Route choice calibration from multi-point vehicle stream measurements

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ABSTRACT

To better und more precisely assess different transportation design alternatives and traffic management strategies, microscopic traffic simulation models are extensively applied. The respective calibration and validation works are getting more and more important. Nowadays, GPS-based systems are broadly applied. More and more route related information can be collected, which promises great improvements of calibration accuracy. An approach using multi-point vehicle stream measurements is proposed in this paper and is shown to work well in synthetic experiments.

Keywords: *route choice, vehicle reidentification, traffic simulation SUMO, CADYTS*

INTRODUCTION

To better und more precisely assess different transportation design alternatives and traffic management strategies, microscopic traffic simulation models are extensively applied. The accurate replication of individual vehicle movements and the respective traffic demands and route choices in a microscopic simulation is crucial for such an assessment.

Nowadays, GPS-based systems are broadly applied. More and more traffic related raw data becomes available, particularly vehicular trajectory data. For example, vehicular trajectory data is available from around 4300 taxis and 2700 taxis every 30 seconds in Berlin and Munich, respectively. Moreover, toll systems are getting increasingly adopted on highways and in environmentally aware metropolitan regions. The data collected by these systems can be immediately applied for calibration purposes as well.

APPROACH

The proposed approach is based on a recent Bayesian demand estimation methodology, which is published elsewhere [5]. Essentially, the traffic simulation itself generates draws from a prior distribution of route choices, which by the calibration is adjusted such that it turns into the posterior distribution given all available sensor data.

In this work, the existing approach is applied to re-identified vehicle streams, which requires specifying an according log-likelihood function. A re-identified vehicle stream is a set of vehicles that all have been observed at one or more given sensor locations within pre-specified time intervals.

Assuming the size of such a stream to be normally distributed, the following log-likelihood function results:

$$L(\mathbf{y} \mid \mathbf{d}) = -\sum_{m=1}^{M} \frac{(y_m - \eta \cdot q_m(\mathbf{d}))^2}{2\sigma_m^2} \qquad (1)$$

where

$m = 1 \ldots M$ is the vehicle stream index (sequence of sensor locations and observation time windows per sensor location); the total number of considered streams is M;

y_m is the observed size of vehicle stream m; the respective vector is $\mathbf{y}$;

η is the detection rate, $0 < \eta \leq 1$;

$q_m(\mathbf{d})$ is the simulated size of vehicle stream m given the route flow vector $\mathbf{d}$;

δ_m^2 is the variance of the observation error of stream m; it is defined as $y_m(1-\eta)+\eta^2 \cdot z$ with z > 0; this expression will be derived in the full article.

COUPLING OF SUMO AND CADYTS

To verify the proposed approach, the microscopic traffic simulation tool SUMO [1] and the calibration tool Cadyts are applied. The proposed method is implemented in the freely available Cadyts code [2, 3]. The coupling of SUMO and Cadyts is described in the following.

First, SUMO generates equilibrated route alternatives in the typical manner of an iterated DTA microsimulation. Cadyts then reads these alternatives and their choice probabilities from file, internally adjusts the choice probabilities such that they are consistent with the data, and then samples routes to be executed in the SUMO network flow simulation. In each iteration, SUMO executes the selected routes in the network and updates link travel times and network flows, which will be used by Cadyts in the next iteration. The respective calibration loop is indicated in Fig. 1.

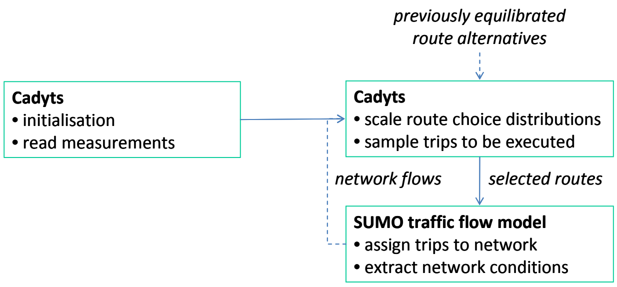

Fig. 1: Calibration process with use of Cadyts and SUMO.

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EXPREMENTAL RESULTS

A synthetic network deployed with four sensors is shown in Fig. 2. Six sets of synthetic observations of link sequences with a traffic demand of 1500 veh/h and different detection rates, of 10%, 30%, 50% 70%, 90% and 95%, are generated and used as measurements. The respective traffic flows on the links without sensors, i.e. 1to2, 1to4, 3to2 and 3to4, are used for evaluation.

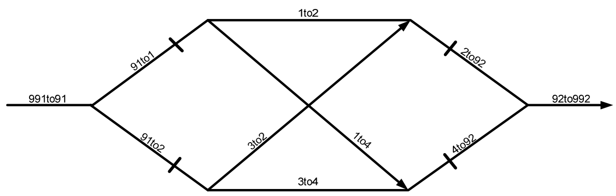

Fig. 2: **Test scenario. Traffic flows from the very left to the very right along four possible routes. The four short bars represent vehicle re-identification sensors.**

EXPERIMENT 1

In this experiment, a total demand of 1500 veh/h is simulated, which corresponds to total demand level from which the synthetic measurements were generated. Fig. 3 shows that relative errors between the detected and the calibrated flows reduce significantly with the increase in the equipment rate.

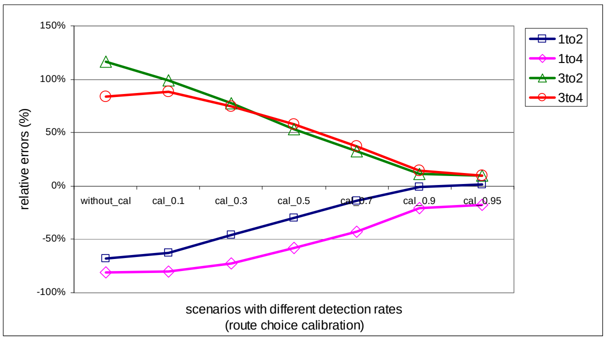

Fig. 3: **Relation errors of the route choice calibration with different detection rates.**

EXPERIMENT 2

In experiment 2, an initial traffic demand of 1000 veh/h is adapted, which is less than the 1500 veh/h from which the synthetic measurements are generated. The intention here is to check if the proposed method is also able to calibrate total demand levels, i.e., origin/destination matrix information. The result of this experiment, shown in Fig. 4, has a comparable tendency of improvement as experiment 1 in that an almost perfect fit is obtained as the detection rate of vehicles increases.

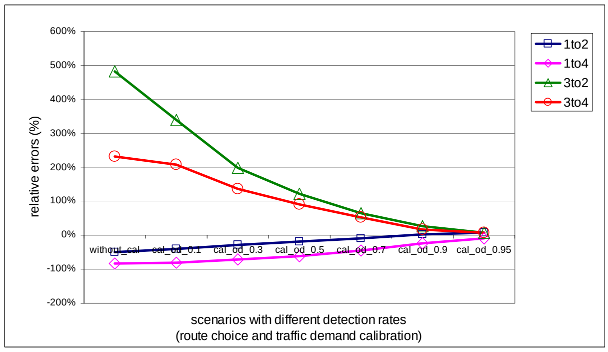

Fig. 4: **Relation errors of the route choice and traffic demand calibration with different detection rates.**

SUMMARY

A method to estimate path flows re-identified vehicle streams is proposed. The method is implemented in the Cadyts calibration software and examined in a synthetic setting that deploys the SUMO traffic microsimulation. The results indicate that consistent path flow estimates can be obtained.

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