Special Issue on Agent-directed Simulation

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The premise of the agent paradigm, its related theory and methodologies together with advances in multilevel modeling of complex systems of interactions are opening new frontiers for advancing the physical, natural, social, military, and information sciences and engineering. Recent trends have made it clear that simulation model complexity will continue to increase dramatically in the coming decades. The dynamic and distributed nature of simulation applications, the significance of exploratory analysis of complex scientific phenomena, and the need for modeling the micro-level interactions, collaboration, and cooperation among real-world entities is bringing a shift in the way systems are being conceptualized. Using intelligent agents in simulation models is based on the idea that it is possible to represent the behavior of active entities in the world in terms of the interactions of an assembly of agents with their own operational autonomy. The possibility to model complex situations whose overall structures emerge from interactions between individual entities and to cause structures on the macro level to emerge from the models at the micro level is making agent paradigm a critical enabler in modeling and simulation of complex adaptive systems.

To this end, the purpose of this special issue is to facilitate dissemination of the most recent advancements in the theory, application, and toolkits of agent-directed simulation. Agent-directed simulation consists of three distinct, yet related areas that can be grouped under two categories as follows: (1) Simulation for Agents (agent simulation), i.e., simulation of systems that can be modeled by agents in engineering, human and social dynamics, military applications etc. (2) Agents for Simulation that can be grouped under two groups: *agent-based simulation* which focuses on the use of agents for the generation of model behavior in a simulation study; and *agent-supported simulation* which deals with the use of agents as a support facility to enable computer assistance by enhancing cognitive capabilities in problem specification and solving. *Agent-supported simulation* is used for three purposes: (i) to provide computer assistance for front-end and/or back-end interface functions; (ii) to process elements of a simulation study symbolically (for example, for consistency checks and built-in reliability); and (iii) to provide cognitive abilities to the elements of a simulation study, such as learning or understanding abilities. Based on this characterization, the accepted manuscripts in this special issue provide a basis to expand our horizons in the use of agents in simulation modeling.

The article by Bingcheng Hu, Jiming Liu, and Xiaolong Jin focuses on quantitatively measuring the impact of local agent behaviors on the global characteristics and patterns in a multi-agent NBA simulation, called RoboNBA. In particular, the authors formulate two sources of different agent local behaviors, including decision making mechanisms and agent strategies. Using experimental results, they demonstrate how rational agents significantly perform better than the simple reactive agents in a team environment. Based on these findings they focus on alternative defense strategies such as Fixed Mark, Adaptive Mark, and Greedy Defense. They found out that Fixed Mark defense strategy is slightly superior to Greedy Defense strategy in

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terms of performance as well as diversity of attack patterns, whereas Adaptive Mark Defense significantly outperforms Greedy Defense. Through this study the authors demonstrate the utility of the agent paradigm in exploratory analysis of various alternative strategies. Furthermore, the illustration of the linking of emergent global patterns to local agent behaviors and strategies at the micro level is a significant contribution of their work.

The article by Zhiming Zao, Dick van Albada, and Peter Sloot focuses on how agents can support a simulation modeling framework by interpreting and controlling the flow of events to improve adaptability of a simulation. The authors present an agent architecture, Interactive Simulation System Conductor (ISS-Conductor) that is deployed over the HLA framework. Using the ISS-Conductor, they encapsulate a simulation or visualization system as a component. The wrapped component is augmented with agents that invoke simulation and visualization services to control the run-time environment. By doing so, the interaction protocols are decoupled from the simulation system to improve reusability of simulation model. Their approach enables a simulation system to become independent of how its submodels are created, composed, and represented. As a result a simulation system can be configured with one of multiple families of components. Furthermore, if a family of related model components is designed to be used together, one can enforce this constraint using the mechanisms underlying ISS-Conductor. Finally, the plausibility of defining a family of protocols, encapsulate each one, and make them interchangeable can let the control protocol vary independently from the context that use it.

The article by Zhen Lei, Bryan C. Pijanowski, Konstantinos T. Alexandridis, and Jennifer J. Olson discusses distributed modeling architecture in a Multi Agent Behavioral Economic Landscape (MABEL) model that simulates land use changes over time and space. The novel features of the developed framework include the distribution of simulation tasks to remote computers over the Internet and parallel operations in multiple computers for large tasks that demand high-end computational capabilities. The operation of the developed simulation framework is illustrated using various types of agents that are involved in the land use change model, the way in which behavior is specified using Bayesian Belief Networks, and how the MABEL infrastructure facilitates multiple simulations of parallel location.

The article by Sean Luke, Claudio Cioffi-Revilla, Liviu Panait, Keith Sullivan, and Gabriel Balan presents the MASON agent-based simulation toolkit. The authors discuss how MASON carefully delineates between model and visualization, allowing models to be dynamically detached from or attached to visualizers, and to change platforms mid-run. They also describe the MASON system, its motivation, and its basic architectural design. A comparative analysis of MASON to related multi-agent libraries in the public domain is also provided to facilitate tool selection. Finally, they discuss six applications of the system to suggest its breadth of utility.

As the envelope of theory, methodology and infrastructures increases, so does the perimeter of ambitious agent-based projects. Therefore, this special issue is devoted to emergent agent methodologies, applications, and environments that can facilitate analysis, design, and implementation of agent-directed simulations for various application areas such as military, business, engineering, human and social dynamics, ecosystems etc. We believe recent developments in theory, methodology, and infrastructures are expected to boost opportunities for previously unforeseen application domains, and in light of this view we hope you enjoy the articles contained in this special issue.