Towards Better Urban Travel Time Estimates Using Street Network Centrality

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Extended Abstract

Accurate vehicle travel times are a prerequisite for many applications in the mobility domain as well as applications which are interested in effects of reachability. This paper describes a novel approach to estimate travel times and their diurnal variation in urban street networks which uses only static map attributes and centrality measures extending the work presented in Leodolter et al. (2015). The method provides a low-cost alternative to expensive travel time measurement campaigns. By integrating closeness and betweenness centrality measures, the model is expanded to take advantage of previously neglected spatial information.

Centrality measures have been used, for example, to study city structure (Crucitti et al. 2006) or explain land use intensity (Wang et al. 2011), and retail and service activity (Porta et al. 2009). In the context of motorized traffic, betweenness centrality has been used as an indicator to predict traffic flows. For example, Jiang (2009) shows that street hierarchies derived from street length, connectivity, and betweenness are a good indicator for traffic flow. Puzis et al. (2013) present a betweenness-driven traffic assignment model which can take into account travel demand and model travel times. Similarly, Gao et al. (2013) combine betweenness with travel demand data and geographical constraints to predict traffic flow. To the best of our knowledge, there is no work so far which uses centrality measures to model travel times and their diurnal variation. Our model predicts vehicle travel times for a given time of day in 15 minute intervals.

We use one year's worth of floating car data (FCD) from about 3,500 taxis, a street network from OpenStreetMap for Vienna, Austria and the Ordinary Least Square linear regression model for estimating travel times presented in Leodolter et al. (in press). This model is extended to include closeness and betweenness centrality measures to addresses shortcomings of the original approach which ignores spatial network aspects. Centrality measures

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are modeled separately by functional road classes (FRC) and calculated using geometric distances for the shortest path.

Based on the estimated model coefficients, the following conclusions can be made: (1) The highest speed estimate increase is observed for important (in terms of betweenness centrality) network links at the periphery. (2) The closer a link is to the network center, the less its speed estimate depends on the betweenness. (3) The relationship of betweenness and closeness respectively, and the speed estimate highly depends on the FRC.

First results show that including centrality in the model reduces the error (RMSE between mean FCD speeds and model predictions per 15 minute interval) by about 8 percent for the whole network or 20 percent for the central city districts. Improvements can be observed especially for important network links in the city center – such as arterials and bridges – as well as rural roads at the periphery. However, for some links the extended model performs worse, probably due to misleading betweenness values. To deal with this problem, we plan to recalculate betweenness based on travel time and implement local centrality which reduces the distortion that lowers centrality values near the edge of a network. This should furthermore enable us to identify multiple centers in a network such as smaller towns surrounding the main city.

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