

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 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
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>

Christian Walloth · Ernst Gebetsroither-Geringer
Funda Atun · Liss C. Werner
Editors

Understanding Complex Urban Systems

Integrating Multidisciplinary Data in Urban
Models

 Springer

Editors

Christian Walloth
Walloth Urban Advisors SPRL
Brussels
Belgium

Funda Atun
Politecnico di Milano
Milano
Italy

Ernst Gebetsroither-Geringer
AIT Austrian Institute of Technology GmbH
Vienna
Austria

Liss C. Werner
Tactile Architecture – Office für
SystemArchitektur
Berlin
Germany

ISSN 1860-0832

Understanding Complex Systems

ISBN 978-3-319-30176-1

DOI 10.1007/978-3-319-30178-5

ISSN 1860-0840 (electronic)

ISBN 978-3-319-30178-5 (eBook)

Library of Congress Control Number: 2016932314

© Springer International Publishing Switzerland 2016

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.

Printed on acid-free paper

This Springer imprint is published by SpringerNature

The registered company is Springer International Publishing AG Switzerland

Preface

Integrating Multidisciplinary Data in Urban Models is the second volume of the book series *Understanding Complex Urban Systems*. With the articles published in the first volume, we aimed at contributing to understanding urban complexity by means of different ways of modeling. This second volume aims to point out how the modeling of complex urban systems can be improved by overcoming data-related challenges.

One aspect of these challenges is related to data availability and data validity. Another aspect is related to producing results that are valid—despite limitations in input data quality—which involves using appropriate modeling techniques. The validity of models and of modeling results depends on data availability, quality, and quantity, as well as on comprehensiveness and temporal scales of models—i.e., the part of the system the model captures and the time that is passed between data gathering and modeling.

Thus, four notions of data and models are relevant in this book: “Quality and Availability,” “Scale,” “Time,” and “Quantity.”

Quality and Availability: Each modeling methodology defines the criteria for data sets to be used. However, in practice, the exact quality of data required may not be available; e.g., data may only be available from different sources of varying quality.

Scale: A representation of complex urban systems on more than one scale requires the integration of different types of data into models of potentially varying degrees of simplification, which are chosen according to their purposes. Both aspects of scale are discussed in the present book: scale referring to the granularity of data, and scale referring to the level of simplification of a model.

Time: Data used in urban models typically originates from one (or a few) specific time period(s). Simulation of future scenarios is then based on tendencies that are linked to these time periods. Furthermore, another aspect of the granularity of data and modeling is the frequency of dynamics of change that can be simulated. Thus, articles featured in this volume will deal with both the aspects of timeliness of data and the dynamic timescale of the model.

Quantity: Modelers are dealing with problems, such as choosing the most appropriate data from large data sets. Some contributions to this volume deal with the pros and cons of large data sets. For example, it may be argued that Big Data methods and sufficiently large data sets can be used to discover principles and relationships that could not be discovered by using smaller data sets.

Furthermore, if complex systems can be sensitive to even minor changes, then not having data available—or leaving out just a little bit of data, or having just a little offset in the data—may yield completely different results. Thus, it may not be sufficient to review and question current approaches, current data-gathering methods, and current use of data—and to get to know their limits. Rather, it may be required to develop new approaches. In this volume, we will also present some new approaches that are now up for discussion.

The present volume is targeted at both researchers and professionals in the fields of urban planning, urban policy design, and decision-making, as well as urban modelers who approach cities by using complex system concepts.

Brussels
Vienna
Milano
Berlin
November 2015

Christian Walloth
Ernst Gebetsroither-Geringer
Funda Atun
Liss C. Werner

Contents

Introduction: Overcoming Limitations of Urban Systems Models and of Data Availability	1
Christian Walloth, Ernst Gebetsroither-Geringer and Funda Atun	
Combining Agent-Based Modeling with Big Data Methods to Support Architectural and Urban Design	15
Matthias Scheutz and Thomas Mayer	
Urban Development Simulator: How Can Participatory Data Gathering Support Modeling of Complex Urban Systems	33
Ernst Gebetsroither-Geringer and Wolfgang Loibl	
Bypassing Data Unavailability in Urban Systems Modeling	49
Najd Ouhajjou, Wolfgang Loibl, Ernst Gebetsroither-Geringer, Stefan Fenz and A. Min Tjoa	
Big Data or No Data: Supporting Urban Decision-Making with a Nested System Model	65
Christian Walloth	
Conceptualizing the Urban System as a System of Flows	79
Pavel Holubec	
Operationalizing the Capabilities Approach for Modeling Household Welfare Shifts in Urban Systems: A Special Focus on the Transportation Outcomes of Urban Resettlement	95
Xin Yang and Jennifer Day	

**Interventions in Complex Urban Systems: How to Enable
Modeling to Account for Disruptive Innovation 113**
Justyna Karakiewicz

About the Authors 129

Index 135

Contributors

Funda Atun Department of Architecture and Urban Studies, Politecnico di Milano, Milan, MI, Italy

Jennifer Day Faculty of Architecture, Building and Planning, The University of Melbourne, Parkville, VIC, Australia

Stefan Fenz Institute of Software Technology and Interactive Systems, Vienna University of Technology, Vienna, Austria

Ernst Gebetsroither-Geringer Energy Department, Austrian Institute of Technology, Vienna, Austria

Pavel Holubec Faculty of Civil Engineering, Department of Urban Design, Town and Regional Planning, Czech Technical University in Prague, Praha 6, Czech Republic

Justyna Karakiewicz University of Melbourne, Melbourne, VIC, Australia

Wolfgang Loibl Energy Department, Austrian Institute of Technology, Vienna, Austria

Thomas Mayer Independent Architect, Vienna, Austria

Najd Ouhajjou Energy Department, Austrian Institute of Technology, Vienna, Austria

Matthias Scheutz Tufts University, MA, Medford, USA

A. Min Tjoa Institute of Software Technology and Interactive Systems, Vienna University of Technology, Vienna, Austria

Christian Walloth Walloth Urban Advisors SPRL, Brussels, Belgium

Xin Yang Faculty of Architecture, Building and Planning, The University of Melbourne, Parkville, VIC, Australia