Chapter 1
Introducing Theories and Simulations of Complex Social Systems

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1 Introduction

Complex networks exist throughout the domains of nature and society: swarms, circulatory systems, roads, power grids. These networks enable the efficient distribution of resources, resulting in greater and more impressive activity. Social systems are networks that go one step further: they are not only there for the distribution of resources, but also to act as a medium for the interaction between numerous intelligent entities. Thus they combine efficient resource use with intense productivity, in the sense that interactions between these entities produce numerous effects on the system, for better or for worse [1]. We live our lives in a nexus of numerous social systems: family, friends, organizations, nations. We benefit from the fruits of their power, including energy, learning, wealth, and culture. We also struggle with the crises they generate, such as crime, war, pollution, and illness. Our motivation for studying these systems is clear: they are the fabric upon which our lives are woven.

Research into social systems is challenging due to their complex nature. Traditional methods of analysis are often difficult to apply effectively. This can be due to a lack of appropriate data, or too much uncertainty. It can also be the result of problems which are not yet understood well enough in the general sense so that they can be classified, and an appropriate solution quickly identified. Simulation is one tool that deals well with these challenges, fits in well with the deductive process, and is useful for testing theory [4]. This field is still relatively new, and much of the work is necessarily innovative, although it builds upon a rich and varied foundation [6]. There are a number of existing modelling paradigms being applied to complex social systems

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research [2, 3, 7–9]. Additionally, new methods and measures are being devised through the process of conducting research. It is vital to point out that this novelty is not a reason for hesitation in following this line of research: the problems under consideration here are of significant concern [5]. The intensification of activity in modern life means that the consequences for mistakes or inaction in public policy are grave. This is true for political, financial, justice, and public health decisions, among many other fields. We present in this volume a selection of research that seeks to address the challenges being faced in these fields, both in terms of finding solutions and the best ways to pursue this kind of research.

2 New Contributions

New directions in science require new ways of thinking about the practice of science. This volume begins with Chap. Software Solutions for Computational Modelling in the Social Sciences with discussion of the challenges of creating the software which underlies modelling research of social systems. A general approach for the development process is presented, along with solutions to common issues. This approach takes advantage of the dynamic nature of software so that it can be effectively used as a tool of discovery and communication. In Chap. Modelling Epistemic Systems, Martins seeks to model the process by which a community of scientists produces scientific knowledge. He employs the ideas considered by precursors in this field and builds upon them by using a computational model to investigate different ideas through experimentation. This extension of traditional approaches through the application of computational experimentation demonstrates some of the new ways in which computational research is expanding the social sciences.

In Chap. Modeling Human Behavior in Space and Time Using Mobile Phone Data, Couronne discusses the properties of mobile phone tracking data. With the ubiquity of mobile phone use in both developed and developing countries, this kind of data has great potential for providing insight into many aspects of human activity. Couronn outlines some of the issues of using this data and describes useful metrics for this purpose. Chapter Change Detection in Dynamic Political Networks: The Case of Sudan derives its data from a more traditional source, newspapers, to consider a recent area of instability. Tambayong and Carley analyse political networks in Sudan through the application of an algorithm to detect social network change. In this way, they are able to pinpoint network behaviour that matches historical activity. In these works, mathematical modelling provides a way to analyze data and encapsulate salient features lying therein.

Complex social systems are found throughout the gamut of large-scale human interaction, including activities of great concern to social policy decision making. The next two chapters consider criminal justice as their topic. In Chap. High-Level Simulation Model of a Criminal Justice System, Dabbaghian et al. present a system dynamics model of the criminal justice system in British Columbia, Canada. This high-level model incorporates the numerous component systems necessary for the wheels of justice to turn, and is designed to give stakeholders better understanding of how the system works as a whole, and how it will behave in certain situations. In Chap. Celerity in the Courts:The Application of Fuzzy Logic to Model Case Complexity Criminal Justice Systems, Reid and Frank propose a methodology for increasing the efficiency of the criminal justice by identifying complex cases early on in the process. Their proposal adopts the expressive capabilities of fuzzy logic to mediate uncertain and ambiguous factors involved in a mathematical manner.

A different kind of interaction that is also of significant concern to policy makers is the widespread transmission of disease. Mniszewski et al. tackle the issue of face-mask use (to prevent the transmission of disease) in Chap. Understanding the Impact of Face Mask Usage through Epidemic Simulation of Large Social Networks. They adopt agent-based simulation to consider face-mask use within the context of an influenza outbreak. Their research underlines the need for a warning that masks alone are not sufficient to fight disease transmission: an integrated approach including education and monitoring is more promising. Chapter e-Epidemic Models on the Attack and Defense of Malicious Objects in Networks (Mishra and Haldar) consider not biological disease but technological: the proliferation of attacks on computer systems. They adopt modelling techniques from the health sciences designed for epidemiology to the aim of developing comprehensive models and methods for dealing with this problem. While these chapters consider fundamentally different kinds of disease, modelling is useful in both cases to capture the essential nature of the phenomena under study.

This volume also includes works which highlight the capabilities of contemporary modelling techniques. Chapter Modelling the Joint Effect of Social Determinants and Peers on Obesity Among Canadian Adults (Giabbanelli et al.) produces results that suggest that network qualities affect the way in which obesity prevention is transferred through social connections. This research is based on a well-founded Fuzzy Cognitive Map (FCM) modelling obesity trends, processed in parallel across a simulated social network. In Chap. Youth Gang Formation: Basic Instinct or Something Else?, Morden et al. apply FCMs to the age-old problem of criminal youth gangs. Here also, FCMs appeal because of their ability to capture interconnected domain knowledge in a theoretical object with useful mathematical properties.

Agent-based modelling (ABM) focuses on the activities and interactions of individual humans within a larger environment. The close ontological match between model and our perception of the phenomena has made ABM a favoured choice for research into complex social systems. Malleson et al. (Chap. Optimising an Agent-Based Model to Explore the Behaviour of Simulated Burglars) combines this technique with a genetic algorithm to model the target selection behaviour of burglars. Problems in criminology are notably difficult to obtain complete data for due to the nature of the field: criminals are unsurprisingly reticent to reveal all the details of their activities. As can be seen here, simulation provides a venue for combining expert knowledge and logic in order to come to better conclusions.

3 Conclusion

The research contained in this volume demonstrates how modelling is being used in the social sciences and public health to formalize knowledge, develop theories and perform experimentation via simulation. We see a different approaches and techniques being applied to unrelated problem domains. This new wave of science has been enabled by advances in computing technology, but its ongoing impact on a variety of sciences and related disciplines is manifold and pervasive. Successes in both experimental results and methodology feed into each other and further reinforce a foundation of knowledge and practice upon which to base evolving vectors of research. The selection of works presented here each seek to meaningfully advance science in their own way, and it is our sincere hope that you will agree that they are valuable and interesting contributions to this dynamic and growing area of inquiry.

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