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POSSIBILITIES OF THE TRAFFIC EMISSION MONITORING IN CONTEXT OF THE SMART CITIES CONCEPT

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Abstract
The issue of emission monitoring from transport and the influence on human health is very actually topic. One of the possible measures in concept of Smart Cities and European strategies is using the obtained on-line data by the dynamic software tool such as DataFromSky system. The data is possible to apply for modelling of intensity and emission load from traffic. The software uses real traffic data about monitored traffic area (type of passing vehicles, speed, acceleration etc.). The data are obtained by the drone technology or camera system. Besides, the obtained data is possible to use as a part of system for emission modelling. The aim of paper is to introduce with one of possible approach for emission load assessment in consistent with the concept of Smart Cities.

Keywords
traffic, emission, software, smart cities, modelling

1 INTRODUCTION

The transport always has been an integral part of society. The modern society couldn't exist today without the constant transport of the goods, products and information. However, it also has a negative impact such as air pollution and environmental pollution. This may cause damage to human health from serious illnesses to untimely death. The pollutants also affect vegetation and may cause reduction in agricultural production. They even cause damage to materials and buildings of historical significance. In recent years, the share of automobile transport in the air pollution has significantly grown, particularly in high-traffic urban areas. In 2015, more than 200 thousand new passenger cars have been increase in Czech Republic and for example in Germany more than 3 million [1]. From emissions emitted by traffic is the highest increase recorded for greenhouse gases CO_2 and N_2O (see Graph 1). The newer vehicles there show higher measured values than older types [2-6].

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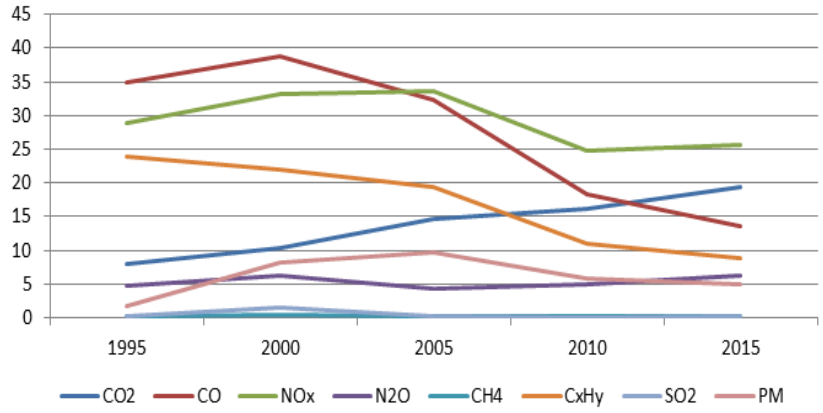

Fig. 1 Percentage share of traffic in total air pollution in Czech Republic [7]

The cause is in the case of CO_2 higher fuel consumption as a result of the increase in the transport performance, in the case of N_2O emissions increasing due to the application of catalytic converters. In the Czech Republic, as well as in the European Union, there is an increase in PAHs. Especially in 2014 there is a relatively significant increase in the sale of the diesel fuel, also the time trends of all monitored pollutants. However, the exceptions with decreasing trend are only CO and CxHy (see Graph 2) [2,8-11].

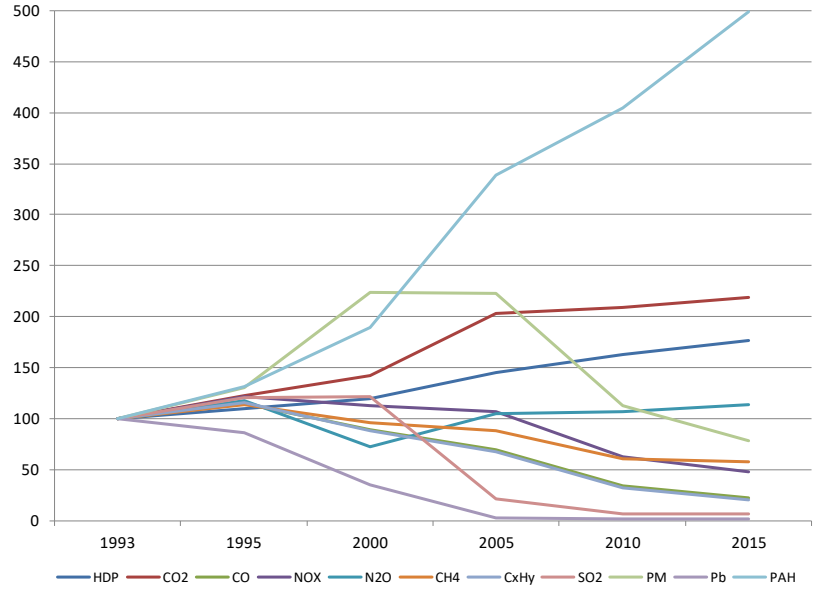

Fig. 2 Index of the emission from traffic development [7]

Negative impacts from traffic, such as air pollution, temperature increase, noise, accidents, and the immobility of the inhabitants are connected with increased untimely death rate and serious illnesses, especially in cities [12, 13]. According to study [14], about 30 % of traffic congestion is caused when drivers are trying to find a free parking space. For example, the results of a study in Barcelona show that every day around a million vehicles spend twenty minutes searching for a parking space, which produces 2,400 tons of CO_2. An example [15] monitors current strategies for introducing cities without cars and promotes more pedestrian and bicycle zones for a healthy city

life. It compares these strategies with, for example, the cities of Hamburg, Madrid or Oslo, which have been implementing their plans in the public transport and personal transport is already partly limited here. Also, there is a lot of another measure, such as multimodal transportation apps allowing to choice the best possibilities of travelling, including friendly to environment vehicles [16, 17], using of electric tricycles for transport carries [18] etc.

There is necessary to have in mind that the negative impacts of the transport are also results of habitant's behaviour and their everyday decisions about their type of transport, the mode of transport and route. Many factors influence this decision: the socio-economic characteristics of population and their relationship to the environment, as well as the characteristics of available transport system (for example travel time, fees, comfort and safety). In connection with the application of reduction measures, the question of their financial difficulty logically arises. However, not all can be quantified only in terms of cost. The realization of measures to reduce of negative impact must be primarily solving conceptually and with regard of the aspects of quality city life (environment, safety and security, well-being, parking, alternative modes of transport, public transport etc.). These conceptual measures, proposing for example the plans for sustainable urban mobility of Smart Cities.

Transport and infrastructure are, therefore, a promising field, in which the latest technologies are used aiming to ensure traffic flow, its reliability and the decrease in the emission load already mentioned. Monitoring emissions is one of the necessary parts of the measures whose goal is to increase the quality of the lives of inhabitants not only in cities. Following text briefly introduces approaches applied in Czech Republic.

2 MONITORING THE EMISSION LOAD FROM TRAFFIC IN CITIES

Currently, the monitoring of emission from traffic, is usually monitored at the specialized stations marked as traffic „hot spots" focusing specifically on information about the air quality in areas which are significantly burdened by traffic [19]. Also, for modelling of emission are used these obtained data by various software tools supporting the Intelligence Transport Systems (ITS) which allow creating models of line sources, are currently used to monitor the emission load from transport in cities (EMME 4.2, Paramics etc.) [20,22]. These software tools have an additional ability to calculate emissions based on the composition of the vehicle fleet (the share of vehicles from each emission group based on their frequency in real traffic) and the properties of the monitored area (corridor). In the Czech Republic are using software tools like MEFA or ATEM for pollution modelling and air quality assessment [23,24]. In 2008, A Methodical Instruction to Reduce Dust Emissions from Traffic was published, which focuses on solid particles emissions [25]. This methodology uses the TIMIS software tool, which contains a vast database of concentration maps and it is commonly available as a Microsoft Excel module. The emission factors used in this programme are based on studies carried out between 2004 and 2008. These software tools have lot of the advantages, but also disadvantages, such as that they do not allow transferring a real situation with the analysis and assessment of this data and displaying not only in the map data.

The ITS have a lot of opportunities for fulfilment of the requirements of the Smart Cities concept in the area of air quality monitoring. For example, there is possible to evaluate data from the Closed-circuit Television (CCTV) such as the total number of vehicles and the number based on the type of vehicle occurring in a specific area and considering the temperature, speed or density is very important [25]. It is the possibility of short-term or continuous monitoring of the emission load from traffic in cities which allows more efficient traffic planning and control and thus dealing with undesirable situations in which traffic congestion or other collisions occur and the concentration of vehicles in the particular section increases. That is why it is beneficial to apply this measure already in the traffic planning stage, if possible before the renovation or construction of new roads, intersections, buildings etc. A complex problem to deal with is the historic city centres and old built-

up areas, which were originally designed for completely different traffic capacities, which are no longer sufficient. That is why measures such as diversion routes, entry of vehicles only with permission, reinforcement of the public transport system etc. are taken. However, these measures are not sufficient in all cities. Therefore, there is also a possibility of monitoring the traffic online with immediate evaluation and if there is a connection with the traffic centre, traffic control is also possible, for example by changing the time intervals at traffic lights intersections, traffic control by the police, changing the driving direction in some streets in critical daytime periods or banning the entry of vehicles in these time periods etc. One possible way of implementing a software tool in the Smart Cities concept is using online monitoring of the traffic and its analysis in selected sections, which are, for example, often affected by high levels of traffic and traffic congestion. Currently, there are existing platforms for on-line air pollution monitoring [26]. The sensors of these measures are static and place on the chosen objects, such as buildings, street lamps etc. Through the moving system such as dron system allows to monitoring the choice area for example during the traffic congestion etc.

3 THE SOFTWARE TOOL DATAFROMSKY AND ITS POSSIBLE USE

This software uses data obtained from aerial photographs and videos, which are taken with cameras installed on high-storey buildings, on drones or other devices with the view of the selected area. Extracting the trajectory data from an aerial video footage is a challenging task due to camera movement, lens distortions, visual variability of the captured traffic scene, occlusions etc. However, from the mathematical point of view, the birdeye images are the most suitable input in case of monocular vision for the accurate localization of ground targets. Therefore, the utilization of aerial images for the collection of telemetry information about each road-user at microscopic level is a very promising approach. It opens many new possibilities, for example in the field of traffic safety, studying of complicated traffic maneuvers or estimating traffic emissions.

The system analyses and processes the data in two stages:

1) Georegistration: Establishing correspondence and mapping between video sequence frames and real world coordinate system.
2) Detection, localization and tracking of objects of interest (vehicles) in the georegistered video sequence.

For the simplicity, the geo-registration process assumes that the road surface is planar and consists of two steps: camera-calibration procedure and the selection of at least for points in the reference image of which the exact positions are known. These points are used for estimation of transformations allows mapping a pixel from image space into coordinate system of an intersection. The precision of mapping is influenced by following factors:

- Quality of camera calibration – undistortion coefficients/model
- Quality of image stabilization - estimation of UAV movement between consecutive images
- The precision of geo-refenced points and its localization in the image space
- Planarity of the road surface

Automatic (re-)identification of objects of interest and its tracking during their passage of an intersection is very difficult task because of complex background, dramatic appearance variations, different light conditions, camera movements etc. Recent very promising state-of-the art methods are based on deep neural networks for both detection and tracking. Trackers for object tracking are typically trained entirely online. A standard approach samples patches near to the expected location of tracked object. These patches are then used to adapt internal classifier, which is used to evaluate patches from the consecutive frame to estimate a new location of the object. Object detection is a task of generating class labels with bounding boxes for one or more objects in an

image. Convolution neural network for object detectors like Fast R-CNN, Faster R-CNN exploits the feature extractor output to propose and classify regions-of-interests. To improve robustness and performance, the detection candidates are prefiltered by expected area of road surface and results of moving object detection. The detections are then matched and tracked through the video sequence. To eliminate a localization noise, the object positions are filtered to form smoothed trajectories based on vehicle kinematic models.

It is possible to monitor traffic density as well as collision situations or the time for which a vehicle remains still or how long it takes it to drive through an intersection. The collected data then can be used to directly derive trivial traffic flow properties, such as origin-destination matrices, dynamics of vehicles and counts. Additionally, the results can be applied to improve or inspect accuracy of traffic behaviour models by deriving their parameters or confronting the results of simulations, as have been done by CITILABS in their study of Dynasim model accuracy [27].

The software tool is using real data, which does not need to be modelled using other software tools. The data obtained may be evaluated not only at intersections but also for specific road sections. Here, it is possible to monitor vehicles changing lanes, the time of a vehicle driving through intersections at a set speed or the time for which a vehicle remains in the monitored section in traffic congestion (Fig. 3, 4). With regard to the form of the videos obtained, which is from an aerial view, faces and vehicle licence plates are not visible so there is no possible security violation. If an infrared camera is used, records can even be made in poor lighting conditions such as at non-lit intersections, at dusk or at night. What may become a disadvantage is the distinguishing ability of the software tool, when it distinguishes the type of the vehicle (a passenger car/ a lorry) but it cannot determine whether the vehicle uses petrol, diesel fuel or, for example, the CNG, LPG fuel. Using the drone technologies also has some limitation, which is the flight time, when videos can be made. That is why other options of camera placement for monitoring roads and intersections are currently being explored, for example on high-storey buildings. However, these may not be present at each section to be monitored. That is why the possibility of using high-lift equipment is also being considered [29].

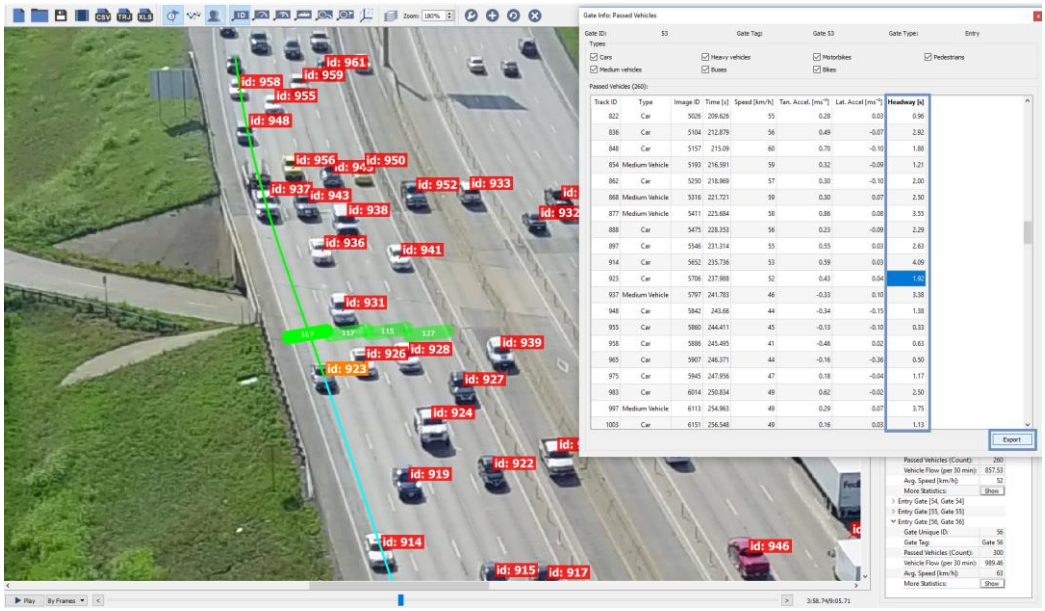

Fig. 3 Identifying of vehicles type [28]

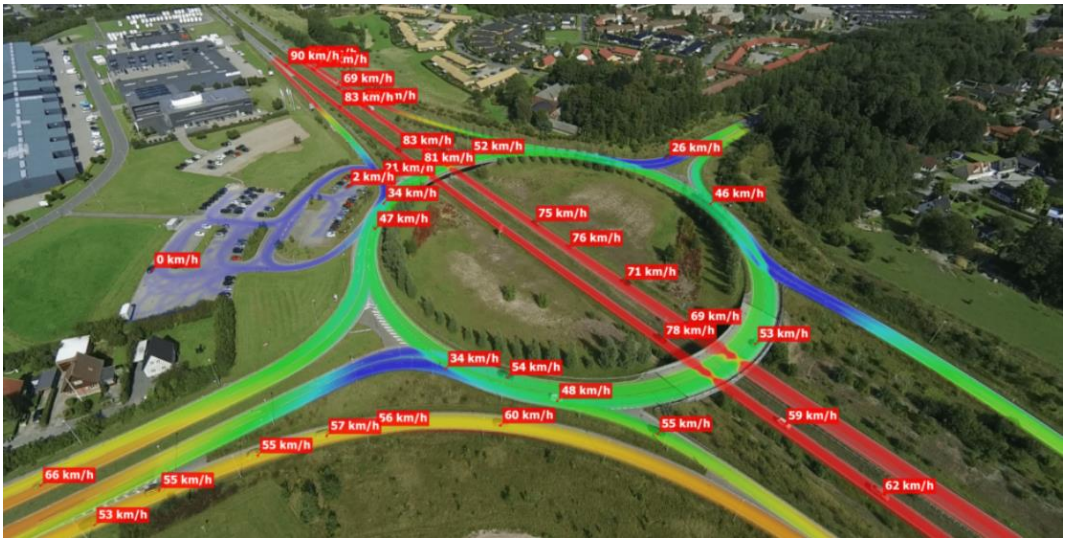

Fig. 4 An analysis of vehicle speed and the intensity of traffic flows [28]

However, in or near cities, congestion occurs especially in specific daytime intervals. Therefore, we can presume that this system may also be used during these time intervals to deal with problematic situations in the section monitored.

4 CONCLUSIONS

Current software allows a lot of possible ways, hot to monitored ait pollution in the cities. The research focuses on a possible connection of the software DataFromSky with the TIMIS software, which is currently, used (Adamec et al., 2006). Another possibility is extending the software functions by modelling the emission load during the analysis of the real data obtained. Ensuring the compatibility with another software tool or carrying out direct calculation modelling increases the efficiency and the possibility of evaluating the immediate situation in real time in the section monitored. The aim is to create a supporting tool for traffic control, which is in accordance with the Smart Cities concept and leads to reducing the emission load from traffic. The issue, not only monitoring and emission reduction, is one of the aim of the Smart Cities concept. That is why other systems are being developed, leading to their fulfilment. The software tool is possible followed other problematic by reducing traffic in cities, such as parking problems and the connected emission increasing. Therefore, such systems are further developed and supplemented by the new technologies, allowing the vehicles detection on the city's parking areas, to inform their visitors to inform drivers etc. [30].

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