They report on lessons learned after 4 years of the PROTEUS project, a

French project supported by the French Research Agency (ANR).

Frigerio, Buchli, Caldwell, and Semini investigate the automatic generation of an efficient implementation of rigid body dynamics and kinematics algorithms for articulated robots, such as humanoids and manipulators. DSLs are used for the specification of robot models with coordinate transforms as an underlying abstraction. Users deal only with high-level information (like a robot model), and are relieved from low-level coding of critical routines. The generated code is efficient, tailored to each robot, and suitable for applications ranging from simulations to hard real-time robot control.

Scioni, Huebel, Blumenthal, Shakhimardanov, Klotzbcher, Garcia, and Bruyninckx advocate the research hypothesis that hierarchical hypergraphs are a better structural meta-model than just graph models. The properties of hierarchical hypergraphs are encoded formally in a DSL called NPC4. It introduces in particular the container primitive. Overall, the paper presents a systematic approach towards introducing meta-meta-model structures supporting in particular the needs of robotics.

Nordmann, Hochgeschwender, Wigand, and Wrede present a survey on domain-specific modeling and languages targeting core robotics concerns. They not only provide a state-of-the-art overview but also investigate the surveyed publications from the perspective of users and developers of model-based approaches in robotics along a set of quantitative and qualitative research questions. Furthermore they map the body of knowledge to robotics subdomains and development phases in systems engineering and analyze the contributions from a language engineering viewpoint. Thus, this contribution is very valuable with respect to identifying the current state-of-the-art and allowing others to get insights into this field of research.

Zeng, Rose, Taha, Duracz, Atkinson, Philippsen, Cartwright and O'Malley consider the question of what language features are needed to model cyber-physical systems. They use an experimental hybrid systems modeling language to show how a number of key aspects of cyber-physical systems can be modeled concisely using a small set of language constructs. Based on a number of case studies, they establish a connection between the engineering needs of the CPS domain and the language features that can address these needs. This in turn builds a case for improving modeling languages by integrating features such as partial derivatives, differentiation without duplication, and support for equations.

Adam, Larsen, Jensen and Schultz propose that functional-safety-critical concerns regarding robot software be explicitly declared separately from the main program, in terms of externally observable properties of the software. A DSL is used to declaratively specify a set of safety-related rules that the software must obey, as well as corresponding corrective actions that trigger when rules are violated. The DSL is integrated with ROS, is shown to be capable of specifying safety-related constraints, and is experimentally demonstrated to enforce safety behaviour in existing robot software.

Acknowledgments

We thank everyone who contributed to this special issue, starting with the participants of the DSLRob workshop series, where our community clearly agreed not only on the need for better abstractions, but also signalled its readiness to participate in the effort of this special issue of JOSER. Together, we are shaping the methods, formats, and priorities of a community which spans many interests and backgrounds. We thank the authors of all submitted manuscripts for their effort, and trust that those authors whose papers did not make it into the special issue found the review comments to be a valuable help. We are extremely grateful to the reviewers who took the time to thoroughly assess the contributions and provide such detailed and helpful comments to the authors.

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