Approximate Shortest Journeys in Compact Directed Temporal Graphs

Siu-Wing Cheng* Zhimeng Gao†

February 13, 2026

Abstract

Many systems with time-dependent connections can be modelled using a compact directed temporal graph. In such a graph, every edge e stores a set of disjoint time intervals in which e is available; each interval I specifies the duration and cost of traversing e during I. A journey visits a sequence of vertices in a way compatible with the intervals on the edges traversed. The cost of a journey is the sum of the costs of the intervals used. The shortest journey problem seeks a journey with the minimum cost that starts from one vertex and reaches another by some deadline. The problem is known to be NP-hard. We propose the first $(1+\varepsilon)$-approximation results. For a fixed source and $\varepsilon \in (0,1)$, we show how to construct a data structure that answers $(1+\varepsilon)$-approximate shortest journey queries in $O(\log \frac{\Delta}{\varepsilon})$ time, where Δ is the total number of intervals on the edges. In the static case where the source, destination, start time, and deadline are given, we present a $(1+\varepsilon)$-approximate shortest journey algorithm that is more efficient than the preprocessing of the query data structure.

*Department of Computer Science and Engineering, HKUST, Hong Kong. Email: scheng@cse.ust.hk.
†School of Computer Science, Georgia Tech, USA. Email: zhimeng@gatech.edu.