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Special Issue of Selected Papers from the 27th International Symposium on Graph Drawing and Network Visualization (GD 2019) Guest Editors' Foreword

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1 Introduction

This special issue of the Journal of Graph Algorithms and Applications is dedicated to some of the best papers from the 27th International Symposium on Graph Drawing and Network Visualization, which was held in Průhonice, near Prague, September 17–20, 2019. The symposium was hosted by Charles University, with Jiří Fiala and Pavel Valtr as co-chairs of the organizing committee. The authors of six of the best papers presented at the symposium were invited to submit a revised and extended version of their work to this special issue. The submitted papers went through the standard reviewing process of the journal and were accepted after further revisions. They span a broad range of topics of interest for the Graph Drawing and Network Visualization community, covering both applied and theoretical aspects of the research field.

The papers appear here in alphabetical order of the last names of the first authors. We briefly introduce all papers.

- The *order type* of a set of n points in the plane determines the intersection pattern (and crossings) of the geometric graphs embedding on such a vertex set. While there are only $e^{\Theta(n \log n)}$ geometrically realizable order types on n points in the plane, it remains an open problem to find efficient data structures that represent an order type with optimal $O(n \log n)$ bits, and can report the orientation of any triple in polylogarithmic time. Aichholzer, Balko, Hoffmann, Kynčl, Mulzer, Parada, Pilz, Scheucher, Valtr, Vogtenhuber, and Welzl study visual representations of an order type, irrespective of its bit complexity. They introduce the concept of *exit edges* for n points in the plane and show that in any continuous deformation of the point set that changes the order type, some point moves across an exit edge. Among several other properties, they prove that the number of exit edges is between $(3n-7)/5$ and $n^2/3 + O(1)$.

- The study of beyond-planarity concerns itself with graphs that are not planar but lie close to planar graphs, more specifically, classes of graphs where certain types crossings are forbidden. Angelini, Bekos, Kaufmann, and Schneck characterize complete and complete bipartite graphs that can be drawn in the plane without such forbidden patterns. Their computer assisted proofs rely on a software, written by the authors, that enumerates the cases and exploits properties of the search space, such as symmetry, to reduce the time required to verify their hypotheses.

- In a k-page book embedding of a graph, the vertices are embedded on a horizontal line (*spine*), the edges are drawn as halfcircles above the spine, and are assigned to k color classes (*pages*) such that no two edges of the same color cross. This is a generalization of outerplanarity that has found countless applications. It is NP-hard to find the book thinkness of a graph, which is the smallest k for which a graph admits a k-plage book embedding. Sujoy, Ganian, Montecchiani, and Nöllenburg use dynamic programming to show that computing the book thickness of a graph is fixed-parameter tractable (FTP) when parameterized by the vertex cover number of the graph, and remains FPT when the order of the vertices along the spine is part of the input.

- The crossing number of a graph G is the minimum number of edge crossings over all drawings of G. To reduce cluttering, Holton (2006) introduced the *bundled crossing number* of a graph, which minimizes the number of bundled crossing, which are pairwise disjoint squares in which two subsets (*bundles*) of edges form a complete bipartite crossing. Chaplick, van Dijk, Kryven, Park, Ravsky, and Wolff show that finding the bundled crossing number of a graph over simple drawings is NP-hard. They also provide an FTP algorithm (where the parameter is the bundled crossing number) in circular layouts, where the vertices are located on the boundary of a disk, and all edges are drawn in the interior of the disk, using Courcelle's theorem on *monadic second order logic* (MSO_2) and embeddings in higher-genus surfaces.

- Representing a graph as the intersection graph of geometric objects in the plane is a classical problem in visualization. The a so-called *stick graphs* are intersection graphs of axis-parallel line segments that all touch a "diagonal" line of slope -1 in the plane. They are necessarily bipartite, as all intersections are between horizontal and vertical segments A and B, respectivey. The recognition of stick graphs was known to be NP-hard in general, and a polynomial-time algorithm was known when the order of the segments in both A and B along the diagonal is fixed. Chaplick, Kindermann, Löffler, Thiele, Wolff, Zaft, and Zink gave a polynomial-time recognition algorithm when the order of A is given along the diagonal. They also show that the variants of the problem where the line segments have given lengths are NP-hard, regardless whether the order of the segments in A or both A and B is given.

- For nearly two decades, nodes with area and removing overlap between such nodes in a drawing has been well studied. The problem of node overlap removal starts with taking a graph, where nodes are not points but have area, and a layout of that graph and efficiently adjusts that layout such that no pair of nodes overlaps while minimising a second metric (often the distance moved during adjustment). This paper tests nine state-of-the-art techniques for node overlap removal and studies how they perform against twenty-two metrics to evaluate the quality of the adjustment, providing insight to practitioners as to which approach they should use for their application. The authors also provide a web platform to allow node overlap algorithm developers to test their approach against all approaches discussed in the experiment.

We thank the authors for contributing their high-quality papers, the referees for their valuable work, and the staff of the Journal of Graph Algorithms and Applications for making this special issue possible.