Theory and Practice of Graph Drawing

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Abstract. A workshop on Theory and Practice of Graph Drawing was held in conjunction with the 20th International Symposium on Graph Drawing to celebrate Peter Eades's 60th birthday. The workshop was hosted by Microsoft Research in Redmond, Washington, USA, on September 18, 2012. This report reviews the contents of the workshop.

1 Introduction

Peter Eades is one of the most influential members of the Graph Drawing community. Peter published more than one hundred papers in prestigious international conferences and journals, and his works have been cited more than 9000 times. He is one of the authors of the book "Graph Drawing: Algorithms for the Visualization of Graphs" [2], that is widely considered as *the book* on Graph Drawing and has been cited almost 2000 times. Peter published ground-breaking papers that initiated some of the most popular topics of research in Graph Drawing, namely spring embedding algorithms [3], three-dimensional graph drawing [1], and clustered planarity [4]. Peter has been a steering committee member and a founding member for the International Symposium on Graph Drawing (GD) and for the International Symposium on Algorithms and Computation (ISAAC). Peter has supervised more than 30 research students.

The workshop on "Theory and Practice of Graph Drawing" held in conjunction with the 20th International Symposium on Graph Drawing celebrated Peter's vast contribution to the theory and practice of Graph Drawing through the talks of some of the most established members of the Graph Drawing community.

2 Workshop Overview

The workshop was chaired by Seok-Hee Hong and Fabrizio Frati, and organized by Fabrizio Frati, Seok-Hee Hong, and Karsten Klein (The University of Sydney). Local arrangements were organized by Tim Dwyer and Lev Nachmanson (Microsoft Research).

The workshop had 43 participants: P. Angelini (Università di Roma Tre), M. Bannister (University of California, Irvine), F. Brandenburg (University of Passau), U. Brandes (University of Konstanz), L. Brankovic (The University of Newcastle), W. Didimo

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(Università degli studi di Perugia), G. Di Bartolomeo (Università di Roma Tre), G. Di Battista (Università di Roma Tre), E. Di Giacomo - (Università degli studi di Perugia), C. Duncan (Louisiana Tech University), C. Dunne (Microsoft Research), T. Dwyer (Microsoft Research), P. Eades (The University of Sydney), D. Eppstein (University of California, Irvine), M. Fink (Universität Würzburg), F. Frati (The University of Sydney), E. R. Gansner (AT&T Labs Research), M. Goodrich (University of California, Irvine), K. Greenfield (MIT Lincoln Laboratory), C. Gutwenger (Technische Universität Dortmund), L. Heyer (Davidson College), S. Hong (The University of Sydney), M. Kaufmann (University of Tuebingen), K. Klein (The University of Sydney), S. G. Kobourov (University of Arizona), B. Lee (Microsoft Research), W. J. Lenhart (Williams College), G. Liotta (Università degli studi di Perugia), D. Mondal (University of Manitoba), H. Nagamochi (Kyoto University), L. Nachmanson (Microsoft Research), R. I. Nishat (University of Victoria), M. Patrignani (Università di Roma Tre), R. Prutkin (Karlsruhe Institute of Technology), S. Pupyrev (Ural Federal University), H. Quan Nguyen (The University of Sydney), N. H. Riche (Microsoft Research), F. Ruskey (University of Victoria), R. Tamassia (Brown University), T. Tantau (Universität zu Lübeck), I. G. Tollis (FORTH-ICS and University of Crete), S. Whitesides (University of Victoria), A. Wolff (Universität Würzburg).

3 Invited Talks

The workshop had six invited talks, whose abstracts are reported below.

Roberto Tamassia (Brown University)
Security and Privacy Issues for Drawing Graphs in the Cloud

The emerging paradigm of cloud computing presents major challenges to data security and privacy. After outsourcing its data to a server in the cloud, the client wants to have assurance of its persistence and completeness, detecting any loss or tampering of data items. Besides this data integrity goal, the client also wants to fully protect the confidentiality of the data, not only encrypting the data items but also obfuscating the pattern of access to the data items.

We begin by overviewing the paradigms of authenticated data structures for integrity protection and of data-oblivious algorithms for privacy protection in a cloud computing scenario. We then present applications of these paradigms to a variety of graph drawing and visualization problems, surveying recent results and mentioning open problems.

Giuseppe Di Battista (Università di Roma Tre)
Relaxing the Constraints of Clustered Planarity

In a drawing of a clustered graph vertices and edges are drawn as points and curves, respectively, while clusters are represented by simple closed regions. A drawing of a clustered graph is c-planar if it has no edge-edge, edge-region, or region-region crossings. Determining the complexity of testing whether a clustered graph admits a c-planar drawing is a long-standing open problem in the Graph Drawing research area. An obvious necessary condition for c-planarity is the planarity of the graph underlying the clustered graph. However, such a condition is not sufficient and the consequences on

the problem due to the requirement of not having edge-region and region-region crossings are not yet fully understood.

In order to shed light on the c-planarity problem, we consider a relaxed version of it, where some kinds of crossings (either edge-edge, edge-region, or region-region) are allowed even if the underlying graph is planar. We investigate the relationships among the minimum number of edge-edge, edge-region, and region-region crossings for drawings of the same clustered graph. Also, we consider drawings in which only crossings of one kind are admitted. In this setting, we prove that drawings with only edge-edge or with only edge-region crossings always exist, while drawings with only region-region crossings may not. Further, we provide upper and lower bounds for the number of such crossings. Finally, we give a polynomial-time algorithm to test whether a drawing with only region-region crossings exist for biconnected graphs, hence identifying a first non-trivial necessary condition for c-planarity that can be tested in polynomial time for a noticeable class of graphs.

Ioannis G. Tollis (FORTH-ICS and University of Crete)
Vertex Ordering in Graph Drawing

Many graph drawing algorithms use vertex ordering (such as st-numberings, or st-orientations, or bipolar orientations) as a first step. As there exist exponentially many st-numberings that correspond to a certain undirected graph G, using different st-numberings in various graph drawing algorithms can result in aesthetically different drawings with different area bounds.

In this talk, we discuss results concerning new algorithms for parameterized (on the length of the longest path) st-orientations, their impact on various graph drawing algorithms. Apart from Graph Drawing, this work applies to other areas such as Network Routing, Graph Coloring, and Longest Path. We also present twin vertex orderings that place the vertices on grid points following a relaxed version of dominance drawing, called weak dominance condition. In this case, orthogonal edge routing is implied automatically by the vertex coordinates resulting in maximum edge reuse and small number of bends. The algorithms can be applied to directed acyclic graphs, planar, non-planar and also undirected graphs.

Ulrik Brandes (University of Konstanz)
Everlasting Springs

Practical graph drawing can be equated with spring embedding. In particular, the vast majority of information visualization tools utilizes (sometimes variants of) one of two layout algorithms from Fruchterman & Reingold (1991) and Kamada & Kawai (1989). Both are usually referred to as force-directed placement methods, which are praised for their general applicability, high adaptability, and simplicity.

I will argue that commonly used implementations and even the approaches themselves are outdated and, in fact, have always been. They should be replaced by variants of multidimensional scaling that display superior results and scalability, and are just as flexible and easy to implement. While I may actually back some of these statements with evidence, all of them will remain inconsequential.

Giuseppe Liotta (Università degli studi di Perugia)
Area Requirement of Drawings with Crossing Edges

A recent research topic in graph drawing is the study of straight-line drawings that are almost planar in some sense. Roughly speaking, a straight-line drawing is almost planar when its edges can cross, but some crossing configurations are forbidden. By changing the definition of forbidden crossing configuration, a different family of almost planar drawings is defined; examples include k-planar, RAC, k-quasi planar, and skewness-k drawings. This talk will recall some recent findings about the area requirement of almost planar straight-line drawings; upper and lower bounds for specific families of graphs and for different types of drawings will be presented.

Frank Ruskey and Sue Whitesides (University of Victoria)
Reminiscences of Research with Peter Eades

Each of us has collaborated with Peter Eades over the years. Here, we recollect some of the many ways in which he has inspired our research in the past, and also, we summarize recent research that we believe he may find interesting. Themes include motion planning, from linkage movement and spring embedding to kinetic graph drawing; complexity lower bounds for graph drawing (the logic engine); and tatami tilings of polyominoes.

References

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