Software and Systems Modeling (2022) 21:963–965
https://doi.org/10.1007/s10270-022-00988-0

GUEST EDITORIAL


# Guest editorial to the theme section on AI-enhanced model-driven engineering

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Received: 11 February 2022 / Accepted: 14 February 2022 / Published online: 11 March 2022


**Abstract**
This theme section brings together the latest research at the intersection of artificial intelligence (AI) and model-driven engineering (MDE). Over the past years, we have witnessed a substantial rise of AI successfully applied to different domains, including software development and MDE. Dedicated events at the intersection of AI and MDE have been created, too, such as the MDE Intelligence workshop series co-located with the MODELS conference. This theme section covers research contributions integrating AI components into MDE approaches—increasing the current benefits of MDE processes and tools and pushing the limits of "classic" MDE with the goal to provide software and systems engineers with the right techniques to develop the next generation of highly complex model-based systems—and applications of MDE to the development of AI components. In total, nine submissions were accepted in the theme section after a thorough peer-reviewing process.

**Keywords** Artificial intelligence · Model-driven engineering · Software engineering · Systems engineering

## 1 Introduction

Artificial intelligence (AI) has become part of everyone's life. It is used by companies to exploit the huge amounts of data they collect to improve their products, processes, and services, and, as a consequence, it is present in almost every device around us. Lately, AI is also starting to impact all aspects of the system and software development lifecycle, from their upfront specification to their design, testing, deployment, operation, and maintenance, with the main goal of helping engineers produce systems and software faster and with better quality while being able to deal even with more complex systems. The hope is that AI will help dealing with the increasing complexity we face in software and systems engineering.

Model-driven engineering (MDE) is an established engineering paradigm to tame until now part of this complexity. However, its adoption by industry still relies on their capacity to manage the underlying methodological changes including among other things the adoption of smart tools and learning new skills. To go one step further, we believe there is a clear opportunity for AI-empowered MDE, which will push the limits of "classic" MDE and provide the right techniques to develop the next generation of highly complex model-based software-intensive systems engineers will have to design tomorrow.

At the same time, AI is software (and complex software, in fact). We believe that AI-powered MDE will also benefit the design of AI artifacts themselves, and specially, to face the challenge of designing "trustable" AI software.

This theme section brings together nine papers representing the latest research at the intersection of AI and MDE.

## 2 Selected papers for this theme section

As the final outcome of a thorough peer review process, nine papers were selected for this theme section. These can be roughly categorized into three groups:

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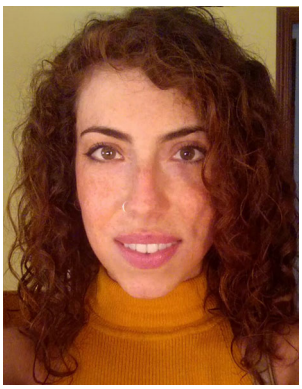
- Works with a focus on machine learning include:
  - José Antonio López, Javier Luis Canovas Izquierdo and Jesús Sánchez Cuadrado, in their paper "ModelSet: a dataset for machine learning in model-driven engineering," provide a labelled dataset of software models and tool support in order to stimulate the application of machine learning algorithms to tackle model-driven engineering problems.
  - Armin Moin, Moharram Challenger, Atta Badii and Stephan Günnemann, in their paper "A model-driven approach to machine learning and software modeling for the IoT," present an approach called ML-Quadrat to support the development of IoT systems with machine learning capabilities.
- Works on supporting modelers with AI-based tools, such as recommender systems, include:
  - Rijul Saini, Gunter Mussbacher, Jin Guo and Jörg Kienzle, in their paper "Automated, and traceable domain modelling empowered by artificial intelligence," present an approach to facilitate the interactions between modeling bots and human modelers by searching for alternative configurations of domain models which can be interactively selected by the modelers and automatically integrated in the domain models.
  - Sagar Sunkle, Krati Saxena, Ashwini Patil and Vinay Kulkarni, in their paper "AI-driven streamlined modeling: Experiences and lessons learned from multiple domains," present five case studies where AI has been used in different modeling activities together with a discussion on how AI and modeling interact, a comparison with existing work, and a discussion of their experiences and lessons learned.
  - Martin Weyssow, Houari Sahraoui and Eugene Syriani, in their paper "Recommending metamodel concepts during modeling activities with pre-trained language models," present a deep learning model that is able to abstract and recommend domain concepts by learning from a corpus of thousands of independent metamodels.
- Works on reinforcement learning and search-based approaches include:
  - Juan Parra-Ullauri, Antonio García-Domínguez, Nelly Bencomo, Changgang Zheng, Chen Zhen, Juan Boubeta-Puig, Guadalupe Ortiz and Shufan Yang, in their paper "Event-driven temporal models for explanations - ETeMoX: explaining reinforcement learning," present ETeMoX, an event-driven infrastructure for representing information generated during model-based reinforcement learning which can then be used to explain learning outcomes.
  - Shekoufeh Kolahdouz-Rahimi, MohammadHadi Dehghani, Massimo Tisi and Dalila Tamzalit, in their paper "Facilitating the migration to microservice architecture via model-driven reverse engineering and reinforcement learning," present a framework that help architects to remodularize legacy systems by leveraging reverse engineering techniques (to obtain a model from the source code of the system) and reinforcement learning (to recommend a mapping from the legacy model to a set of microservices).
  - Angela Barriga, Adrian Rutle and Rogardt Heldal, in their paper "AI-powered model repair: an experience report - Lessons learned," present their experience in applying reinforcement learning approaches to the model repair problem.
  - Edouard Batot and Houari Sahraoui, in their paper "Promoting social diversity for the automated learning of complex MDE artifacts," present a new diversity measure, called Social Diversity, for genetic programming algorithms, which is applied to learning well-formedness rules in MDE.

**Acknowledgements** We would like to thank all authors who submitted papers. We would also like to thank our reviewers for their efforts and high-quality reviews, which greatly contributed to improving the selected papers. Finally, we would like to express our gratitude to the SoSyM editorial office, specifically to Martin Schindler and Bernhard Rumpe who were always very helpful and supportive.





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