People don’t use the shortest path

Shanjiang Zhu∗    David Levinson†

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Abstract

Keywords:

1 Introduction

Route choice analysis investigates the path travelers follow to implement their travel plan. It is the most frequent, and thus arguably the most important decisions travelers make on a daily basis (empirical studies have shown that route and schedule changes are the most dominant reactions to network changes (Cairnes S. and Goodwin, 2002; Giuliano and Golob, 1998)). Any sound arguments for infrastructure initiatives or policy changes must be built on precise and reliable prediction of link flow, and thus on underlying route choice decisions. Travelers differ in attributes (value of time (VOT), willingness to pay, time budgets, etc.), behavioral preferences (e.g. willingness to take risk, willingness to switch routes with potential savings) experience, and knowledge about travel, all of which could lead to significant heterogeneity in route choice behavior. Mainstream research and practice, however, has treated trips as the units of analysis since the 1950s. This trip-based modeling paradigm assumes homogenous route users and only investigates the equilibrium state, in which “the journey times in all routes actually used are equal and less than those which would be experienced by a single vehicle on any unused route” (known as Wardrop’s first principle (Wardrop, 1952)). Some researchers addressed the concern about heterogeneity by introducing a random perception error in travel time and proposed the Stochastic User Equilibrium model (Daganzo and Sheffi, 1977). This shortest-path (usually in travel time) assumption and the resulting aggregate equilibrium approach (UE or SUE) has been adopted over the fast few decades because of its simplicity. Although the insufficiency of this modeling paradigm has been frequently pointed out in the literature, empirical

∗University of Minnesota, Department of Civil Engineering, 500 Pillsbury Drive SE, Minneapolis, MN 55455 USA zhuxx120@umn.edu http://nexus.umn.edu
†dlevinson@umn.edu

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studies on the validity of this assumption are very limited, partially due to the difficulty in obtaining real route travel time in the field. Therefore, this study will investigate the route choice behavior and evaluate the gap between the shortest-path assumption and route decisions observed in the field. This study differs from previous literature by evaluating travel time on alternative routes on a real metropolitan network (Minneapolis-St. Paul, Minnesota, USA) and by considering the impacts of travel time variance. Longitudinal observations of travel time are provided by in-vehicle GPS units and loop detector monitoring system. Findings from this study could advance our understanding of route choice behavior and inform travel demand modeling.

2 Literature review

There have been significant literature on individual route choice criteria. Goodwin (1977) argues travelers follow habitual routes most of the time and do not carefully and deliberately evaluate their choices. Researchers such as Srinivasan and Mahmassani (2003) investigated the impacts of traffic information and ATIS. Other researchers (Tversky and Simonson, 1993; Zhang et al., 2004) emphasized the role of spatial knowledge and learning process in route choice decisions. Travel time reliability is also frequently cited as one of the most important factor in route choice (e.g. (Avineri and Prashker, 2004; de Palma and Picard, 2005; Small et al., 2005)). Chen et al. (2001); Bekhor et al. (2006) provided a review of route choice criteria proposed in the literature. However, most of these studies are based on stated preferences and provide limited insight on the validity of shortest-path assumption. Instead, Li et al. (2005) used GPS data to investigated the likelihood for commuters to use multiple commute routes. Morikawa et al. (2005) investigated GPS data from 1500 taxis in Nagoya, Japan during two months. They found a high percentage of trips employed non-shortest path and they concluded that this phenomenon is due to the lack of knowledge either in network connectivity or travel time reliability. However, observations in this study lack internal consistency because they had no control on decision makers (taxi riders), which compromised the significance of their findings.

3 Methodology and preliminary conclusions

This study evaluates travelers day-to-day route choice revealed by GPS data during an 8-week study for over 150 subjects in a period in Fall 2008. Route travel time is monitored by GPS data and supplemented by loop detector observations. These data are merged with digitized maps, which helps to reveal travel time on alternative routes. Variance in travel time is captured through longitudinal observations and is used to model travel time uncertainty perceived by travelers.

This abstract presents preliminary results obtained from a hand-out, mail-in
survey conducted by the University of Minnesota, after the collapse of I-35W Mississippi River Bridge in the Twin Cities, Minnesota in September 2007. Four identical maps of the surface road network in the Twin Cities were included in the survey and respondents were asked to draw their commute route during four time periods: before the I-35W bridge collapse, the second day after the bridge collapse, several weeks later, and late September. Loop detector data was well documented by the Minnesota Department of Transportation (MnDOT), which provides traffic conditions travelers actually experienced. Average travel time of 15 minutes intervals on freeway system during 7:00 am to 8:00 am was collected and matched with the regional planning agency (Metropolitan Council) planning network. Arterial travel time is estimated directly from the Metropolitan Council planning network due to lack of field data. Average route travel time during July and September is reconstructed by using the route information provided by respondents. This travel time should briefly capture the actual travel time experienced by travelers each day during the study period since the freeway travel time represents the majority of commute time for most respondents. We investigate whether the shortest path (in travel time) assumptions hold when traffic is stable (i.e. July and September in this case). We compared the shortest path according to measured travel time and the actually route chosen. Only 18 out of 59 respondents chose the shortest path consistent with that computed on the planning network before the bridge collapse (see Figure 1 for example) and 8 out of 37 respondents chose the shortest path after the bridge collapse.

If we consider the variance in travel time and evaluate the shortest path based on a random set of link travel time, following the mean and variance observed in the field, choices by 29 out of 59 respondents are predicted at least once by the shortest algorithm in a 10 round random draw of link travel time in July. In September, the hit ratio was 4 out of 18 respondents. The low hit ratio in September may be due to the lack of sufficient information about the network after the bridge collapse.

According to the preliminary results, travel time alone is insufficient to fully capture route choice behavior, even after considering the perception error introduced by day-to-day variance in travel time. However, more samples are needed to draw convincing conclusions. And the upcoming GPS data could help to reveal the extent of those sub-optimal route decisions in terms of travel time and their impacts on travel demand modeling, and help provide better estimates of travel times on alternative routes. Those results will be documented in the final paper.

References


Figure 1: An example of routes reported by respondents (in red) and predicted by shortest path algorithm (in blue)