

EVALUATION OF SPEED ESTIMATION BY FLOATING CAR DATA WITHIN THE RESEARCH PROJECT DMOTION

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Abstract:

The research project Dmotion aims at a comprehensive traffic management strategy for regional and local authorities, as well as for private service providers. The use of floating car data (FCD) provides an efficient way to estimate speeds and traffic state.

Availability and quality of FCD from taxi fleets and public transport were compared. FCD speeds from taxis were evaluated against independent route speed measurements. Furthermore a model was developed to integrate FCD from public transport fleets into traffic state detection.

OBJECTIVES OF THE PROJECT DMOTION

Dmotion is a German research project within the VM 2010 (Traffic Management 2010) research initiative funded by the German Ministry of Economy and Technology (BMWi). The aim of Dmotion is to develop and implement an integrated traffic management system for the conurbation of Düsseldorf.

This system is based on a comprehensive data, information and strategy network for regional and local authorities, as well as for private service providers. Thus, one major objective of Dmotion is to generate a consistent and comprehensive report on traffic conditions for Greater Düsseldorf. For this reason, many different possibilities for the calculation of the current traffic state are in the focus of this research project, e.g. traffic models based on loop detectors near traffic lights and various methods based on floating car data (FCD). Methods for data fusion are used to get a consistent view of the network. This provision of an overview on the current traffic situation is a precondition for deciding on corrective actions, using roadside information systems (VMS), internet and on- and off-board navigation.

TECHNICAL SETUP: TAXIS AND PUBLIC TRANSPORT VEHICLES AS DATA SOURCE

Speed calculation based on floating car data represents an alternative, respectively a supplementation to stationary sensors. Several research projects in European cities (e.g. Vienna, Berlin, Munich) have shown that measured speeds from taxis are representative of the average speed of the whole driving population [4]. Furthermore taxi fleets mostly dispose of fleet management systems including positioning technology and communication networks. These preconditions allow for cost-effective integration of representative fleets. Typically the trips of taxis are not uniformly distributed in the city network, but they are rather concentrated to the city centre and relevant areas, e.g. conference centres, soccer stadiums, and to the arterial road network [2].

Within the research project Dmotion, data is provided by a fleet consisting of 1200 taxis.

Most of the taxis provide origin - destination (OD) trip data, because the bandwidth for transmitting information from the taxis to the taxi management centre is limited. Merely a few test vehicles of the fleet transmit position information with high accuracy from their GPS receiver. Evaluation of trip length and average speed of taxi trips has shown that only trips with passengers on-board are representative for the normal driving situation.

Percentage of links per time interval with available probe records on a typical working day ranges between 2 and 10 percent from midnight to 6 a.m., whereas it is higher from 6 a.m. until midnight (between 10 and 30 percent). From the percentage of links with available probe records and the aggregation period of currently 15 min, the equipment ratio (ratio of the number of trips of floating cars in relation to all trips in the network) can be estimated [1]. This estimated equipment ratio is up to 0.2 % from midnight to 6 a.m. and between 0.2 and

0.5 % from 6 a.m. until midnight. Estimating equipment ratio based on the mileage of taxis is difficult, because data on the exact mileage of taxis is not readily available.

As an additional source of information on the current traffic state, probe data from public transport vehicles is utilized in Düsseldorf. PT vehicles send online messages at fixed locations in the streets to the next traffic controller on their route to gain their right of way. These messages are then passed on to the traffic control centre. The time between different messages from the same vehicle can be interpreted as travel time, and thus it can be used to collect information on traffic state on the affected roads.

ESTIMATING AVERAGE SPEED BASED ON TAXI DATA

On basis of taxi FCD, a multi-stage algorithm (Floating Car Evaluator, FCE) is employed to calculate average speeds per road link.

A map matching module projects trip data (message points) to the road graph. Distance to the nearest road and heading of trip in relation to road heading are taken into account for map matching.

A routing module calculates the route for trips based on the referenced message points. If only start and stop of trips are known or if GPS messages are sparse, an optimised shortest path algorithm is applied for route search. The algorithm uses several labels in order to reduce spatial imprecision of routing and calculates an average speed. In order to take into account different speed levels of each road, average route velocity is distributed to each road proportional to its free speed or historical speed.

A third module calculates space mean speed from all speed values available for a road in a time interval (of currently 15 min). Calculation of mean speed is usually restricted to higher functional road classes (FRC) for an efficient handling of system resources (currently FRC 0 to 4).

A module for historical timeseries aggregates speed information of similar days for each road [3]. A classification scheme with (currently) 4 day classes is used for calculation. For each time interval in each day class, a harmonic average of route speeds is calculated. As floating car data only represent a sample of the whole driving population, speed information from several days should be aggregated in order to arrive at a good approximation of average speed for total traffic. In a study based on microsimulation in the city of Lausanne, aggregating at least 25 days resulted in a good approximation with less than 5 % relative error between estimated speed and average speed for all simulated cars ([1]). Speed time series are smoothed in order to reduce noise in speed measurements, which is typical for traffic in urban networks.

ESTIMATING LEVEL-OF-SERVICE BASED ON PUBLIC TRANSPORT TRAVEL TIMES

Data from public transport vehicles are used as an additional FCD source. The basic idea behind this model is that such vehicles are forced to adapt their speed to the general volume of traffic, as long as they do not have a track of their own. Another precondition is that public transportation is prioritized in the city under consideration. In the following we describe briefly our way of deducing the momentary traffic situation from public-transport data.

Nowadays, public transportation in big cities is usually prioritized. This prioritization demands that light-signal systems be informed of a public-transport vehicle approaching or leaving. Therefore, there are two or three points of announcement in front of the light-signal system for the registration of the vehicle and one behind the system for its deregistration. In this first approach, we use only the interval between the very last registration point and deregistration for our model.

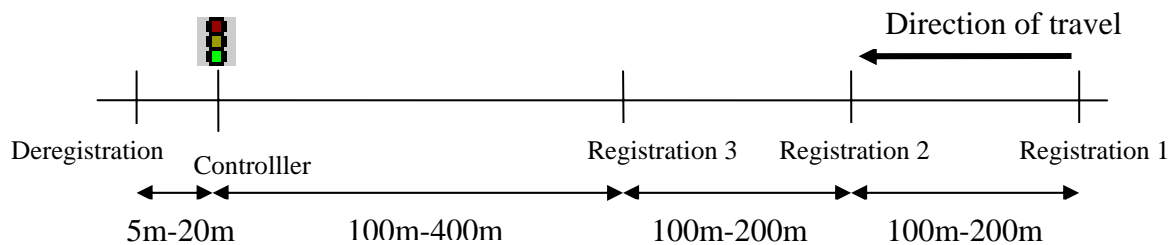


Figure 1: Public transport at prioritized traffic lights

For deducing traffic quality from public-transport FCD, we apply as a first step a rather simple algorithm within the project Dmotion: We restrict ourselves to only three different qualities (LOS), i.e. we distinguish only between free traffic (LOS A/B), traffic with noticeable disturbance (LOS C/D/E) and traffic jam (LOS F). The latter is defined by a waiting time of the vehicle in front of the traffic light for more than one cycle. The limit between the first two grades is 120% of the free flow, i.e. undisturbed travel time, a value that seems reasonable, but can still be varied. From the spatial distance of the two points of announcement under consideration and the time spent by the vehicle between them, one can easily derive its average speed. Besides LOS and average speed we extract from the model the waiting time and an estimated value for the queue length in front of the light-signal system.

The proof of principle of our model is given in Figure 2, using data from a microscopic simulation. Obviously, the LOS determined by the buses approaching is correlated with the travel time of the automobiles. Data from a field test carried out on May 24th, 2006 also demonstrate that in principle deriving individual travel times from those of public transport vehicles is possible. However, the external conditions during the test – low traffic, missing data – do not allow for a clear distinction of LOS (see Figure 3)**Figure 3:** . It has to be pointed out that the model is restricted to the case of a prioritized traffic-light system without a separate public-transportation track in front of it. Therefore the model is not intended to be the single source of data for traffic management, but it is a valuable building block for a comprehensive traffic state calculation that implements data fusion techniques. Registration and deregistration times of public transport vehicles are very often available with low effort via the central traffic center, so the application of the model proves to be easy.

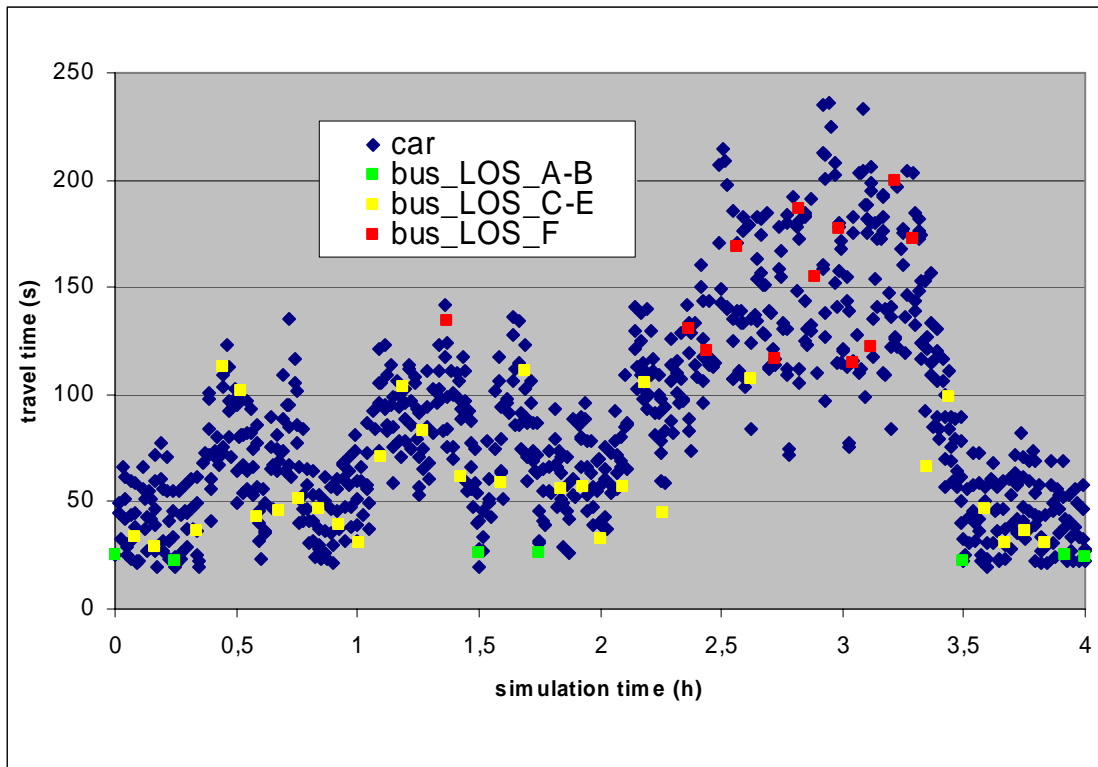


Figure 2: Comparison of simulated car and bus travel times in front of node 136 in Hamburg between last registration point in eastern direction and deregistration

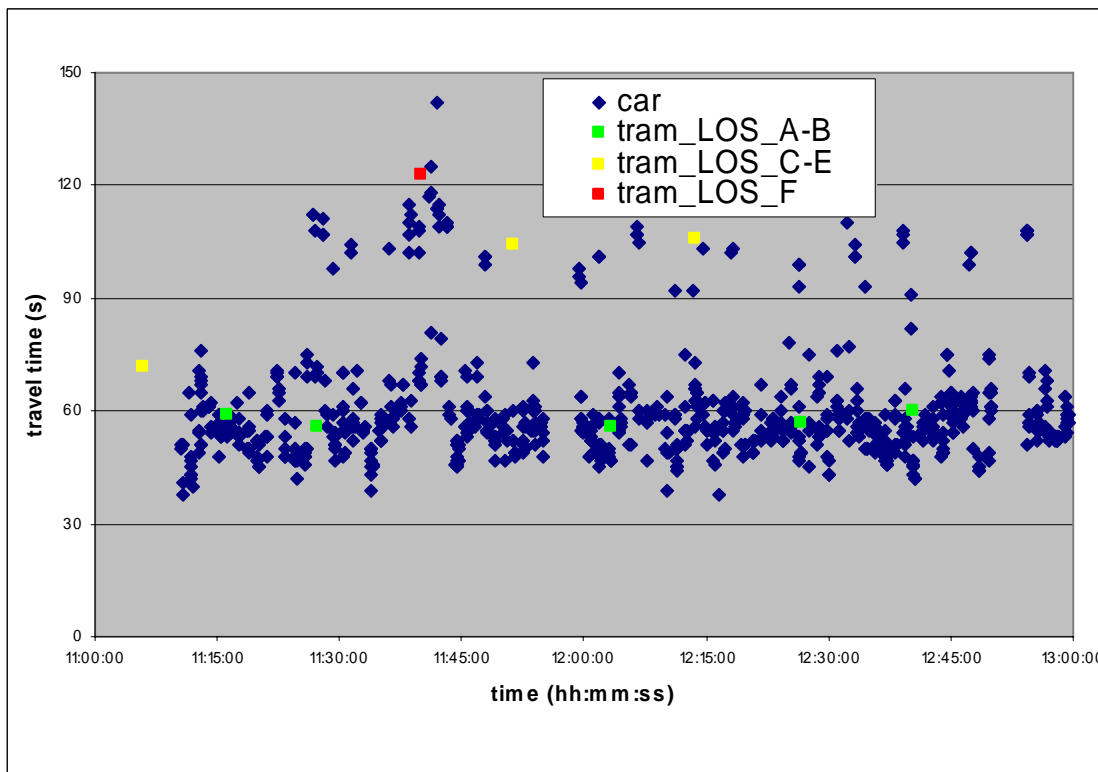


Figure 3: Comparison of real car and tramway travel times between Brehmplatz and Gruner Str. in Düsseldorf; data taken during a field test in May 2006

RESULTS: EVALUATION OF AVERAGE SPEEDS BASED ON TAXI DATA

In order to evaluate results within the scope of Dmotion, a field trial on main roads in the city centre of Düsseldorf was carried out on an ordinary working day in April 2006. Average path speed was measured on two paths using Automated Number Plate Recognition (ANPR) for approximately 7 hours each. In addition, 3 cars equipped with a GPS tracking device performed several round trips on a predefined route.

Comparison of average path speeds (measured by ANPR) with estimated path speed based on FCD showed that the trend of estimated path speeds followed the trend of average path speed. The level of estimated speeds was however lower than average path speed (mean absolute error MAE -13 to -16 km/h, root mean squared error RMSE 75 to 88 km/h). The comparison of path speeds on one route is shown in Figure 4. A likely explanation is the fact that mainly OD information of each taxi trip is transmitted. Trips with passengers on-board may contain waiting time at the customer's address which cannot be separated from the driving time of the taxi.

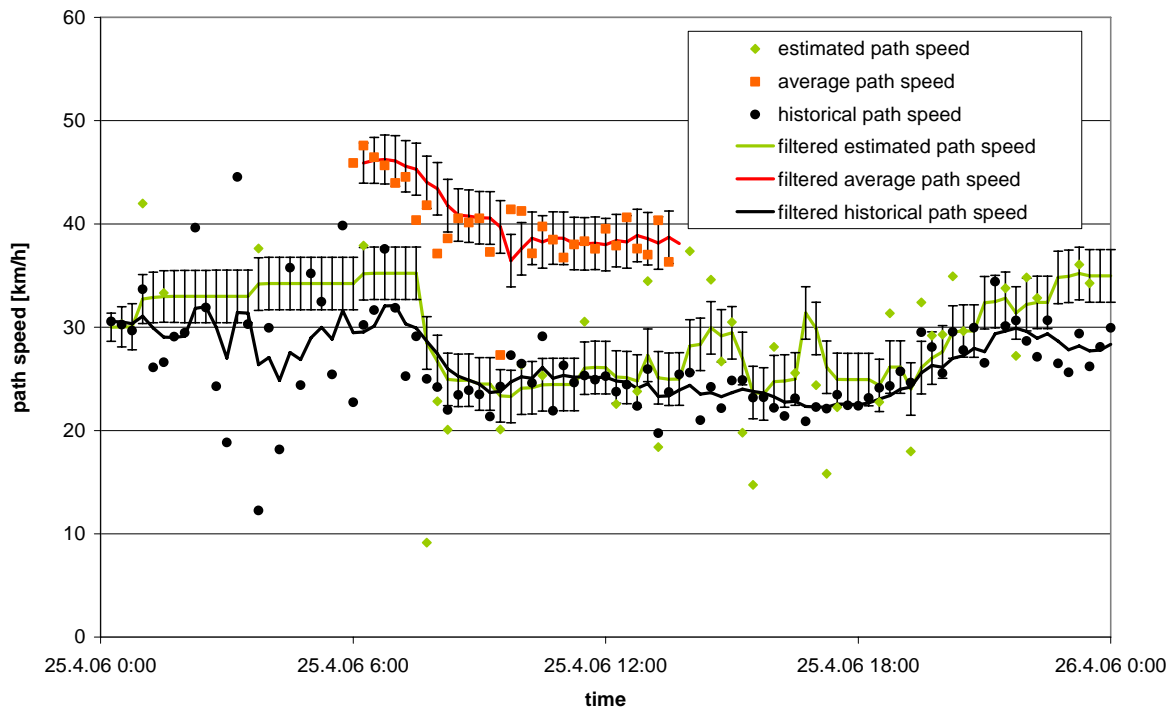


Figure 4: Comparison of estimated and average path speed (route 101, Klever Str. - Oberkassler Brücke)

Filtered historical path speed was based on FCD from 8 months. The historical time series of average speed from day category “working day, no holiday” was compared with the trend for the day, on which the field trial took place. The time series of the typical working day closely resembled the current time series (MAE -3 to -6 km/h, RMSE 27 to 55 km/h). Therefore, deviations between historical and current speeds can be used as substitute values for missing values.

A second field trial that also focused also on public transportation vehicles used as floating cars took place at the beginning of May, 2007. Unfortunately it was not possible to evaluate the data in time for the final paper, but results will be presented at the ITS 2007 in Beijing.

CONCLUSION

Results of route speeds based on FCD show that taxi data can be used for estimating average route speeds of the whole driving population. Temporal trends of average speeds during a day can be captured by taxi data. Spatial resolution of trip information (i.e. frequency of messages), however, has to be improved in order to avoid biased results. As FCD from taxi fleets only cover a limited percentage of links per time interval, substituting information from historical timeseries for missing values is of basic importance. Completing speed information greatly improves its value for data fusion.

The use of public transport vehicles as floating cars proves to be an interesting and cheap additional data source for urban traffic state estimation. The spatial scope for this model is obviously limited, but the application is straightforward.

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