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Bus arrival time prediction based on network model

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Abstract

Providing accurate information on bus arrival and departure times at bus stops is one of the key parameters of high-quality public transport today. This paper proposes a model for the real-time prediction of arrival times at bus stops. The proposed model is based on information about the current location of the bus, the classification of runs into time periods with respect to the historical data, and the data model of the bus network. We discuss four types of data models: a data model defined by bus stops and crossings of the road network, a data model defined by bus stops, a data model which addresses the individual parts of the network in relation to the potential barriers that affect the travel speed of buses, and a data model with fixed-length links of the bus network. Travel times are classified according to the average travel speed into four time periods: morning, afternoon, early morning or late evening, and weekend. The results of the analysis showed that both the data model of the bus network and classifying runs into time periods affect the accuracy of predictions of bus arrival times at bus stops.

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Keywords: public transportation; network data model; bus arrival prediction; tracking, real-time information system

1. Introduction

Information systems for real-time arrival times at bus stops (RTPI) are systems which provide passengers and potential passengers with real-time information about bus arrival times at bus stops. In order to deliver accurate and reliable information the system must be able to give a precise and probable estimate about the travel time predictions given all possible traffic conditions and circumstances[1]. The operation of these systems requires intelligent transport systems such as automatic vehicle location, automatic vehicle identification, systems for the validation of passengers entering and exiting the vehicles, and systems for the transmission and display of data. Real-time information about

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bus arrival times at the bus stop has many positive effects on the users of public transport services and, consequently, (may) lead to an increase in the use of bus transport. Positive effects of RTPI systems – user perceived[2]:

- Decrease in perceived waiting time.
- Positive psychological factors, such as lower uncertainty.
- Increased ease of use and increased sense of security.
- Increased willingness to pay.
- Adapted travel behavior (i.e. better use of waiting time and more efficient travel).
- The impact on the choice of means of transport.
- Improved overall image of public transport.

The estimated bus arrival time at the target bus stop is calculated based on knowledge of current bus locations and estimated travel time that the bus needs from the current location to the target bus stop. Huge amounts of data on vehicle locations are nowadays obtained through the global positioning system (GPS)[3] that makes it possible to determine the current location and to obtain samples of past travel speeds.

Although numerous products and systems for predicting the operation of public transport in real time have been developed globally, there are still deviations between the predictions and the actual travel time[4]. Discrepancies between the prediction and the actual bus arrival time at the bus stop are particularly common in public bus transport systems that use the same road infrastructure as individual transport. Thus the bus travel times in different time periods, for example during peak hours, off-peak, or during weekends, can greatly vary.

2. Literature review

Many researchers, who used different paradigms in their models, have studied predictions of bus arrival times at the bus stop within public passenger transport. Altinkaya and Zontul[4] classified models that have been proposed thus far into four categories: models based on the historical data, statistical models, Kalman filtering models and machine learning models. Balasubramanian and Rao[5] proposed a bus arrival prediction model with cyclic variation explicitly incorporating information about seasonality in the data series (day of week, time of day). Deng et al.[6] have proposed a model for prediction of travel times based on a Bayesian network by comparing data on the traffic situation and travel times of buses from historical data. Chen et al.[7] used an automatic passenger counter as a key parameter in the model for prediction of the bus arrival time at a bus stop. Cats and Loutos[8] have developed three different schemes for the calculation of travel time:

- A method that calculates the arrival of the bus at the bus stop based on the current location of the bus and the pre-defined timetable.
- A method based on estimated travel times depending on the time period (day of week, time of day).
- A method which deals separately with travel times between bus stops and the time spent at the bus stop. To determine traffic conditions for travel times between bus stops it takes into account the speed of the preceding buses on the same route.

Numerous studies have been conducted to compare the accuracy of predictions using different methods and models. These methods and models can be classified as: Kalman filter models[9,10,11], artificial neuron network models[9,11,12], support vector methods[9,13,14], linear regressions[9] and nearest neighbour methods[9].

Alejandro et al.[15] used the average speed along the line with free traffic flow for prediction, and additionally their algorithm accounted time loss for each signalised intersection, roundabout, acceleration and deceleration at the bus stops, and the opening and closing of the bus door and passengers boarding.

Numerous authors have developed various proposals for predicting bus arrival times at the bus stop, but due to the complexity and nature of the data individual models or algorithms are not suitable for all environments[4].

Previous research in most cases did not focus on the data model of the bus network. Chen et al.[16] proposed and compared a model for prediction of the bus arrival time at stops, which is based on a section-based model of the bus network and a link-based model of the bus network. Zegeye et al.[1] proposed a model with bus stops and reference points that are defined by the distance from the selected bus stop.