Urban Travel Time Estimation from Sparse GPS Data

An Efficient and Scalable Approach

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Abstract

The use of GPS probes in traffic management is growing rapidly as the required data collection infrastructure is increasingly in place, with significant number of mobile sensors moving around covering expansive areas of the road network. Many travelers carry with them at least one device with a built-in GPS receiver. Furthermore, vehicles are becoming more and more location aware. Vehicles in commercial fleets are now routinely equipped with GPS.

Travel time is important information for various actors of a transport system, ranging from city planning, to day to day traffic management, to individual travelers. They all make decisions based on average travel time or variability of travel time among other factors.

AVI (Automatic Vehicle Identification) systems have been commonly used for collecting point-to-point travel time data. Floating car data (FCD) - timestamped locations of moving vehicles- have shown potential for travel time estimation. Some advantages of FCD compared to stationary AVI systems are that they have no single point of failure and they have better network coverage. Furthermore, the availability of opportunistic sensors, such as GPS, makes the data collection infrastructure relatively convenient to deploy.

Currently, systems that collect FCD are designed to transmit data in a limited form and relatively infrequently due to the cost of data transmission. Thus, reported locations are far apart in time and space, for example with 2 minutes gaps. For sparse FCD to be useful for transport applications, it is required that the corresponding probes be matched to the underlying digital road network. Matching such data to the network is challenging.

This thesis makes the following contributions: (i) a map-matching and path inference algorithm, (ii) a method for route travel time estimation, (iii) a fixed point approach for joint path inference and travel time estimation, and (iv) a method for fusion of FCD with data from automatic number plate recognition. In all methods, scalability and overall computational efficiency are considered among design requirements.

Throughout the thesis, the methods are used to process FCD from 1500 taxis in Stockholm City. Prior to this work, the data had been ignored because of its low frequency and minimal information. The proposed methods proved that the data can be processed and transformed into useful traffic information. Finally, the thesis implements the main components of an experimental ITS laboratory, called iMobility Lab. It is designed to explore GPS and other emerging data sources for traffic monitoring and control. Processes are developed to be computationally efficient, scalable, and to support real time applications with large data sets through a proposed distributed implementation.

Keywords
map-matching, path inference, sparse GPS probes, floating car data, arterial, urban area, digital road network, iterative travel time estimation, fixed point problem, Stockholm, taxi