Transactions of the VŠB – Technical University of Ostrava, Mechanical Series
No. 1, 2014, vol. LX
article No. 1974

Ján HALGAŠ[*], Rastislav PIRNÍK [**] and Tomáš ŠARINA[***]

TRACKING OF VEHICLE MOVEMENT ON A PARKING LOT BASED ON VIDEO DETECTION

TRASOVANIE VOZIDLA NA OTVORENOM PARKOVISKU NA ZÁKLADE VIDEO DETEKCIE

Abstract

This article deals with topic of transport vehicles identification for dynamic and static transport based on video detection. It explains some of the technologies and approaches necessary for processing of specific image information (transport situation). The paper also describes a design of algorithm for vehicle detection on parking lot and consecutive record of trajectory into virtual environment. It shows a new approach to moving object detection (vehicles, people, and handlers) on an enclosed area with emphasis on secure parking. The created application enables automatic identification of trajectory of specific objects moving within the parking area. The application was created in program language C++ with using an open source library OpenCV.

Abstrakt

Tento príspevok sa zaoberá problematikou identifikácie dopravných prostriedkov v dynamickej a statickej doprave na základe video detekcie. Ozrejmuje niektoré technológie a postupy, ktoré sú pri spracovaní špecifickej (dopravné situácie) obrazovej informácie nevyhnutné. V článku je ďalej opísaný navrhnutý algoritmus na detekciu vozidla s následným záznamom pohybovej trajektórie do virtuálneho prostredia. Práca prináša nový pohľad na detekciu ale hlavne záznam trajektórie pohybujúcich sa objektov (vozidiel, osôb, manipulátorov) na uzavretých plochách, pričom kladie hlavne dôraz aj na zvyšovanie konformity služieb otvorených parkovísk. Na základe takejto aplikácie je možné automatizovane identifikovať trajektóriu pohybu špecifického objektu po parkovisku. Aplikácia bola vytvorená v opensourse softvérovom prostriedku Microsoft Visual Studio s využitím knižnice OpenCV [1].

Keywords

video detection, open parking, security

1 INTRODUCTION

Systems inherent in field of transportation, people and a cargo transport focusing on identification of moving objects are mainly intended for oversight, management and alternatively control activities [2], e.g. camera systems designed for monitoring of tool payment (Czech Republic – DRSC, Slovakia – based on a combination of GPS, GSM and DSRC technology) [3]; video

[*] Ing. PhD, Division Intelligent transport systems, University Science Park in Zilina, University of Žilina, Univerzitná 1, 01026 Žilina, Slovak Republic, (+421) 41 513 3333, jan.halgas@uniza.sk
[**] Ing. PhD, Department of Control and Information Systems, University of Žilina, Faculty of Electrical Engineering, Univerzitná 1, 01026 Žilina, Slovak Republic, (+421) 41 513 3351, rastislav.pirnik@fel.uniza.sk
[***] Ing. Department of Control and Information Systems, University of Žilina, Faculty of Electrical Engineering, Univerzitná 1, 01026 Žilina, Slovak Republic

monitoring of usage of vignettes (Slovenia) and, last but not least, systems enabling identification of vehicle based on the vehicle's number plate. Within static transportation oversight camera systems are installed mainly for monitoring of parked vehicles and thus increase their security [4]. These systems aim to provide for security of the parking lot, monitoring of unauthorized (suspicious) movement of persons and tracing of movement of vehicles in the parking lot [6] after theft and thus also possible identification of offenders [6]. Therefore, the research team within the internal project ITS_UVP has been looking for an algorithm for options of identification and subsequent recording of the trajectory of the vehicle with recorded time of the movement.

2 CONCEPTUAL DESIGN OF VEHICLE DETECTION AND TRACKING

The parking area of the university campus is large and comprises tree entrance and exit terminals. The conceptual design is applied on all parking lots but the created application and video system are applied only in one part of the parking lot since it would be costly to cover all parking lots within the first stage of the project. However, it should be sufficient to confirm utility of designed approach and algorithm. The black rings (Fig. 1) represent entrance and exit terminals with installed security arm. Every car has to stop at this point.

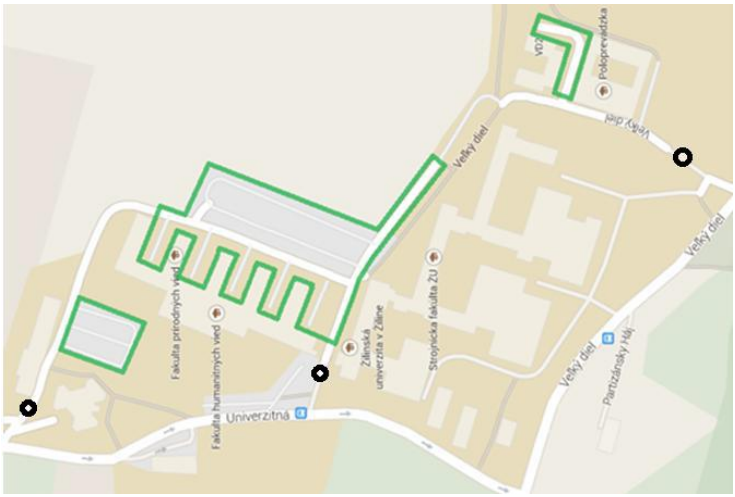


Fig. 1 University of Zilina campus with marked parking lots

The correct layout of video cameras is important for proper functioning of the system. Cameras should be mounted in correct angle because of scanning of number plate or other features of the vehicle such as length, width and color.

On Figure 2 we can see the placement of video cameras (Fig. 2) so that all parking lots are covered. It is important to use outdoor video cameras with high resolution and sensitivity. High parameters should improve the overall results of detection and thus also functioning of the algorithm. The picture also describes communication infrastructure. Layout regions of interest (ROI) to the parking area are dependent on the accuracy with which we aim to track the moving vehicle. Therefore, if we saw the precise position of parking spot where a car is parked then we should use more nodes. If only the approximate trajectory with accuracy of location on the road among parking spots is sufficient then we need much less nodes.

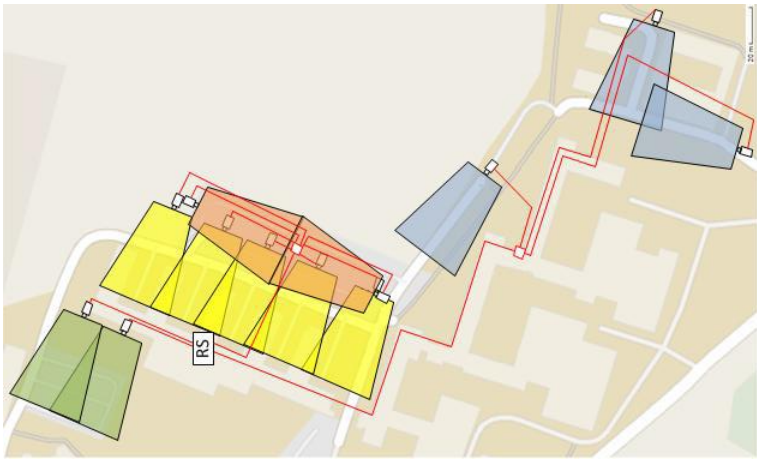


Fig. 2 Deployment of cameras in the parking lot

Figure 3 shows two variants of placement ROI. Variant no. 1 represents supervision of all parking spots and the possibility of remarking the vehicle's position accurately. Simplified processing of data offers variant no. 2. It is enough to know the block where vehicle is parked and this variant enables a more effective tracking of vehicles.

Fig. 3 Deployment loops (variant 1 on the left, variant 2 on the right)

People do not need to know where their car is parked if it has been stolen. It is better to know which way it leaves the parking area or which way it goes through. It is easier to find the offender when there is a more extensive record. The method of detailed monitoring of each parking spot should be used for monitoring of occupation of parking spots for the handicapped, monitoring prohibited parking areas or similar applications.

The designed system should capture basic cognitive elements (plate number, length, width, color) of the vehicle at the entrance. These are subsequently stored in the database. The plate number is the most prominent feature of vehicle. Based on this all vehicles can be simply identified on other records; further features of vehicle could be used as complements if the plate number is not visible. Best resolution and properties of video camera increase the accuracy of vehicle features and the percentage of detection.

For better illustration, Figure 4 describes two ROI. There are tree video cameras monitoring the driveways on parking spots. ROI1 is paced in field of vision of Camera 3 and ROI2 is placed in field of vision of Camera 2. If the vehicle was identified on ROI1 then the circuit is drawn on this position. The program assumes which of the ROI will be the next occupied and waits. It is clear that vehicle is between ROI1 and ROI2 until the next ROI will be occupied.

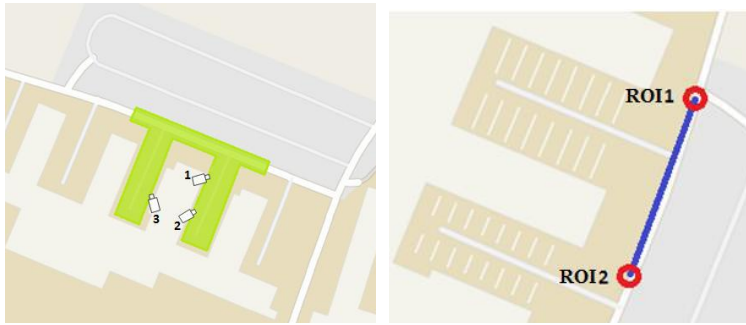
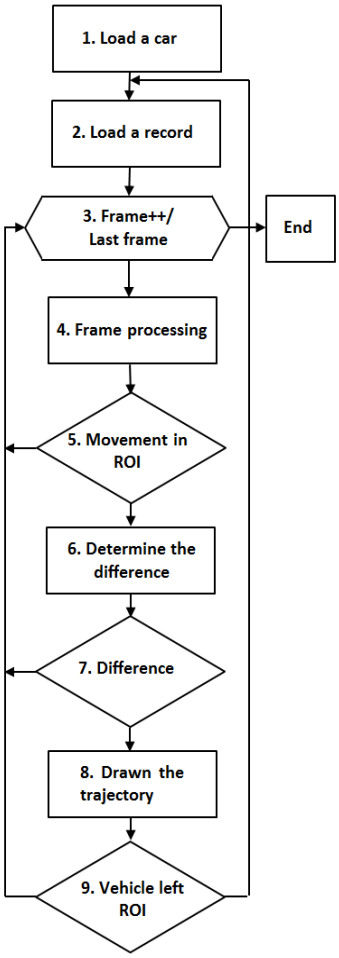


Fig. 4 Deployment of cameras during test (left) and way of drawing trajectory (right)

3 ALGORITHM FOR VIDEO PROCESSING

The program combines object detection methods based on motion [7] and color information [8]. Source code is written pursuant to specification described in this article. The structure of the algorithm is explained in this chapter. A correct definition of ROI and a correct processing of recording frames are necessary.



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 [9] difference images, thresholding, dilation, erosion, and mask (Fig.5).

Block 5
The decision whether the movement is detected in one of ROI or not.

Block 6
Determination of the difference between a moving and the searched 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. 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.

Fig. 5 Processing a moving object in Block4 (from left); original, difference images, thresholding, dilation and erosion, mask

4. CONCLUSION

Our approach contains two algorithms. The first one is used for capturing vehicles at the entrance. Photo information of vehicle is stored here which is very important for the next processing. This information (in our example especially color) is significant for presented algorithm whose objective is tracking the vehicle in a parking area. Firstly, the number plate of the wanted vehicle is entered by an operator, subsequently the program starts searching all video records stored in storage. Searching is based on movement detection on ROI and stored sight comparing. Result of successful searching is drawn into the reference map of parking lot. The position and the time are plotted. Algorithm was tested with different recordings recorded on tree video cameras mounted on the university building. The initial times of records are different so it is not possible to use time information. If the operator enters a vehicle which is not in the database program is closed.

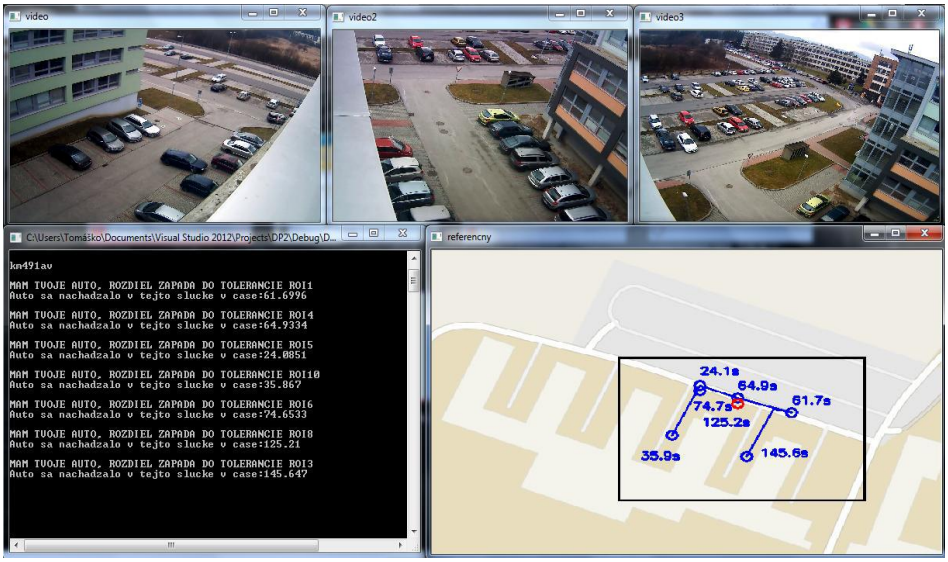


Fig. 6 The interface of application

The interface (Fig. 6) is arranged with the video at the top. At the bottom there is a console and a reference map of parking lot by recording the trajectory. The map with marked trajectory contains:

- black rectangle marks area of mounted video cameras
- blue circles represent positions where the vehicle was located
- red circles represent the latest position of the vehicle, respectively input or output of vehicle image from the camera view
- the current detection time for the relevant loop is also displayed, we are informed about the transit time of each vehicle

ACKNOWLEDGEMENTS

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.

REFERENCES

[1] BRATSKI, G., KAEHLER, A.: *Learning OpenCV*. O'Reilly media USA, 2008, 580s. ISBN 978-0-596-51613-0

[2] SCHLOSSER, T. *Inteligentné dopravné systémy*, Bratislava: JAGA, 2001. 216s. ISBN 80-88905-64-8

[3] SAIJIE, L., TIEJUN, H., ZHAOHUI, G.: *Electronic Toll Collection System based on Global Positioning System Technology*, 2010 International Conference on Challenges in Environmental Science and Computer Engineering, Wuhan, China, 2010. ISBN 978-1-4244-5924-7

[4] CHEN, L., HSIEH, J., WEI-RU L., CHIH-XUAN, W., SHIN-YU, CH.: *Vision-Based Vehicle Surveillance and Parking Lot Management Using Multiple Camera*, Intelligent Information Hiding and Multimedia Signal Processing (IIH-MSP), Darmstadt, 2010. ISBN 978-1-4244-8378-5

[5] KOSTIA, R.: *Video-based traffic monitoring at day and night*, Proceedings of the 12th International IEEE Conference on Intelligent Transportation Systems, St. Louis, MO, USA, October 3-7, 2009. ISBN 978-1-4244-5519-5

[6] XUEHUA, S., LIGUO, W., HONG, W., YUHUA, Z.: *Detection and identification in the Intelligent Traffic Video Monitoring System for pedestrians and vehicle*, Networked Computing and Advanced Information Management (NCM), Gyeongju, 2011. ISBN 978-1-4577-0185-6

[7] PEIJIANG, Ch.: *Moving Object Detection Based on Background Extraction*, Computer Network and Multimedia Technology, Wuhan, 2009. ISBN 978-1-4244-5272-9

[8] DURUCAN, E., EBRAHMI, T.: *Moving Object Detection Between Multiple and Color Images*, Advanced Video and Signal Based Surveillance, Proceedings. IEEE Conference, 2003. ISBN 0-7695-1971-7

[9] NONG, Y., CHANGYONG, W., FANMING, L.: *Morphological filtering algorithm for moving target detection*, Control and Automation ICCA, Xiamen, 2002. ISBN 0-7803-7412-6