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# Concepts and Methodologies for Modeling and Simulation

A Tribute to Tuncer Ören



Springer

*Editor*

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# Foreword

The work of Tuncer Ören, the archetypal Renaissance man of the modeling and simulation community, embodies the vision of M&S as the essential enabler of future science and engineering. Ören’s vision stretches widely over the whole M&S domain encompassing its fundamental body of knowledge, its methodology, its practice, and its ethics. It also includes the quality of M&S products and specific application domains such as cognitive and emotive social simulation. The authors of this tribute book pursue a few—essential—threads of the many emanating from Ören’s core vision. As a consequence of the underlying unity of conception, the book is more than a collection of disparate state-of-the art articles. This integration is enhanced by the fact that every chapter is explicitly connected to pertinent features of Ören’s thought. Within this perspective, the book covers cutting-edge topics in simulation methodologies; modeling methodologies; quality assurance and reliability of simulation studies; and cognitive, emotive, and social simulation. Notably, it touches on Ören’s intense interest in the body of knowledge of modeling and simulation, with a review of existing M&S literature through the newly emerging techniques of journal profiling and co-citation analysis. This book beckons you, whether theorist or practitioner, generalist or domain application professional, to partake in and contribute to Ören’s powerful vision.

Potomac, MD, USA  
December 29, 2014

Bernard P. Zeigler



# Preface

*Concepts and Methodologies for Modeling and Simulation* aims to present recent advances in the theory and methodology of Modeling and Simulation (M&S). By connecting these developments to the conceptual, theoretical, and methodological foundations developed by Professor Tuncer Ören, this volume serves as a testimonial that honors Dr. Ören's long-lasting and fundamental contributions to the M&S discipline for over 50 years.

Since 2003, I have had the privilege to collaborate with Dr. Ören, whom I see as my mentor and a titan in our field. The articles in this book are a testament to the diversity and innovativeness of his thoughts. As evidenced by this volume, his influences in the philosophy, theory, methodology, ethics, and the body of knowledge of M&S have numerous connections to recent advancements in our field and continue to provide directions for its further development. This book is largely due to the efforts and contributions of the authors, who shared their recent research in the context of Dr. Ören's seminal contributions to the M&S discipline. I am indebted to them for their contributions to this tribute volume. They are not only authorities in their field but also colleagues of Dr. Ören. Hence, they are qualified and entitled to trace recent advancements in their fields to the most influential concepts and methods introduced by him.

In the area of simulation methodologies, Dr. Ören's earlier work on model-based M&S and detailed categorizations and taxonomies of M&S has been highly influential. In particular, normative views for the advancement of M&S, including synergies of artificial intelligence and systems theories, and his comprehensive and integrative views have provided a sound and thorough framework for the development of advanced simulation methodologies. To explain these contributions, the book starts with my reflections on the recent developments in agent-directed simulation (ADS), providing a framework that explores synergies between simulation and agent technologies. The readers can trace the provenance of various ideas explored under ADS to concepts introduced by Dr. Ören when he first examined and demonstrated how artificial intelligence methods can assist simulation. The second chapter in this section presents how model engineering and

service technologies can be leveraged to contribute to System-of-Systems (SoS) Engineering. The third chapter overviews emerging trends and drivers in high-performance simulation systems, while the fourth chapter examines the role of data in the context of dynamic data-driven simulations that connect real-time sensor data to online simulations.

The second section of the book focuses on advanced modeling methodologies. The first chapter in this area focuses on the philosophical fields of ontology and epistemology to delineate the role and use of simulations in relation to the taxonomies and categories of M&S developed by Dr. Ören as part of his contributions to the M&S body of knowledge. The second chapter demonstrates how innovations in modeling formalisms can help manage the challenges in hybrid model composition, especially in the context of agent-based, human, social, and environment models. Specifically, the authors describe the use of a polyformalism model composition approach and highlight its relation to multimodeling strategies that Dr. Ören and I have developed during the early 2000s. The third chapter of this section underlines the importance of a model-based approach to M&S and underlines model building, model-based management, and model processing activities advocated by Dr. Ören. The authors then present a formal, declarative, and visual transformation (model processing) methodology to translate a domain conceptual model to a distributed simulation architecture model.

The third section of the book is devoted to the reliability and quality assurance of models. The section starts with an overview of quality indicators that can be used to support a structured and quality-centered approach to simulation development throughout the entire M&S life cycle. The second paper reviews, summarizes, and describes the influence of important M&S quality assurance papers developed by Dr. Ören. The paper also promotes strategies for the replicability and reproducibility of simulation studies to instill confidence in simulation experiments. The third paper in this section refers to challenges involved in qualitative and quantitative comparisons of agent-based models to calibrated statistical models for the purpose of validation and reproducibility. The last chapter in this section introduces the Generalized Discrete Event System Specification to build more accurate discrete-event models of dynamic systems. This work highlights the need for engineering quality into models to improve their accuracy.

The fourth section of the book focuses on the specification and simulation of human and social behavior, acknowledging Dr. Ören's contributions to model specification language development as well as his recent research in cognitive and emotive simulation modeling including the specification of models of personality, emotions, conflict management, perception, and anticipation. In this section, the first chapter presents work on social science models that benefits from the principles based on Dr. Ören's influences of model specification languages, goal-directed agents, anticipatory simulation, agent perceptions, and multifaceted models. Similarly, the second chapter in this area refers to the multisimulation methodology as a basis to examine bridging human decision processes and computer simulation while also referring to multisimulation as an enabling technology



for backtracking and replaying situated simulation histories with altered conditions as well as futures generated before exploring alternative realities in social sciences.

The last section of the book is devoted to M&S body of knowledge work. The chapter presented in this section was inspired by Dr. Ören's work and shares common ground by profiling and classifying M&S publications in terms of techniques, application areas, and their context in a relevant way with the second and third parts of the body of knowledge, which defines the M&S core areas and supporting domains.

Auburn, AL, USA  
December 19, 2014

Levent Yilmaz



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