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Preface to Special Issue on Theory and Applications of Graph Searching

This special issue of *Theoretical Computer Science* contains papers selected from, but not limited to work presented in the *10th International Workshop on Graph Searching: Theory and Algorithms* (GRASTA 2022), which took place in Porquerolles, France from May 16 to May 20, 2022. This workshop series has established itself as the main forum on the field of Graph Searching, with a wide participation of researchers in several disciplines in Computer Science, Mathematics, and Operations Research.

In a graph searching game, a number of hiding entities that are sometimes called evaders, or fugitives, or hidiers (depending on the application) hide in a domain that can be represented as a graph or a network. A number of seeking entities called searchers or pursuers aim to locate the evaders. In this context, the searchers aim to locate the evaders as efficiently as possible, where the concept of efficiency depends on the specific setting. Several variants of this fundamental game can be defined depending on the characteristics of the evaders and the searchers in terms of parameters such as the relative speed, visibility, sensor capabilities, etc.

Graph searching provides a rigorous framework for modeling concepts such as hiding, pursuing, sense of direction, collaboration and coalition formation. Graph searching thus provides the tools to model real-life activities such as search-and-rescue operations, coal mining, or motion planning in robotics. The field has several applications in the domains of Artificial Intelligence, and Operations Research. Equally important, it is driven by foundational issues rooted in Complexity Theory, Graph Theory, Analysis of Algorithms, and Discrete Mathematics.

This Special Issue received 5 submissions in total. All submissions were reviewed according to the highest standards of *Theoretical Computer Science*, and the Editorial Team ensured that the submissions were reviewed in a

timely manner, and all final decisions were made within 17 months from the submission deadline. The selected papers cover a wide range of topics such as search and rescue games, searching with unreliable detection, parameterized complexity of graphs searching, visibility parameters in searching, and cops and robbers games. A more detailed description of the accepted papers is as follows.

- The paper “The Search and Rescue Game on a Cycle” by Lidbetter and Xie studies a type of search game in which a target or targets hidden on a graph must be located by a Searcher who faces some sort of danger in the searching process. Namely, when any given vertex of the graph is searched, there is a certain probability that the search will come to an end, otherwise with the complementary success probability the search can continue. The objective for the Searcher is to find all targets with maximum probability, and the focus is on cycle graphs. In the case that there is only one target, the work solves the game for equal success probabilities, and for a class of games with unequal success probabilities. For multiple targets and equal success probabilities, it gives a solution for an adaptive Searcher and a solution in a special case for a non-adaptive Searcher. It also considers a continuous version of the model, giving a full solution for an adaptive Searcher and approximately optimal solutions in the nonadaptive case.
- In the paper “Search For Home in Networks with Unreliable Directions: The Faulty Satnav (GPS) Problem”, Alpern studies a search problem with unreliable advice. A Searcher wants to find the Home node on a given network Q , a Satnav (GPS) points to the arc leading to the destination, or home node, H , but only with a high known probability p . The pointer is fixed in time, so does not change when a node is revisited. If one wishes to reach H in least expected time, with what probability $q = q(Q, p)$ should one trust the pointer (if not, one chooses randomly among the other arcs)? The work also consider versions where the trust probability q can depend on the degree of the current node and a ‘treasure hunt’ where two searchers try to reach H first. The agent searching for H need not be a car, that is just a familiar example – it could equally be a UAV receiving unreliable GPS information.
- In their paper “A graph searching game for block treedepth and a cubic

kernel by vertex cover”, Giannopoulou and Mavropoulos consider the block elimination distance, which is a graph parameter that measures the distance of the biconnected components of a graph from a given class. When the indicated graph class is the class of edgeless graphs, the parameter is called block treedepth. This work introduces a vertex and an edge coloring that can serve as alternative definitions for block treedepth. Moreover, it makes a connection between block treedepth and graph searching games by introducing two versions of the cops and robbers game and a min-max theorem for the block treedepth of a graph. Finally, the paper shows that the Block Treedepth problem has a cubic kernel when parameterized by vertex cover number.

- In the paper “The one-visibility Localization game”, Bonato introduces a variant of the Localization game in which the cops only have visibility one, along with the corresponding optimization parameter, the one-visibility localization number ζ_1 . By developing lower bounds using isoperimetric inequalities, the work gives upper and lower bounds for ζ_1 on k -ary trees with $k \geq 2$ that differ by a multiplicative constant, showing that the parameter is unbounded on k -ary trees. It provides a $O(\sqrt{n})$ bound for K_h -minor free graphs of order n , and shows that Cartesian grids meet this bound by determining their one-visibility localization number up to four values. Last, the paper gives upper bounds on ζ_1 using pathwidth and the domination number, and upper bounds on trees via their depth and order.
- The paper “Tipsy cop and tipsy robber: collisions of biased random walks on graphs” by Harris, Insko and Lehner studies a variant of the cop and robber game on graphs in which the robber simply moves randomly along the graph, while the cop moves directed towards the robber some fixed proportion of the time and randomly the remainder. The article adopts a slightly different interpretation of tipsiness of the cop and robber where one assumes that in any round of the game there are four possible outcomes: a sober cop move, a sober robber move, a tipsy (uniformly random) move by the cop, and a tipsy (uniformly random) move by the robber. The work studies this tipsy cop and tipsy robber game on the infinite grid graph and on certain families of infinite trees including δ -regular trees and δ -regular trees rooted to a Δ -regular tree, where $\Delta \geq \delta$. The main results analyze strategies for the cop and

robber on these graphs.

We are hopeful that the papers selected for this Special Issue will motivate further advances in the exciting field of Graph Searching.

Guest Editors

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