

EDITORIAL

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Multidisciplinary applications of complex networks modeling, simulation, visualization, and analysis

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Complex systems and networks

Complex Adaptive Systems (CAS) or complex systems are characterized by the interactions between their numerous elements. The word ‘complex’ comes from the Latin *plexus* which means entwined. In other words, it is difficult to correlate global properties of complex systems with the properties of the individual constituent components. This is primarily because the interactions between these individual elements partly determine the future states of the system (Gershenson 2013). If these interactions are not included in the developed models, the models would not be an accurate reflection of the modelled phenomenon.

While numerous techniques and frameworks for modeling complex systems have previously been devised (Niazi 2011), clearly one of the most explicit and intuitive methodology is the modeling of interactions using *networks* (Niazi and Hussain 2012). Networks consist of *nodes* or *vertices*, which can be used to represent elements, and *links* or *edges*, which usually represent interactions or relations between the elements. In this context, networks represent the *structure* of complex systems; how elements interact. However, networks can also be used to represent the *dynamics* or *function* of complex systems, e.g. considering nodes as states and links as transitions. Thus, the same analysis can be applied to the structure and the function of networks. Understanding the relationship between structure and function is one of the major open questions across sciences, which can also be posed using networks: how do changes in the structural network affect the state network? (Boccaletti et al. 2006; Gershenson 2012). For example, what will be the effect of knocking out a gene in the behavior of a cell? Several systems change their structure over time, and their properties can be modelled with *temporal networks* (Holme and Saramäki 2012). Likewise, there are several instances when the structural changes are triggered by the state of the network, as has been studied in *adaptive networks* (Gross and Sayama 2009).

With not much more than a decade of network research, there are already numerous applications of networks in diverse areas, such as epidemiology (Colizza et al. 2007; Christakis and Fowler 2007; Pastor-Satorras and Vespignani 2001), human mobility (Gonzalez et al. 2008), social networks (Huberman et al. 2009; Niazi and Hussain 2011), artificial life (Gershenson and Prokopenko 2011), life sciences (Bullmore and Sporns 2009; Gershenson 2004; Guimera and Nunes Amaral 2005; Montoya et al. 2006), theory of

computation (Gershenson 2010), and engineering (Broder et al. 2000; Helbing et al. 2006; Niazi and Hussain 2013a, 2013b; Prehofer and Bettstetter 2005), just to mention a few. Some other examples of research in the area of networks include (Albert and Barabási 2002; Barabási 2002; Barrat et al. 2008; Caldarelli 2007; Motter and Albert 2012; Newman 2003; Newman et al. 2006; Newman 2010; Strogatz 2001).

Papers in the special issue

In the first paper “Penetration capacity of the wood-decay fungus *Physisporinus vitreus*”, the authors Matthias Jörg Fuhr, Mark Schubert, Chris Stührk, Francis WMR Schwarze and Hans Jürg Herrmann propose the study of bioincising by means of a model considering many factors affecting the growth and effects of *P. vitreus* in Norway spruce (Fuhr et al. 2013).

In the next paper, “Information theoretical methods for complex network structure assessment”, the authors Enrique Hernández-Lemus and Jesús M Siqueiros-García discuss how information theory can provide effective means for structural assessment in domains such as biological and social network analysis (Hernandez-Lemus and Siqueiros-Garcia 2013).

In the paper “Information and Phase Transitions in Socio-Economic Systems”, the authors Terry Bossomaier, Lionel Barnett and Michael Harré present an interesting study on the role of information-based measures in detecting and analysing phase transitions. They contend that phase transitions have general features and can be detected in diverse systems using information theory (Bossomaier et al. 2013).

In the next paper, “Clustering Datasets by Complex Networks Analysis” by Giuliano Armano and Marco Alberto Javarone, the authors propose a method based on complex network analysis which allows clustering on multidimensional datasets (Armano and Javarone 2013).

In the article “PyCX: a Python-based simulation code repository for complex systems education”, Hiroki Sayama introduces PyCX, an online python-based code repository of simple, crude but easy-to-understand sample codes for various complex systems simulation, including iterative maps, cellular automata, dynamical networks and agent-based models (Sayama 2013).

In the article “Segregation mechanisms of tissue cells: from experimental data to models”, Előd Méhes and Tamás Vicsek present a review of pattern formation by segregation of tissue cells. In addition, the authors present experimental observations, including some new results on various aspects of two and three dimensional segregation events and then summarize various computational modeling approaches (Méhes and Vicsek 2013).

In the final article, “Large-scale global optimization through consensus of opinions over complex networks” by Omid Askari-Sichani and Mahdi Jalili, the authors present a model based on consensus of opinions among agents interacting over a complex networked structure for a large-scale task optimization. They demonstrate how agents can solve such tasks using collaborations and forming consensus of opinions (Askari-Sichani and Jalili 2013).

Acknowledgements

The editors would like to acknowledge the continual support provided by Leslie De La Vega and Natalie Shon from SpringerOpen during the production of the special issue. C.G. was partially supported by SNI membership 47907 of CONACYT, Mexico.

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Received: 30 August 2013 Accepted: 30 August 2013

Published: 08 Nov 2013

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10.1186/2194-3206-1-17

Cite this article as: Gershenson and Niazi: Multidisciplinary applications of complex networks modeling, simulation, visualization, and analysis. *Complex Adaptive Systems Modeling* 2013, **1**:17

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