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Author: Zuzana Purkrábková, Pavel Hrubeš

Czech Technical University in Prague, Czech Republic

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ANALYSIS OF DRIVER CHOICE AT THE CLOSURE OF THE MAIN ROAD USING FLOATING CAR DATA

Zuzana Purkrábková, Pavel Hrubeš

Czech Technical University in Prague

ABSTRACT

Progress in the option of transport data collection allows users to collect data using floating vehicles. This data provides real-time information about the road network. In the Czech Republic, these data were published in a pilot project last year. The article uses this new data source. Data can be spatially displayed using GIS software. Analysis options can be used and drivers' choice when the main road is closed can be detected.

Keywords: GIS, floating car data, traffic data, data analysis

INTRODUCTION

A modern trend today is the collection of large amounts of data. A new source of traffic data was opened last year in the Czech Republic, where the Directorate of Roads and Motorways published data from floating vehicles in a pilot interface.

This data is collected from fleet vehicles and sent to the server at periodic intervals. The data is then anonymized and provided to customers for further analysis. Unlike conventional detectors, data from floating vehicles provide real-time information without the need to install technology along the road. It is thus an additional source of data to stationary detectors, such as data from toll gates. In this paper, the authors focus on the behavior of the user when closing the main road due to an accident. These are the first steps and their results in this research. Two events from the summer of this year were selected. Selected events caused the closure of the main D1 road leading across the Czech Republic. Furthermore, data from floating vehicles for these specific events were examined. The movement of the traffic flow during and after these events was monitored. The article publishes the results of this research.

Current use of floating vehicles

The use of floating car data is a relatively actual topic today. There have been several such data in recent years, and many research groups are trying to use the data to improve knowledge about traffic flows. Compared to stationary detectors, no installation is required, which is a great advantage. Data from stationary detectors are already used for a wide range of support systems, such as driver information, information collection and distribution, or crisis management (Růžička et al., 2020). These possibilities are generally also investigated on floating car data. It is currently possible to follow several studies on this topic in urban area.

The research (Tiedong et al., 2014) to create a data platform unifying floating car data, which will enable the prediction and visualization of traffic flow. The study (Astarita et al., 2020) examines the use of floating car data to control the intersection, which would be further useful for the concept of connected vehicles and infrastructure. The research (Mikat et al., 2003) deals with the selection of a route in the urban area, where it followed the selection of routes for taxi drivers from

Berlin Airport to the city centre and the reason for their choice.

There is a small amount of research working in the suburbs working with floating vehicles. In particular, Dutch research (Houbraken et al., 2015) uses data from floating vehicles to control the highway. Other research (Jin et al., 2020) compares data from floating vehicles with stationary detectors and their reliability. The authors have previously prepared a study of the reliability of Czech floating car data (Hrubeš et al., 2020), which was the input for this research. Sufficient coverage of the road infrastructure by floating car was proved and also some errors that the model showed (blind sections, required parameters, etc.) were debugged.

RESEARCH INPUTS

In the Czech Republic, there are a large number of lower-class roads that can be used as an alternative route to the destination. Due to the relatively dense coverage of the republic by the road infrastructure and the small area, there are often detour routes selected based on the driver's knowledge of the site. There is often a situation where it is possible to go around three or more possible alternative routes. Drivers will most often use these options to speed up their journey or for greater comfort (knowledge of the route makes it easier for the driver to travel). Therefore, the authors conclude this behavior should be investigated further.

Thanks to a new data source, which has been available in the Czech Republic since last year, it is possible to monitor traffic flows based on data from floating vehicles. This is real time data, which is provided with a sampling frequency of 1 minute and covers almost the entire road network of the Czech Republic. As previously discussed by the authors in previous studies (Hrubeš et al., 2020), vehicle penetration is satisfactory, and so the behavior of the entire traffic flow can be inferred from floating car data.

Data and model of the infrastructure

The research is in its first year. Data collection and their initial analysis were ensured. A contract with the data provider was required for data collection. It is therefore not open data to the public. After the settlement of this contract, the required location and parameters of the monitored roads were defined in the web interface. In the interface, it is possible to choose from two formats (DATEX and Native XML) and further specify, for example, the class of communication or area in the Czech Republic. The data is sent to the specified address, in our case to the data server. The data is sent in 5-minute aggregation, where the data for the past 5 minutes are put together. The data can be spatially analyzed thanks to the identifier of the so-called TMC segment, which is the designation of individual segments of the communication network. The official map of these segments is managed by CEDA company, whose layer was used. Thanks to the numbering of TMC segments, it was then possible to connect the communications database with the data of floating vehicles.

Furthermore, the data include the date and time stamp, information on the number of vehicles per segment, the total current speed and travel time per segment, the travel time and speed of the free traffic flow, the reliability level of the data, and further data indicating congestion. More specifically, binary information on whether congestion exists on a given segment (0 or 1). Further in the data is an estimate of the distance in meters from which the congestion is formed. And there is also an estimated length of the congestion in meters. In the first step, it was also necessary to define the monitored road network on which the events will be examined. Highways, motorways and first-class roads were selected for this

phase of the project. According to the data used, this is less than 10,000 km of roads, which is about 15% of the road infrastructure in the Czech Republic. To give you an idea, it is possible to see these roads on the map below.

Figure 1: Map of selected roads in the Czech Republic

In the map shown it is clear that the selection of these roads covers a large part of our republic and therefore not missed a significant portion of the traffic in the Czech Republic. These three classes of roads cover the whole area relatively evenly and also extend into mountain areas. Their selection will not eliminate any important user behavior or neglected part of the republic.

Data for the entire road network in the Czech Republic are collected for this project. Despite the focus of the model on the main roads, it is also necessary to monitor traffic on lower roads, where traffic can often move. The model is focused on the monitored events, however, the movement of traffic flow is monitored on the entire road infrastructure in the Czech Republic.

According to the initial analysis of data for the whole month of July, it is clear that floating vehicles cover a satisfactory part of the road infrastructure. According to figure , the outline borders of the Czech Republic is also obvious on the basis of floating car data. The colour scale represents data coverage, dark colour indicates high data concentration, and with a lighter colour, data concentration decreases. In the peripheral parts of the republic, coverage is declining. This fact does not interfere with this research of alternative routes.

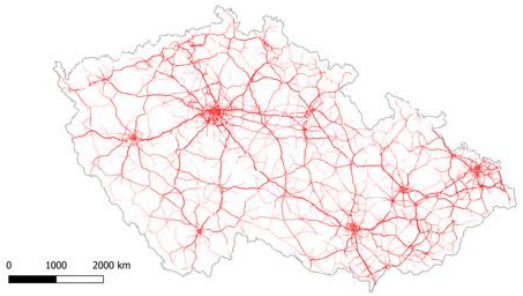

Figure 2: Data coverage in the Czech Republic

Detection of the alternative routes in the network

The research is currently in the second phase. The authors examine the creation of alternative routes with the complete closure of the main traffic route. It is primarily a matter of detecting alternative routes and if an alternative route is recommended, examining why some users have chosen a detour other than the recommended ones.

Furthermore, similar parameters and behavior of users in the event of an accident or partial closure of the main route will be examined. At that time, the traffic flow is still moving, but for example, some driver's applications can lead to alternative routes to reduce the travel time of the vehicle.

Selected two incidents are located on the main highway D1 between the capital city of Prague and the other two metropolises Brno and Ostrava. Both excesses led to the overall closure of the highway and the leading the traffic flow to a detour route. These incidents were detected in July this year. This is a holiday

operation, however, due to the current coronavirus situation, no large differences in traffic are detected between June and July.

The monitored incidents took place on Monday, July 13, which is not affected in any way by public holidays, etc. The connection between Monday and weekend days and thus the possible influence of traffic could be discussed. There are public holidays in the Czech Republic on 5 and 6 July, so there is no presumption of a significantly extended weekend a week later. Traditionally, traffic flow has been affected the week before (influenced by the public holidays just mentioned).

Selected events were not mutually affected. Both events are located at a distance of 139 km, respectively 177 km between Prague and Brno. The first solved event happened at kilometer 177 in the direction of Prague at approximately 2:00 p.m. The second event happened at kilometer 139 in the direction of Prague after 9 p.m.

Incident 1

An official detour route was created for the event at 177 km when it was recommended to take the 178 km exit towards Ostrovačice and return to the D1 at the 168 km exit called Devět Křížů. This event happened in a narrowed communication profile. The main road D1 is undergoing a long-term modernization and on several sections, the traffic is diverted into two narrow lanes with alternating driving. The accident happened in one of the modernized sections when a truck crashed. According to available information, up to 20 km, long congestion was formed. After removing the consequences of the accident with heavy machinery, it was possible to partially bypass the site directly in the main route.

According to the schematic map in figure , the affected locality can be observed, including the surrounding roads. There are not many options for choosing a detour. The lowest road of the 3rd class connects two higher roads, which can be directed to immediately after the exit from D1. There is no presumption of the use of road III / 00213.

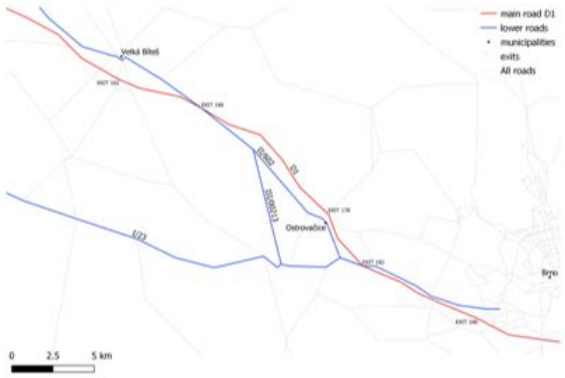

Figure 3: Schematic map of situation on km 177

Based on the recommended detour route, it is assumed that a large part of the traffic flow will be transferred to the marked detour. Between exits 168 and 178, there is no other possible exit from the highway, and even in the vicinity, there are not a large number of lower-class roads that can be used for a smoother ride. With knowledge of the area, the following scenarios are offered:

- The driver follows a detour (road II / 602) and takes D1 at exit 168
- The driver follows a detour route, his destination was around the town of Velká Bíteš and the vehicle did not drive on the D1
- The destination was towards the town of Náměšť nad Oslavou and the driver does not follow a detour immediately after exiting the highway but chooses road I / 23 to his destination

This behavior was monitored on a model created in QGIS. Data on the number of floating vehicles and their speed were compared. The speed data were very comparable for the whole period, which did not contribute to the explanation of the data. The reason will

probably be the narrowing of the D1 highway, where the speed is limited to 80 km / h. According to the combination of the meanings of the data on speed and number of vehicles, the following course of the situation resulted.

The solved period was divided into 5 minute intervals for better clarity of data. When displaying the number of vehicles in the section, the probably searched event is monitored after 2 pm. It is obvious that the number of vehicles on the segments decreased from an average of 5-7 (green to blue) to 1 vehicle (light red), see figure . It is also possible to monitor the movement of floating vehicles on road II / 395.

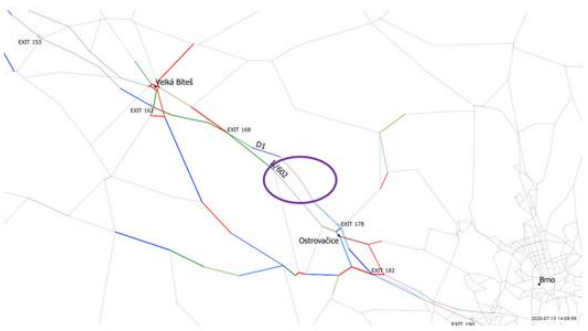

Figure 4: Incident km 177 starting point

Over time, it was possible to observe an increase in the number of floating vehicles on lower roads, especially on roads II / 602 and II / 395. This can be seen in figure . This shift can be explained by the information of drivers of floating cars who chose the alternative route II / 602, or took the former exit 182 and continued through the village Rosice after II / 395 to exit 168.

During the removal of the accident, the drivers deviated more from the main route and chose the two mentioned alternatives, as evidenced by figure when a minimum of floating vehicles remained on the highway (light red), on the contrary, detour road II / 602 is busy.

Even at this moment, however, the speed model shows a speed in the range of 60-80 km / h on all roads. This starts to change around 17:20, when the speed and number of vehicles on the highway increases compared to the alternative route, which can be seen in figure (on the right is the number of vehicles, on the left is the speed when the highway is dark green, 80-120 km / h).

Figure 5: Growing number of vehicles on detours

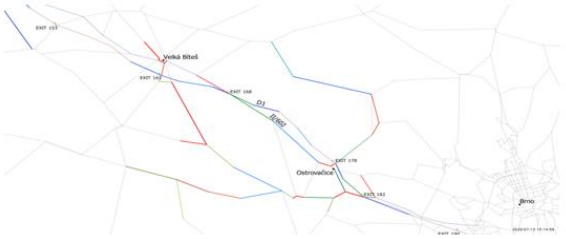

Figure 6: Comparison of the number of vehicles on the motorway and detours

Figure 7: Moving traffic flow back to the highway

The modelled situation shows that the data do not show the complete closure of the highway. This situation can be explained by the timely reaction of drivers of floating vehicles when the principle of operation of floating vehicles (mostly commercial use) is an effort to ensure that vehicles do not spend time in congestion. Drivers thus reacted quickly to the situation and chose detours almost immediately, when their load can be monitored in the model. Alternatively, it

may also be due to the small amount of floating car data for this situation, which needs to be further checked.

It is astonishing that, according to information from the media, congestion up to 20 km long formed on the main route, which was not evident in the data. It is advisable to further check the data, for example with data from stationary detectors, whether they are adequate and real, and to look for an explanation of this phenomenon.

Incident 2

Three trucks collided on km 139 and units of the integrated rescue system intervened at the incident. The accident occurred between exits 141 Velké Meziříčí - West and exit 134 Měřín. According to available information, congestion up to 6 km long formed on the site. A detour was not officially recommended for this event.

The schematic map in figure shows the infrastructure in the area concerned. In this area, a lower-class road II/602 runs along the D1 highway, so it is possible to choose this alternative to avoid an accident on the main road. Compared to the previous situation, there are more lower-class connecting roads for higher class roads in the area.

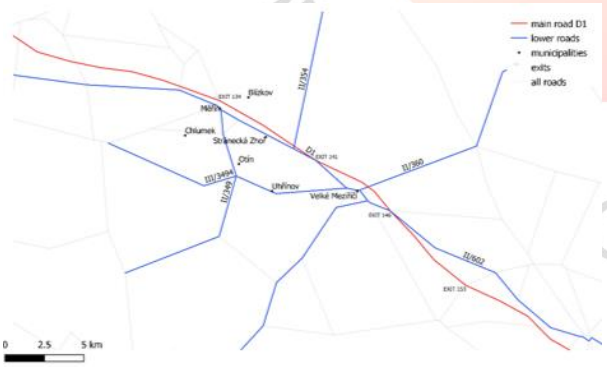

Figure 8: Schematic map of situation on km 139

This event is different from the first solved event in that the formed congestion was not so long. Detours were also not recommended, so official navigation did not have to divert traffic from the main road. The accident also occurred in the later hours. The traffic was resumed at about 10 pm when the traffic intensity is no longer so marked. The following driver behavior options can be expected:

- The driver remains on the main road D1 and waits until the road clears
- The driver will take exit 141 and will continue parallel to the highway on road II / 602, take exit 134 again and continue on the highway
- The driver's destination is located between these exits, the driver chooses a direct route to the destination
- The driver is heading to Netín, he chooses route II / 602 and then turns on road II / 354
- The driver takes exit 146 in Velké Meziříčí and also chooses a detour either via the road II / 602 or via Uhřínov on the 3rd class road III / 3494

Furthermore, this behavior was monitored on a model created in QGIS. The solved period was divided into 5-minute intervals for better clarity of data. When monitoring the number of floating vehicles, the situation on the main road does not change significantly during the accident. On average, 5-10 floating vehicles move on sections D1 and on the monitored detour route. For this reason, the authors further focus on the speed parameter.

In the speed data, it is possible to observe the formation of congestion, or a significant slowdown of the traffic flow after a traffic accident (see figure 9, red segment). Furthermore, in time it is possible to observe first the movement of vehicles and then again a significant slowdown in traffic flow, probably due to the arrival of rescue units (green segment in the picture on the left, then again red

segment on the right picture, see figure 10). Approximately between 21:30 and 21:50, the formation of a congestion on D1 can be observed, as well as the increased use of the alternative road II / 602. This shows a summary image n. 11, which shows 3 situations. Road II / 602 is gradually colored green to blue (blue means highest speed). Drivers chose this route until exit 134, where most of them probably drove back to D1. In the last image 12 it is possible to watch the return of traffic flow to the main route D1.

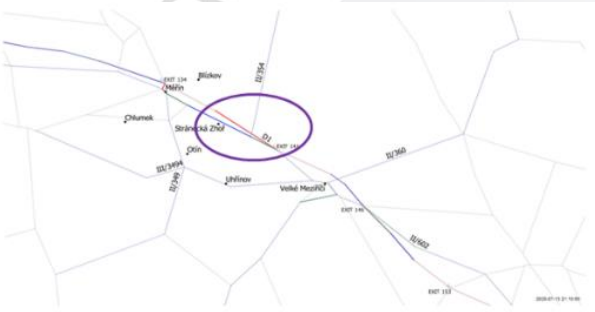

Figure 9: Incident km 139 starting point

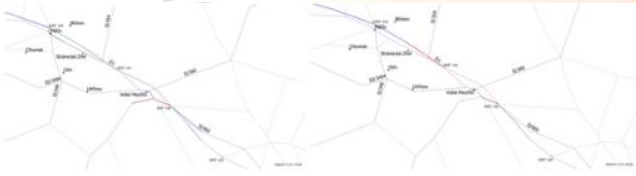

Figure 10: Medium speed of the traffic flow and deceleration of traffic flow again

Figure 11: Demonstration of the shift of traffic flow from the main road to the alternative road

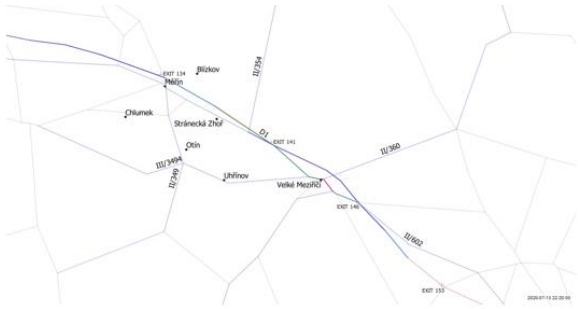

Figure 12: Return of traffic flow to the main traffic road

According to these findings, it is clear that drivers with a detour of the main road are waiting to see if the situation calms down. There was no obvious immediate reaction, but rather a reaction to the information provided when they used the earlier exit to correct their route. This may also be because exit 141 is 2 km from the accident site and could therefore already be in the congestion area. Therefore, drivers chose more exit 146. In this situation it is obvious, drivers of floating cars do not use lower class roads.

FUTURE WORK

Two incidents that took place in July of this year on the main traffic route through the territory of the Czech Republic were examined. In the first case, it was a major accident with the recommended detour. In the second case, it was only a momentary complete closure of the main traffic route. Both events were examined from the point of view of floating car data in geographic software.

Despite the assumption of better data distortion at the first accident, probably due to traffic restrictions in the whole area, the data were not so convincing. Speed and number of vehicles data were compared. Based on it, it was found to select not only the recommendation of a detour route but also the use of another

route of the 2nd class road. For further monitoring, information on the formation of congestion will be submitted, which is based on data but cannot be monitored in the model. For the second event, a change in traffic flow with a time delay was detected. Probably because the main road did not close directly, more drivers remained on the main road. Furthermore, it was found that drivers do not use lower class roads, although this would be possible in this case. Drivers of floating vehicles are likely to make their choice of the route based on information from their controller centers or verified information sources. Based on them, the traffic probably moved to the detours at the first possible exit.

It is clear that when examining incidents on lower-class roads, there may not be enough data from floating vehicles to track alternative routes. Therefore, research will continue to focus only on highways, motorways, and, where appropriate, first-class roads. The next step will be to examine other similar events that occur on the network and their impact on the driver's route selection. For further work, accidents that have only partially limited traffic on major transport routes will also be examined. If the previous ideas are confirmed, it would then be possible to automatically search for these events in the network based on the entered parameters and send this information to the drivers on the network with a minimum of delay.

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