

Springer Complexity

Springer Complexity is an interdisciplinary program publishing the best research and academic-level teaching on both fundamental and applied aspects of complex systems—cutting across all traditional disciplines of the natural and life sciences, engineering, economics, medicine, neuroscience, social and computer science.

Complex Systems are systems that comprise many interacting parts with the ability to generate a new quality of macroscopic collective behavior the manifestations of which are the spontaneous formation of distinctive temporal, spatial or functional structures. Models of such systems can be successfully mapped onto quite diverse “real-life” situations like the climate, the coherent emission of light from lasers, chemical reaction-diffusion systems, biological cellular networks, the dynamics of stock markets and of the Internet, earthquake statistics and prediction, freeway traffic, the human brain, or the formation of opinions in social systems, to name just some of the popular applications.

Although their scope and methodologies overlap somewhat, one can distinguish the following main concepts and tools: self-organization, nonlinear dynamics, synergetics, turbulence, dynamical systems, catastrophes, instabilities, stochastic processes, chaos, graphs and networks, cellular automata, adaptive systems, genetic algorithms and computational intelligence.

The three major book publication platforms of the Springer Complexity program are the monograph series “Understanding Complex Systems” focusing on the various applications of complexity, the “Springer Series in Synergetics”, which is devoted to the quantitative theoretical and methodological foundations, and the “Springer Briefs in Complexity” which are concise and topical working reports, case studies, surveys, essays and lecture notes of relevance to the field. In addition to the books in these two core series, the program also incorporates individual titles ranging from textbooks to major reference works.

Editorial and Programme Advisory Board

Henry Abarbanel, Institute for Nonlinear Science, University of California, San Diego, USA

Dan Braha, New England Complex Systems Institute and University of Massachusetts Dartmouth, USA

Péter Érdi, Center for Complex Systems Studies, Kalamazoo College, USA and Hungarian Academy of Sciences, Budapest, Hungary

Karl J Friston, Institute of Cognitive Neuroscience, University College London, London, UK

Hermann Haken, Center of Synergetics, University of Stuttgart, Stuttgart, Germany

Viktor Jirsa, Centre National de la Recherche Scientifique (CNRS), Université de la Méditerranée, Marseille, France

Janusz Kacprzyk, System Research, Polish Academy of Sciences, Warsaw, Poland

Kunihiko Kaneko, Research Center for Complex Systems Biology, The University of Tokyo, Tokyo, Japan

Scott Kelso, Center for Complex Systems and Brain Sciences, Florida Atlantic University, Boca Raton, USA

Markus Kirkilionis, Mathematics Institute and Centre for Complex Systems, University of Warwick, Coventry, UK

Jürgen Kurths, Nonlinear Dynamics Group, University of Potsdam, Potsdam, Germany

Ronaldo Menezes, Florida Institute of Technology, Computer Science Department, 150 W. University Blvd, Melbourne, FL 32901, USA

Andrzej Nowak, Department of Psychology, Warsaw University, Poland

Hassan Qudrat-Ullah, School of Administrative Studies, York University, Toronto, ON, Canada

Linda Reichl, Center for Complex Quantum Systems, University of Texas, Austin, USA

Peter Schuster, Theoretical Chemistry and Structural Biology, University of Vienna, Vienna, Austria

Frank Schweitzer, System Design, ETH Zürich, Zürich, Switzerland

Didier Sornette, Entrepreneurial Risk, ETH Zürich, Zürich, Switzerland

Stefan Thurner, Section for Science of Complex Systems, Medical University of Vienna, Vienna, Austria

Understanding Complex Systems

Founding Editor: S. Kelso

Future scientific and technological developments in many fields will necessarily depend upon coming to grips with complex systems. Such systems are complex in both their composition-typically many different kinds of components interacting simultaneously and nonlinearly with each other and their environments on multiple levels-and in the rich diversity of behavior of which they are capable.

The Springer Series in Understanding Complex Systems series (UCS) promotes new strategies and paradigms for understanding and realizing applications of complex systems research in a wide variety of fields and endeavors. UCS is explicitly transdisciplinary. It has three main goals: First, to elaborate the concepts, methods and tools of complex systems at all levels of description and in all scientific fields, especially newly emerging areas within the life, social, behavioral, economic, neuro- and cognitive sciences (and derivatives thereof); second, to encourage novel applications of these ideas in various fields of engineering and computation such as robotics, nano-technology, and informatics; third, to provide a single forum within which commonalities and differences in the workings of complex systems may be discerned, hence leading to deeper insight and understanding.

UCS will publish monographs, lecture notes, and selected edited contributions aimed at communicating new findings to a large multidisciplinary audience.

More information about this series at <http://www.springer.com/series/5394>

Bruce Edmonds • Ruth Meyer
Editors

Simulating Social Complexity

A Handbook

Second Edition



Springer

Editors

Bruce Edmonds
Centre for Policy Modelling
Manchester Metropolitan University
Business School
Manchester, UK

Ruth Meyer
Centre for Policy Modelling
Manchester Metropolitan University
Business School
Manchester, UK

ISSN 1860-0832

ISSN 1860-0840 (electronic)

Understanding Complex Systems

ISBN 978-3-319-66947-2

ISBN 978-3-319-66948-9 (eBook)

<https://doi.org/10.1007/978-3-319-66948-9>

Library of Congress Control Number: 2017957650

1st edition: © Springer-Verlag Berlin Heidelberg 2013

© Springer International Publishing AG 2017, corrected publication 2018

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by Springer Nature

The registered company is Springer International Publishing AG

The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Contents

Part I Introduction

1	Introduction	3
	Bruce Edmonds and Ruth Meyer	
2	Historical Introduction	13
	Klaus G. Troitzsch	
3	Types of Simulation	23
	Paul Davidsson and Harko Verhagen	
4	Different Modelling Purposes	39
	Bruce Edmonds	

Part II Methodology

5	Informal Approaches to Developing Simulation Models	61
	Emma Norling, Bruce Edmonds, and Ruth Meyer	
6	What Software Engineering Has to Offer to Agent-Based Social Simulation	81
	Peer-Olaf Siebers and Franziska Klügl	
7	Checking Simulations: Detecting and Avoiding Errors and Artefacts	119
	José M. Galán, Luis R. Izquierdo, Segismundo S. Izquierdo, José I. Santos, Ricardo del Olmo, and Adolfo López-Paredes	
8	The Importance of Ontological Structure: Why Validation by ‘Fit-to-Data’ Is Insufficient	141
	Gary Polhill and Doug Salt	
9	Verifying and Validating Simulations	173
	Nuno David, Nuno Fachada, and Agostinho C. Rosa	

10	Understanding Simulation Results	205
	Andrew Evans, Alison Heppenstall, and Mark Birkin	
11	How Many Times Should One Run a Computational Simulation? ...	229
	Raffaello Seri and Davide Secchi	
12	Participatory Approaches	253
	Olivier Barreteau, Pieter Bots, Katherine Daniell, Michel Etienne, Pascal Perez, Cécile Barnaud, Didier Bazile, Nicolas Becu, Jean-Christophe Castella, William's Daré, and Guy Trebuil	
13	Combining Mathematical and Simulation Approaches to Understand the Dynamics of Computer Models	293
	Luis R. Izquierdo, Segismundo S. Izquierdo, José M. Galán, and José I. Santos	
14	Interpreting and Understanding Simulations: The Philosophy of Social Simulation	331
	R. Keith Sawyer	
15	Documenting Social Simulation Models: The ODD Protocol as a Standard	349
	Volker Grimm, Gary Polhill, and Julia Touza	
Part III Mechanisms		
16	Utility, Games and Narratives	369
	Guido Fioretti	
17	Social Constraint	411
	Martin Neumann	
18	Reputation for Complex Societies	443
	Francesca Giardini, Rosaria Conte, and Mario Paolucci	
19	Social Networks and Spatial Distribution	471
	Frédéric Amblard and Walter Quattrociocchi	
20	Learning	501
	Michael W. Macy, Steve Benard, and Andreas Flache	
21	Evolutionary Mechanisms	525
	Edmund Chattoe-Brown and Bruce Edmonds	
Part IV Applications		
22	Agent-Based Modelling and Simulation Applied to Environmental Management	569
	Christophe Le Page, Didier Bazile, Nicolas Becu, Pierre Bommel, François Bousquet, Michel Etienne, Raphael Mathevet, Véronique Souchère, Guy Trébuil, and Jacques Weber	

23 Distributed Computer Systems	615
David Hales	
24 Simulating Complexity of Animal Social Behaviour	633
Charlotte Hemelrijk	
25 Agent-Based Simulation as a Useful Tool for the Study of Markets	671
Juliette Rouchier	
26 Movement of People and Goods.....	705
Linda Ramstedt, Johanna Törnquist Krasemann, and Paul Davidsson	
27 Modeling Power and Authority: An Emergentist View from Afghanistan	721
Armando Geller and Scott Moss	
28 Human Societies: Understanding Observed Social Phenomena.....	763
Bruce Edmonds, Pablo Lucas, Juliette Rouchier, and Richard Taylor	
29 Some Pitfalls to Beware When Applying Models to Issues of Policy Relevance	801
Lia ní Aodha and Bruce Edmonds	
Erratum	E1
Index	823