ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 3 [July – September]
ISSN: 2067 – 3809

[1.] Ján HALGAŠ, [2.] Rastislav PIRNÍK

MONITORING OF PARKING LOT TRAFFIC USING A VIDEO DETECTION

[1)] University of Žilina, University Science Park, Žilina, SLOVAKIA
[2)] University of Žilina, Faculty of Electrical Engineering, Department of Control and Information Systems, Žilina, SLOVAKIA

Abstract: The information obtained from the camera image processing is used to increase the safety and comfort of parking users. Detection and tracing of the vehicles movement in open, large parking areas comes across problems with clear identification of the object from the image based on the primary character. The article describes the approach of vehicle tracking using the registration number that is recorded upon entrance and combining some secondary characters such as colour, size and way of movement. This solution has been tested with the created software which consisting of functional units providing an input, a passing and a stopping the vehicle. The provided services are based on assigning a unique identity character to each vehicle (EVN), which allows increased safety of vehicles and targeted monitoring.
Keywords: car park occupancy, video detection, object tracking

INTRODUCTION

In the context of static traffic (parking, parking spaces on the street and parking areas) the camera systems are deployed which are primarily designed to monitor the situation around parked vehicles. They have a preventive effect and can record a critical incident (theft, accidents etc.).

The CCTV discourages some part of potential offenders. However, the presence of cameras on the parking area doesn't protect primarily the vehicle against theft and damage. The extension of surveillance camera within existing infrastructure it is possible to increase the level of service and security in parking areas [1].

The aim of such systems is to ensure the most reliability of the parking area, to provide a view of unauthorized (suspicious) movement of persons or to find a subsequent movement of the vehicle (exit from the parking lot) on the parking lot after the theft with possibility of identification of the perpetrators. Therefore, the research team were targeted in an internal pilot project ITS-USP (Intelligent Transport Systems – University Science Park) focused on the design of algorithms for the possibility of identifying and recording the subsequent trajectory of the vehicle and the recording time sequence of a motion, i.e. entering, stopping and leaving the parking lot.

The proposed approach and algorithms were tested on the premises of the campus of University of Žilina. The entry into the area of parking is realized through three input-output terminals equipped with barrier system. The existing technical infrastructure [2] allows a collection of parking fee at the exit or a pre-paid resident input simultaneously. Proposed and partially tested system is a software extension for the actual hardware implementation. The conceptual proposal covers the entire parking area; the system itself is implemented only on part of the parking lot [3]. The coverage of university campus by cameras to the state allowing fully automatic operation will implement during construction of technological infrastructure of USP. The actual verification of functionality of the proposed algorithms and the system is implemented only in part of the area (five cameras used). The black circles (Figure 1) represent three input-output terminals for parking lot.

Figure 1. The distribution of parking spaces in University campus, input-output terminals are marked (left), a design of deployed cameras showing the coverage of sectors (right)

Each vehicle shall be operated at these points at the entrance /exit getaway. This fact can be used to obtain information about vehicles which enter the parking area. Layout of cameras in the area of university campus should meet these requirements:

- *The location of cameras with a view to maximize the number of parking spaces;*
- *An ideal view of the parking places without smaller vehicles being covered by larger ones (e.g. a van covering a parking space for passenger cars).*

The placement requirements of cameras in parking areas will not allow determining the number plate (EVN) because the resolution of is not sufficient. The vehicle registration plate is only a universal unique identifier. Therefore, the requirements for placement of cameras at the input terminals are different and enable accurate capturing of EVN in sufficient quality. Cameras placement should be at an appropriate angle to be able to determine the EVN and other characteristics of the vehicle such length, width and color [4]. It is advantageous to combine the information about EVN captured as the vehicle enters the campus and the information about the vehicle movement recorded between sectors of parking lot covered by cameras.

Complex monitoring of static traffic within the campus of the University of Žilina enables a proposal of three functional units of the system. These are selected so as to achieve the necessary functionality with the lowest economic effort - particularly savings in the hardware part (the number of cameras, cables etc.). Functional units consist of: data processing at the entrance to the premises, data processing to track the trajectory of the vehicle and data processing in order to evaluate a pulled-up (parked) car in the designated area.

RECORD INFORMATION AT THE ENTRANCE

By installing cameras at the entrance on the parking lot to obtain primary information was obtained which is needed for basic identification data of the vehicle itself. The primary identification element of the vehicle is its number plate. Automatic number plate recognition supports several freely available algorithms collected in libraries for standard programming languages.

Used algorithms achieve high detection rate and low error text. Converting EVN into digital form is a standardized process and has been used as a black box system. The output is a number plate of the vehicle in digital form. That information shall be attached to elementary specific characteristics of the vehicle (the length, width, colour), which will be store in a database.

EVN is assigned to tracking moving object (usually a vehicle) so it is a primary identified which is carried forward in the detection of the vehicle. EVN detection is not primarily used in next part of proposed software. Other cameras (located on parking area) will be used for capturing secondary cognitive characteristics of the vehicle. Properties of used cameras increase the accuracy of the characteristics of the vehicle and the percentage of correct detection.

Figure 2 . Layout of cameras at terminal (left), an example of the vehicle and the number plate recorded at the entrance (right)

PASSING VEHICLES AND THEIR TRACKING

The main function of the designed system is to allow the identification of the vehicle within sectors in the parking area. The main aim of camera location is to cover the largest part of the parking areas and thus the number of parking spaces. This reduces the number of required hardware with the same functionality of the system. Such placement of cameras will not allow detecting and identifying EVN as the unique identifier of the object. The proposed approach allows the assignment of number plate of the vehicle based on secondary identifiers together with the monitoring of movement between sectors parking. It combines object detection method based on motion and color information. Detection process is described in the flowchart (Figure 3).

Block 1

Firstly, the number plate of vehicle which should be tracked is entered. The vehicle photo captured at the entrance is assigned to the number plate.

Block 2

One of the videos recorded in storage is loaded.

Block 3

The cycle is repeated until all frames are processed - from the beginning to the end of the video.

Block 4

Processing of frame to moving object detection using operations difference images, thresholding, dilation, erosion, and mask

Block 5

The decision whether the movement is detected in one of ROI or not.

Block 6
Differences between a moving and the search object. In this case, the color information is used.
Block 7
The decision whether the difference corresponds with the wanted object. Tolerance varies for each ROI.
Block 8
The movement trajectory is drawn in the reference frame of the place where the object was detected along with the time of detection.
Block 9
The last block is determined that the vehicle left the range of cameras.

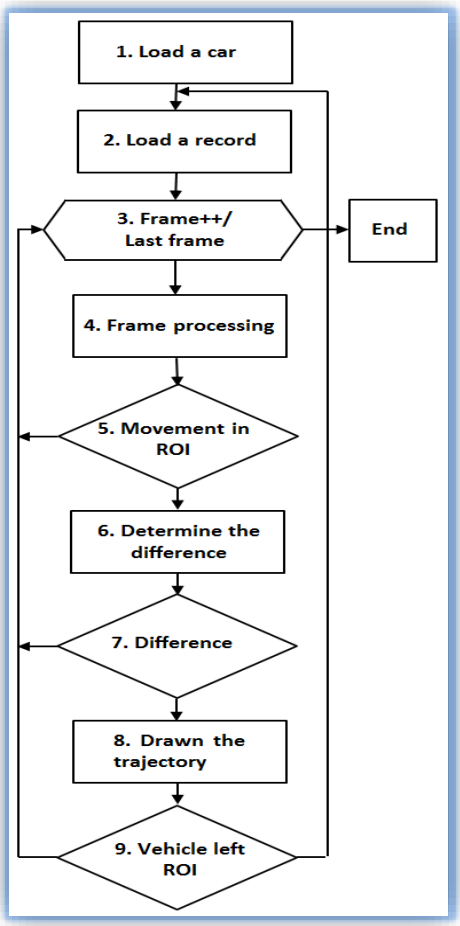

Figure 3. *The procedure of vehicle tracking among sectors from video data processing*

Program starts a processing of the next video if the vehicle occupies the boundary loops (ROI). That means the vehicle leaves the maximum possible view of the video camera and the next close record of video camera should be processed.
The proper definition of the region of interest (ROI) is important for correct functionality and correct handling of recorded sequences. ROIs are placed in the processed images; first the movement presence in ROI is detected. The idea of the ROI distribution is based on the coverage of boundary sections, where vehicles are moving and cameras monitoring. The transit of the vehicle between adjacent sections covered by cameras is monitored (Figure 4). It is based on the idea of transit of the vehicle in the desired direction. If the vehicle occupies an input ROI (entrance to actual sector covered by camera) then the camera in the scene is covering the actual section. If during the time interval the vehicle does not occupy an output ROI it can be assumed that it is parked in the area covered by a given camera. If the vehicle leaves the picture (occupy output ROI) algorithm is expected to arrive in the camera image according to the following practical possibilities movement in the parking lot. The vehicle can be tracked by combining the movement time information in the image and the color information (or other secondary characters) captured at the entrance where EVN was recorded. The vehicle information is retained this way, which cannot be directly obtainable from cameras designed to cover the surface parking spaces.

Figure 4*. Proposed deployment of ROIs among sectors (left); an example of ROIs deployment in the monitored sector, aimed at motion detection (right)*

DIFFERENT OCCUPANCY STATUS OF PARKING SPACES

A related service of the vehicle tracking on the premises of the campus is a record of the place where the vehicle was parked. To avoid incorrect identification of the vehicles that stop out of the prescribed places, it uses the information about moving objects among the sectors. Information about the EVN is taken (as indicated) from entrance as information of monitoring procedures for the tracking of the object to the final stopping point. For correct monitoring of occupancy of parking spaces two optical loops are placed at each parking space (Figure 5). The determination of the actual status between them is determined by the current state of occupancy [5].
The proposed algorithm is designed to evaluate the changes in occupancy of parking places, is resistant to the impact of weather conditions and the movement of people in the parking lot. The algorithm is based on the secondary characteristics (colour, size) of objects (vehicles) that need to be captured. The functionality of the program has been verified on a university parking lot. Percentage of

correct evaluation of occupancy has been compromised just too fast moving cars in the parking area. Implementation of the proposed approach allowed an authentication of functionality in real conditions. During the tests only a minor part of the campus was covered by cameras, it was sufficient to confirm the correct detection of vehicle in different camera records. Temporal information is recorded about detected occurrence in ROI along with the EVN based on secondary characters. Thusly recorded information is used to draw the route of a particular vehicle during the presence in the monitored areas. The processing of the recorded data is transferred into the application (Fig. 6) allowing basic operations on the structure of the data stored in the database using the approach presented in the article.

Figure 5. Detected movement of persons does not affect the change of parking space occupancy (left), a vehicle detected release a parking space (right)

Figure 6 . GUI using described algorithms for vehicle routing based on secondary characters on parking area where EVN is no visible. A route of single vehicle is marked.

CONCLUSION

The results of our tests confirm the applicability of the presented approach to vehicles tracing in open parking areas. Weaknesses of the system periodically occurred in non-standard behaviour of drivers of vehicles. Sudden deceleration rate in the monitored sectors of the first vehicle and current transit of another vehicle with similar secondary characters results in a confusion of these vehicles. This fact is subject of research, which should eliminate this scarcity.

The main advantages of this approach, compared with the traditional parking lots systems without image processing, are:

- *Automated monitoring of eligibility of occupancy rights at a designated place.*
- *Overview of the movement of particular vehicles usable for statistical purposes. The number of transits through the parking lot, parking time of each vehicle.*
- *Personal security parking. Mobile application allows informing the holder of the vehicle.*
- *Easy to re-trace the route of the vehicle, for example in the case of unauthorized movement.*
- *Services for registered employees as standard paying for parking usage.*
- *Blocking departure of vehicles in case of theft or unauthorized leaving of the area.*
- *Navigation to free parking sectors or places.*

ACKNOWLEDGEMENT

This paper is supported by the following project: University Science Park of the University of Zilina (ITMS: 26220220184) supported by the Research & Development Operational Program funded by the European Regional Development Fund.

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