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Travel Time of Public Transport Vehicles Estimation

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Abstract

Effective prediction of speed is central to advanced traveler information and transportation management systems. The speed of public transport vehicles is affected by many external factors including traffic volume, organization and infrastructure. The literature presents methods for estimating travel time on sections of a transport network and vehicle arrival at stops, often making use of the AVL (automatic vehicle location). The aim of the authors of this paper is to identify these factors, their impact and significance on the average speed of public transport vehicles in selected sections of the transport network. The paper presents the results of field studies involving the measurement of travel time of public transport vehicles in the main streets of the Tri-City Agglomeration (Gdansk, Sopot, Gdynia). The study was carried out within the framework of the project for the construction of the urban traffic control system TRISTAR. Based on the collected data the authors built a model of the relationship between the average speed of public transport vehicles and these external factors. The results will be used to calibrate the macroscopic transport model in the Tri-City Agglomeration.

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Keywords: modelling; public transport; travel time estimation

1. Introduction

Speed is an essential parameter in describing traffic conditions in the transport network. This parameter can be used to estimate the quality of travelling in the area. Moreover, with the development of intelligent transport systems, vehicle speed and vehicle flow play an important role in advanced traffic management systems. The speed, along with other parameters, such as traffic flow, provide information about the current situation in the transport network. This issue also applies to public transport, for which the estimation of travel time, including the speed, is necessary for the dynamic transmission of reliable information to passenger information systems. This allows passengers to be kept informed about the arrival times of particular vehicles, thus enabling them to plan possible alternative itineraries, therefore saving time. Information about the variability of travel time on the various sections of the network is also useful for the transport operator's control.

The problem of having to estimate speed and travel time is also present in traffic modelling. In order to make the most accurate representation of traffic flows, occupancy of private sections of the network, as well as considering the issue more broadly - travel behaviour, the average speed for each type and sub-type of link and mode of transport should be properly estimated. Although the speed of private transport is widely discussed in literature, in the case of public transport fixed travel times are generally assumed due to scheduling.

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When considering methods of estimating the average speed of public transport vehicles the movement of these vehicles must be analyzed, this includes travel time, loss of time due to various causes, and also allowing for the stop service times. Identification and analysis of these factors should enable the formulation of a relationship between them and the average speed of the vehicle. This paper presents the statistical summary of the results of travel time research conducted for Tri-City intelligent traffic control system (TRISTAR) and show the complexity of the estimation problem for traffic modelling.

2. Literature review

The literature describes that in estimating average speed and travel time the dynamic information from the road network is mainly used. Four variable parameters are required for the management of the traffic system, volume N(t), occupancy O(t), speed S(t), and vehicle length L(t). To obtain such information, some tools are needed. For example, the simplest device for detection of vehicles, i.e. induction loops can be used for this purpose. Induction loops allow for gathering information on traffic volume, that combined with the known capacity of the road, which depends on its parameters and the traffic signals program, describe the occupancy of a section in the road network.

There are other, more modern methods of average travelling speed measurement that enable collecting more detailed data. The most popular measure is using GPS. The effect of the method can be seen in several web portals which on the map illustrate present (for example, updated every 10 minutes) and historical speed on each section of the transport network. A detailed description of estimating the average travel time with this method has been described in several scientific publications - for example (Li Siyu & Enam & Abou-Zeid & Ben-Akiva, 2013),(Sanaullah & Quddus & Enoch, 2013),(Miyata & Muroaka & Akiyama & Abe, 1997).

Also for public transport the literature describes methods of travel time estimation using advanced passenger information systems (ATIS) and automatic vehicle location (AVL) based primarily on GPS technology.

The extent of discussion related to these topics show that the problem of estimating the speed of motorised transport both private and public is very important. It has been customarily proven that these values are also important in the process of trip modeling, where travel time is one of the key parameters affecting the trip distribution, modal split and trip routing.

To estimate the travel time of private transport vehicles we must know the function of resistance of every link using the variables such as traffic volume, capacity and free flow speed. One of the simplest functions is the one formulated by Overgaard, which is a combination of Soltman's and Smock's function:

$$T = T_0 + \left(1 + \alpha \cdot \left(\frac{Q}{C_p}\right)^{\beta}\right) + \gamma \cdot Q, \tag{1}$$

where:
T – travel time,
T_0 – travel time in free flow,
Q – traffic volume,
C – capacity,
α,β – parameters.

The main feature of this type of function is a discontinuity at the point of critical capacity, compared to the previously used functions. The most popular of the functions for estimating link resistance is BPR function (Bureau of Public Roads, 1964), along with all its varieties BPR2, BPR3:

$$T = T_0 + \left(1 + \alpha \cdot \left(\frac{Q}{C_p}\right)^{\beta}\right) + \gamma \cdot Q \tag{2}$$

where:
T – travel time,
T_0 – travel time in free flow,
Q – traffic volume,
Cp – critical capacity,
α,β,γ – parameters.

When estimating the travel time and speed of public transport vehicles constant scheduled travel times are assumed for modelling. Or they are estimated based on the average travel time on the particular type of link, categorised according to the technical class of road (Birr & Zawisza & Budziszewski & Jamroz, 2012). However, this approach is often undermined, and it is