Simulation

Special Issue Editorial

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Special Issue: On editing 100 volumes of SIMULATION

As we conclude the 100th volume of SIMULATION—Transactions of the Society for Modeling and Simulation International (SCS), we reflect on this momentous year in which we celebrated the Journal's publication and evolution through a range of activities highlighted in our June issue. It has been my pleasure and honor to organize a double issue featuring contributions from members of our Editorial Board, along with a curated selection of articles from this volume, accessible on the journal's website (https://journals.sagepub.com/topic/collections-sim/sim-1-volume_100_highlights?journalCode=sim). This curated list shows the variety of topics we publish, and it showcases the research contributions of our authors, reviewers, and Editorial Board members.

This final issue of the year offers a special treat, as it features a thoughtful reflection by the Editors-in-Chief of SIMULATION spanning the last 30 years. This is a collection of invited articles curated by a dedicated team of editors, in which each piece highlights the work accomplished by our Editors-in-Chief over the years, while also showcasing their individual contributions to the field of Modeling and Simulation. The insights shared by these researchers represent a culmination of decades of expertise, innovation, and leadership that have shaped the journal and advanced the discipline of Modeling and Simulation. This unique collection features articles by Bernard P. Zeigler, Richard Fujimoto, Pieter Mosterman, Levent Yilmaz, Mikel Petty, Adelinde Uhrmacher, and myself, together with their close collaborators. It has been both an honor and a privilege to have the support of such a distinguished team, each of whom has played a pivotal role in advancing the dialogue and research within our field. Reading their articles has been a rewarding experience. I hope that you find as much enjoyment and inspiration in these contributions as I did.

In his article, Bernard P. Zeigler presents critical insights into the concept of homomorphism and defines essential principles for constructing homomorphisms through structural and coupling mechanisms. He shows how homomorphism can help build low-resolution models that serve as surrogate or metamodels, streamlining complex and computationally demanding simulations for system optimization. Furthermore, Zeigler emphasizes the significance of homomorphism in developing a novel approach for tractable trajectory sampling in stochastic simulations. The paper illustrates how to formulate multi-resolution model families from base-lumped model pairs, advocating for the advantages of a model family over a singular ''high fidelity'' simulation. These simpler models can yield clearer insights, enhance generalizability, and make complex behaviors more accessible. Zeigler provides contemporary examples that demonstrate the conditions favorable for lumped model construction and approximate morphisms. He presents brain simulation modeling, showing how lumped models can dramatically reduce computational demands while maintaining essential information from the base model. In addition, he discusses applications in combat modeling, where lumped models clarify base model behaviors and support simplifications. The article concludes with an examination of open research areas aimed at refining this methodology and expanding our understanding of its implications for multi-resolution modeling and simulation.

In his article, Richard Fujimoto provides a historical overview of the parallel and distributed simulation (PADS) field, with a particular focus on the advancements in parallel discrete event simulation (PDES) technology over the last four decades. He highlights synchronization as a critical technical challenge that spurred the development of PDES, exploring two primary solution approaches that evolved into the time management services outlined by the high-level architecture (HLA) standard. Fujimoto details how HLA effectively bridged the gap between the PADS and defense modeling communities, enabling PDES to transition from academia to real-world challenges, particularly in the telecommunications and defense sectors. He emphasizes the importance of the PADS conference and collaborations among researchers and reputable journals like SIMULATION in fostering participation and engagement within the PDES community. Finally, Fujimoto discusses ongoing research at the intersection of parallel computing and discrete event simulation, noting that emerging computing platforms and paradigms are likely to sustain future developments in PDES technologies.

Pieter Mosterman delves into the significant advancements in the miniaturization of structures in the Digital Age, emphasizing the profound impacts of computation, digitization, and communication. He highlights the evolution of Cyber-Physical Systems (CPS) as instrumental in creating systematic approaches to manage the increasing complexity inherent in modern systems. The article investigates the relationship between information technology, embedded technology, and operational technology, outlining how these domains have influenced the field of

miniaturization and system design. Mosterman articulates the current challenges posed by the heterogeneity of technologies, which complicates integration and interoperability. They also discuss the role of advanced technologies: digital twins, which allows for real-time simulation and monitoring; digital engineering, which enhances the design process; and DEVOPS, which fosters collaboration between software development and operations. The paper concludes with a detailed vision for the future, advocating for the seamless integration of system design and operation through live connectivity, thereby paving the way for more efficient, adaptive, and responsive CPS in an increasingly interconnected world.

Levent Yilmaz explores a restructuring phase of SIMULATION from 2008 to 2016, emphasizing the crucial alignment of modeling and simulation elements with advancements in the broader field and associated initiatives from the Society for Computer Simulation. The paper assesses technological innovations, emerging scientific trends, and evolving societal demands, outlining future aspirations for the discipline. It highlights modeling and simulation as a multidisciplinary field while addressing advancements in simulation theory and methodology, alongside the current void of well-defined guidance regarding its foundational knowledge and criteria for high-quality research. The discussion offers valuable insights on how the M&S discipline can remain relevant and transformative amid emerging challenges such as sustainability, digital transformation, and medical sciences. Yilmaz analyzes the necessary steps to sustain the discipline's significance while fostering meaningful engagement among practitioners.

Mikel Petty addresses the increasingly critical issue of cybersecurity, proposing a novel approach through cybersecurity modeling. He introduces a comprehensive research program that encompasses several interconnected projects aimed at developing models using extended Petri nets to capture the dynamics of cyber warfare, including strategies, actions, and associated costs for both attackers and defenders. He considers an attacker-centric database that allows for the definition of cyberattack component models, integrating defender actions and responses. These models are further enhanced through simulations combined with reinforcement learning, enabling iterative improvements in both attack and defense strategies against targeted computer systems. The paper also outlines future research directions, such as the development of realistic transition rates informed by empirical data from actual cyberattacks, enhancements in software integration via a unified interface, and the exploration of alternative probability distributions to generate inter-firing times for specific transitions based on the nature of the events they represent.

Adelinde Uhrmacher's paper centers on the innovative concept of (self-)adaptive simulation models, which incorporate adaptive simulation techniques to refine (iteratively) model structures to achieve optimal performance in varying environments. The authors suggest that these self-adaptive models can revolutionize methodologies across different disciplines by integrating diverse knowledge sources that support their evolution. They explore strategies for integrating adaptations into simulation models and examine these models' potential as subjects of adaptation, advocating for models capable of both responding to environmental shifts and directing their developmental paths. Insights from signaling models illustrate how such approaches can enhance simulation's longevity and reliability, addressing dynamic challenges. They discuss how the emergence of digital twins has further heightened the interest in automating the adaptation of simulation models, for instance in the case of real-time monitoring of their physical counterparts, which can trigger modifications in response to evolving inquiries, assumptions, or behavioral requirements. Ultimately, this work aims to pave the way for sophisticated models that intelligently evolve to meet the demands of rapidly changing contexts across numerous fields.

We conclude this issue with an article that presents a comprehensive collection of publications related to discrete event system specification (DEVS) from the past two decades, categorized into four key areas: theory, methodology, tools, and applications. This categorization not only showcases the evolution of simulation methodologies but also underscores the growing significance of DEVS in various domains, particularly in real-time embedded applications, which have become increasingly complex. The article emphasizes how modeling and simulation has emerged as a factor in enhancing product quality and minimizing lifecycle costs, particularly in the context of modern hard real-time distributed systems. The performance efficiency of such systems is heavily influenced by the underlying communication network, necessitating the development of robust, deterministic, and reliable communication protocols to ensure that critical deadlines are met. The DEVS formalism has proven to be instrumental in addressing these challenges, providing a strong theoretical foundation for the establishment of discrete event systems that can effectively manage the intricacies of complex applications. The analysis presented in the article reaffirms DEVS as a vital platform for a wide range of research initiatives in the fields of modeling and simulation, fostering innovation and driving advancements in technology.

As we conclude the celebration of this remarkable milestone (the 100th volume of SIMULATION), we extend our gratitude to all those who have contributed their time and expertise over the years. This is only thanks to the commitment and dedication of our volunteers, editorial board members, and organizers who tirelessly support the journal's mission (in particular, those who collaborated with us on this special issue, delivering their valuable

insights in a timely fashion). Their contributions have not only advanced the scope of our publication but have also helped ensure that SIMULATION remains aligned with the forefront of 21st-century research. As we reflect on our collective achievements and the collaborative spirit that has fueled our progress, we look forward to the future with enthusiasm and optimism. We are excited about the potential for continued innovation and exploration in the field of modeling and simulation and eagerly anticipate the contributions of new voices and perspectives as we embark on the next chapter of our journey together.

We look forward to the innovations and insights that the next 100 volumes will bring to this rapidly evolving field of research.

Cheers!

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