Vehicular Mobility Modeling At large-scale: An Approach to Combine Stationary Sensing and Mobile Sensing

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Abstract

Real-time mobility is important for many real-world applications, e.g., transportation, urban planning, given different level administrative jurisdiction. However, most of the existing work focuses at small scale with limited data samples (e.g. region or city level with samples over all the taxis). Recently, with upgrades of transportation infrastructures, we have new opportunities to capture real-time mobility at a larger scale. With emerging of multiple sensors e.g., traffic cameras, toll systems, traffic loop sensors and GPS equipped vehicle fleets, we have unprecedented opportunities to capture real-time state-level mobility. In this dissertation, we analyze the challenges and opportunities for mobility modeling at large scale and design a mobility prediction model called StateFlow to capture real-time intracity and intercity vehicular mobility. In particular, StateFlow is based on (i) a stationary sensor network capturing aggregated mobility at the highway toll station level; (ii) a mobile sensor network capturing individual mobility at the local grid level. The key novelty of StateFlow is in its two-level structure where we investigate the correlation between highway station-level mobility and grid-level mobility for fine-grained mobility modeling. With multiple models built upon the two-level structure, we address ii a key intellectual challenge of sensing heterogeneity in terms of spatiotemporal granularity. In station level, we use Bayesian Inference to predict the exit stations based on vehicle historical travel records including when and where they enter the highways and use K-Nearest Neighbors to predict the travel time between two stations considering both real-time including real-time traffic condition and weather condition and historical information including personal driving habits. In grid level, we build a random-based model to predict vehicle final destinations based on personalized features and crowd features. Based on this two-level prediction, we can track individual vehicles from entering the highways to arriving the final destinations. More importantly, we implement StateFlow in Guangdong

Province, China with (i) an electric toll collection system with tracking devices at 1439 highway entrances and exits in Guangdong, functioning as a stationary sensing part of StateFlow; (ii) a vehicle fleet system consisting of both commercial logistics truck and private vehicles in Guangdong with in total 114 thousand GPS-equipped vehicles, functioning as a mobile sensing part of StateFlow. We compared StateFlow with the two benchmark mobility models based on our data, and the experimental results show that StateFlow outperforms others in terms of accuracy.

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