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Automated supervision systems for Limited Traffic Zones

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ABSTRACT

More and more cities implement solution for motorized traffic reduction in separate areas of the cities. These areas include mostly cultural and historic centers, promenades and often all centers of large cities. To achieve traffic reduction, special fees for entrance to the city center are introduced and special bus lanes for emergency vehicles and public transport are isolated. Such solutions with paid or limited entrance to city centers occur in London and Berlin and dedicated bus lanes has also appeared in Poland in the major urban centers. These examples are often referred by the authorities of other cities wishing to introduce similar schemes. In order to effectively enforce the respect for the rules in Limited Traffic Zones automatic monitoring and supervision solutions are introduced. Automatic Number Plate Recognition (ANPR or ALPR – Automatic License Plate Recognition) is one of the elementary and most widely used system for LTZ security and effectiveness. ANPR allows the identification of the vehicles that appear on the entrances to the Limited Traffic Zone or move within the zone (for example, the bus lane). This article presents an implemented and successfully operating automatic Limited Traffic Zone in Katowice.

KEYWORDS: Limited Traffic Zone, safety, Automatic License Plate Recognition

1. Limited Traffic Zones

1.1 Introduction

Heavy traffic is the main problem in the cities and on frequently attended roads. Significant congestion of the road transport system during peak hours or increased intensity leads to traffic congestion, commonly called traffic jam. They are formed as a result of poor planning of transport routes, existence of bottlenecks, and lack of existing infrastructure adaptation to the current traffic load [6]. Centers of large cities were planned at a time when there were no cars. Hence their incompatibility with the existing conditions.

The occurrence of traffic congestion is a negative factor in the functioning of society. It causes delays in people and goods transport. It also increases environment pollution, especially in urban areas - where people work and live. As a negative economic factor, traffic congestion cause unnecessary fuel consumption. It is estimated [2] that the total losses resulting from the occurrence of congestion in European countries are as follows: 1.5% of GDP in the UK, 1.3% of GDP in France and 0.9% of GDP in Germany. For the United States of America, this cost amount to 0.6% of GDP (in 2007).

In order to move traffic out of the city to the highway ring roads, special fees are introduced for the entrance to the city centers. These special zones function as restricted areas. Entry is limited to the zone. Vehicles are allowed to move freely within its borders. Restriction of movement is forced through the introduction of the congestion charge for the entrance to the designated zone. Its boundaries include the usual central districts or historic centers (the old town, pedestrian streets, promenades, etc.). Fees are to encourage travelers to optimize the number of trips, to choose an alternative means of communication (use of public transport), to better plan the route or even the time of departure. It should be noted, however, that city centers are still "centers of the cities" where stores and other commercial premises are located, where goods should be delivered. Commercial vehicles during discharge

obstruct traffic lanes and increase air pollution [6]. In [6] some initiatives have been proposed (in the context of Spanish cities), seeking to release the inner cities from vehicles.

Introduction of charges where road infrastructure has limited capacity seems to be the best solution in terms of congestion reduction [2, 1]. Despite the success of the operating zones there is a large public opposition for the implementation of such schemes [2, 1]. Examples include referendums conducted among citizens in Edinburgh (2005), Manchester (2008) or the political debate and opposition in New York (2008) [2]. Detailed analysis of dissenting voices was considered in [1].

1.2 Examples and solutions of LTZ in Europe.

The center of London is an example of operating limited traffic zone. The zone was introduced in 2003 and has now 10 years of functioning. London Charging zone is a restricted area with a fee for entry. It initially covered an area of 21 km^2 and the entrance to the zone was £ 5. At present the zone covers larger area and the charge varies from £ 9 to £ 12 [3]. Figure 1 presents the map of Congestion Charging Zone. The fee is charged on weekdays from 7:00 to 18:00. There are exemptions and some vehicles can drive in the zone free of charge. These include vehicles of: public service, public transport, taxis. Those vehicles complying with the Euro 5 standard for air quality qualify for a 100 per cent discount [3]. Residents of the area can get a 90 per cent discount. There are several methods of payment, promoted one is by automatic charging (Auto Pay method).

Fig.1. Congestion Charging Zone in London [3].

The functioning of the London system is based on the automatic license plate recognition. Every vehicle entering the zone is verified with the database, which stores information about fees and exemptions from the payment. In case of absence of appropriate record a penalty is issued automatically to the vehicle owner.

There is also special zone of low emission in London, called the Low Emission Zone. It operates since 2008. The introduction of this area was motivated by the desire to reduce emissions in the capital of Great Britain.

For users with the largest and most polluting vehicles equipped with diesel engines the solution is to adapt to the new conditions: the change to a more eco-friendly vehicle, the installation of a filter or pay the daily congestion charge. The fee ranges from 100 pounds (for larger minivans) to 200 pounds for buses and vehicles exceeding the gross weight of five tons [3].

Similar to London's solution is the „Stockholm congestion tax" (Swedish: Trängselskatt and Stockholm), introduced in Stockholm in 1 August 2007, after seven months of testing in the first half of 2006. It is the second solution is introduced in Europe. It is worth mentioning that in the remaining 14 agglomerations Swedish citizens in referendums spoken out negatively for the introduction of similar zones. The zone operates on the basis of monthly tax dependent on the time inside the area. The owner of the car gets a bill through the e-mail or directly to the Internet bank. The third option includes automatic toll charging.

Technical solution of the Stockholm zone is based on wireless RFID technology. Vehicles are equipped with transmitters lent to drivers. An important element of the system is the video subsystem. Its task is to automatically recognize number plates of vehicles without transmitters. It also verifies the correspondence of data from the transmitters with the database data. Finally, it collects evidence against the owners who avoids charges. Fees are collected in an automated manner from a bank account from people who have equipped vehicles with transmitters. There are also unmanned electronic toll stations, a total of 18, located on the borders of the zone.

Another example of restricted traffic zone is the Umweltzone. Umweltzone are ecological zones that are functioning in German cities. In Berlin the zone was introduced at the beginning of 2008 [4]. In contrast to the restricted traffic areas in London or Stockholm, entry to the center is free of charge. Fee is charged only for the issue of a special badge denoting emissions standards for a vehicle. The number on the sticker denotes the area where the driver can freely move. The most restrictive zone is the one designated with four (green badge). To get the badge with "4" and the possibility of entering the green zone a vehicle must meet at least Euro 4 emissions standard. The regulations of each zone are determined by individual cities. In Berlin, the zone is restricted to the internal ring of S-Bahn. Hence, the entrance to the center is exclusively reserved for those vehicles meeting the appropriate standards. For an unauthorized entry there is a penalty of 40 Euro.

Milan is an example of Italian city which introduced charges for city center entry. The zone is called the "Area C" and corresponds to the central Cerchia dei Bastioni area [5]. The zone was introduced in 2012. The entrance is limited with a valid entry ticket (5 Euros) which must be activated before entering. The activation is possible with the use of SMS service, a telephone, the Web, or directly in the office. The zone has 43 access points, 7 of which are solely for public transport. ALPR cameras operate in all access points.

Vehicles with low or zero-emission (motorcycles, scooters, electric vehicles, hybrid or gas-powered) or vehicles transporting persons with disabilities or in need of medical attention are not subjected to charges. During hours of operation (from 7:30 to 18 or 19:30 depending on the day) it is forbidden to enter the area for standard gasoline vehicles with Euro 0 and diesel vehicles

with the standard of „Euro 0, 1, 2, 3" exceeding 7.5 meters in length. Temporarily, diesel vehicles that comply with the „Euro 3" belonging to area residents, vans and tourist vehicles have the opportunity to enter the zone.

1.3 Implementation LTZ in Poland.

There is also some movement observed in Poland where major cities are considering or already working on introduction of restricted traffic zones. Examples include Krakow, Lodz and Katowice.

In Krakow, for example, implementation of access control system for traffic calming zones and supervision of public transport lanes is realized within the project "Development of public transport management system in Krakow". The task is to implement the control system of bus passes and implement solutions that could affect drivers' behavior and attitude within the "B" zone. An automatic access control system to the "B" zone will be introduced. It will control bus lanes and enable automatic detection of movement violation by unauthorized vehicles. The system will provide the possibility of quick punishments for drivers committing offenses. By elimination of unauthorized vehicles to enter the "B" area, the attractiveness of downtown Krakow, mainly the Main Square and Plant district, will increase.

2. The SOR Katowice system

2.1 Opening

The SOR Katowice system was built by PHU TELSAT [8] within the street: Mariacka, Stanisława and Mielęckiego. It is a comprehensive system for monitoring traffic in a restricted traffic zone. It operates on the basis of automatic license plates recognition (ALPR system). The system is designed to enforce restrictions on the availability of transport and parking to a restricted area, located in the center of Katowice. An additional objective of the scheme is to improve the city functioning by providing ongoing supervision in scheduled areas for occurrence of events affecting the proper operation of urban infrastructure, public transport, pedestrian and vehicle traffic, threats to people and property.

By using dedicated ALPR cameras [7], the system identifies the license plates of vehicles entering or leaving the zone in existing access points (see fig. 2 for the example). Then, the system automatically handle the vehicles with subscription („known to the system") or through a single system operator entries or departures from the zone (Those vehicles, „unknown to the system", are handled by system operator, who grants single pass.

It is worth noting that the system has been made with a view to minimize the operator involvement in the general-use of subscribed vehicles. For such vehicles it is possible to define any time ranges, i.e.: days of the week, working days, not working days, hours, minutes, holidays, etc., freely configured by the system administrator.

ALPR cameras via fiber-optic networks transmit PAL video signal to an acquisition computer, which is responsible for image analyzes. After recognition, the message with identified license plate is transmitted to the database server. Registered vehicles movement through access points is handled automatically by the application on the database server – via TCP / IP and microcontrollers. Microcontrollers send signals to hydraulic pillars which unlock the way. Figure 3 presents a pillar with built-in camera for automatic license plate recognition. The pillar is equipped with red and green lights for signaling a driver possibility of movement.

Fig.2. The entry and the exit of limited traffic zone on Mariacka St.

For the direct supervision of the zone, installation of CCTV video surveillance cameras has been made. Surveillance subsystem serves to protect hydraulic pillars and other elements of the system infrastructure against acts of vandalism and road accidents. Recordings from the CCTV system provide further proof in guilt determination (e.g. attempts of enter during red light).

Fig.3. Pillar with built-in camera for automatic license plate recognition equipped with red-green light signaling (on the left hand side lowered hydraulic pillar on the ground level).

An intercom or video intercom may be the additional element supporting the work of the system allowing direct communication for a driver with the operator.

2.2 Location of the main access points of the system

The system consists of four access points localized on the Mariacka Street (two access points), the Stanisława Street (one access point) and the Mielęckiego Street (one access point). Each of the above mentioned passage is equipped with at least two hydraulic pillar operated via control unit supervised by the application server (for automatic passages) and system operator software.

Control center is located in the building of the Municipal Police, and communications between the different elements of the system is implemented by fiber-optic network. Figure 4 presents hardware allocated in the control center.

Fig.4. Hardware supervising the restricted traffic zone system in Katowice.

The primary objective of the system is to regulate the movement to traffic-restricted area. The task is to limit entry to the zone for unauthorized vehicles and automatically authorize entry into or departure from the zone for authorized vehicles – located on the so-called „White list". Control over hydraulic pillars is automatic (for vehicles permitted to travel in the zone) and semi-automatic or manual by the operator of the system.

There is also the possibility of combining data from ALPR cameras with optional short-range RFID readers. RFID readers are designed to support the users with temporal access to specific part of the zone, between consecutive entrances and departures (for example, for people with disabilities, suppliers, temporary hotel guests, etc.).

The system operator has an overview over the situation of entry and exit from the area, made possible by means of an additional monitor of the CCTV surveillance system. After granting the appropriate permissions, the operator also has the ability to add vehicles to eligible groups. Thus, during next entrance or exit from the zone the vehicle is handled automatically. The operator panel in the Web interface is presented in fig. 5.

Fig.5. The operator panel in the Web interface.

2.3 Software for supervision of Limited Traffic Zone system

Software for supervision of Limited Traffic Zone system provides full functionality of supported vehicles or groups of vehicles on:

- accurate reading of license plates of all patterns allowed in European Union (including square shape format and obsolete black license plate in good lighting conditions);
- the ability to detect vehicles without license plates;
- access to system archive data with the ability of criteria definition for records selection and aggregation;
- the ability to define groups of registration numbers;
- available operation modes:
  - automatic – pillars are automatically lowered after proper identification of license plate of authorized vehicles,
  - semi-automatic – the system suggests the operator a requirement for a specific group of vehicles of conditional entry to the zone,
  - manual – the operator manually controls movements of pillars;
- possibility of remote diagnostics of the system;
- the ability to generate manual reports, create automated reports and statistics on the performance of the system in each application mode, cross-group and cross-temporal;
- the ability for the operator to manually edit vehicle license plates numbers identified by the system;
- the ability to define time ranges, in which the vehicles or groups of vehicles are granted permission to enter and exit a specific area;
- reports on each access point load (number of vehicles that pass) in different modes: daily, weekly, monthly, yearly and other including user-defined;
- the ability to create statistics about the operators of the system labor – including reporting on registration numbers of vehicles which have been granted access in manual mode;
- software interface in Polish;
- acoustic system provided for operators for a specific events;
- use of MSSQL Server database or equivalent (e.g. Oracle);
- work in a client-server mode;

- access to the system with an unlimited number of computers using a Web browser;
- the ability to secure access to applications via a USB dongle PKCS#11 (access token);
- integral part of the software is a module of travel time.

Image of example vehicle from waiting to enter the restricted traffic zone and observed in IT system is presented in fig. 7.

Fig.6. Image of example vehicle waiting to enter the restricted traffic zone.

The software enables full management of groups of vehicles, including full management and definition of new groups such as:

- a group of vehicles permitted to enter the designated area – operated by issued IDs;
- a group of vehicles defined separately for each entry / exit;
- a group of sought vehicles;
- a group of temporary vehicles such as wedding or other event service, medical transport;
- a group of vehicles permitted to enter the zone, a separate list for each entry / exit.

Panel for groups' management is presented in fig. 7.

Fig.7. Groups and license plates belonging to subscribers.

3. Conclusion

The article presents the latest developments dedicated to automatic supervision of limited traffic zones introduced in Poland and abroad. Based on example implemented in Katowice by Telsat ultra-modern system for automatic surveillance and control of restricted traffic zone has been presented. The openness of the system and ease of adaptation to a particular task allow to take full advantage of the system, its capabilities, continuous development and adaptation to the demands of investors. It is worth noting that the system has been awarded the title of Lider of the ITS in 2011 for contractors – PHU Telsat for Best Product and prize for the Investor – Katowice City Hall – In the category of Best Deployment. This demonstrates the high level of innovation and effectiveness of the developed solution.

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