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Editorial

Special Issue on "Algorithm Engineering: Towards Practically Efficient Solutions to Combinatorial Problems"

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Abstract: The purpose of this special issue of *Algorithms* was to attract papers presenting original research in the area of algorithm engineering. In particular, submissions concerning the design, analysis, implementation, tuning, and experimental evaluation of discrete algorithms and data structures, and/or addressing methodological issues and standards in algorithmic experimentation were encouraged. Papers dealing with advanced models of computing, including memory hierarchies, cloud architectures, and parallel processing were also welcome. In this regard, we solicited contributions from all most prominent areas of applied algorithmic research, which include but are not limited to graphs, databases, computational geometry, big data, networking, combinatorial aspects of scientific computing, and computational problems in the natural sciences or engineering.

Keywords: journey planning; temporal graphs; influence maximization; network analysis; bamboo garden trimming problem; convex hull; experimental algorithmics; algorithm engineering; computational social choice; statistical analysis of algorithms; scheduling; approximation algorithms

1. Introduction

Algorithm engineering is an emerging discipline whose main aim is bridging the gap between classical algorithm design and complexity theory and practical algorithmics and applications (we refer the interested reader to [1] for a comprehensive survey).

Studies in this field have grown when extreme advancements in the available computing hardware have rendered traditional computational models more and more unrealistic and have led to a constantly increasing demand for solutions to real-world problems that are efficient in theory but also practical. In particular, driven by concrete applications, the algorithm engineering methodology complements theory by the benefits of experimentation and puts equal emphasis on all aspects arising during the process of designing of an algorithmic solution, ranging from realistic modeling, design, analysis, and robust and efficient implementations to careful experiments.

2. Special Issue

In response to the call for papers, a total of fourteen manuscripts were submitted. Out of them, we have selected six submissions to appear in the special issue at hand. All submissions have been reviewed by at least three experts of the field, and all accepted papers are thus of high quality, reflecting the growing interest in the area of algorithm engineering. In what follows, we chiefly overview the content of all published papers in increasing order of their publication dates.

Paper [2] studies issues affecting the implementation, testing, and experimentation of algorithms for computational geometry problems. The focus, in particular, is on the effect of the "quality of implementation" on the resulting performance of an algorithm of this category. In more detail, the main contribution provided by the authors is an investigation of the efficiency of six known algorithms to compute the convex-hull problem in the two-dimensional Euclidean space, namely plane-sweep, torch, quickhull, poles-first, introhull and throw-away. The authors show that these implementations are space-efficient and time-efficient, both in theory and practice. Moreover, a test framework that can be used to make the programs computing convex hulls self-testing is introduced. Finally, general conclusions and observations on how the quality of implementation really matters in experimental studies are presented.

Paper [3] deals with the bamboo garden trimming (BGT) problem, a periodic scheduling problem with several practical applications, e.g., in machine maintenance or cloud computing. The problem is known to be NP-hard due to its close relationship to another well-known optimization problem, namely, the pinwheel scheduling problem. The contributions of this paper are twofold and are both theoretical and experimental. In particular, the main focus is on understanding the behavior of natural strategies for solving the problem that are known as priority schedulings: several results are provided for this category of algorithm, ranging from stabilization properties to approximation guarantees. Furthermore, an extended experimental evaluation is conducted to support a conjecture that is presented in the paper.

Paper [4] addresses methodological issues and standards in algorithmic experimentation and accordingly provides broad guidelines for experimental algorithmics. In particular, the authors focus on methodologies for the experimental part of algorithm engineering for network analysis, which is an important ingredient for a research area with an empirical nature. More precisely, for the empirical analysis of network data, existing recommendations from different fields are unified and adapted, and universal guidelines for the systematic evaluation of network analysis algorithms are proposed, including statistical analyses. This way, the behavior of newly proposed algorithms can be properly assessed, and comparisons to existing solutions become meaningful. The main technical contribution of the paper is SimexPal, a highly automated tool to perform and analyze experiments following the mentioned guidelines. To illustrate the merits of SimexPal and of the guidelines, the authors apply them to a recently proposed algorithm for approximating betweenness centrality, a prominent problem in network analysis. Both the guidelines and SimexPal can modernize and complement previous efforts in experimental algorithmics; they are not only useful for network analysis, but also in related contexts.

Paper [5] investigates the problem of link recommendation via social influence, a network design problem arising in the context of election control. More specifically, political parties recently learned that they must use social media campaigns along with advertising on traditional media to defeat their opponents. Before the campaign starts, it is important for a political party to establish and ensure its media presence, e.g., by enlarging their number of connections in the social network to reach a larger portion of users. Indeed, adding new connections between users increases the capabilities of a social network to spread information, which in turn can increase the retention rate and the number of new voters. In this work, the authors address the problem of selecting a fixed-size set of new connections to be added to a subset of voters that, with their influence, will change the opinion of the network's users about a target candidate, maximizing the candidate's chances of winning the election. The problem is NP-hard; therefore, the authors introduce a constant factor approximation algorithm. On top of that, they provide experimental evidence showing that, with few new links and a small computational time, the algorithm is able to maximize the chances of making the target candidate win the elections.

Paper [6] tackles the problem of approximating the temporal neighborhood function of large temporal graphs. Temporal networks are graphs whose edges have temporal labels, specifying their starting times and their traversal times. Several notions of distances between two nodes in a temporal network have been analyzed in past works by referring, for example, to the earliest arrival time or to the latest starting time of a temporal path connecting the two nodes. In this paper, the authors consider the notion of temporal reachability by using the earliest arrival time and show how the sketch approach, which has already been used in the case of classical graphs, can be applied to the case of temporal networks in order to approximately compute the sizes of the temporal cones of a temporal network. Through this approach, they also show how to approximate the temporal neighborhood function (that is, the number of pairs of nodes reachable from one another in a given time interval) of large temporal networks in a few seconds. Finally, the considered algorithm is applied in order to analyze and compare the behavior of 25 public transportation temporal networks. The presented results can be easily adapted to the case in which one wants to refer to the notion of distance based on the latest starting time.

Paper [7] presents a new model, known as the multimodal dynamic timetable model (MDTM), for computing optimal multimodal journeys in schedule-based public transport systems. The new model is an extension of the dynamic timetable model (DTM) [8], which was originally developed for a different setting, namely for unimodal journey planning. MDTM combines a very fast query algorithm that meets the requirements for real-time response to best-journey queries in modern applications, with an ultra-fast dynamic algorithm to update the timetable information in case of delays occurring on schedule-based vehicles. An experimental study of real-world metropolitan networks is presented to support the above claim and to empirically show that MDTM compares favorably with other state-of-the-art approaches when public transport, including unrestricted traveling with respect to departing time (e.g., walking and electric vehicles) is considered.

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