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Traffic Information System for Hanoi

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Abstract

To improve the traffic situation in Hanoi it is necessary to have a good overview of the existing traffic situation and to monitor the development of the traffic over longer time periods. Floating Car Data (FCD) Systems can help to acquire area wide traffic information; here a FCD system based on taxis, busses and motor-cycles is described. It consists of Web and App tools and a Hotspot-Monitoring for long term traffic analysis.

Peer-review under responsibility of the organizing committee of CUTE 2016

Keywords: Traffic information system; floating car data; floating bus data; floating phone data; traffic management; hot spot monitoring

1. Introduction

The daily traffic situation in Hanoi is characterized by a great volume of motor cycles and a road network with rarely technical infrastructure. This situation has developed mainly in the last two decades (see Hansen, A. [1]). The number of motor-cycles in Vietnam has grown at an astonishing pace, driven by the country's economic growth. According to official statistics there were about 4 million motor-cycles in all of Vietnam in 1996; today there are about that many in Hanoi alone. Recently VNS [2] wrote, that the Ha Noi People's Committee has predicted that the city's economy in the fourth quarter could grow by 8.9 - 9 percent and rise to 8.1 - 8.2 percent for the entire year.

The combination of these facts led to a quick rising number of cars, making the traffic situation in the city worse and worse. Here Floating Car Data (FCD) Systems can help to acquire area wide traffic information without big investments in infrastructure. In the following a traffic information system for Hanoi is described which was developed during the project REMON, funded by the German Ministry of Science and Technology (BMBF) from 2012 to 2015. The system relies on Floating Car, Floating Phone and Floating Bus Data.

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2. Data sources

2.1. Floating Car Data (Taxi-FCD)

Taxi-FCD is an established data source for generating area wide traffic information. Since 2002 a FCD system is developed at the German Aerospace Center. Several fleets and projects in Europe and Asia are benefitting from this. The system was tested during several field tests (e.g. see [3]). Within the REMON project the system was adopted and extended for the special needs of the city of Hanoi.

FCD of about 3000 taxis are used for the estimation of current traffic conditions. Fig. 1 shows the spacial coverage and frequency of the data exemplarily for June 2015 on the main road network (other roads are marked as a thin gray line). It can be seen that current data are available at least every 10 minutes on a very big share of the main road network, especially nearly every main road in the central area - between river Song Hong and ring road 3 (Duong vanh Dai 3) - and even on arterial roads - reaching from the suburban to the central area and back. For a big share of these new current data are available even every 5 minutes or more often. For these parts of the road network the actuality of the data is of that high quality that nearly all typical "state of the art" traffic management services (traffic condition maps, routing on current traffic situation, even steering of traffic signals, …) are possible and can be provided with these high quality data. For the area on the west side of the river Song Hong this is true except for the two arterial roads to the west beginning at ring road 3 and the east part of ring road 3 where data are only available every 20 minutes or rare. The same is for the roads eastern of the river which are no arterial roads and for which provided traffic information cannot be provided "up-to-date".

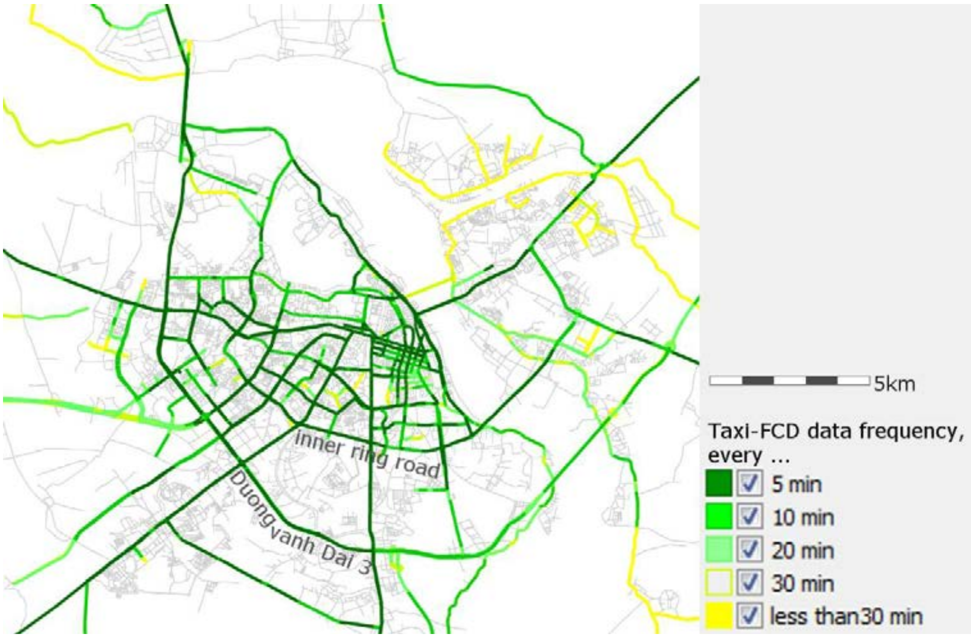

Fig. 1: Coverage of the REMON traffic information system based on 3000 taxis in Hanoi for June 2015

2.2. Floating Phone Data

Taxi-FCD fleets deliver good traffic information about car traffic. But generating a system based only on car positions is not enough for a city like Hanoi, where the main traffic is produced by motor-cycles. It is necessary to get position data also from motor-cycles. For this the traffic information system (TIS) was extended by a smartphone app. On one hand the smartphone app is very useful for all road users of Hanoi to see the changing traffic situation; on the other hand it can collect traffic data from the motor-cycles. A GPS signal is requested every

10 seconds and the recorded positions are sent every 60 seconds to the TIS. In the TIS a special routing function for two-wheelers was developed, because they are allowed to pass roads that are forbidden for cars while other roads (for example some freeways) are forbidden for motor-cycles. Much effort in the project REMON was done to set correct according attributes concerning the motor-cycle driven permissions. Thus, two internal street-maps are used: one for cars and one for two-wheelers. The collected motor-cycle positions and their trajectories need a different interpretation than the ones of cars. Often motor-cycles can drive around obstacles so that the calculated speeds and travel times get a different calculation concerning generated traffic states (level of service; LOS). If there are several motor-cycles and cars on one street within the same time slice, the average LOS is determined by weighting all vehicles equally with “1”.

2.3. Floating Bus Data

General Characteristics

In comparison to the FCD based on taxis or mobile individual vehicles, the FCD based on busses delivers only data on special routes – the bus-routes. The advantage is that this data source delivers traffic information on those special routes in regular intervals (e.g. 5-10 minutes). Due to the fact that busses have to stop at stations, the data in the surrounding of a bus stop has to be rejected, because it doesn’t represent the surrounding traffic condition. Fig. 2 shows the raw GPS positions combined to a trace of colored speeds and the position of the according bus-stations. It can be seen that the local-speed of the bus is lower in the surrounding of the stations.

Fig. 2: Raw bus GPS speeds and bus-stations (green dots), (Source: Google Earth)

Map matching process

The used raw data does not include information at which route the bus is currently driving, only a counter representing the index of the next station on the route. Thus, the first idea was to filter all bus positions in the surrounding of a bus-station, no matter what route the bus drives. But in Hanoi city there exist now ~80 bus-lines, which partly go over the same streets but use different stations. This means that too much relevant data would be filtered by that method.

So at first the driven route is detected without map-matching by looking at all stations near to the GPS-positions and save them in a candidate list. Then the next position in the timeline is looked at. After some time only the stations of the correct bus-line stay in this candidate list, because the correct following of stations is checked as well.

The second step is to filter out positions which are nearby the obviously correct stations. Then a map-matching based on known technology from taxi-FCD can be applied. In the last step the derived travel times are fused with traffic information from the other sources.

3. Traffic Management Applications

3.1. System Architecture

The REMON traffic information system (TIS) consists of three essential domains:

- Available GPS data from various sources,
- Processing of raw data and
- Provision of results in the form of a traffic situation.

Fig. 3 shows the relationship between the domains of this architecture.

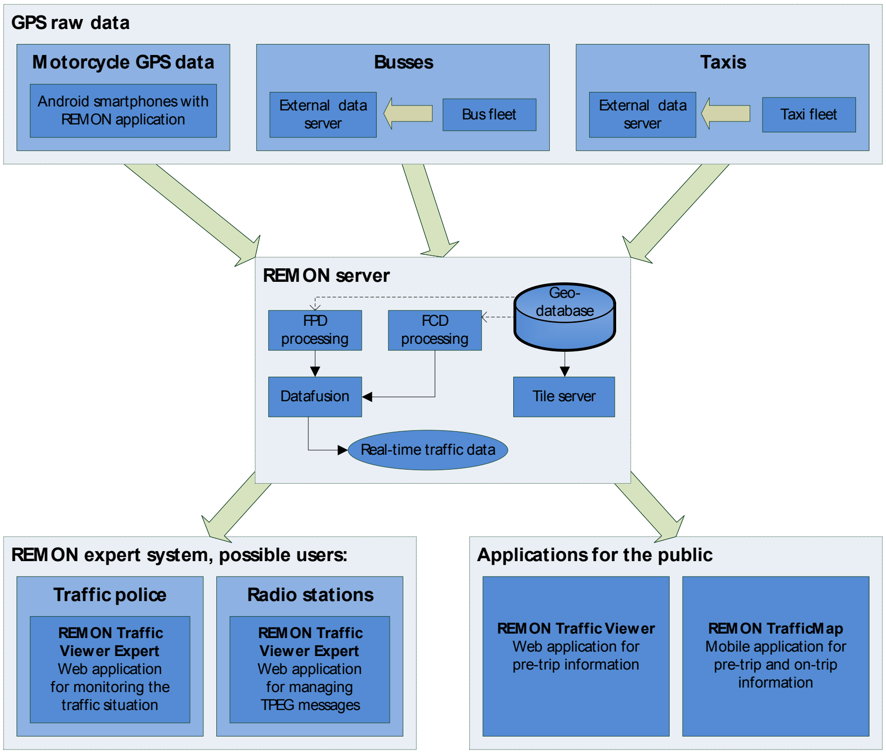

Fig. 3: TIS System Architecture

The raw data includes on the one hand position data of taxis and busses and on the other hand position data of mobile users. They own the mobile REMON application on their smartphone and use this actively while driving. The application determines and sends the GPS positions over a HTTP interface to the REMON server, which stores the received data in the geo database. In addition, the server downloads cyclically the taxi and bus data from an external server via HTTP and stores it persistently.

The different raw data are periodically read from the geo database, processed, fused and stored. As a result, the current traffic situation exists. The current traffic situation is used then in the smartphone application “REMON Traffic Viewer”, the “REMON Traffic Viewer” and the “REMON Traffic Viewer Expert” which are described in the following section.

3.2. Traffic Information System - TIS

REMON Traffic Viewer

The Traffic Viewer is a web application for the public. It offers the following functionalities:

Show the current traffic situation and additional TPEG messages (traffic messages using an international standard, developed by TISA, see [4])

Routing functionality

Search for streets and points of interest

Add special additional layers like public transport, gas stations, banks & ATMs, …

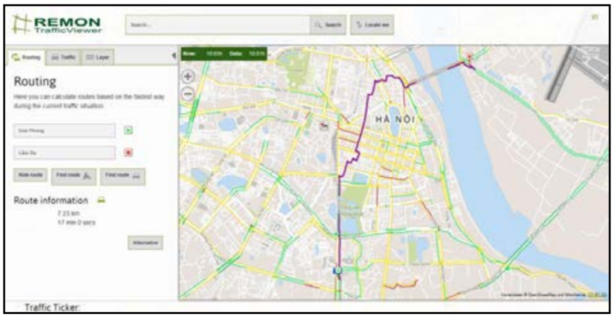

Fig. 4: REMON Traffic Viewer with routing request

REMON Traffic Viewer Expert

The Traffic Viewer Expert offers the same functionality as the public Traffic Viewer but it is extended for traffic experts. It is created for experts that overview the traffic and feed it with additional information (see Fig. 4). The expert version uses a four-level LOS (free flow, dense traffic, very dense traffic, congestions/traffic jam) while the public viewer only uses three levels (free flow, queued traffic, congestions/traffic jam) and the road network of the expert version is divided into shorter segments to see details in crossing areas. In addition to the public Traffic Viewer the Traffic Viewer Expert has the following features:

Route Monitoring

Possibility to watch the traffic situation for a whole route, divided into single road segments and get information about the tendency of the travel speeds on that route. (see **Error! Reference source not found.**)

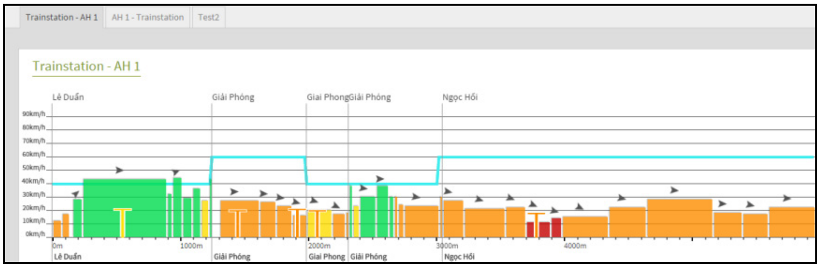

Fig. 5. Route Monitoring of Traffic Viewer Expert

Fig 6.Crossing Monitoring of Traffic Viewer Expert

It is also possible to compare the historical travel time with the current one and the allowed maximum speed.

Crossing Monitoring

It is possible to overview the traffic situation of a selected crossing with detailed incoming and outgoing lanes. (see **Error! Reference source not found.**)

Traffic Prediction

The Traffic Viewer Expert can display the expected traffic conditions on the streets for the next 20, 40 or 60 minutes in the whole map. The results are calculated from historical data that is stored in the database for each day of week in slices of 20 minutes.

TPEG messages

The expert viewer also offers the possibility to enter and manage TPEG messages. TPEG messages are an international standard developed by TISA, see [4]. The TPEG messages consist of predefined events and dependent on the event several sub attributes. The main event types of TPEG messages are: Accident, roadwork, weather, incident, event, traffic congestion, network condition, travel time and news. Each message contains three blocks: The WHAT happened, the WHEN does/did it happen and the WHERE does/did it happen block. These messages are considered while routing. If necessary the additional travel times are added or road closures are considered and an alternative route is suggested.

3.3. Hotspot Monitoring

The crossing monitoring (see 3.2) delivers an online overview of the current traffic situation at selected intersections while Hotspot Monitoring is a detailed long term analysis of the strongly jammed areas in the city. The analysis consists of two parts, on the known hotspots, which are for the most part the intersections from the crossing monitoring; and second the automatic hotspot detection, which analyses the traffic conditions over a longer time period by clustering the jammed areas above a threshold to identify the hotspot without any previous knowledge.

3.3.1. Known Hotspots

In this section the traffic situation at typical workdays and weekends are presented exemplarily for some known hotspots.

Fig. shows a map overview on these consisting of three routes and one crossing. These are in detail:

- Train station Ga Ha Noi -> Duong vanh dai 3 (“AH 1”) along the streets Le Duan and Giai Phong: a typical arterial road from the outer ring road to city center and train station.
- Duong vanh dai 3 (“AH 1”) -> Train station Ga Ha Noi (opposite direction of 1.).
- Pho Hue: A typical, often jammed road in the city center.
- Crossing Dai Phong / Dai Co Viet (“4”): A typical crossing near the center where main roads intersect.

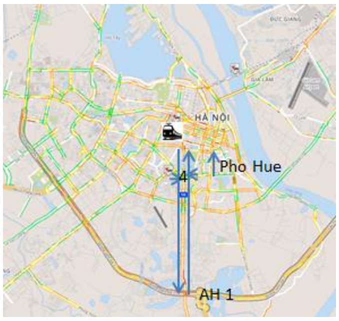

Fig. 7: Overview on selected hotspots.

All analyses have been done taking the traffic information generated on the basis of the 3000 taxis in March 2015.

Fig. shows daily variation curves of the average speeds for the three routes differentiated by workdays and weekends. All routes show variation curves with some typical characteristics. For the first route “train station -> AH 1” the average speed at free flow traffic is about 43 km/h. In the morning rush hour the speed goes down to 25 km/h at about 7 a.m. and has a “lunch relaxing” around 12 a.m. up to 30 km/h. More pronounced than the morning peak is of course the afternoon rush hour, because the direction is from the center to the outskirts with average speeds of only 20 km/h around 5 p.m., then stepwise relaxing to free flow speed in the night. In comparison the opposite direction to the train station / center shows slightly lower free flow speeds at night with about 38 km/h and – as expected - a more clear morning peak with speeds of 22 km/h at about 7:30 a.m.. For both directions at weekends there are no clear rush hours and thus no peaks. Speeds go only down to about 27 km/h. The third route "Pho Hue" as a typical road in the city center shows generally draws a similar picture. Speeds are in general lower with free flow of about 35 km/h and 20 km/h at peak hours. Remarkably here is that this low speed is nearly constant over the whole time from about 5:30 a.m. to 8 p.m. only relaxing a bit at lunch time around 1 p.m.. As can be seen also for the other two routes, but here more clear, is that at the weekends the morning peak is reached about 2 hours later than on workdays. Furthermore remarkable here, that on the "Pho Hue" traffic situation over the whole day does not differ so much between workdays and weekends. Thus, there is always heavy traffic.

Fig. shows daily speed variation curves for the four inflow sections of crossing 4 (Dai Phong / Dai Co Viet) exemplarily. As for the routes the variations show typical structures as expected. For all four directions the average speeds on workdays and weekends are similar, but differ especially at peak hours. On workdays direction "from south" (towards center) has a very clear morning peak with speeds going down to about 20 km/h. For direction "from north" (towards outskirts) there is an even more clear peak with an average speed of 14 km/h at 5:30 p.m. For the transverse directions ("from east" and "from west") the rush hour peaks are visible, but not so clearly with speeds going down from about 45 to 30 and 25 km/h.

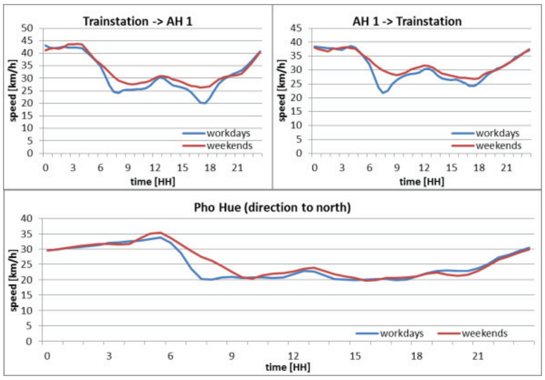

Fig. 8: Daily speed variation curves calculated from data of March 2015 for three selected routes.

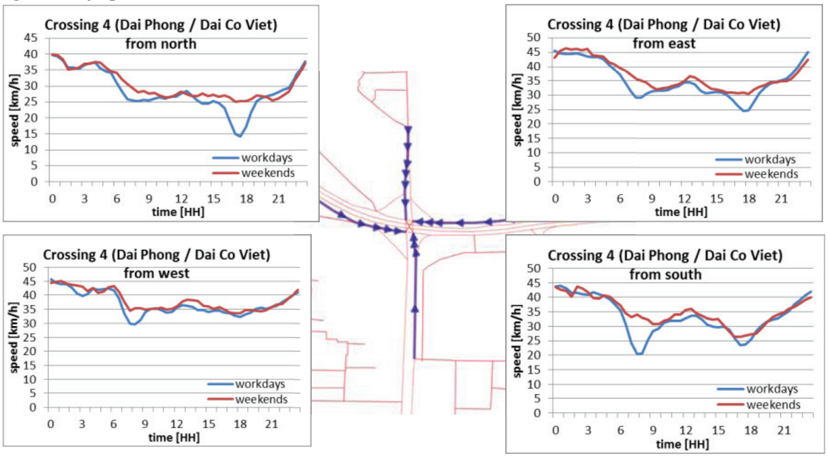

Fig. 9: Daily speed variation curves calculated from data of March 2015 for the four inflow directions at a selected crossing.

3.3.2. Automatic Hotspot detection

For the automatic hotspot detection all available traffic data information of the last three months (here 03.2015-05.2015) is used. This time period ensures a valid data source which represents the traffic of the season. Additionally only weekdays (Monday – Friday) are in the scope.

Fig. 10: Automatically detected Hotspots

Then for every edge in the road network daily variation curves based on this 3-month of data are used. In order to get an impression of the “normal” traffic condition on each particular road segment a free-flow speed is derived. It is calculated with the traffic data between 11:00 p.m. and 4:00 a.m. Furthermore the standard deviation of the daily variation is used to get those road segments with have a high variation in daily traffic, because these are the areas in the city with high potential for jams. These edges are then in a final step clustered to traffic hotspots. The so derived hotspots are shown in Fig. .

4. Conclusion

The REMON Traffic Information System (TIS) delivers comprehensive information about the traffic in Hanoi in real-time. It is on the one hand a traffic-information-website and -App for all road users; on the other hand it is a monitoring tool for traffic operators and the traffic police, which can use it to have online information, and to get a detailed insight in the development of the situation over time. The TIS can monitor known hotspots and identify new hotspots with the automatic hotspot detection.

Furthermore the average speeds aggregated in 20min intervals for each day of the week and each street-segment were delivered to TDSI, so it can be used to improve the traffic-model of Hanoi and help city planners in their decisions.

So it contributes to better traffic situation knowledge and congestion detection and avoidance.

Acknowledgements

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