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Editorial

Special Issue on "Graph Algorithms and Applications"

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Abstract: The mixture of data in real life exhibits structure or connection property in nature. Typical data include biological data, communication network data, image data, etc. Graphs provide a natural way to represent and analyze these types of data and their relationships. For instance, more recently, graphs have found new applications in solving problems for emerging research fields such as social network analysis, design of robust computer network topologies, frequency allocation in wireless networks, and bioinformatics. Unfortunately, the related algorithms usually suffer from high computational complexity, since some of these problems are NP-hard. Therefore, in recent years, many graph models and optimization algorithms have been proposed to achieve a better balance between efficacy and efficiency. The aim of this Special Issue is to provide an opportunity for researchers and engineers from both academia and the industry to publish their latest and original results on graph models, algorithms, and applications to problems in the real world, with a focus on optimization and computational complexity.

Keywords: analysis and design or graph algorithms; distributed graph and network algorithms; graph theory with algorithmic applications; computational complexity of graph problems; experimental evaluation of graph algorithms

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1. Introduction

Graphs represent mathematical abstractions that can be used to represent networks of various types: physical (e.g., the Internet or transportation networks), biological (e.g., brain networks), or social (e.g., online social networks). This led the development of algorithmic graph theory as a classical research area in computer science. It focuses on the discovery of characterization theorems on (different types of) graphs, which in turn often lead to the development of efficient algorithms for practical problems that can be modeled on graphs.

2. Special Issue

In response to the call for papers, a total of eighteen manuscripts were submitted. Out of them, we selected six submissions to appear in this Special Issue. In what follows, we summarize the contents of all six published papers.

In [1], the authors faced a typical problem concerning the visual analysis of real-world networks. To this end, they introduce and study the following beyond-planarity problem that they call h-CLIQUE2PATH PLANARITY. Let G be a simple topological graph for which the vertices are partitioned into subsets of size at most h, each inducing a clique: h-CLIQUE2PATH PLANARITY asks whether it is possible to obtain a planar subgraph of G by removing edges from each clique so that the subgraph induced by each subset is a path. They investigate the complexity of this problem in relation to k-planarity. In particular, they prove that h-CLIQUE2PATH PLANARITY is NP-complete even when $h = 4$ and G is a simple 3-plane graph, while it can be solved in linear time when G is a simple 1-plane graph, for any value of h. The results provided contribute to the growing fields of hybrid planarity and of graph drawing beyond planarity.

In [2], the authors used graph theory models to cope with problems arising in the field of molecular biology and bioinformatics. They considered the ancestral mixture model proposed by Chen and Lindsay in 2006, an important model building a hierarchical tree from high dimensional binary sequences. As a phylogenetic tree (or evolutionary tree), a mixture tree created from ancestral mixture models involves the inferred evolutionary relationships among various biological species. Moreover, it contains the information of time when the species mutates. The tree comparison metric, an essential issue in bioinformatics, is used to measure the similarity between trees. Since the approach to the comparison between two mixture trees is still unknown, the authors proposed a new metric to measure the similarity of two mixture trees and designed efficient algorithms for computing it.

In [3], the authors proposed graph models and algorithms for social network analysis. In particular, they considered the phenomenon occurring in many political campaigns where social influence is used in order to convince voters to support/oppose a specific candidate/party. In election control via the social influence problem, an attacker tries to find a set of limited influencers to start disseminating a political message in a social network of voters. A voter changes their opinion when they receive and accept the message. In constructive case, the goal is to maximize the number of votes/winners of a target candidate/party, while in the destructive case, the attacker tries to minimize them. Recent works considered the problem in different models and presented some hardness and approximation results. In that paper, the authors considered multi-winner election control through social influence on different graph structures and diffusion models, and the goal was to maximize/minimize the number of winners in our target party. They showed that the problem is hard to approximate when voters' connections form a graph, and the diffusion model is the linear threshold model. They also proved the same result considering an arborescence under independent cascade model. Moreover, they presented a dynamic programming algorithm for the cases that the voting system is a variation of straight-party voting and voters form a tree.

In [4], the authors considered congestion games, a well-known class of noncooperative games that have the capability to model several interesting competitive scenarios while maintaining nice properties. In these games, there is a set of players sharing a set of resources. Each resource has an associated cost function, which depends on the number of players using it (the so-called congestion). Players aim to choose subsets of resources to minimize the sum of resource costs. In particular, the authors introduced multidimensional congestion games, that is, congestion games for which the set of players is partitioned into $d+1$ clusters $C_0, C_1, \ldots, C_d$. Players in C_0 have full information about all of the other participants in the game, while players in C_i, for any $1 \leq i \leq d$, have full information only about the members of $C_0 \cup C_i$ and are unaware of the others. This model has at least two interesting applications: (*i*) it is a special case of graphical congestion games induced by an undirected social knowledge graph with independence number equal to d, and (*ii*) it represents scenarios in which players have a type and the level of competition they experience on a resource depends on their type and on the types of the other players using it. The authors focused on the case in which the cost function associated with each resource is affine and bound to the price of anarchy and stability as a function of d with respect to two meaningful social cost functions and for both weighted and unweighted players. They also provided refined bounds for the special case of $d = 2$ in the presence of unweighted players.

The remaining two papers addressed typical problems in algorithmic graph theory. In [5], the authors studied the maximum-clique independence problem and some variations of the clique transversal problem such as the $\{k\}$-clique, maximum-clique, minus clique, signed clique, and k-fold clique transversal problems from algorithmic aspects for k-trees, suns, planar graphs, doubly chordal graphs, clique perfect graphs, total graphs, split graphs, line graphs, and dually chordal graphs. They gave equations to compute the $\{k\}$-clique, minus clique, signed clique, and k-fold clique transversal numbers for suns and showed that the $\{k\}$-clique transversal problem is polynomial-time solvable for graphs in which the clique transversal numbers equal their clique independence numbers. They also showed the relationship between the signed and generalization clique problems and presented NP-completeness results for the considered problems on k-trees with unbounded k, planar graphs, doubly chordal graphs, total graphs, split graphs, line graphs, and dually chordal graphs.

Finally, in [6], the class of k-distance-hereditary graphs was studied. The considered graphs have nice properties for which the distance in each connected induced subgraph is at most k times the distance in the whole graph. The defined graphs represent a generalization of the well-known distance-hereditary graphs, which actually correspond to 1-distance-hereditary graphs. This paper provides characterizations for the class of all k-distance-hereditary graphs such that $k < 2$. The new characterizations are given in terms of both forbidden subgraphs and cycle-chord properties. Such results also lead to devising a polynomial-time recognition algorithm for this type of graph that, according to the provided characterizations, simply detects the presence of quasi-holes in any given graph.

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