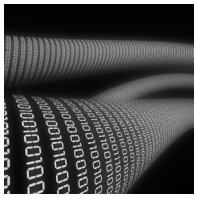

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A system for monitoring and analysis of vehicular traffic

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ABSTRACT
The main purpose of the system described in this paper is optimization of traffic in the city by collecting and analyzing data related to traffic flow. Devices used in the process of collecting traffic information are installed in vehicles and send the information about current vehicle's position and momentary speed. Based on that it is possible to find the best routes for any two points in the city.

KEYWORDS: route optimization, GPS, traffic flow analysis

1. Introduction

The main purpose of the system described in this paper is optimization of traffic in the city by collecting and analyzing data related to traffic flow. Based on that it would be possible to present to drivers the best routes to their destinations. Data collected in a real time process would be used as an input for the algorithm for adaptive traffic light management, similar to those described in [1]. Devices used in the process of collecting traffic information are installed in public transport vehicles, so it is also possible to provide the passengers with up-to-date information about vehicles arrival times.

This goal can be achieved by collecting information about vehicles movement in the city, and based on that preparing a map of traffic flow. Having this information, detailed analysis can be performed and a list of the best routes between any two points in the city can be obtained. To get the information about traffic flow some vehicles are equipped with devices that precisely detect their position and wirelessly transmit it to the computation centre.

All elements of the system have been tested in Cracow. The algorithm which analyses tracks of transmitting vehicles and provides information for interactive traffic map has been applied for a patent [2].

2. System components

In this chapter the main system components like the infrastructure for traffic data collection, data analysis module and visualization module will be described.

Information about vehicle traffic is collected by devices installed in the selected vehicles. Those devices consist of a GPS receiver and GSM module responsible for localization of the vehicle and wireless transmission of this data to the computation centre. Electronic devices have been programmed and successfully tested in vehicles of public transport authority MPK S.A. in Cracow, taxis of MPT Corporation and also in private cars. In the extended version not only the information about vehicle's position and speed is transmitted to the server but also the image captured by a photo camera installed in the front of the car. In that way it is possible to calculate the flow on motorways especially in the case when separate lanes for taxis and public transport vehicles exist.

On the server side data is filtered and analyzed. Vehicle tracks are assigned to the roads, and computations related to road capacity are performed. After that a map of traffic flow in the city with distinguished congestion areas

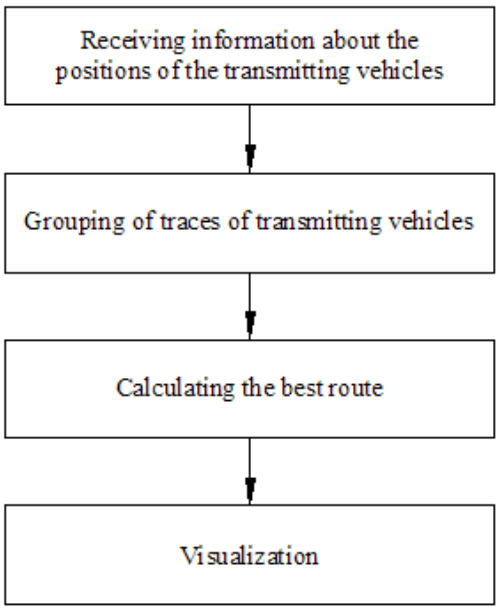

Fig. 1. Processing stages

is prepared. The map is available on the web page which can be accessed from desktop computers, personal digital assistants or mobile phones.

Another possible way of visualization is an interactive road map on which the end users can plan their routes. The process of selection of the best way takes into account the current traffic conditions in the city. For trips planned in the near future estimated traffic conditions based on the historical data are used for computations.

Cumulated data can be also used for further analysis in order to create an adaptive algorithm for traffic lights management system.

2.1. Data sources

The input data for the system originate from devices which wirelessly transmit information about vehicle's position and speed to the computation centre. The received information is stored in anonymized form. It means that only information about vehicle type (public transport vehicle, taxi, privileged car, and so on) and its position and speed in a given moment is stored. The devices can be freely installed in all types of vehicles, like public means of transport, taxis or private passenger cars. Each group of vehicles has different properties which influence the data collected by them.

Public transport authority often has the biggest fleet in the city. Moreover it is almost all the time in move on the main city roads. Routes of those vehicles are constant, stops are well defined and vehicles parameters are similar. Fleet utilization is usually very high (in Cracow it is 75%). In consequence transmitting devices are used almost all the time.

Taxis are driving on unpredictable routes according to the customer order. Vehicle tracks made by them cover not only primary roads but also secondary, tertiary and residential roads. Utilization of the fleet is lower than utilization of public means of transport, but is also quite high (in MPT, one of major Cracow taxi corporations, 160 out of 200 taxis are driving during the day).

Private cars are not used so extensively as public transport vehicles or taxis. But data acquired from them came from areas in which the drivers are traveling each day and often in rush hours. Those trips take place between several points like office, school and home. Good drivers seeing traffic congestion from a distance would rather avoid this road, selecting a shortcut or a longer road which allow them to arrive earlier. The average time of traveling of private cars which participated in the tests was around two hours per day.

2.1.1. Public transport vehicles in the context of passenger information system

Having the information about accurate position of public means of transport, it is possible to provide this information to the people waiting on stops. They can receive this information in various ways. It can be presented on displays mounted on bus stops or by providing additional software to show it on automatic tickets selling machines, which are in common use in Cracow.

Blind people can also get the information about the time of arrival of a bus or the information about the line number of a bus that has just arrived. To achieve this goal dedicated application for mobiles phones equipped with a

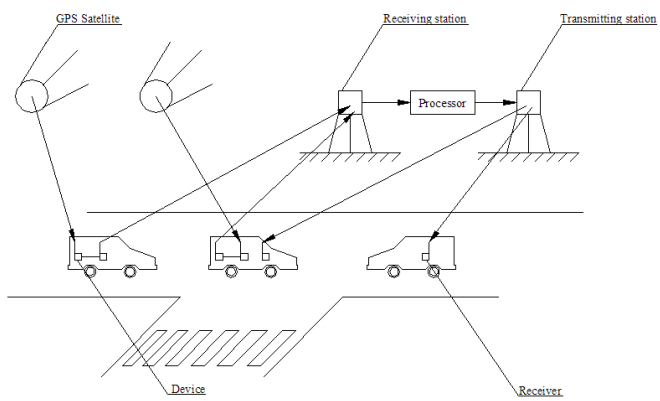

Fig. 2. The structure of the system for monitoring vehicular traffic

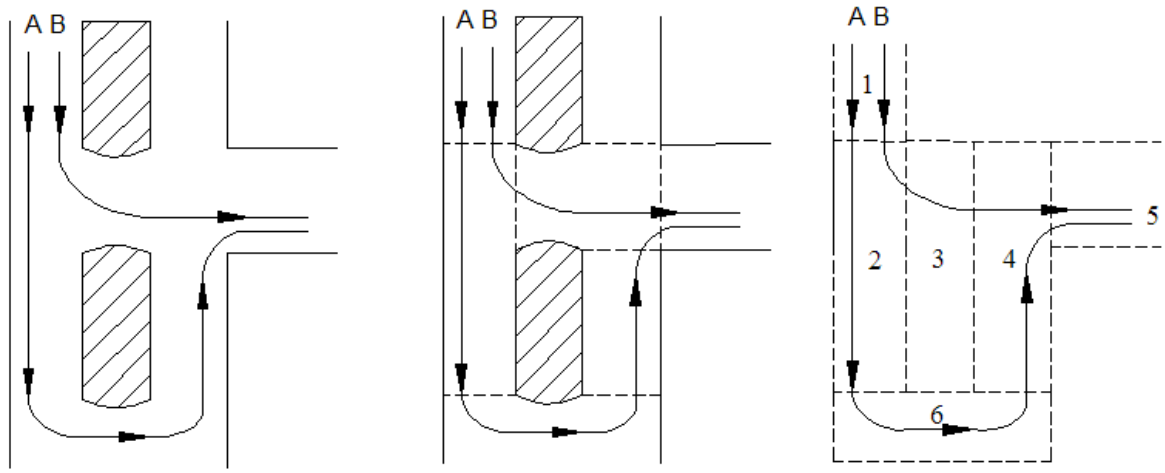

Fig. 3. Method of choosing the best route basing on traces of transmitting vehicles

GPS receiver can be used. After establishing connection to the server and sending position of the end user, the data related to public vehicles movement can be transferred to the mobile phone and presented to the end user in the form of sound messages. It is also possible to provide this information by emitting sound inside and outside the public transport vehicles.

2.2. Data Analysis

Detailed analysis of vehicles tracks is performed in small areas called segments. Each segment has an identifier which uniquely describes a two dimensional area in which all vehicles were moving in the same direction. Process of decomposition of the whole city area into segments is performed simultaneously with the process of data collecting but it is initiated rarely: usually once a day during the lowest load of the system.

2.2.1. Graph of BEST Routes

After setting out the segments, the analysis of momentary speeds of transmitting vehicles in a specific segment may be carried out. Based on that a mathematical model is designed in the form of a graph with nodes representing segments and edges that represent an average speed and average time of traveling between segments. Fig.3 shows the creation of graph with respect to the time of passage from one segment to another.

In that way the knowledge that skilled drivers have about how to drive avoiding congested areas can be presented to the others. The system based on information gained from monitoring many routes and reactions of drivers on a traffic situation nearby can learn which route should be chosen between any two places. This knowledge is available for the end users via a web page which allows interactive route planning.

One can ask: What happens when the optimal route chosen by a good driver will be presented to the others and all of the drivers decide to choose this route? To avoid this unexpected behavior, during the analysis additional information regarding current road capacity and dynamics of traffic flow is acquired. Assuming that the system can influence traffic lights, it is possible to construct adaptive traffic lights management system which prefers the most congested roads and using early detecting dropping of average velocity allow preventing breakdowns of traffic flow.

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