Improved Distance Oracles for Avoiding Link-Failure*

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Abstract

We consider the problem of preprocessing an edge-weighted directed graph to answer queries that ask for the shortest path from any given vertex to another avoiding a failed link. We present two algorithms that improve on earlier results for this problem. Our first algorithm, which is a modification of an earlier method, improves the query time to a constant while maintaining the earlier bounds for preprocessing time and space. Our second result is a new algorithm whose preprocessing time is considerably faster than earlier results and whose query time and space are worse by no more than a logarithmic factor.

1 Introduction

Given an edge-weighted directed graph $G = (V, E, w)$, where w is a weight function on E, the *distance sensitivity problem* asks for the construction of a data structure called the *distance sensitivity oracle* that supports any sequence of the following two queries:

- distance(x, y, u, v): return the shortest distance from vertex x to vertex y in G avoiding the edge (u, v).
- path(x, y, u, v): return the shortest path from vertex x to vertex y in G avoiding the edge (u, v).

This problem as formulated above was first addressed by Demetrescu and Thorup in [DT02] for directed graphs with nonnegative real valued edge weights. In an earlier paper, King and Sagert [KS99] addressed a variant of this problem related to reachability in directed acyclic graphs.

As in [DT02], in this paper we concentrate on answering distance queries in digraphs with nonnegative real valued edge weights under the failure of a single link. The goal is to preprocess the graph in order to answer distance queries quickly when a link failure is detected. It is assumed that the time gap between two successive link failures is long enough to permit us to compute a new data structure in the background that will assist us in answering distance queries when the next link failure is detected.

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