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Preface

This volume contains the papers presented at CALDAM 2021 (the 7th International Conference on Algorithms and Discrete Applied Mathematics) held during February 11–13, 2021 at IIT Ropar, Rupnagar, Punjab, India. CALDAM 2021 was organised by the Department of Computer Science and Engineering, Indian Institute of Technology Ropar, and the Association for Computer Science and Discrete Mathematics (ACSDM), India. The program committee consisted of 31 highly experienced and active researchers from various countries.

The conference had papers in the areas of algorithms, graph theory, combinatorics, computational geometry, discrete geometry, and computational complexity. We received 82 submissions with authors from all over the world. Each paper was extensively reviewed by program committee members and other expert reviewers. The committee decided to accept 39 papers for presentation. The program included two Google invited talks by Professors Martin Fürer (of Pennsylvania State University) and Anil Maheshwari (of Carleton University).

As volume editors, we would like to thank the authors of all submissions for considering CALDAM 2021 for potential presentation of their works. We are very much indebted to the program committee members and the external reviewers for providing serious reviews within a very short period of time. We thank Springer for publishing the proceedings in the Lecture Notes in Computer Science series. Our sincerest thanks are due to the invited speakers Martin Fürer and Anil Maheshwari for accepting our invitation to give a talk. We thank the organizing committee chaired by Nitin Auluck and Arti Pandey of Indian Institute of Technology Ropar for the smooth conduct of CALDAM 2021 and Indian Institute of Technology Ropar for providing the necessary facilities. We are very grateful to the chair of the steering committee, Subir Ghosh, for his active help, support, and guidance throughout. We thank our sponsors Google Inc. for their financial support. We also thank Springer for its support for the best paper presentation awards. We thank the EasyChair and Springer OCS conference management systems, which were very effective in handling the entire process.

February 2021

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Abstracts of Invited Talks

Width Parameters for Hard and Easy Problems

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Abstract. The most obvious success of width parameters is the abundance of algorithms that make NP-hard problems FPT (fixed parameter tractable). These FPT algorithms are often very efficient for small parameter values. However, the origin of the notion of treewidth is also tied to solving systems of sparse linear equations. For large sparse system, a cubic algorithm is not good enough. Traditionally, such systems have been approached by heuristics trying to minimize the fill-in by appropriate pivot strategies for Gaussian elimination.

In the most prevalent case of systems of linear equations, the matrix is symmetric and positive definite, always allowing a diagonal pivot strategy. This results in an $O(k^2 n)$ algorithm for an $n \times n$ matrix with treewidth k. If the matrix is symmetric, but not positive definite, then off-diagonal pivots are sometimes required. Nevertheless, the matrix can be kept symmetric throughout the algorithm. However, for a long time, it seemed impossible to control the fill-in for treewidth k matrices. Recently, this has been achieved for cliquewidth k and for treewidth k, by a delaying method. This results in an $O(k^2 n)$ algorithm for determining the number of eigenvalues of a graph in a given interval, an important task in spectral graph theory.

A major obstacle for employing treewidth as a tool for efficient algorithms is the construction of tree decompositions of small width and the computation of the treewidth itself. There has been significant progress in this respect, with many challenges still ahead.

A simple modification of the definition of cliquewidth results in the notion of multi-cliquewidth. For many graphs, the clique-width is exponentially larger than the multi-cliquewidth. Nevertheless for some fundamental problems, like Maximum Independent Set and Chromatic Number, the running times of the standard dynamic programming algorithms are the same functions of the multi-cliquewidth as of the cliquewidth. Thus an exponential speed-up is achieved for these graphs by using multi-cliquewidth instead of cliquewidth, assuming the corresponding tree decompositions are known.

Matching and Spanning Trees in Geometric Graphs

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Abstract. In this talk, we survey some recent work on matching and spanning trees in geometric graphs.

The *matching problem* is to find the largest set of independent edges in a graph. We are especially interested in graphs whose edge set is defined with respect to geometrical shapes. For a given shape S, and a point set P in the plane, the graph $G_S = (P, E)$ has an edge between two points $p, q \in P$ if there exists a shape S that has p and q on its boundary, and it does not contain any point of P in its interior. The Delaunay triangulation, L_∞-Delaunay, Θ_6 graph, and Gabriel graphs are obtained by considering S to be a circle, a square, an equilateral triangle, and a diametral disk, respectively. We will outline results on matchings in G_S where S is a circle, a square, an equilateral triangle, a diametral-disk, etc. We will consider variants of geometric matching problems such as the *bottleneck matching* - find a perfect matching that minimizes the length of the longest edge; the *plane matching* - find a maximum matching so that the edges in the matching are pairwise non-crossing; the *strong matching* - find a maximum matching so that the shapes representing the edges of the matchings are pairwise disjoint; *local-to-global* - matching M is said to be *k- local optimal* if for any subset $M' \subset M$ of k edges, the optimal matching of the endpoints of M' is M'. Do k-local matchings approximate global matchings?

We will highlight some recent algorithmic results on the computation of spanning trees in bipartite and complete geometric graphs for a point set in the plane. We wish to compute spanning trees that optimize the total weight and are plane, or have bounded degree, or minimize the bottleneck length and are of bounded degree, or have all incident edges within a cone of a specific angle.

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