On the k shortest simple paths : A faster algorithm with low memory consumption

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The classical k shortest simple paths problem ($kSSP$) returns top-k shortest simple paths between a pair of source and destination nodes in a graph. This problem has numerous applications in various kinds of networks (road, transportation and social networks, etc.) and is also used as a building block for solving optimization problems.

Let $D = (V, A)$ be a digraph with n vertices and m arcs, we define an s, t directed simple path as a sequence of vertices $s = v_1, v_2, \cdots, v_l = t$ s.t. $v_i \in V$, $(v_i, v_{i+1}) \in A$ for all $1 \leq i < l$ and $v_i \neq v_j$ for all $0 \leq i < j \leq l$. Yen's algorithm [1] is the algorithm with the best known time complexity for solving the $kSSP$ problem, that is $O(kn(m + n \log n))$. Since then, the problem has been widely studied from an algorithm engineering perspective, and impressive improvements have been achieved.

The current fastest algorithm solving the $kSSP$ is the *Sidetracks-Based* (SB) algorithm proposed by Kurz and Mutzel (2016) [2] followed by an improvement of Al Zoobi et al. [4]. The major issue of the SB algorithm is its big memory consumption. Considering low working memory, the fastest algorithm solving the $kSSP$ problem is the *Node-Classification* (NC) algorithm proposed by Feng (2014) [3]. Here, we propose a new algorithm called *Postponed Node-Classification* (PNC) to solve the $kSSP$ with a small working memory. We did experiments on some road networks of the 9th DIMAC's challenge and our computational results show an average speed up by a factor of 2 to 6 with a similar working memory consumption as NC.

Références

[1] Yen, J. Y. "An algorithm for finding shortest routes from all source nodes to a given destination in general networks." Quarterly of Applied Mathematics 27.4 (1970).

[2] Kurz, Denis, and Petra Mutzel. "A Sidetrack-Based Algorithm for Finding the k Shortest Simple Paths in a Directed Graph." (ISAAC 2016).

[3] Feng, Gang. "Finding k shortest simple paths in directed graphs : A node classification algorithm." Networks 64.1 (2014) : 6-17.

[4] Al Zoobi, Ali, David Coudert, and Nicolas Nisse. "Space and time trade-off for the k shortest simple paths problem."(SEA 2020).