Springer Proceedings in Mathematics & Statistics

Volume 247

Springer Proceedings in Mathematics & Statistics

This book series features volumes composed of selected contributions from workshops and conferences in all areas of current research in mathematics and statistics, including operation research and optimization. In addition to an overall evaluation of the interest, scientific quality, and timeliness of each proposal at the hands of the publisher, individual contributions are all refereed to the high quality standards of leading journals in the field. Thus, this series provides the research community with well-edited, authoritative reports on developments in the most exciting areas of mathematical and statistical research today.

More information about this series at http://www.springer.com/series/10533

Valery A. Kalyagin · Panos M. Pardalos
Oleg Prokopyev · Irina Utkina
Editors

Computational Aspects and Applications in Large-Scale Networks

NET 2017, Nizhny Novgorod, Russia, June 2017

Springer

Editors
Valery A. Kalyagin
Higher School of Economics
National Research University
Nizhny Novgorod, Russia

Panos M. Pardalos
Department of Industrial
and Systems Engineering
University of Florida
Gainesville, FL, USA

Oleg Prokopyev
Department of Industrial Engineering
University of Pittsburgh
Pittsburgh, PA, USA

Irina Utkina
Higher School of Economics
National Research University
Nizhny Novgorod, Russia

ISSN 2194-1009 ISSN 2194-1017 (electronic)
Springer Proceedings in Mathematics & Statistics
ISBN 978-3-319-96246-7 ISBN 978-3-319-96247-4 (eBook)
https://doi.org/10.1007/978-3-319-96247-4

Library of Congress Control Number: 2018948592

Mathematics Subject Classification (2010): 05C82, 90B10, 90B15

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

This volume is based on the papers presented at the 7th International Conference on Network Analysis held in Nizhny Novgorod, Russia, June 22–24, 2017. The main focus of the conference and this volume is centered on the development of new computationally efficient algorithms as well as underlying analysis and optimization in large-scale networks. Various applications in the context of social networks, power transmission grids, stock market networks, and human brain networks are also considered. The previous books based on the papers presented at the 1st–6th Conferences International Conference on Network Analysis can be found in [1–6]. The current volume consists of three major parts, namely, network computational algorithms, network models, and network applications.

The first part of the book is focused on algorithmic methods in large-scale networks. In the Chapter "Tabu Search for Fleet Size and Mix Vehicle Routing Problem with Hard and Soft Time Windows", the authors present an efficient algorithm for solving a computationally hard problem in a real-life network setting. In the Chapter "FPT Algorithms for the Shortest Lattice Vector and Integer Linear Programming Problems", fixed-parameter tractable (FTP) algorithms are discussed. The main parameter is the maximal absolute value of rank minors of matrices in the problem formulation. The Chapter "The Video-Based Age and Gender Recognition with Convolution Neural Networks" reviews the problem of age and gender recognition methods for video data using modern deep convolutional neural networks. A new video-based recognition system is implemented with several aggregation methods that improve the method identification accuracy. The Chapter "On Forbidden Induced Subgraphs for the Class of Triangle-König Graphs" considers a hereditary class of graphs with the following property: the maximum cardinality of a triangle packing for each graph of the class is equal to the minimum cardinality of a triangle vertex cover. Then, some minimal forbidden induced subgraphs for this class are described. The Chapter "The Global Search Theory Approach to the Bilevel Pricing Problem in Telecommunication Networks" deals with the hierarchical problem of optimal pricing in telecommunication networks.

New methods of local and global search for finding optimistic solution are developed. In the Chapter "Graph Dichotomy Algorithm and Its Applications to Analysis of Stocks Market", a new approach to graph complexity measure is presented. This new measure is used to study short-term predictions of crises at the stock market. In the Chapter "Cluster Analysis of Facial Video Data in Video Surveillance Systems Using Deep Learning", a new approach is proposed for structuring information in video surveillance systems. The first stage of the new approach consists of grouping the videos, which contain identical faces. Based on this idea, a new efficient and fast algorithm of video surveillance is developed. The Chapter "Using Modular Decomposition Technique to Solve the Maximum Clique Problem" applies the modular decomposition technique to solve the weighted maximum clique problem. Developed technique is compared against the state-of-the-art algorithms in the area.

The second part of the book is focused on network models. In the Chapter "Robust Statistical Procedures for Testing Dynamics in Market Network", a sign similarity market network is considered. The problem of testing dynamics in market network is formulated as the problem of homogeneity hypotheses testing. Multiple testing techniques to solve this problem are developed and applied for different stock markets. The Chapter "Application of Market Models to Network Equilibrium Problems" describes an extension of the network flow equilibrium problem with elastic demands and develops a new equilibrium type model for resource allocation problems in wireless communication networks. In the Chapter "Selective Bi-coordinate Variations for Network Equilibrium Problems with Mixed Demand", a modification of the method of bi-coordinate variations for network equilibrium problems with mixed demand is proposed. Some numerical results that confirm efficiency of the method are presented. The Chapter "Developing a Model of Topological Structure Formation for Power Transmission Grids Based on the Analysis of the UNEG" studies the nodes degrees distribution in the United National Electricity Grid (UNEG) of Russia. This study allows to develop a new Random Growth Model (RGM) to simulate UNEG, and to identify the key principles for the network formation. In the Chapter "Methods of Criteria Importance Theory and Their Software Implementation", a general approach for solution of the multicriteria choice problem is developed on the basis of the criteria importance theory. These methods are implemented in the computer system DASS. The Chapter "A Model of Optimal Network Structure for Decentralized Nearest Neighbor Search" discusses the problem of the best structure of network for the decentralized nearest neighbor search algorithm. Mathematical programming model for the problem is proposed. Optimal structures of small size networks are computed. A generalization for large-scale networks is also discussed. In the Chapter "Computational Study of Activation Dynamics on Networks of Arbitrary Structure", new results on modeling dynamical properties of collective systems are presented. A general technique for reducing the problems to SAT problem is developed. This approach is then applied to computer security networks. The Chapter "Rejection Graph for Multiple Testing of Elliptical Model for Market Network" uses the symmetry condition of tail

distributions to test elliptical hypothesis for stock return distributions. Multiple testing procedures are developed to solve this problem. These procedures are then applied to the stock markets of different countries. Specific structure of the rejection graph is observed and discussed. In the Chapter "Mapping Paradigms of Social Sciences: Application of Network Analysis", the network approach is applied to studying the relationships between various elements that constitute any particular research in social sciences. A set of relations between various elements from textbooks on methodology of social and political sciences is extracted and analyzed.

The third part of the book deals with network applications. The Chapter "Using Geometry of the Set of Symmetric Positive Semidefinite Matrices to Classify Structural Brain Networks" presents a method of Symmetric Positive Semidefinite (SPSD) matrices classification and its application to analysis of structural brain networks (connectomes). Existing Symmetric Positive Definite (SPD) matrix-based algorithms are generalized to SPSD case. The performance of the proposed pipeline is demonstrated on structural brain networks reconstructed from the Alzheimer's Disease Neuroimaging Initiative (ADNI) data. In the Chapter "Comparison of Statistical Procedures for Gaussian Graphical Model Selection", the uncertainty of statistical procedures for Gaussian graphical model selections is studied. Different statistical procedures are compared using different uncertainty measures, such as Type I and Type II errors, ROC and AUC. The Chapter "Sentiment Analysis Using Deep Learning" analyzes advantages of the deep learning methods over other baseline machine learning methods using sentiment analysis task in Twitter. In the Chapter "Invariance Properties of Statistical Procedures for Network Structures Identification", optimality of some multiple decision procedures is discussed in the class of scale/shift invariant procedures. In the Chapter "Topological Modules of Human Brain Networks Are Anatomically Embedded: Evidence from Modularity Analysis at Multiple Scales", an MRI data set is used to demonstrate that modular structure of brain networks is well reproducible in test–retest settings. These results provide evidence of the theoretically well-motivated hypothesis that brain regions neighboring the anatomical space also tend to belong to the same topological modules. The Chapter "Commercial Astroturfing Detection in Social Networks" is devoted to constructing a model capable of detecting astroturfing in customer reviews based on network analysis. In the Chapter "Information Propagation Strategies in Online Social Networks", the authors discuss the problem of predicting information propagation using social network interactions. They suggest a new approach to construct the model of information propagation and test it on a real data set from social networks. The Chapter "Analysis of Co-authorship Networks and Scientific Citation Based on Google Scholar" investigates the problem on how scientific collaboration represented by co- authorship is related to citation indicators of a scientist. In the Chapter "Company Co-mention Network Analysis", a new company network is constructed on the basis of news mentioning two companies together. Different types of social network analysis metrics (degree centrality, closeness centrality, betweenness centrality, eigenvector centrality, and frequency) are used to identify key companies in the network.

We would like to thank all the authors and referees for their efforts. This work is supported by the Laboratory of Algorithms and Technologies for Network Analysis (LATNA) of the National Research University Higher School of Economics and by RSF grant 14-41-00039.

Nizhny Novgorod, Russia — Valery A. Kalyagin
Gainesville, FL, USA — Panos M. Pardalos
Pittsburgh, PA, USA — Oleg Prokopyev
Nizhny Novgorod, Russia — Irina Utkina

References

1. Goldengorin, B.I., Kalyagin, V.A., Pardalos, P.M. (eds.): Models, algorithms and technologies for network analysis. In: Proceedings of the First International Conference on Network Analysis. Springer Proceedings in Mathematics and Statistics, vol. 32. Springer, Cham (2013)
2. Goldengorin, B.I., Kalyagin, V.A., Pardalos, P.M. (eds.): Models, algorithms and technologies for network analysis. In: Proceedings of the Second International Conference on Network Analysis. Springer Proceedings in Mathematics and Statistics, vol. 59. Springer, Cham (2013)
3. Batsyn, M.V., Kalyagin, V.A., Pardalos, P.M. (eds.): Models, algorithms and technologies for network analysis. In: Proceedings of Third International Conference on Network Analysis. Springer Proceedings in Mathematics and Statistics, vol. 104. Springer, Cham (2014)
4. Kalyagin, V.A., Pardalos, P.M., Rassias, T.M. (eds.): Network models in economics and finance. In: Springer Optimization and Its Applications, vol. 100. Springer, Cham (2014)
5. Kalyagin, V.A., Koldanov, P. A., Pardalos, P.M. (eds.): Models, algorithms and technologies for network analysis. In: NET 2014, Nizhny Novgorod, Russia, May 2014. Springer Proceedings in Mathematics and Statistics, vol. 156. Springer, Cham (2016)
6. Kalyagin, V.A., Nikolaev, A.I., Pardalos, P.M., Prokopyev, O.A. (eds.): Models, algorithms and technologies for network analysis. In: NET 2016, Nizhny Novgorod, Russia, May 2016. Springer Proceedings in Mathematics and Statistics, vol. 197. Springer, Cham (2017)

Contents

Contributors

Marina Ananyeva Higher School of Economics, National Research University, Moscow, Russia

P. K. Anikin Saratov State University, Saratov, Russian Federation

V. A. Balash Saratov State University, Saratov, Russian Federation

Mikhail Batsyn Higher School of Economics, National Research University, Moscow, Russia; Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics, Nizhny Novgorod, Russia

Mikhail Belyaev Skolkovo Institute of Science and Technology, Moscow, Russia; Kharkevich Institute for Information Transmission Problems, Moscow, Russia

Daria Belyaeva Skolkovo Institute of Science and Technology, Moscow, Russia; Kharkevich Institute for Information Transmission Problems, Moscow, Russia

Margarita Burova Higher School of Economics, National Research University, Moscow, Russia

Ilya Bychkov Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics, Nizhny Novgorod, Russia

A. Z. Chekmareva Saratov State University, Saratov, Russian Federation

Yulia Dodonova Kharkevich Institute for Information Transmission Problems, Moscow, Russia

Daria Drozdova Higher School of Economics, National Research University, Moscow, Russia

A. R. Faizliev Saratov State University, Saratov, Russian Federation

Joshua Faskowitz Imaging Genetics Center, Stevens Neuroimaging and Informatics Institute, University of Southern California, Marina del Rey, CA, USA; Indiana University, Bloomington, USA

Dmitry Gorbatenko Matrosov Institute for System Dynamics and Control Theory SB RAS, Irkutsk, Russia

Ivan S. Grechikhin Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics, Nizhny Novgorod, Russia

D. V. Gribanov Lobachevsky State University of Nizhny Novgorod, Nizhny Novgorod, Russian Federation; National Research University Higher School of Economics, Nizhny Novgorod, Russian Federation

A. A. Gudkov Saratov State University, Saratov, Russian Federation

Boris Gutman Kharkevich Institute for Information Transmission Problems, Moscow, Russia; Imaging Genetics Center, Stevens Neuroimaging and Informatics Institute, University of Southern California, Marina del Rey, CA, USA

Neda Jahanshad Imaging Genetics Center, Stevens Neuroimaging and Informatics Institute, University of Southern California, Marina del Rey, CA, USA

Valery A. Kalyagin Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics, Nizhny Novgorod, Russia

Ilia Karpov Higher School of Economics, National Research University, Moscow, Russia

Nikolay Karpov Higher School of Economics, National Research University, Moscow, Russia

Angelina S. Kharchevnikova Higher School of Economics, National Research University, Nizhny Novgorod, Russia

Stepan Kochemazov Matrosov Institute for System Dynamics and Control Theory SB RAS, Irkutsk, Russia

A. P. Koldanov Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics, Nizhny Novgorod, Russia

Petr A. Koldanov Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics, Nizhny Novgorod, Russia

Larisa Komosko Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics, Nizhny Novgorod, Russia

Igor Konnov Kazan Federal University, Kazan, Russia; Kazan Federal University, Institute of Computational Mathematics and Information Technologies, Kazan, Russia

Nadezhda Kostyakova Higher School of Economics, National Research University, Moscow, Russia

Egor Krivov Skolkovo Institute of Science and Technology, Moscow, Russia; Kharkevich Institute for Information Transmission Problems, Moscow, Russia; Moscow Institute of Physics and Technology, Moscow, Russia

Anvar Kurmukov Higher School of Economics, National Research University, Moscow, Russia

Rodion Laptsuev Higher School of Economics, National Research University, Moscow, Russia

Alexander Lyashuk Higher School of Economics, National Research University, Moscow, Russia

Ilya Makarov Higher School of Economics, National Research University, Moscow, Russia

Sergey Makrushin Financial University under the Government of the Russian Federation, Moscow, Russia

Nataliya Matveeva Higher School of Economics, National Research University, Moscow, Russia

Dmitry Meinster Higher School of Economics, National Research University, Moscow, Russia

Dmitry B. Mokeev Department of Algebra, Geometry and Discrete Mathematics, Lobachevsky State University of Nizhny Novgorod, N.Novgorod, Russia; Laboratory of Algorithms and Technologies for Networks Analysis, Higher School of Economics in Nizhny Novgorod, N.Novgorod, Russia

Ayagoz Mussabayeva Higher School of Economics, National Research University, Moscow, Russia

Andrey Pavlovich Nelyubin Mechanical Engineering Research, Institute of the RAS, Moscow, Russia

Alexey Nikolaev Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics, Nizhny Novgorod, Russia

Andrei V. Orlov Matrosov Institute for System Dynamics and Control Theory of SB RAS, Irkutsk, Russia

Dmitry Petrov Kharkevich Institute for Information Transmission Problems, Moscow, Russia; Imaging Genetics Center, University of Southern California, Los Angeles, USA

Olga Pinyagina Kazan Federal University, Institute of Computational Mathematics and Information Technologies, Kazan, Russia

Vladislav Vladimirovich Podinovski Higher School of Economics, National Research University, Moscow, Russia

Oleg Poldin Higher School of Economics, National Research University, Moscow, Russia

Alexander Ponomarenko Higher School of Economics, National Research University, Moscow, Russia

Mikhail Andreevich Potapov Institute of Computer Aided Design of the RAS, Moscow, Russia

Alexander Rubchinsky Higher School of Economics, National Research University, Moscow, Russia; National Research Technological University "MISIS", Moscow, Russia

Andrey V. Savchenko Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics, Nizhny Novgorod, Russia

Alexander Semenov Matrosov Institute for System Dynamics and Control Theory SB RAS, Irkutsk, Russia

D. P. Semenov Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics, Nizhny Novgorod, Russia

S. P. Sidorov Saratov State University, Saratov, Russian Federation

Anastasiia D. Sokolova Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics, Nizhny Novgorod, Russia

Paul Thompson Imaging Genetics Center, Stevens Neuroimaging and Informatics Institute, University of Southern California, Marina del Rey, CA, USA

Irina Utkina Higher School of Economics, National Research University, Moscow, Russia; Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics, Nizhny Novgorod, Russia

Arsenii Vizgunov Higher School of Economics, National Research University, Moscow, Russia

M. A. Voronina Laboratory of Algorithms and Technologies for Network Analysis, National Research University Higher School of Economics, Nizhny Novgorod, Russia

Dmitry Zaytsev Higher School of Economics, National Research University, Moscow, Russia

Leonid E. Zhukov Higher School of Economics, National Research University, Moscow, Russia