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Evaluation of a transport mode detection using fuzzy rules

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Abstract

GPS and other sensor data available from smartphones are more and more used to derive the mobility behavior of their users. This contribution evaluates an own developed three step algorithm to derive transportation modes from such data by taking the trajectory data of some dozen trips of users with a focus on obtaining road traffic information. The algorithm itself consists of first a segmentation phase, second fuzzy rule transport mode detection and third consistency corrections. Results obtained so far are promising with correct detections of about 75 %, but further analysis will be needed to substantially enhance the algorithm.

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Keywords: transportation mode detection; mode detections; gps data; smartphone sensor data; fuzzy rules

1. Introduction

Since decades for many applications in traffic management and mobility services mobility patterns, movement profiles and traces of people are of big interest. This reaches from origin destination matrices, with which the demand for long- and mid-term traffic simulation models is defined and typically fed by results from surveys, to traffic information services using traces of vehicles as basis for current traffic state detection (Floating Car Data). The vast dissemination of smartphones over the last years with sensors like GPS and accelerator data is a great possibility to substantially enhance the quality of according models and applications. In most cases the determination of the used transport modes (CAR, TRAIN, BICYCLE ...) is a crucial thing to do, as far as possible in an automated way. Some algorithms already exist, typically focusing on the detection of the used transport modes on single trips, while algorithms for multi- or inter-modal trips are rare.

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For the detection of transport modes there are some approaches. One is the use of conditional probabilities in Bayesian networks, which is exemplarily described in the work of Feng et. al. [1]. Here - besides speeds and accelerations - the knowledge about the ownership of a car, bicycle or motor cycle is used to feed the Bayesian network. Other approaches use learning neuronal networks, e.g. Gonzalez et. al. [2], who use only GPS data and derived measurement parameters. But only the three modes car, bus and walk are distinguished in their work. Malazi et. al. [3] suggest the use of fuzzy methods [4] and Rasmussen et. al. [5] combines fuzzy logic with additional GIS information. Upadhyay et. al. [6] also uses fuzzy logic, but does not realize multi modal transport mode detection.

This contribution presents an analysis on the quality of such a multi-modal method using fuzzy rules and limiting the algorithm to the use of only the sensor data and nothing additionally (e.g. infrastructure, general traffic situation). The aim is that it works fast, to get results in realtime, and independend of the location of the trips. The basics of the algorithm are already published [7]. This work focuses on the quality of the results.

In the methodology part of the paper the algorithm will be sketched. Then challenges in general and especially for transportation mode CAR are addressed. The focus is on determination of road traffic, especially car trips for which about 120 trips are analyzed. For all analyzed data - which are produced by smartphones - the used modes in reality are known and they were not recorded under optimized conditions, but simply “as one typically uses it in reality”. Results of analyzing the detection for about 120 car trips are followed by an analysis of further multi modal trips leading to some conclusions and future work for enhancements of the analysis as well as for the algorithm itself.

2. Methodology

The described transportation mode detection works on the following requirements:

- The tracked person sends its position regularly at least every 4 seconds
- The tracking data is recorded and sent from a mobile device with integrated GPS module
- The algorithm must be able to work as real-time
- The track may be multi modal
- Except the transmitted smartphone data there are no additional information about the tracked person
- There is no street map used
- There are no information about public transport opportunities
- The transportation modes WALK, BICYCLE, BUS, CAR and TRAIN are to detect
- The mode detection should work everywhere, but the focus is on urban traffic/movements
- For urban traffic movement some general assumptions are used.

A tracked person sends its position regularly (for example with a frequency of every second) so that it can be tracked constantly. Its position and moving direction can be determined relatively exact, depending on the used GPS module and the environment (location problems between high buildings). If the mobile device is a smartphone further helpful data can be recorded and sent together with the position data. An example is the accelerator sensor data that nearly every smartphone provides. The most difficulties exist by deciding between means of transportation with similar speeds and by detecting a slow driving car because of congestions. From the ITS business point of view the latter is of special interest for example to be able to detect queueing traffic and jams or to calculate and provide current travel times for distinct means of transportations for streets.

For this approach of transport mode detection a three-step algorithm was chosen consisting of phase segmentation, fuzzy rule mode detection and consistency corrections.
In the first step the position data - as known at that time - of a tracked person is divided into smaller segments, in that a change of the mean of transportation is implausible, for example because there was no stop or at least very slow speed that make a change possible. Figure 1 shows this segmentation procedure exemplarily, each consisting of