Springer Proceedings in Complexity

Series editors

Henry Abarbanel, San Diego, USA Dan Braha, Dartmouth, USA Péter Érdi, Kalamazoo, USA Karl Friston, London, UK Hermann Haken, Stuttgart, Germany Viktor Jirsa, Marseille, France Janusz Kacprzyk, Warsaw, Poland Kunihiko Kaneko, Tokyo, Japan Scott Kelso, Boca Raton, USA Markus Kirkilionis, Coventry, UK Jürgen Kurths, Potsdam, Germany Andrzej Nowak, Warsaw, Poland Hassan Qudrat-Ullah, Toronto, Canada Linda Reichl, Austin, USA Peter Schuster, Vienna, Austria Frank Schweitzer, Zürich, Switzerland Didier Sornette, Zürich, Switzerland Stefan Thurner, Vienna, Austria

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 "SpringerBriefs 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.

More information about this series at http://www.springer.com/series/11637

Bruno Gonçalves · Ronaldo Menezes Roberta Sinatra · Vinko Zlatic Editors

Complex Networks VIII

Proceedings of the 8th Conference on Complex Networks CompleNet 2017



Editors Bruno Gonçalves Center for Data Science New York University New York, NY USA

Ronaldo Menezes BioComplex Laboratory, School of Computing Florida Institute of Technology Melbourne, FL USA Roberta Sinatra Center for Network Science and Mathematics Department Central European University Budapest Hungary

Vinko Zlatic Rudjer Bošković Institute Theoretical Physics Division Zagreb Croatia

ISSN 2213-8684 ISSN 2213-8692 (electronic) Springer Proceedings in Complexity ISBN 978-3-319-54240-9 ISBN 978-3-319-54241-6 (eBook) DOI 10.1007/978-3-319-54241-6

Library of Congress Control Number: 2017932410

© Springer International Publishing AG 2017

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

Preface

The International Workshop on Complex Networks CompleNet (www.complenet. org) was initially proposed in 2008, and the first workshop took place in 2009 in Catania. The initiative was the result of efforts from researchers from the (i) BioComplex Laboratory in the Department of Computer Sciences at Florida Institute of Technology, USA, and the (ii) Dipartimento di Ingegneria Informatica e delle Telecomunicazioni, University di Catania, Italy. CompleNet aims at bringing together researchers and practitioners working on complex networks or related areas. In the past two decades, we have indeed witnessed an exponential increase of the number of publications in this field. From biology to computer science, from economics to social systems, complex networks are becoming pervasive in many fields of science. CompleNet aims at addressing this interdisciplinary nature of complex networks. CompleNet 2017 was the eighth event in the series and was hosted at the Inter University Center Dubrovnik, Croatia, during March 21–24, 2017.

This book includes the peer-reviewed list of works presented at CompleNet 2017. We received 106 submissions from 32 countries. Each submission was reviewed by at least three members of the Program Committee. Acceptance was judged based on the relevance to the symposium themes, clarity of presentation, originality and accuracy of results and proposed solutions. After the review process, 9 full papers and 13 short papers were selected to be included in this book. The 22 contributions in this book address many topics related to complex networks and have been organized in seven major groups: (1) Theory of complex networks, (2) Community detection, (3) Dynamics and spreading phenomena on networks, (4) Applications of network science, (5) Social structure, (6) Human behavior, (7) Biological networks. We would like to thank the Program Committee members

for their work in promoting the event and refereeing submissions. We are grateful to our speakers: Johan Bollen, Guido Caldarelli, Gourab Ghoshal, Aniko Hannak, Ágnes Horvát, Vito Latora, Jörg Menche, Stasa Milojevic, Anastasios Noulas, Giovanni Petri, Zoltan Toroczkai; their presentation is one of the reasons CompleNet 2017 was such a success.

New York, NY, USA Melbourne, FL, USA Budapest, Hungary Zagreb, Croatia Bruno Gonçalves Ronaldo Menezes Roberta Sinatra Vinko Zlatic

Contents

Part I Theory of Complex Networks

Second-Order Assortative Mixing in Social Networks Shi Zhou, Ingemar J. Cox and Lars K. Hansen	3
Network Motifs Detection Using Random Networks with Prescribed Subgraph Frequencies Miguel E.P. Silva, Pedro Paredes and Pedro Ribeiro	17
Fuzzy Centrality Evaluation in Complex and Multiplex Networks Sude Tavassoli and Katharina A. Zweig	31
Part II Community Structure	
Enhancing Space-Aware Community Detection Using Degree Constrained Spatial Null Model Remy Cazabet, Pierre Borgnat and Pablo Jensen	47
Node-Centric Community Detection in Multilayer Networks with Layer-Coverage Diversification Bias R. Interdonato, A. Tagarelli, D. Ienco, A. Sallaberry and P. Poncelet	57
Community Detection in Signed Networks Based on Extended Signed Modularity Tsuyoshi Murata, Takahiko Sugihara and Talel Abdessalem	67
Characterising Inter and Intra-Community Interactions in Link Streams Using Temporal Motifs Jean Creusefond and Remy Cazabet	81
Part III Dynamics of Networks	
Modeling the Impact of Privacy on Information Diffusion in Social Networks	95

Livio Bioglio and Ruggero G. Pensa

Nazim Choudhury and Shahadat Uddin Stochastic Modeling of the Decay Dynamics of Online Social	
Stochastic Modeling of the Decay Dynamics of Online Social	
Networks. 1 Mohammed Abufouda and Katharina A. Zweig	19
Part IV Applications of Network Science	
Complex Reaction Network in Silane Plasma Chemistry1Yasutaka Mizui, Kyosuke Nobuto, Shigeyuki Miyagiand Osamu Sakai	.35
Seeing Red: Locating People of Interest in Networks	41
Understanding Subject-Based Emoji Usage Using Network Science	51
Characterization of Written Languages Using Structural Features from Common Corpora 1 Younis Al Rozz, Harith Hamoodat and Ronaldo Menezes	61
Optimal Information Security Investment in Modern SocialNetworking1Andrey Trufanov, Nikolay Kinash, Alexei Tikhomirov,Olga Berestneva and Alessandra Rossodivita	.75
Part V Social Structure	
Emergence of Social Balance in Signed Networks 1 Andreia Sofia Teixeira, Francisco C. Santos 1 and Alexandre P. Francisco 1	.85
Community Detection in the Network of German Princes in 1225: A Case Study 1 S.R. Dahmen, A.L.C. Bazzan and R. Gramsch	.93
Comparative Topological Signatures of Growing Collaboration Networks 2 Siddharth Pal, Terrence J. Moore, Ram Ramanathan 2	201

Part VI Human Behavior

Explaining Changes in Physical Activity Through a Computational Model of Social Contagion Julia S. Mollee, Eric F.M. Araújo, Adnan Manzoor, Aart T. van Halteren and Michel C.A. Klein	213
Everyday the Same Picture: Popularity and Content Diversity Alessandro Bessi, Fabiana Zollo, Michela Del Vicario, Antonio Scala, Fabio Petroni, Bruno Gonçcalves and Walter Quattrociocchi	225
Part VII Biological Networks	
Investigating Side Effect Modules in the Interactome and Their Use in Drug Adverse Effect Discovery Emre Guney	239
Attractor Analysis of the Asynchronous Boolean Model of the Klotho Gene Regulatory Network Malvina Marku, Inva Koçiaj, Klotilda Nikaj and Margarita Ifti	251
Author Index	261

Contributors

Talel AbdessalemComputer Science and Networks Department, TelecomParisTech, Paris, France

Mohammed Abufouda Computer Science Department, University of Kaiserslautern, Kaiserslautern, Germany

Eric F.M. Araújo VU University Amsterdam, Amsterdam, The Netherlands

A.L.C. Bazzan Instituto de Informática da UFRGS, Porto Alegre, Brazil

Olga Berestneva National Research Tomsk Polytechnic University, Tomsk, Russia

Alessandro Bessi Information Sciences Institute, University of Southern California, Los Angeles, CA, USA

Livio Bioglio Department of Computer Science, University of Turin, Turin, Italy

Pierre Borgnat CNRS, Laboratoire de Physique, Univ Lyon, Ens de Lyon, Univ Claude Bernard, Villeurbanne, France

Remy Cazabet Sorbonne Universites, UPMC Univ Paris 06, Paris, France

Nazim Choudhury Faculty of Engineering and IT, Centre for Complex Systems Research, The University of Sydney, Redfern, NSW, Australia

Ingemar J. Cox Department of Computer Science, University College London (UCL), London, UK

Jean Creusefond GREYC, Normandie Université, Caen, France

S.R. Dahmen Instituto de Física da UFRGS, Porto Alegre, Brazil

Alexandre P. Francisco INESC-ID/Instituto Superior Técnico, Universidade de Lisboa, Lisbon, Portugal

Ralucca Gera Department of Applied Mathematics, Naval Postgraduate School, Monterey, CA, USA

Bruno Gonçalves Center for Data Science, New York University, New York, NY, USA

R. Gramsch Historisches Institut der Universität Jena, Jena, Germany

Emre Guney Joint IRB-BSC-CRG Program in Computational Biology, Institute for Research in Biomedicine (IRB), Barcelona, Spain

Aart T. van Halteren VU University Amsterdam, Amsterdam, The Netherlands; Philips Research, Eindhoven, The Netherlands

Harith Hamoodat BioComplex Laboratory, School of Computing Florida Institute of Technology, Melbourne, USA

Lars K. Hansen Department of Applied Mathematics and Computer Science, Danish Technical University (DTU), Kongens Lyngby, Denmark

D. Ienco IRSTEA - UMR TETIS, Montpellier, France

Margarita Ifti Faculty of Natural Sciences, University of Tirana, Tirana, Albania

R. Interdonato DIMES - University of Calabria, Rende, Italy

Pablo Jensen CNRS, Laboratoire de Physique, Univ Lyon, Ens de Lyon, Univ Claude Bernard, Villeurbanne, France

Nikolay Kinash Irkutsk National Research Technical University, Irkutsk, Russia

Michel C.A. Klein VU University Amsterdam, Amsterdam, The Netherlands

Inva Koçiaj Faculty of Natural Sciences, University of Tirana, Tirana, Albania

Adnan Manzoor VU University Amsterdam, Amsterdam, The Netherlands

Malvina Marku Faculty of Natural Sciences, University of Tirana, Tirana, Albania

Ronaldo Menezes BioComplex Laboratory, School of Computing, Florida Institute of Technology, Melbourne, USA

Shigeyuki Miyagi The University of Shiga Prefecture, Hikone, Shiga, Japan

Yasutaka Mizui The University of Shiga Prefecture, Hikone, Shiga, Japan

Julia S. Mollee VU University Amsterdam, Amsterdam, The Netherlands

Terrence J. Moore U.S. Army Research Lab, Adelphi, USA

Tsuyoshi Murata Department of Computer Science, School of Computing, Tokyo Institute of Technology, Tokyo, Japan

Klotilda Nikaj Faculty of Natural Sciences, University of Tirana, Tirana, Albania

Kyosuke Nobuto The University of Shiga Prefecture, Hikone, Shiga, Japan

Vatsal Ojha Dougherty Valley High School, San Ramon, CA, USA

Siddharth Pal Raytheon BBN Technologies, Cambridge, USA

Pedro Paredes CRACS & INESC-TEC, DCC-FCUP, Universidade do Porto, Porto, Portugal

Ruggero G. Pensa Department of Computer Science, University of Turin, Turin, Italy

Fabio Petroni Sapienza University of Rome, Rome, Italy

P. Poncelet LIRMM - Université de Montpellier, Montpellier, France

Walter Quattrociocchi IMT Institute for Advanced Studies, Lucca, Italy

Ram Ramanathan Raytheon BBN Technologies, Cambridge, USA

Pedro Ribeiro CRACS & INESC-TEC, DCC-FCUP, Universidade do Porto, Porto, Portugal

Alessandra Rossodivita Luigi Sacco Academic Hospital, Milan, Italy

Younis Al Rozz BioComplex Laboratory, School of Computing Florida Institute of Technology, Melbourne, USA

Osamu Sakai The University of Shiga Prefecture, Hikone, Shiga, Japan

A. Sallaberry LIRMM - Université Paul Valéry, Montpellier, France

Francisco C. Santos INESC-ID/Instituto Superior Técnico, Universidade de Lisboa, Lisbon, Portugal

Antonio Scala ISC CNR, Rome, Italy

S.M. Mahdi Seyednezhad BioComplex Laboratory, School of Computing, Florida Institute of Technology, Melbourne, USA

Miguel E.P. Silva CRACS & INESC-TEC, DCC-FCUP, Universidade do Porto, Porto, Portugal

Sucheta Soundarajan Department of Electrical Engineering & Computer Science, Syracuse University, New York, USA

Takahiko Sugihara Department of Computer Science, School of Computing, Tokyo Institute of Technology, Tokyo, Japan

Ananthram Swami U.S. Army Research Lab, Adelphi, USA

A. Tagarelli DIMES - University of Calabria, Rende, Italy

Sude Tavassoli Graph Theory and Complex Network Analysis Group, Computer Science Department, Kaiserslautern University of Technology, Kaiserslautern, Germany

Andreia Sofia Teixeira INESC-ID/Instituto Superior Técnico, Universidade de Lisboa, Lisbon, Portugal

Alexei Tikhomirov Inha University, Incheon, Republic of Korea

Andrey Trufanov Irkutsk National Research Technical University, Irkutsk, Russia

Shahadat Uddin Faculty of Engineering and IT, Centre for Complex Systems Research, The University of Sydney, Redfern, NSW, Australia

Michela Del Vicario IMT Institute for Advanced Studies, Lucca, Italy

Pivithuru Wijegunawardana Department of Electrical Engineering & Computer Science, Syracuse University, New York, USA

Shi Zhou Department of Computer Science, University College London (UCL), London, UK

Fabiana Zollo IMT Institute for Advanced Studies, Lucca, Italy

Katharina A. Zweig Graph Theory and Complex Network Analysis Group, Computer Science Department, Kaiserslautern University of Technology, Kaiserslautern, Germany