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Automatic Incident Detection Based on Bluetooth Detection in Northern Bavaria

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Abstract

This work describes an approach to determine the current travel times on freeways based on the detection and re-identification of Bluetooth devices onboard of vehicles using stationary roadside Bluetooth detection technology. It also aims at using this information for the traffic state determination of a whole freeway network with the goal of a fast and reliable dynamic net control in incident situations. Based on a four-year experience in a Bluetooth detector test bed in Northern Bavaria, Germany, and after the evaluation of hundreds of millions of single detections, the technology as well as the developed algorithms for validation and evaluation of the data show their feasibility in practical use, especially in areas with a low density of stationary detectors like inductive loops.

The data-driven part of the approach is divided into three subsequent steps. These steps are the determination of travel times, the data filtering and validation of plausible travel times and the automatic incident detection. The determination of travel time is based on the time stamp of the detection of a Bluetooth device with the shortest estimated distance to the position of the Bluetooth detector. For the data filtering the "Time Dependent Comparison to Neighbor Values Filter" will be applied. This filter allows for a fast and reliable differentiation between unrealistic (due to stops, detours, back and return trips etc.) and plausible travel time values for a certain segment of the freeway and is based on a method to validate if the determined travel time is in a plausibility threshold corridor defined by the values of the previous and the next neighboring travel times.

The outcome is a detailed travel time information for the whole freeway network which is used for an automatic incident detection, which was developed and calibrated within this research project. This includes the detection of the start of an incident as well as the end of an incident. The result is continuous information about the prevailing travel times and a fast and reliable traffic state information for all segments, which allows for a dynamic large-scale re-routing in the Bavarian freeway network in case of congestions or other disturbances of the traffic flow.

Keywords: Automatic Incident Detection, Bluetooth, Congestion Warning, Re-Routing, Traffic State

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1 Background and motivation

Traffic, transportation and mobility in general, play a more and more prominent role in today's society. A continuously increasing traffic demand can be observed almost everywhere whereas the supply of infrastructure is remaining nearly constant, especially in the developed countries. Therefore, the better use of the already available road network and the optimization and extension of road capacities is the major focus nowadays and in the near future. Keeping that in mind, it is a crucial task for traffic control and management to determine in time the localization of bottlenecks and temporal reductions of capacities to be able to directly avoid their negative impacts on the traffic network – if possible – or at least to reduce their intensity and spatial propagation.

The foundation for this has to be detailed and up-to-date data on the current traffic state. Only with that information an effective reaction on imminent capacity reductions or traffic breakdowns can be realized. In addition to mobile traffic detection systems like traffic helicopters, congestion reporting volunteers or Floating Vehicle Data (FVD) stationary detectors are available like Automatic License Plate Recognition (ALPR) cameras, inductive loops, radar detectors, CCTV cameras etc. However, most of these systems have very high costs of ownership together with a mostly poor spatial or temporal coverage of detection and a complicated subsequent installation in existing infrastructure.

Since several years, the use of Bluetooth detectors for the purpose of travel time recognition achieves good results in more and more traffic-related application areas. The general idea of this technology relies on the presence of activated Bluetooth devices on board of vehicles, which can be used for vehicle identification to determine their travel times. Several studies in the past years have already shown the promising benefits of the application of Bluetooth sensors as a cheap and easy-to-use technology for determining reliable travel times on freeways and also in urban areas.

As one of the first studies on the applicability of Bluetooth sensors for travel time determination Haghani et al. (2010) state, that it is a promising method for providing reliable ground truth travel time data with a high quality comparing it to floating vehicle data in Maryland and Northern Virginia. Also Barcelo et al. (2010), based on Bluetooth sensor data from the AP-7 motorway in Spain between Barcelona and the French border, prove the quality of the travel time determination based on the detection of Bluetooth devices. In a study of Martchouk et al. (2011), where Bluetooth data was collected at the I-69 in Indianapolis, also discuss the great potential of this technology for accurate travel time determination. Aliari and Haghani (2012) show an approach for Bluetooth data validation and verification on the Interstate 95 together with an evaluation of the travel time accuracy using probe vehicle data. Araghi et al. (2012) compare three different estimation methods of Bluetooth data collection with ground truth travel time data obtained by cameras resulting in the highest accuracy for their Peak-Peak method.

Based on these experiences, within the framework of this work the traffic application of using this sensor technology for an automatic incident detection on freeways is discussed. Using Bluetooth antennas installed next to the roadway, Bluetooth devices in passing cars and trucks can be detected and re-identified by means of their globally unique MAC address identifier. Based on these detections – available at several measuring cross sections along the freeways in the North of Bavaria, a federal state in the South of Germany – a representative subset of the overall achieved travel times on selected routes can be determined. This data is used for the large scale dynamic net control system in Bavaria called "dNet Bayern". The dNet venture consists at the moment of a total of 27 standard routes and additionally 60 alternative routes to which the drivers can be dynamically redirected in cases of lower travel times in comparison to the corresponding standard route. This re-routing advices are presented to the drivers at neuralgic decision points of the freeway network using dynamic guidance panel signs with integrated traffic state information (called "dWiSta"). For more details on the venture dNet Bayern and the used technologies see also Scharrer (2009) and Margreiter et al. (2015).

Within this paper the necessary steps towards a reliable and fast automatic incident detection is described, which is the basis for a successful application of the dynamic net control. Therefore,