Generalizations of Binary Search: Finding a Target in Partially Ordered Sets

Internship Proposal (2016)

Adrian Kosowski
Institut de Recherche en Informatique Fondamentale (IRIF), Paris
kosowski@liafa.univ-paris-diderot.fr

Research context. The extension of the binary search technique beyond sorted arrays and totally ordered sets is motivated by numerous applications, mostly focused around database query optimization and design of balanced data structures. Such extensions take into account the non-linear organization of data, e.g., in the form of a tree or an even more general partial order (represented as a poset). When the data is represented as a tree T, the simplest type of considered search query asks about a chosen edge e of T, and returns as a reply the connected component of $T \setminus \{e\}$ which contains the node representing the search target [4]. The main research challenge concerns the design of an optimal or near-optimal search strategy for a given instance of the data structure. The computational flavor of the problem depends on the exact type of considered search query, the cost of performing a query to specific edges, and the relative frequency of search targets in the node set of the graph. The studied problems can be perceived as a form of adaptive scheduling task, but also have equivalent formulation so-called ranking problems in graph theory [3]. Some scenarios of search strategy design (such as the uniform-cost tree case and the nonuniform-cost total order case) admit surprisingly elegant polynomial-time algorithms, others (such as the nonuniform-cost case of trees and the uniform cost case of posets) are NP-hard and sometimes hard to approximate [1, 2, 3].

Objectives. This internship is intended to focus on a theoretical study of variants of the search strategy design problem.

In the course of the internship, we expect the student to familiarize themselves with the state-of-the-art on search strategies in partial orders. Depending on the progress of our research discussions, we will then proceed to address one (or more) research questions, such as:

- Obtaining better approximation algorithms for search in classes of weighted trees, under different cost measures.
- Studying the complexity of the search problem in an advice model (e.g., given an oracle with partial information about the location of target).
- Establishing connections between the search problem and questions of search and exploration in agent-based models of distributed computing.
- Simulation and experiments on random search problem instances.

We also provide the student with the opportunity to integrate with the scientific environment of the LIAFA/IRIF, to participate in seminars held at the institute, take part in workshops, etc.

Skills. During the internship, we will rely on knowledge of concepts in the areas of algorithm design and analysis, graph theory, data structures, and distributed algorithms. In the course of the internship, we expect the student to develop their skills in these areas.

References

[1] R. Carmo, J. Donadelli, Y. Kohayakawa, and E. Laber: Searching in random partially ordered sets. Theoretical Computer Science, 321: 41–57, 2004.

[2] F. Cicalese, T. Jacobs, E. Labe, M, Molinaro: On the complexity of searching in trees and partially ordered structures Theoretical Computer Science, 412: 6879–6896, 2011. (also Proc. ICALP'10.)

[3] D. Dereniowski: Edge ranking of weighted trees. Discrete Applied Mathematics, 154: 1198–1209, 2006.

[4] K. Onak, P. Parys: Generalization of Binary Search: Searching in Trees and Forest-Like Partial Orders. FOCS 2006: 379-388