Regional Route Choice Behaviour in Large-Scale Urban Networks

Extended Abstract for hEART, Copenhagen

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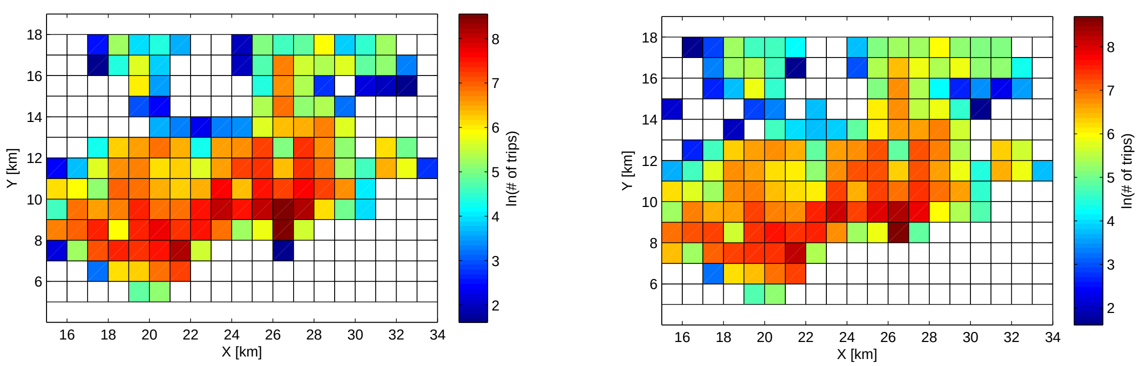
To develop macro-level traffic management strategies, a large scale traffic modeling is essential. A homogeneous urban region (with small spatial link density heterogeneity) can be modeled with macroscopic fundamental diagram (MFD), which provides a unimodal, low-scatter, and demand-insensitive relationship between network vehicle density and space-mean flow (1). Real-time coordinated traffic management strategies (e.g. perimeter control, gating) that benefit from parsimonious models with aggregated network dynamics, provide promising results towards a new generation of smart hierarchical strategies to improve network capacity and performance. However, this raises the question of route choice behavior in case of heterogeneous urban networks, where different parts of the city are subject to different types of control. Yildirimoglu and Geroliminis (*2*) develops a traffic assignment model that establishes equilibrium conditions in multi-region urban networks with MFD dynamics. Considering the aggregated representation in MFD, this model defines alternative regional paths (i.e. sequence of urban regions modeled with MFD), and associates its attributes with the properties of shortest sequence of links that goes through these regions. This paper conducts further analysis with real data to shed light on this phenomenon.

Route choice (RC) models concern the choice of path between origin and destination points given a transportation network with certain traffic conditions. Path or route is conventionally represented by the sequence of links in a connected network graph. Although most of the simulation models capture RC effect through repeated implementation of shortest path algorithms, the poor behavioral realism of shortest path assumption motivates the researchers to exploit more sophisticated approaches such as discrete choice models.

Transportation networks, by design, consist of urban motorways, expressways, large arterials, local streets, etc. In this work, we scrutinize a route choice model to address how drivers select routes in this hierarchical framework. Normally, long trips are expected to be bound to higher category roads, while short trips may use the local, finer-meshed network that can be continuously approximated. We replace conventional link-level paths with regional paths (e.g. going through the city center or using the expressway at the periphery). This key feature of the framework allows us to build a behaviorally more realistic model, reduce the complexity and understand the mobility patterns in large-scale networks with multi-level hierarchy. In this work, we claim that link-level path is the result of RC decision taken at a higher level. While strategic RC decision tackles the use of certain parts of the network (e.g. city center, a highway or a neighborhood), link-level path results from the way the traveler implements his/her strategic decision. In addition, link-level paths may be correlated even though they do not physically overlap. *For instance, two paths going through the city center may share unobserved attributes, even if they do not share any link.* (3). In this context, the aim of this paper is to develop a RC model which replicates the strategic decision taken by the travelers and tackles the problem of correlated attributes through aggregated urban regions.

We utilize GPS data from taxis in a fast growing Chinese mega-city; Shenzhen. The dataset consists of trips on the same day from 13000 taxis equipped with a GPS sensor that stores the location of the taxi every 10-40 seconds. For every GPS point, it is also known whether the taxi carries a passenger or not, which allows us to distinguish between trips with and without passengers. Assuming that taxi passengers follow routes similar to regular cars in the network, we only focus on taxi trips with passengers. In order to exploit diversity of RC decision, we employ trips longer than 5 km here.

To organize the dataset, we create arbitraty 1x1 km cells, and aggregate the trips that start and end within the cells. Figure 1 introduce the contour plots for starting and ending trips; the number of trips that start and end in each cell. Although start and end points of trips concentrate in a rather small area, almost all regions have significant amount of trip production and generation. Note that the trips that start and end outside the network presented in Figure 1 are not considered in this analysis.

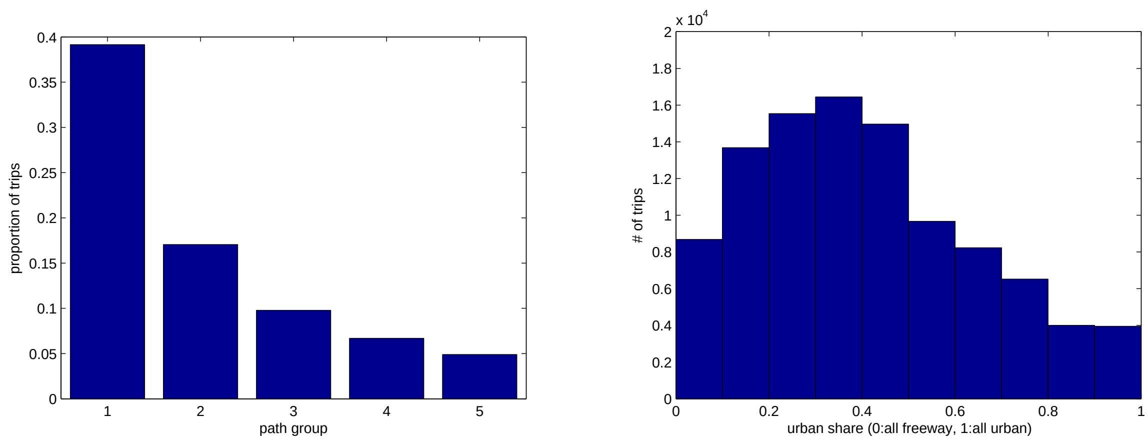


(a) (b)

FIGURE 1: (a) Origin flows, (b) destination flows

In order to show the significance of RC behavior in the regional context, we track vehicle trajectories and build a regional path library. This allows us to observe all the regional paths chosen by drivers. Note that a path between a regional origin-destination pair consists of all the regions (i.e. 1x1 km) where there is at least one GPS observation. We also compute the frequency of each regional path; i.e. how many times a particular regional path is repeated by vehicles that travel between the same origin-destination pair. We then sort the paths with respect to the use of them, and assign the most frequent path in all OD pairs to path group 1, second most frequent path to path group 2, and so on. Figure 2(a) presents the distribution of trips among 5 most frequent path groups. Note that number of alternative paths for an OD pair can be more or less than 5. If there are only 2 alternative paths for an OD pair, they only contribute to the first 2 path groups presented in Figure 2(a). This analysis reveals that RC at the regional context is still valid; travelers make different strategic decisions. This property should be further investigated with respect to time of day and traffic conditions. More detailed results will be included in the final version of the paper.

Intuitively, it is known that travelers tend to use freeways (if available) because of its uninterrupted nature in order to cross a long distance in an urban environment. In this context, we develop a RC model that respects the hierarchy of roads and assigns distinct attributes to each level in the hierarchy. For each trip in our dataset, we define an urban share parameter that provides the percentage of GPS signals map-matched with urban links. In other words, an urban share parameter close to 0 represents a trip mostly done on the freeway, while a parameter close to 1 indicates a trip that solely crosses urban links. Figure 2(b) depicts the distribution of urban share parameter among the trips. Although it presents a right-skewed distribution (i.e. most of the trips are done on the freeway), a significant part of trips is still done in the urban context which we plan to further exploit with a RC model.



(a) (b)

FIGURE 2: (a) Distribution of most frequent paths, (b) distribution of urban share

Two main components are defined for RC model; (i) the choice set, the alternative regional paths that travelers can choose, and (ii) the attributes of the available alternatives (e.g. MFD properties in urban regions, length in freeways). First, the aggregation of urban regions allows us to avoid impractical link-level choice set generation step. As the number of alternative regional paths is significantly smaller than link-level paths, we expect the observed path library to cover all alternatives that need to be found in a choice set. Second, attributes of alternatives are defined with respect to the hierarchy level of roads. In this work, attributes of urban regions are based on MFD features, while attributes of the freeway network may be based on an elegant travel time estimation model and trip length to cross. The estimation of the RC model could be accomplished by maximum likelihood estimation technique and a logit or a more advanced discrete choice model.

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