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IMAGE PROCESSING TECHNIQUE USED IN ROAD TRAFFIC ANALYSIS – OPPORTUNITIES AND CHALLENGES

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Abstract: *Video detection of vehicles in road traffic can measure traffic parameters like traffic flow, speed, and density. This article presents the opportunities and challenges encountered in applying the image processing technique to video files obtained through the video camera of a drone. The purpose of this research is to highlight the opportunities and challenges encountered in video detection using a vehicle counting application developed in Matlab. The results show that the main opportunities are related to providing an overview of the traffic on an analysed road segment, but also to obtaining the most important traffic parameter, vehicle flow. The challenges are closely related to the weather conditions that directly influence video detection.*

Key words: *Image; Processing; Video; Detection; Matlab; Traffic*

1. INTRODUCTION

For the study of road traffic, field surveys have been and are always needed to determine its main characteristics. Knowledge of these characteristics is necessary to validate the correspondence of theories with what is happening in reality, in the field.

Knowledge of traffic characteristics or data is fundamental for traffic engineers, but also for all organizations that, due to the obligations of regulation or planning of the road network, are obliged to develop, manage, and maintain the road network at national level.

In recent decades, several methods of recording traditional parameters have been developed, some of which are still used today, in an updated form to the needs of modern systems: pneumatic tubes, inductive loops, radar instruments and laser technology. These methods are aimed at conducting traffic surveys through the ability to count the number of vehicles on a road sector.

Among the modern methods of acquiring traditional data is the aerial monitoring technique, which was initially performed with the help of aircraft flying over a road segment, the images being captured by a camcorder operator. Nowadays this video detection system uses drones and allows the knowledge of traffic information much more detailed than the methods mentioned above. In most cases, the use of drones is limited by the legal framework in the country where the flight takes place. Romania has a very strict legal framework for flying drones and their use is not allowed over populated areas, which means that traffic surveillance can be done by air only in suburban areas, not at all populated. The height of the drone flight is not very clearly delimited, but to obtain clear images, which can be used in image processing with various applications and software, the height should not exceed 70-80 meters altitude. In this paper, the flight altitude was limited to 50 meters, the aerial filming being done at a fixed point, perpendicular to the axis of the extra-urban road, in 3 sessions, for 15 minutes.

In the paper [1] the authors tried to detect vehicles by image processing using images from satellite. They used neural network to have a vehicle model and then to classify pixels into moving objects like vehicles and other objects which are not vehicles.

In the paper [2] was developed a method to obtain a better performance of video detection in tracking many vehicle targets. The proposal was

a detection algorithm that combines the Histogram of Oriented Gradients and Harr feature. The conclusions shown that the method was successful, and the vehicles could be detected even if urban environment.

In the published article [3], the detection of vehicles was made using images obtain above a parking lot. The authors developed a vehicle detection operator using four elongated edge operators. Those operators were designed to collect responses from the side of vehicles.

Regarding the paper [4], the image processing technique was to differentiate the background from the moving object. The next step was applying a segmentation method based on the Gaussian model. The results shown that the proposed background that can adapt at the variance of illumination can help extract the moving object completely and very accurately.

The paper [5] describes the appliance of Histograms of Oriented Gradients to verification of objects from images. The results shown that the method has a detection rate of over 96%.

2. IMAGE PROCESSING ALGORITHM

Matlab software is known for the various tools it offers in programming and in general in creating applications in the field of engineering. The image processing toolbox provides algorithms for image processing and analysis. Using the features offered for image processing, an application for recognizing vehicles in traffic and counting them in each frame has been developed in the Matlab environment. Several image processing toolbox functions were used to result in a functional vehicle recognition application.

The first step was to create a GUIDE interface in Matlab for the application. The second step was to set the video format that can be read by the application and for that we considered the *.avi and *.mp4 formats, which are the most common.

The third step was to use the Kalman Filter to cancel the image noise. Thus, after the detection of the vehicles by the background image differentiation technique, the histogram of the vehicle will be generated from the image, thus eliminating the shadows. Then we created bounding boxes for the moving object, in this case, the vehicles and finally the number of vehicles in frame is shown.

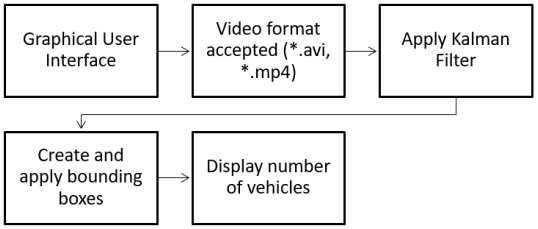

Fig. 1. Image processing algorithm

3. EXPERIMENTAL RESULTS

To verify that the application can be used on a larger scale, tests were performed in real traffic conditions. With the help of a DJI Mavic2Pro drone, an extra-urban area was surveilled, thus developing three cases. In the first case, the drone was raised to a height of 50 meters above the ground on a cloudy weather, perpendicular to the traffic artery and in the second case the drone was raised to a height of 50 meters above the ground, perpendicular to the traffic artery, at approximately the same point, on a sunny weather. The third case shows an experiment with a drone raised at 30 meters altitude, on a cloudy weather.

3.1 Case 1 – Drone flight height: 50 m – Cloudy weather

At a drone flight height of 50 m, vehicles can be clearly detected, because the shooting angle is wider and then the vehicles can fully enter the frame.

Fig. 2. Experiment with video file from drone with 50 m flight height– Case 1

Because the studied traffic artery is an extra-urban one, the flow of vehicles is insignificant, in most frames there are no more than 1 or 2 vehicles. As can be seen in Figure 2, the detection system is 100% accurate, the number of detected vehicles is 1 and in this frame is also one vehicle.

Table 1

Causes of inefficient detection – Case 1.

Detected vehicles	Real number of vehicles	Main cause
1	1	No cause

3.2 Case 2 – Drone flight height: 50 m – Sunny weather

In the second case, the experiment was done with a video filmed using a drone in strong sunlight, at a height of 50 meters. It can be seen in figure 3 that there are two physical vehicles on the road, whose shadow is projected to the opposite direction. This aspect is a negative one and has an extremely great influence on the accuracy of video detection in road traffic. This is the challenge that needs to be improved, because the detection of vehicles by image processing involves very good quality filming, in real time, regardless of weather conditions.

Fig. 3. Experiment with video file from drone with 50 m flight height– Case 2

It can be seen in Fig. 3 and in table 2 that the detection error is caused by the shadow projected from the cars.

Table 2

Causes of inefficient detection – Case 2.

Detected vehicles	Real number of vehicles	Main cause
4	2	Shadow

3.3 Case 3 – Drone flight height: 30 m – Cloudy weather

In the third case we decided to reduce the flight altitude to 30 meters, instead of 50 meters, to see if this aspect changes the accuracy of the detection. As can be seen in fig. 4 and in table 3, there are no causes for inefficient detection in this case, but because the analyzed road segment is an extra-urban one, it must be considered that it is also transited by heavy vehicles in a large proportion.

Fig. 4. Experiment with video file from drone with 30 m flight height - Car – Case 3

Table 3

Causes of inefficient detection – Case 3 – Cars.

Detected vehicles	Real number of vehicles	Main cause
1	1	No cause

In fig. 5 and in table 4 can be seen that at this height, heavy vehicles cannot be detected completely, due to their long length which enters the limit in the frame observed through the video camera of the drone. This aspect leads to a major error in detection by including parts of the road as part of the vehicle.

Fig. 5. Experiment with video file from drone with 30 m flight height – Heavy Vehicle – Case 3

Table 4

Causes of inefficient detection – Case 3 – Heavy Vehicles.

Detected vehicles	Real number of vehicles	Main cause
36	1	Length of vehicle

4. OPPORTUNITIES AND CHALLENGES

4.1 Opportunities in image processing used in road traffic analysis

Video Detection used in road traffic has been developed in recent years as an alternative to automatic vehicle detection by inductive loops or other similar intrusive technologies. This technique is non-intrusive and has begun to be studied in detail with the advent of fixed traffic surveillance video cameras.

Regarding the macroscopic traffic parameters, only the flow of vehicles and their speed could be determined with the help of intrusive technologies. Along with the use of video traffic detection, the density of vehicles on a road segment can be determined, without the need for additional calculations between the other two parameters.

Another opportunity is that of low costs for mounting equipment, for fixed video cameras being necessary only to fix them on poles or consoles above the road. If we refer to drones, they do not require installation, only flight permits, and can be used on all categories of extra-urban roads.

The shooting angle of the latest generation cameras is wide, so it can include more road in the detection area. Also, the quality of filming is getting better every day, on the vast majority of cameras in surveillance cameras or drones there is 4k technology. This aspect helps to observe the details in the video even if the mounting or flight height is even 50 meters.

4.2 Challenges in image processing used in road traffic analysis

Even if we refer to the images obtained from fixed surveillance cameras or drones, the problem of confusing the color of the vehicle with the asphalt is a common one. Mainly this aspect is generated by the fact that there is a demand for cars of similar colors to asphalt, such as gray or blue-gray, because it would be easier to maintain their body. In image processing, colors or a mixture of non-colors are standard and when it is very difficult to differentiate color tones, detection errors occur, mainly by detecting more moving objects than the actual number.

Another challenge is represented by the weather conditions, more precisely by the extremely sunny weather, by the abundant rains and frost, which can affect the quality of the obtained image. These conditions can not only damage the camcorder over time, but by changing the characteristics can appear in shadow images of moving objects or change the color of the asphalt by wetting it, covering it with snow or even freezing it.

The mounting height of the surveillance camera must be established in advance by field measurements, so that the images obtained capture the entire area to be analyzed. The same aspect must be considered in the case of drone flight. The major difference between the two types of video detection systems is that changing the location of the fixed camera is harder to do than with the drone.

These mentions were made because, if the entire field of vision of the video camera does not enter the vehicle, it can no longer be identified and subsequently classified correctly.

5. CONCLUSIONS AND FUTURE SCOPE

Image processing applied in road traffic is increasing day by day due to the ease with which it is used when the images captured in traffic have a high quality and are stable in terms of interference.

Nowadays, drones have become smaller and smaller in size, but still equipped with more and more powerful video cameras, as is the case of the drone used in this study, DJI Mavic2Pro. The use of the drone is particularly easy and safe enough in unpopulated areas, so that, for very short-term road traffic surveillance, it can be an alternative to fixed surveillance cameras.

The main opportunity of video detection in road traffic is to obtain important traffic parameters in characterizing road traffic on an artery, without the need for digging or

uncovering in the roadway, as in the case of inductive loops.

One of the parameters of road traffic at macroscopic level is the flow of vehicles on a road, it was determined in this paper through an application developed in Matlab software. This was the starting point in the research conducted on the opportunities and challenges in video detection.

Video detection opportunities list the possibility of determining the traffic density parameter without the need for additional calculations, relatively low costs for the installation and use of equipment, regardless of whether it is a fixed surveillance camera or a drone. We can also discuss the ratio between the opening angle of the camcorder and the image quality, which gets better and better over time.

The challenges are also present in the research and bring into discussion a problem often encountered in video detection, not only in the one used for road traffic, but also on a large scale, namely the presence of shadows of detected objects. These shadows of moving objects double the number of detections, because the application considers the shadow another object in the video image.

Another challenge encountered during the research was the confusion between the color of the asphalt and the grey colour of the vehicles. In rainy weather conditions the asphalt becomes even darker and then even black vehicles can be confused with it in images.

Also, the actual weather conditions can be a very important factor and refers not only to rainy weather, but also to sunny weather when the shadows of moving objects become more evident in images. There are situations in winter when the temperatures are extremely low in certain areas and then the batteries of the equipment are discharged much faster, and on the other hand, the icing changes the colour of the road.

As a goal in the future, it is to improve the performance of the developed system, this includes the application part in Matlab software but also the equipment for obtaining images for processing. It is desired to eliminate as much as possible the current challenges, but also to advance towards determining the other traffic parameters, vehicle speed and traffic density.

6. ACKNOWLEDGEMENT

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Tehnica de procesare a imaginii utilizată în analiza traficului rutier

Rezumat: Video detecția vehiculelor în traficul rutier poate măsura parametrii traficului rutier precum: debitul, viteza și densitatea traficului. Acest articol prezintă oportunitățile și provocările întâmpinate în aplicarea tehnicii de procesare a imaginilor la fișierele video obținute prin intermediul camerei video a unei drone. Scopul acestei cercetări este de a evidenția oportunitățile și provocările întâmpinate în detecția video utilizând o aplicație de numărare a vehiculelor dezvoltată în Matlab. Rezultatele arată că principalele oportunități sunt legate de furnizarea unei imagini de ansamblu a traficului pe un segment de drum analizat, dar și de obținerea celui mai important parametru de trafic, debitul de vehicule. Provocările sunt strâns legate de condițiile meteorologice care influențează în mod direct detecția video.

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