TRAFFIC FLOW MONITORING BASED ON FLOATING CAR DATA

Zuzana PURKRÁBKOVÁ[1], Pavel HRUBEŠ [2]

[1] Department of Transport Telematics, Faculty of Transportation Sciences, Czech Technical University in Prague, Konviktská 20, Prague 1, Czech Republic
purkrzuz@fd.cvut.cz

[2] Department of Transport Telematics, Faculty of Transportation Sciences, Czech Technical University in Prague, Konviktská 20, Prague 1, Czech Republic
hrubepav@fd.cvut.cz

Abstrakt

Moderním trendem oblastí “Smart” je sběr dat k ovlivňování, řízení, optimalizaci nebo predikci obecných procesů, dopravy nevyjímaje. V České republice jsou od loňského roku k dispozici data modelu o rychlosti silničních dopravních proudů vycházející z pohybu tzv. plovoucích vozidel, tedy nový zdroj dat o dopravní situaci s celoplošným pokrytím. Tato data jsou publikována nejen na tradičních hlavních komunikacích, ale také na komunikacích, které dosud nebyly a nejsou vybavené žádnou detekční technologií. Díky tomuto modelu je možné sledovat a analyzovat rychlost dopravního proudu a jeho vývoj v čase pro velkou část dopravní sítě celé ČR. Článek pojednává o využití těchto dat, jejich prostorovém významu a zpracování v GIS

Abstract

The modern trend in the "Smart" areas is the collection of data to influence, control, optimize or predict general processes, including transport. In the Czech Republic, model data on the speed of road traffic flow based on the movement of floating vehicles, as it is called, have been available since last year. It is a new source of data on the traffic situation with nationwide coverage. These data are therefore published not only on traditional main roads but also on roads that have not been and are not equipped with any detection technology. Thanks to this model, it is possible to monitor and analyze the speed of the traffic flow and its development over time for a large part of the transport network throughout the Czech Republic. The article deals with the use of this data, their spatial significance, and processing in GIS.

Klíčová slova: data z plovoucích vozidel; GIS; analýza dat; zpracování dat.

Keywords: floating car data; GIS; data analysis; data processing.

1 INTRODUCTION

In discussions about the smart city and the smart region, the collected data are very important from a point of view in transport, which are the main building element of the architecture of telematics systems. A new data source, floating car data, can also be used for many applications.

The principle of floating vehicles is based on the location of vehicles (most often by the GNSS system) during their journey and the sending of position and speed data to a central system for processing. Thanks to this, it is possible to collect data on multiple communications, as there is no need for installed elements in this technology.

The authors have been dealing with the issue of floating vehicles for a long time. They work with the Directorate of Roads and Motorways in the role of experts to create a whole data model provided to the public. Based on the acquired knowledge and data, the article deals with the analysis of this data, their spatial representation on the road network, and anomalies in the data.

2 STATE-OF-THE-ART

Floating car data technology is now a relatively popular topic. This is an issue that is addressed by both scientific groups and commercial entities.

Most research deals with the use of data from floating vehicles in the city, very often it is the control of traffic or, for example, traffic flow management. These studies are very often referred to selected fleet vehicles, such as taxis or public transport vehicles. An example of a project based on taxi vehicles is [1] or [2]. Significantly less research on data from floating vehicles is in the suburbs. In the vast majority of cases, these are pilot projects on the motorway. Most of these projects also used data for traffic management on arrivals to large metropolises, such as [3]. Similar data has already been processed using GIS, for example by research [4], which also uses data from taxi vehicles.

There are a number of research and pilot projects in the commercial sphere. It is obvious that these projects are built primarily for the purpose of profit and saleability of the service. Common services use the data of the provider or operator of roads, which are focused only on the main roads and do not have data on secondary ones. Conversely, company TomTom [5], is on the other side, processes all its data and thus has the opportunity to look at lower-class roads, which can be used in the event of the need for vehicle routing. At the forefront in this respect is company TomTom

3 PROCESSED DATA

Floating car data is published freely to the public. The role of the provider is taken over by the Directorate of Roads and Motorways, which manages the data, stores it on its servers and further distributes it to applicants. Company VARS BRNO a.s. was also involved in data collection and model development and calibration. CTU in Prague, Faculty of Transport was in the role of expert observer. The company VARS BRNO manages many ITS applications and traffic detectors in the Czech Republic and also takes care of the calibration and background of the model of floating vehicles. This model runs on the software of the German company PTV Group.

Data from floating vehicles are records of on-board units in these vehicles. These records are sent at minute intervals to a central server, where they are anonymized and stored. When collecting data from the server, it is possible to use them for a wide range of applications. The output model data contain basic transport parameters, count of floating vehicles and speed of floating vehicles on individual segments of roads. They also contain additional parameters for possible analyzes. We can talk about a total of 15 parameters that are available, which can be read in Table 1.

Table 1: Sending parameters of FCD vehicles

name of parameter	**format**	**meaning**
defined TMC segment	text	communication segment where the data was measured
day	YYYY-MM-DD	
time	HH:MM:SS +02:00	
count	integer	current number of FCD vehicles in the segment
speed	integer	current average speed of FCD vehicles in the segment
travel time	integer	travel time in current condition

delay	integer	difference between the current travel time and the travel time in free traffic flow
freeflow_speed	integer	speed of traffic flow in free traffic flow
freeflow_time	integer	travel time of traffic flow in free traffic flow
reliability	range 0-1	characterizes the quality of data
reaction time	integer	system reaction time
traffic level	range 1-5	traffic parameter according to convention in the Czech Republic
congestion	binary 0/1	binary description of the occurrence of congestion
congestion_from	string	estimation of the beginning of the congestion
congestion_length	string	estimation of the length of the congestion

For the pilot operation of the system, it is a condition of the supplier to contractually provide over 150 000 floating vehicles. This is less than 3% of the total number of registered vehicles in the Czech Republic. The fleet of vehicles was selected so as not to affect the parameters by the predominance of trucks. The composition of the fleet is thus in a ratio of about 3: 1 for vehicles up to 3.5 t [6]. The specific number of fleet vehicles on a well-covered section of traffic is in the order of percentage units, compared to the total number of vehicles.

Thanks to the described new source, it is possible to obtain real-time data from the entire road network. Compared to conventional detectors, they have the advantage that there will be no outages in the data caused by intermediate sections between the detectors. On the other hand, one of their adverse characteristic is low penetration, especially at night. In general, one of the main reasons why the penetration of floating vehicles is not higher is probably the financial side of the issue. For many commercial entities, information about the location of their fleet is not valuable enough to need to invest in it.

It should be noted that the data does not show each vehicle. This is summary data for individual TMC segments. A TMC segment is a selected section of communication that has its own unique ID. It is based on state materials of the Localization Tables of the company CEDA. This identifier can be used to assign data to the road network. A diagram of the principle of data display is shown in the Fig. 1.

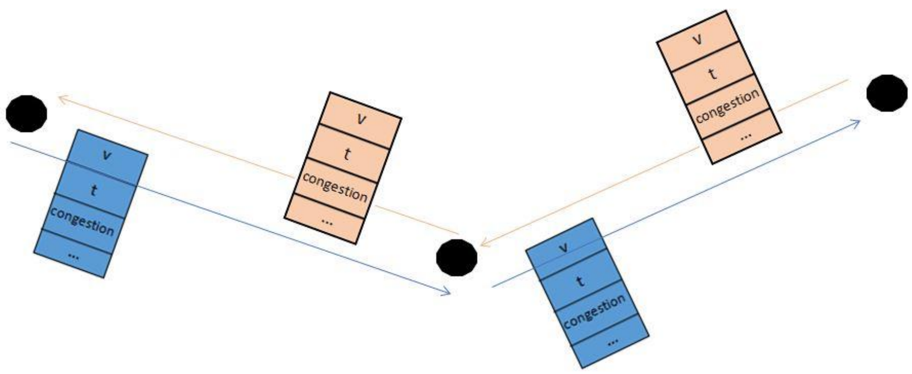

Fig. 1: Floating car data between two TMC segments

For further work, it was first necessary to process the data properly. First, erroneous measurements (inconsistent data, missing data) were discarded. Then the selected area, roads and dates according to the time stamp and day, were selected. Furthermore, the data were assigned to the spatial network using the already mentioned TMC segments. Thanks to this step, the data acquire spatial information.

4 ANALYZED SITUATION

In cooperation with the Directorate of Roads and Motorways, the model based on floating car data was analyzed. Next, some of the identified outputs are described, either as data characteristics or transport network characteristics.

5.1 Model calibration

In cooperation with the Directorate of Roads and Motorways, the floating data model was tuned by FTS CTU in Prague. The floating car data were assigned to the spatial network and the traffic parameters and their anomalies were further investigated. For example, a constant course of speeds or counts in some segments has become problematic, which may not necessarily be a model error, but these segments need to be further investigated. Furthermore, it was necessary to solve extreme low or high values, especially speeds, measured in some segments. As a result, these anomalies greatly distort the data collected.

An example of a mistake found in calibrating a model may be a sawtooth intensity over time. During the last examination of the model, these sawtooth waveforms of vehicle intensity were found in some segments. It is not possible to find an explanation for this behavior by the common phenomena of traffic flow, and so this behavior was pointed out. An error in the implementation of the computational model was demonstrated, after its elimination this phenomenon no longer occurs. The described course can be watched during the month in Fig. 2. The figure describes the days during January 2020 on the x-axis, the average speeds of floating vehicles for minute intervals are shown on the y-axis.

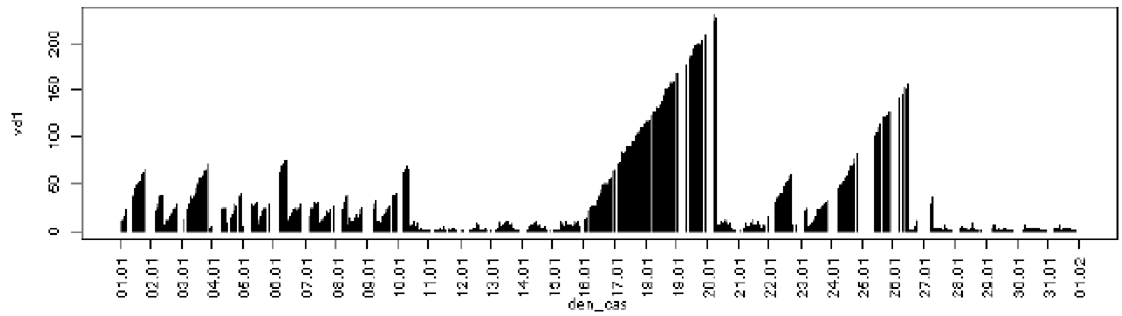

Fig. 2: Error course of intensity over time

6.1 Specific features of data from floating vehicles

With the knowledge of the characteristics of the solved source, it was assumed that with low penetration of floating vehicles, the specified parameters will be unstable. This can be expected especially on weekends and in the evening and at night. This is precisely because the elements of the floating vehicle fleet are often company vehicles. This feature needs to be taken into account when examining individual behavioral deviations, on which it would be possible to automatically analyze current traffic data. For example, the decrease in intensity at night is shown in the chart Fig. 3. This is a section of the D1 motorway at 176 km in the direction of Prague, measured in July 2020. The figure shows the fluctuation of the speed parameter with a lower number of floating vehicles. During the day, the speed of the fleet is more or less constant, but with the decrease in the number of floating vehicles between 8 pm and 4 am, the speed is unstable. It is also obvious that the early morning saddle between 8 am and 10 am when the number of floating vehicles on the road is declining. This can be caused by the character of the road when in the urban area the traffic saddle occurs after about 9 am, so this event can be shifted on the motorway.

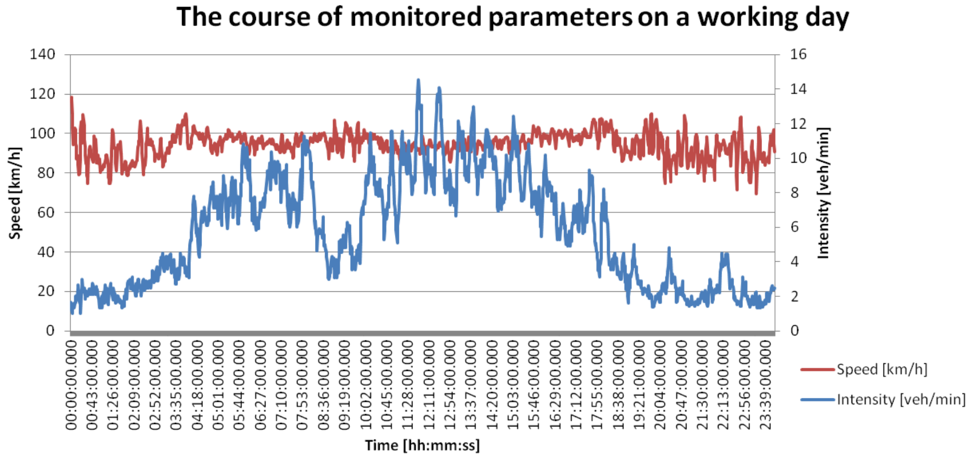

Fig. 3: The course of monitorred parameters

The graph shows the average count of vehicles as well as average speeds. Already in the generated data from the provider interface, it indicates the speeds on average per time unit for individual segments.

Another feature of floating car data is that drivers of these vehicles follow the road traffic rules. As already mentioned, it is often the case that a floating vehicle is a business vehicle. Alternatively, we are talking about the user who needs a vehicle and a driver's license for his work. This may be a specific feature that needs to be considered in the future. Earlier [7], this feature was discussed in urban areas. According to the monitored motorway segments, it can be stated that this feature is also observed in the suburbs. The graph below (Fig. 4) shows the selected section of the D1 motorway (direction Prague) in a narrower profile (due to the reconstruction of this road). It can be read from the graph that the FCD fleet runs relatively according to the rules of the road and its speed is around the required speed of 80 km / h.

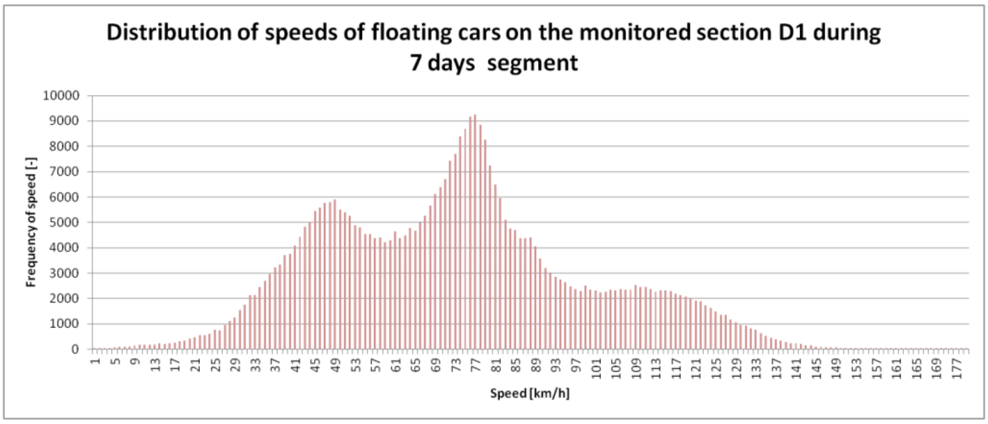

Fig. 4: Distribution of speeds of floating cars

7.1 Categorization by speed

Data connected to the spatial component (TMC segments of the communication) can be analyzed on the transport network. The classification was performed based on the average count of cars and trucks and the average speed per segment. The result is a map based on five classes, see Fig. 5. The classes correspond to the type of the roads.

The classification shows that in cities there are low traffic intensities and low average speed (marked in gray on the map). Floating vehicles in this category move at speeds below 50 km/h. Slightly faster, about 60 - 65 km/h, drivers of floating vehicles drive near large cities and on lower roads (colored in orange). On first and second-class roads, floating car data on average indicate speeds between 70 and 75 km/h, and the average count of vehicles reaches up to 20 cars/min. These roads are colored green.

Unsurprisingly, the fastest vehicles are on motorways and some sections of first-class roads (shown in blue). On these roads, a speed of around 100 km/h and a very frequent occurrence of cars and trucks are shown. The average number of vehicles in the segment for cars and trucks is growing up to 35 vehicles/min. Even from the average speed, it is clear that trucks predominate over cars on these roads.

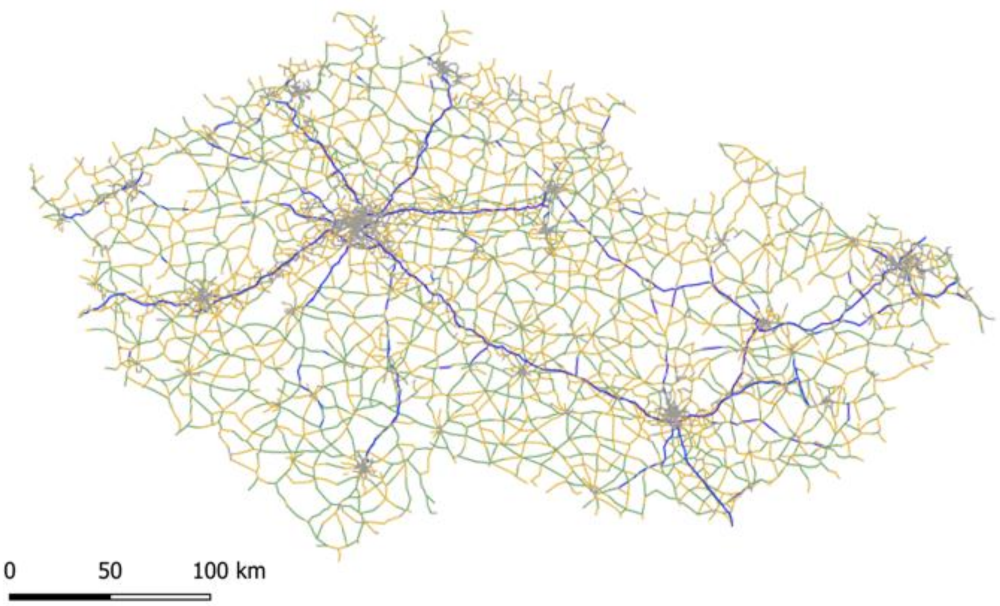

Fig. 5: Road categorization by speed

It is also clear from the map that floating car data cover a large part of the road network in the Czech Republic. This is very important in the future when there is an idea of using this data for traffic management. For that, it is necessary to collect data evenly from all roads of interest. And that is the subject of research into whether this is already so. Data from floating vehicles could contribute to this in the future.

5 CONCLUSION AND FUTURE WORK

A new data source is available in the Czech Republic, which is freely accessible and guaranteed by the state. The article describes the processing of floating car data and their analysis. Initially, their modification was described. Irregularities detected during model tuning in cooperation with the Directorate of Roads and Motorways were also described.

Furthermore, the article deals with the specific characteristics resulting from the collection of this data. These graphs show great discipline in drivers of floating vehicles. It has also been shown that on weekends and in the evening and at night when there are few floating vehicles on the network, the data flows are not stable. This must be taken into account when applying data to telematics systems. After categorization of roads according to speeds, the analysis of data supports the idea of using this data as a characteristic of traffic flow. It is obvious that the speed data are lower than the maximum allowed speed according to the type of communication, but the communications are clearly legible.

The analyzed data from floating vehicles show a positive promise for the future. The article does not provide a complete qualitative analysis of the model. Selected analyzed parameters are listed and the parameters look promising from the above analyzes. In the future, the data could be used for a wide range of applications, whether in traffic management, traffic management, or traffic optimization.

In the future, the authors of the article will further deal with the quality of these traffic data and the associated possibilities of use for transport systems. The COVID-19 epidemic probably affected the data and it is necessary to monitor their development in the future, among other things in terms of penetration. If it is still shown that the data can be considered as characteristic of the traffic flow, their limit number for this statement needs to be determined and data could be used as an additional or main data source for traffic systems.

The question is to thoroughly analyze whether this data source can be used to control, direct and optimize traffic throughout the network. In the future, it could be a powerful data source for these tools.

ACKNOWLEDGEMENT

Data from the Transport Portal of the Czech Republic were used for this project (data source: ŘSD ČR – JSDI – www.dopravniinfo.cz). This research was supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS SGS21/080/OHK2/1T/16 - Detection of detours of an accident on main roads based on floating car data.

REFERENCE

[1] Schäfer R. P., Thiessenhusen, K. U, Bockfeld E., Wagner P., 2002, A traffic information system by means of real-time floating-car data. In: ITS World Congress 2002.

[2] Rahmani M, Jenelius E., Koutsopoulos H. N., 2015, Nonparametric estimation of route travel time distributions from low-frequency floating car data, In: Transportation Research Part C: Emerging Technologies, vol. 58, pp. 343–362.

[3] Houbraken M. et al., 2015, Real-time traffic monitoring by fusing floating car data with stationary detector data, 2015 International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS), Budapest, Hungary, pp. 127-131, doi: 10.1109/MTITS.2015.7223247.

[4] Z. Deng Z., Bai Y., 2016, Floating car data processing model based on Hadoop-GIS tools, 2016 Fifth International Conference on Agro-Geoinformatics (Agro-Geoinformatics), Tianjin, China, pp. 1-4, doi: 10.1109/Agro-Geoinformatics.2016.7577677.

[5] TomTom, Maps and navigation for all: We go better together. https://www.tomtom.com/cs_cz/, cited 16.02.2021.

[6] Milan Frydryšek, 2020, Standardizovaná data z plovoucích vozidel jsou zdarma k dispozici široké veřejnosti, 31.7.2020, https://www.dnoviny.cz/informatika/standardizovana-data-z-plovoucich-vozidel-jsou-zdarma-k-dispozici-siroke-verejnosti, cited 07.03.2021.

[7] Hrubeš P., Purkrábková Z., Kovaljov M., Kovaljová K., Hampl J., Novotný T, 2020, Kontrolní a expertní činnost při zavádění a následném provozu FCD – kalibrace výpočetního modelu II, Research report č.: 97/2019a.