

Commenced Publication in 1973

Founding and Former Series Editors:

Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Editorial Board

David Hutchison

Lancaster University, Lancaster, UK

Takeo Kanade

Carnegie Mellon University, Pittsburgh, PA, USA

Josef Kittler

University of Surrey, Guildford, UK

Jon M. Kleinberg

Cornell University, Ithaca, NY, USA

Friedemann Mattern

ETH Zurich, Zurich, Switzerland

John C. Mitchell

Stanford University, Stanford, CA, USA

Moni Naor

Weizmann Institute of Science, Rehovot, Israel

C. Pandu Rangan

Indian Institute of Technology, Madras, India

Bernhard Steffen

TU Dortmund University, Dortmund, Germany

Demetri Terzopoulos

University of California, Los Angeles, CA, USA

Doug Tygar

University of California, Berkeley, CA, USA

Gerhard Weikum

Max Planck Institute for Informatics, Saarbrücken, Germany


More information about this series at <http://www.springer.com/series/7407>

Fabrizio Frati · Kwan-Liu Ma (Eds.)

Graph Drawing and Network Visualization

25th International Symposium, GD 2017
Boston, MA, USA, September 25–27, 2017
Revised Selected Papers

Editors

Fabrizio Frati 
Roma Tre University
Rome
Italy

Kwan-Liu Ma 
University of California
Davis, CA
USA

ISSN 0302-9743 ISSN 1611-3349 (electronic)
Lecture Notes in Computer Science
ISBN 978-3-319-73914-4 ISBN 978-3-319-73915-1 (eBook)
<https://doi.org/10.1007/978-3-319-73915-1>

Library of Congress Control Number: 2017963772

LNCS Sublibrary: SL1 – Theoretical Computer Science and General Issues

© Springer International Publishing AG 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

Preface

This volume contains the papers presented at the 25th International Symposium on Graph Drawing and Network Visualization (GD 2017), which was held September 25–27, 2017, in Boston, Massachusetts, USA. Graph drawing is concerned with the geometric representation of graphs and constitutes the algorithmic core of network visualization. Graph drawing and network visualization are motivated by applications where it is crucial to visually analyze and interact with relational datasets. Information about the conference series and past symposia is maintained at <http://www.graphdrawing.org>. The 2017 edition of the conference was hosted by Northeastern University, with Cody Dunne and Alan Keahey as co-chairs of the Organizing Committee. The conference sessions took place in the Pavillion room of the Northeastern University Alumni Center at Columbus Place. A total of 85 participants attended the conference.

Regular papers could be submitted to one of two distinct tracks: Track 1 for papers on combinatorial and algorithmic aspects of graph drawing and Track 2 for papers on experimental, applied, and network visualization aspects. Short papers were reserved a separate category, which welcomed both theoretical and applied contributions. An additional track was devoted to poster submissions. All the tracks were handled by a single Program Committee. In response to the call for papers, the Program Committee received a total of 107 submissions, consisting of 87 papers (35 in Track 1, 31 in Track 2, and 21 in the short paper category) as well as 20 posters. More than 320 expert reviews were provided, roughly a third of which were contributed by external reviewers. After extensive electronic discussions, the Program Committee selected 43 papers and 16 posters for inclusion in the scientific program of GD 2017. This resulted in an overall paper acceptance rate of 49% (65% in Track 1, 35% in Track 2, and 42% in the short paper category). This year it became mandatory for authors to publish an electronic version of their accepted papers on the ArXiv repository; a conference index with links to these contributions was made available before the conference.

There were two keynote talks at GD 2017. Timothy M. Chan, from the University of Illinois at Urbana-Champaign, USA, showed us how to have “Fun with Recursion and Tree Drawings.” Alessandro Vespignani, from the Northeastern University, USA, talked about methods for “Mapping the Next Pandemic.” Abstracts of both talks are included in the proceedings.

Springer sponsored awards for the best papers in Track 1 and Track 2, plus a best presentation award and a best poster award. As a result of a vote taken by the Program Committee, the award for the best paper in Track 1 was assigned to “Ordered Level Planarity, Geodesic Planarity, and Bi-Monotonicity” by Boris Klemz and Günter Rote, and the award for the best paper in Track 2 was assigned to “Revisited Experimental Comparison of Node-Link and Matrix Representations” by Mershack Okoe, Radu Jianu and Stephen Kobourov. The participants of the conference voted as the best presentation the one given by Philipp Kindermann for the paper “Experimental

Analysis of the Accessibility of Drawings with Few Segments” and as the best poster the one by Theresa Fröschl and Martin Nöllenburg entitled “Minimizing Wiggles in Storyline Visualizations.” Congratulations to all the award winners for their excellent contributions!

Following the tradition, the 24th Annual Graph Drawing Contest was held during the conference. The contest was divided into two parts – the creative topics and the live challenge – each with two categories, automatic and manual. The creative topics featured two graphs, one about citations among papers from previous GD symposia and one about human metabolism. The live challenge focused on maximizing the minimum crossing angle in straight-line drawings. Awards were given in each of the four categories. We thank the Contest Committee for preparing interesting and challenging contest problems. A report about the contest is included in the proceedings.

Many people and organizations contributed to the success of GD 2017. We would like to thank the Program Committee members and the external reviewers for carefully reviewing and discussing the submitted papers and posters; this was crucial for putting together a strong and interesting program. Thanks to all the authors who chose GD 2017 as the publication venue for their research. The Organizing Committee did a terrific job; a big thanks goes to Cody Dunne and Alan Keahey, who co-chaired the committee, as well as to the other local organizers and volunteers. GD 2017 thanks the “gold” sponsor Tom Sawyer Software, the “silver” sponsor yWorks, and the “bronze” sponsor Springer. Their generous support helps to ensure the continued success of this conference.

The 26th International Symposium on Graph Drawing and Network Visualization (GD 2018) will take place in September 2018 in Barcelona, Spain. Therese Biedl and Andreas Kerren will co-chair the Program Committee, Vera Sacristán and Rodrigo Silveira will co-chair the Organizing Committee.

November 2017

Fabrizio Frati
Kwan-Liu Ma

Organization

Steering Committee

Therese Biedl	University of Waterloo, Canada
Giuseppe Di Battista	Università Roma Tre, Italy
Fabrizio Frati	Università Roma Tre, Italy
Andreas Kerren	Linnaeus University, Sweden
Michael T. Goodrich	University of California at Irvine, USA
Yifan Hu	Yahoo Research, USA
Giuseppe Liotta (Chair)	Università di Perugia, Italy
Kwan-Liu Ma	University of California at Davis, USA
Martin Nöllenburg	Technische Universität Wien, Austria
Roberto Tamassia	Brown University, USA
Ioannis G. Tollis	FORTH-ICS and University of Crete, Greece
Alexander Wolff	Universität Würzburg, Germany

Program Committee

Daniel Archambault	Swansea University, UK
Benjamin Bach	University of Edinburgh, UK
Fabian Beck	Universität Duisburg-Essen, Germany
Michael Bekos	Universität Tübingen, Germany
Therese Biedl	University of Waterloo, Canada
Giordano Da Lozzo	University of California at Irvine, USA
Vida Dujmović	University of Ottawa, Canada
Stephane Durocher	University of Manitoba, Canada
Tim Dwyer	Monash University, Australia
Fabrizio Frati (Co-chair)	Università Roma Tre, Italy
Martin Gronemann	Universität zu Köln, Germany
John Alexis Guerra Gómez	Los Andes University, Colombia, and Berkeley, USA
Michael Hoffmann	ETH Zürich, Switzerland
Yifan Hu	Yahoo Research, USA
Takayuki Itoh	Ochanomizu University, Japan
Anna Lubiw	University of Waterloo, Canada
Kwan-Liu Ma (Co-chair)	University of California at Davis, USA
Fabrizio Montecchiani	Università di Perugia, Italy
Martin Nöllenburg	Technische Universität Wien, Austria
Arnaud Sallaberry	LIRMM, France
Andrew Suk	University of Illinois at Chicago, USA
Antonios Symvonis	National Technical University of Athens, Greece
Ioannis Tollis	FORTH-ICS and University of Crete, Greece
Csaba Tóth	California State University Northridge, USA

Alexander Wolff	Universität Würzburg, Germany
Jian Zhao	FX Palo Alto Lab, USA

Organizing Committee

Cody Dunne	Northeastern University, USA
Alan Keahey	Conversant, USA

Contest Committee

Philipp Kindermann	FernUniversität in Hagen, Germany
Maarten Löffler (Chair)	Utrecht University, The Netherlands
Ignaz Rutter	Technische Universiteit Eindhoven, The Netherlands
Will Devanny	University of California at Irvine, USA

Additional Reviewers

Shivam Agarwal	Luca Grilli	Saeed Mehrabi
Marco Angelini	Karen Gunderson	Debajyoti Mondal
Patrizio Angelini	Daniel Harabor	Pat Morin
Alessio Arleo	Haleh Havvaei	Lev Nachmanson
Alan Arroyo	Jose Tiberio Hernandez	Cydney Nielsen
David Auber	Marcel Hlawatsch	Dömötör Pálvölgyi
Yeganeh Bahoo	Christophe Hurter	Maurizio Patrignani
Juan Jose Besa Vial	Juan C. Ibarra Lopez	Michael Pelsmajer
Carla Binucci	Dino Ienco	Claire Pennarun
Johannes Blum	Veronika Irvine	Emmanuel Pietriga
Prosenjit Bose	Timothy Johnson	Alexander Pilz
Romain Bourqui	Sanjay Kairam	Sergey Pupyrev
Guido Brückner	Konstantinos Kakoulis	Chrysanthi Raftopoulou
Hsien-Chih Chang	Michael Kaufmann	Alexander Ravsky
Steven Chaplick	Philipp Kindermann	Vincenzo Roselli
Maxime Cordeil	Karsten Klein	Natan Rubin
Anthony D'Angelo	Stephen Kobourov	Ignaz Rutter
Éric Colin de Verdière	Myroslav Kryven	Christiane Spisla
William E. Devanny	Shahid Latif	Sabine Storandt
Emilio Di Giacomo	Fritz Lekschas	Alessandra Tappini
Walter Didimo	Fabian Lipp	Marc Van Kreveld
Thomas C. Van Dijk	Zhicheng Liu	Sue Whitesides
William Evans	Andre Löffler	Tilo Wiedera
Krzysztof Fleszar	Maarten Löffler	Steve Wismath
Siwei Fu	Min Lu	Yanhong Wu
Radoslav Fulek	Sven Mallach	Michael Wybrow
Ellen Gethner	Kim Marriott	Yalong Yang
Daniel Gonçalves	Fintan Mcgee	Wang Yong
Martin Graham	Tamara Mchedlidze	Jiawei Zhang

Sponsors

Gold Sponsor



Tom Sawyer[®]
SOFTWARE

Silver Sponsor



Bronze Sponsor



Keynote Presentations

Fun with Recursion and Tree Drawings

Timothy M. Chan

Department of Computer Science, University of Illinois at Urbana-Champaign,
USA

`tmc@illinois.edu`

Abstract. Divide-and-conquer has always been one of my favorite algorithm design paradigms. In this talk, I will survey existing techniques on drawings of trees on grids with small area or width, which nicely illustrate the power of recursive thinking. I will also mention some new improved upper bounds (work in progress) for certain types of tree drawings. Along the way, we will encounter a number of interesting functions and recurrences, and plenty of open problems.

Mapping the Next Pandemic

Alessandro Vespignani

College of Computer and Information Science, Northeastern University, USA
a.vespignani@northeastern.edu

Abstract. In the last ten years, we have seen dramatic advances in data collection and availability in a number of areas ranging from pathogen genetic sequences to human mobility patterns, and social media data. These advances, often dubbed as the “big data” revolution, have finally lifted many of the limitations affecting epidemic predictive modeling.

The results of these modeling approaches however must be communicated to policy makers and public health practitioners, possibly lifting the veil of the mathematical and statistical jargon. For this reason a visual approach to the data exploration/exploitation is often required. Here I will introduce recent development in the field and show some of the challenges to the development of visualization tools that show commonalities and patterns in emerging health threats, as well as explore the wide range of possible scenarios that can be used by policy makers to anticipate trends, evaluate risks, and eventually manage future pandemics.

Contents

Straight-Line Representations

Aligned Drawings of Planar Graphs	3
<i>Tamara Mchedlidze, Marcel Radermacher, and Ignaz Rutter</i>	
On the Edge-Length Ratio of Outerplanar Graphs	17
<i>Sylvain Lazard, William Lenhart, and Giuseppe Liotta</i>	
On Vertex- and Empty-Ply Proximity Drawings	24
<i>Patrizio Angelini, Steven Chaplick, Felice De Luca, Jiří Fiala, Jaroslav Hančl Jr., Niklas Heinsohn, Michael Kaufmann, Stephen Kobourov, Jan Kratochvíl, and Pavel Valtr</i>	
An Interactive Tool to Explore and Improve the Ply Number of Drawings . . .	38
<i>Niklas Heinsohn and Michael Kaufmann</i>	
Experimental Analysis of the Accessibility of Drawings with Few Segments	52
<i>Philipp Kindermann, Wouter Meulemans, and André Schulz</i>	

Obstacles and Visibility

Obstacle Numbers of Planar Graphs	67
<i>John Gimbel, Patrice Ossona de Mendez, and Pavel Valtr</i>	
Grid-Obstacle Representations with Connections to Staircase Guarding	81
<i>Therese Biedl and Saeed Mehrabi</i>	
Reconstructing Generalized Staircase Polygons with Uniform Step Length . . .	88
<i>Nodari Sitchinava and Darren Strash</i>	
3D Visibility Representations of 1-planar Graphs	102
<i>Patrizio Angelini, Michael A. Bekos, Michael Kaufmann, and Fabrizio Montecchiani</i>	

Topological Graph Theory

Lombardi Drawings of Knots and Links	113
<i>Philipp Kindermann, Stephen Kobourov, Maarten Löffler, Martin Nöllenburg, André Schulz, and Birgit Vogtenhuber</i>	

Arrangements of Pseudocircles: Triangles and Drawings	127
<i>Stefan Felsner and Manfred Scheucher</i>	
Drawing Bobbin Lace Graphs, or, Fundamental Cycles for a Subclass of Periodic Graphs	140
<i>Therese Biedl and Veronika Irvine</i>	
Many Touchings Force Many Crossings	153
<i>János Pach and Géza Tóth</i>	
Thrackles: An Improved Upper Bound.	160
<i>Radoslav Fulek and János Pach</i>	

Orthogonal Representations and Book Embeddings

On Smooth Orthogonal and Octilinear Drawings: Relations, Complexity and Kandinsky Drawings	169
<i>Michael A. Bekos, Henry Förster, and Michael Kaufmann</i>	
EPG-representations with Small Grid-Size	184
<i>Therese Biedl, Martin Derka, Vida Dujmović, and Pat Morin</i>	
Mixed Linear Layouts of Planar Graphs.	197
<i>Sergey Pupyrev</i>	
Upward Partitioned Book Embeddings.	210
<i>Hugo A. Akitaya, Erik D. Demaine, Adam Hesterberg, and Quanquan C. Liu</i>	
Experimental Evaluation of Book Drawing Algorithms	224
<i>Jonathan Klawitter, Tamara Mchedlidze, and Martin Nöllenburg</i>	

Evaluations

Visual Similarity Perception of Directed Acyclic Graphs: A Study on Influencing Factors	241
<i>K. Ballweg, M. Pohl, G. Wallner, and T. von Landesberger</i>	
GiViP: A Visual Profiler for Distributed Graph Processing Systems	256
<i>Alessio Arleo, Walter Didimo, Giuseppe Liotta, and Fabrizio Montecchiani</i>	
Drawing Big Graphs Using Spectral Sparsification	272
<i>Peter Eades, Quan Nguyen, and Seok-Hee Hong</i>	
Revisited Experimental Comparison of Node-Link and Matrix Representations	287
<i>Mershack Okoe, Radu Jianu, and Stephen Kobourov</i>	

Tree Drawings

Improved Bounds for Drawing Trees on Fixed Points with L-Shaped Edges.	305
<i>Therese Biedl, Timothy M. Chan, Martin Derka, Kshitij Jain, and Anna Lubiw</i>	
On Upward Drawings of Trees on a Given Grid.	318
<i>Therese Biedl and Debajyoti Mondal</i>	
Simple Compact Monotone Tree Drawings.	326
<i>Anargyros Oikonomou and Antonios Symvonis</i>	
Visualizing Co-phylogenetic Reconciliations.	334
<i>Tiziana Calamoneri, Valentino Di Donato, Diego Mariottini, and Maurizio Patrignani</i>	

Graph Layout Designs

Anisotropic Radial Layout for Visualizing Centrality and Structure in Graphs	351
<i>Mukund Raj and Ross T. Whitaker</i>	
Computing Storyline Visualizations with Few Block Crossings.	365
<i>Thomas C. van Dijk, Fabian Lipp, Peter Markfelder, and Alexander Wolff</i>	
MLSEB: Edge Bundling Using Moving Least Squares Approximation.	379
<i>Jieting Wu, Jianping Zeng, Feiyu Zhu, and Hongfeng Yu</i>	
Drawing Dynamic Graphs Without Timeslices	394
<i>Paolo Simonetto, Daniel Archambault, and Stephen Kobourov</i>	

Point-Set Embeddings

Colored Point-Set Embeddings of Acyclic Graphs.	413
<i>Emilio Di Giacomo, Leszek Gasieniec, Giuseppe Liotta, and Alfredo Navarra</i>	
Planar Drawings of Fixed-Mobile Bigraphs	426
<i>Michael A. Bekos, Felice De Luca, Walter Didimo, Tamara Mchedlidze, Martin Nöllenburg, Antonios Symvonis, and Ioannis G. Tollis</i>	
Ordered Level Planarity, Geodesic Planarity and Bi-Monotonicity.	440
<i>Boris Klemz and Günter Rote</i>	
Non-crossing Paths with Geographic Constraints.	454
<i>Rodrigo I. Silveira, Bettina Speckmann, and Kevin Verbeek</i>	

Special Representations

Planar L-Drawings of Directed Graphs.	465
<i>Steven Chaplick, Markus Chimani, Sabine Cornelsen,</i> <i>Giordano Da Lozzo, Martin Nöllenburg, Maurizio Patrignani,</i> <i>Ioannis G. Tollis, and Alexander Wolff</i>	
NodeTrix Planarity Testing with Small Clusters	479
<i>Emilio Di Giacomo, Giuseppe Liotta, Maurizio Patrignani,</i> <i>and Alessandra Tappini</i>	
The Painter’s Problem: Covering a Grid with Colored Connected Polygons	492
<i>Arthur van Goethem, Irina Kostitsyna, Marc van Kreveld,</i> <i>Wouter Meulemans, Max Sondag, and Jules Wulms</i>	
Triangle-Free Penny Graphs: Degeneracy, Choosability, and Edge Count. . . .	506
<i>David Eppstein</i>	

Beyond Planarity

1-Fan-Bundle-Planar Drawings of Graphs.	517
<i>Patrizio Angelini, Michael A. Bekos, Michael Kaufmann,</i> <i>Philipp Kindermann, and Thomas Schneck</i>	
Gap-Planar Graphs	531
<i>Sang Won Bae, Jean-Francois Baffier, Jinhee Chun, Peter Eades,</i> <i>Kord Eickmeyer, Luca Grilli, Seok-Hee Hong, Matias Korman,</i> <i>Fabrizio Montecchiani, Ignaz Rutter, and Csaba D. Tóth</i>	
Beyond Outerplanarity.	546
<i>Steven Chaplick, Myroslav Kryven, Giuseppe Liotta, Andre Löffler,</i> <i>and Alexander Wolff</i>	
The Effect of Planarization on Width.	560
<i>David Eppstein</i>	

Contest Report

Graph Drawing Contest Report.	575
<i>William Devanny, Philipp Kindermann, Maarten Löffler,</i> <i>and Ignaz Rutter</i>	

Poster Abstracts

Minimizing Wiggles in Storyline Visualizations	585
<i>Theresa Fröschl and Martin Nöllenburg</i>	
Graph Drawing for Formalized Diagrammatic Proofs in Geometry	588
<i>Nathaniel Miller</i>	
Drawing Graphs on Few Circles and Few Spheres	591
<i>Myroslav Kryven, Alexander Ravsky, and Alexander Wolff</i>	
Counterexample to the Variant of the Hanani–Tutte Theorem on the Genus-4 Surface	594
<i>Radoslav Fulek and Jan Kynčl</i>	
A Geometric Heuristic for Rectilinear Crossing Minimization	597
<i>Marcel Radermacher, Klara Reichard, Ignaz Rutter, and Dorothea Wagner</i>	
A Note on Plus-Contacts, Rectangular Duals, and Box-Orthogonal Drawings	600
<i>Therese Biedl and Debajyoti Mondal</i>	
Grid Obstacle Representation of Graphs	603
<i>Arijit Bishnu, Arijit Ghosh, Rogers Mathew, Gopinath Mishra, and Subhabrata Paul</i>	
Summarizing and Visualizing Graph Ensembles with Rank Statistics and Boxplots	606
<i>Mukund Raj, Ian Ruginski, Robert M. Kirby, and Ross T. Whitaker</i>	
Planar k -NodeTrix Graphs: A New Family of Beyond Planar Graphs	609
<i>Emilio Di Giacomo, Giuseppe Liotta, Maurizio Patrignani, and Alessandra Tappini</i>	
Towards Characterizing Strict Outerconfluent Graphs	612
<i>Fabian Klute and Martin Nöllenburg</i>	
Flattening Polygonal Linkages via Uniform Angular Motion	615
<i>Hugo A. Akitaya, Matthew D. Jones, Gregory A. Sandoval, Diane L. Souvaine, David Stalf, and Csaba D. Tóth</i>	
Optimal Compaction of Orthogonal Grid Drawings for Graphs of Arbitrary Vertex Degrees	618
<i>Eduardo Santiago Ramos and Adriano Chaves Lisboa</i>	

BCSA: BC Tree-Based Sampling and Visualization of Big Graphs	621
<i>Seok-Hee Hong, Quan Nguyen, Amyra Meidiana, and Jiayi Li</i>	
Low Ply Drawings of Trees of Bounded Degree	624
<i>Michael T. Goodrich and Timothy Johnson</i>	
Which Graph Layout Gives a Good Shape for Large Graphs?	627
<i>Quan Nguyen, Peter Eades, and Seok-Hee Hong</i>	
MetagenomeScope: Web-Based Hierarchical Visualization of Metagenome Assembly Graphs	630
<i>Marcus Fedarko, Jay Ghurye, Todd Treangen, and Mihai Pop</i>	
Author Index	633