4th International Conference on Intelligent Systems, Modeling and Simulation,
IEEE Computer Society Press, Bangkok, Thailand, Jan 29-31, 2013.

Keynote

A Formal Approach for Understanding Emergent Properties in Simulation Models

Yong Meng TEO
Department of Computer Science
National University of Singapore
Email: teoym@comp.nus.edu.sg
url: www.comp.nus.edu.sg/~teoym

In complex systems, simple interactions between components and their environment often lead to unexpected behaviors. These properties, called *emergent properties,* represent one of the most significant challenges in engineering complex systems [2, 3]. Examples of emergent properties include connection patterns in social network, trends in big data analytics and traffic congestion among others. Emergence can be a positive addition to the designed properties of a product because this property can be adapted to support tasks that designers never originally intended. On the other hand, emergent properties such as the Ethernet capture effect and router synchronization problems in computer science are undesirable. Thus, emergence may also lead to unforeseeable failures, making it harder to design, analyze and control systems. Though there is a growing interest in understanding emergence, there is considerable disagreement among the nature of emergent properties. This keynote attempts to provide a framework for understanding emergent properties from the computer science perspective.

This keynote is divided into two main parts. Firstly, different perspectives of emergence from philosophy, natural and social sciences to computer science [3]; and key methods of formalizing emergent properties are reviewed. Secondly, a *grammar-based approach* is presented for identifying *weak emergence* in component-based simulation models [1, 4, 5]. Automatic detection of emergent properties is demonstrated using the Boids model. In conclusion, open issues including the validation and reasoning of emergence are discussed.

Biography

TEO Yong Meng is an Associate Professor with the Department of Computer Science at the National University of Singapore. He heads the Information Technology Unit and the Computer Systems Research Group. Since 2010, he is a Visiting Professor at the Shanghai Advanced Research Institute, Chinese Academy of Sciences. He was a Fellow of the Singapore-Massachusetts Institute of Technology Alliance from 2002-2006. He received his Master and PhD, both in Computer Science, from the University of Manchester in UK. His main research interest is parallel & distributed computing. Current projects include SkyBoxz: Elastic Computation on Multiple Clouds, semantic validation in component-based modeling and simulation, concurrency verification and performance analysis of large systems. He has held various visiting positions at MIT (USA), KTH (Sweden), Hitachi Central Research Lab (Japan) among others.

References

1. C. Szabo and Y.M. Teo, **An Integrated Approach for the Validation of Emergence in Component-based Simulation Models,** Proceedings of the Winter Simulation Conference, pp. xx, IEEE Computer Society Press, Berlin, Germany, Dec 9-12, 2012.

2. C. Szabo and Y.M. Teo, **An Objective-based Approach for Semantic Validation of Emergence in Component-based Simulation Models**, Proc. of 26th ACM/IEEE/SCS Workshop on Principles of Advanced and Distributed Simulation, pp. 155-162, ZhangJiaJie, China, Jul 15-19, 2012

3. Y.M. Teo and C. Szabo, **Semantic Validation of Component-based Models with Emergent Properties**, Book Chapter in Ontology, Epistemology, and Teleology of Modeling and Simulation – Philosophical Foundations for Intelligent M&S Applications, edited by Andreas Tolk, Springer-Verlag, 2012.

4. C. Szabo, Y.M. Teo and S. See, **A Time-based Formalism for the Validation of Semantic Composability**, Proceedings of the Winter Simulation Conference, pp. 1411-1422, IEEE Computer Society Press, Austin, Texas, USA, December 13-16, 2009, (ACM SIGSIM Best PhD Student Paper Award).

5. Y.M. Teo and C. Szabo, **CODES: An Integrated Approach to Composable Modeling and Simulation**, Proceedings of 41st Annual Simulation Symposium, pp. 103-110, IEEE Computer Society Press, Ottawa, Canada, Apr 13-16, 2008.