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APPLICATION OF DASH-CAMS IN ROAD VEHICLE LOCATION SYSTEMS

In the Department of Transport Telematics at the University of Technology and Humanities in Radom the system - which purpose is to monitor road vehicles based on chosen features - is being developed. Visual data come from the network of observation points. There are two kinds of units tested: stationary points (I2CU – Intelligent Interconnected Camera Unit) and mobile points (LC2U – Low Cost Camera Unit). The article presents the considerations about currently available devices – CAR DVRs, which can be a source of visual information in case of mobile LC2U points. Also the empirical research with a chosen dash-cam model have been described.

INTRODUCTION

The article presents recent developments in the research concerning a system as described previously in [1-13]. We will call this project RETINA, which stands for a system capable of tracking vehicles described by a list of visual features. It is assumed that the system processes information obtained from optical devices – observation units, mostly cameras – in order to provide actual locations and possibly forecasts of future positions of distinguished road vehicles. Up to now, only high quality stationary observation units were considered as suitable data sources, given limitations on quality and accessibility of mobile units. Bearing in mind the recent increase in quality and drop in price of so-called dash-cams, together with the growing speed in wireless data-transmission, mobile units enter the focus of research. The aim of the presented study is a review of available hardware, a case study and discussion of results obtained in different situations, and finally the assessment of options including car DVRs for the functionality of RETINA.

We start from a brief market analysis, collecting parameters of some of recent models newly introduced by producers of camera equipment and car accessories. These devices may be considered as LC2Us (LC2U – Low Cost Camera Unit), since their cost of acquisition is by two orders smaller than that of a stationary unit, e.g. a modern speed camera like in fig.1.

Fig. 1. *Speed camera*

Next, we analyze data recorded by a chosen dash-cam during test drives in varying conditions, shown in fig.2. The ultimate objective is to identify vehicles, mostly on the basis of their number plates. Hence, we estimate the probability of obtaining useful data when passing another vehicle, in dependence of relative speeds, light and weather conditions. The obtained results serve as basis for the assessment of the potential of car DVRs in the framework of research and development on car tracking systems.

1. RELEVANT PARAMETERS OF CAR DVRS

Obviously, one of the most relevant parameters for a successful image analysis is the resolution of the registered photo frames, measured usually in dpi (dpi – dots per inch). Mostly, for OCR software (OCR – optical character recognition) 600dpi is the minimum to guarantee an acceptable quality of text recognition. When it comes to the automatic identification of number plates, there are two additional aspects to consider. On the one hand, most number plates have a (or one of a small number of) standard formats. On the other hand, in real life situations, the number plate occupies just a tiny portion of a frame, and further it is highly probable that the image is distorted – other than in the case of images obtained from a flatbed scanner. Average DVRs feature rather small LCD-chips, which places them well below the image quality of customer cameras. The function of dash cams is gathering proof in case of accidents or vandalism. Thus for clients the most important parameters are image quality, resolution, angles of vision, sensibility, focus, but also available memory capacity and speed of registration.

Some of the reviewed devices are even equipped with a 16Mpix chip, usually of CMOS type (CMOS - Complementary Metal Oxide Semiconductor). For the registration of Full HD video, i.e. 1920 by 1080 pixels, cf. [14], a 2 Mpix chip is sufficient. Of course, in still-mode, e.g. for series of stills at given time intervals, a higher resolution might be desired and useful.

An essential parameter, for everyday use, is the memory capacity of the device. In particular in full HD or 4k (ultraHD) mode, it is desirable to have 32, 64 or 128 GB of onboard memory. For the registration of long distance journeys, options of uploading video material to a cloud or remote server are also wanted options. However, most considered DVRs were missing the capability of online wireless transfer of data at running time. The internal memory of the devices is usually rather limited, image and movie data are stored on external flash memory, like microSD or SD. For the application in real-time tracking systems, the objective is clearly to transmit data as quickly as possible to a remote server, hence the need for storage is limited. In fact, in conditions of very good network coverage, movies and still should be uploaded nearly in real-time. Storage is only the option for travel through (short) distances of bad coverage. It should be stressed that mostly the value of information is fast aging, so that a disk full with data of sighted vehicles, delivered by mail the next day, is of little interest. This is the more so when it comes to predictions.

For the purposes of vehicle identification, the properties of the cameras lens system are of great importance. A wide angle of vision gives a better chance to spot an object moving by. On the other hand, it also increases the risk of image distortions, which might compromise the interpretation of characters on the depicted plates. An opening angle of 120°, i.e. one third of a full panorama view, is commonly accepted as minimum requirement. Some producers propose multi-lens systems with more than one independently orientable objective.

Next, the frame rate, or the opening time for stills, is of the essence, when high relative velocities between the observer vehicle and the observed vehicle are considered. So for DVRs, a frame rate of 30 fps (fps – frames per second) is the present standard. It has to be stressed that for our considerations, this is still a very unsatisfactory speed. Between two frames, a vehicle driving in the opposite direction, approaches by around 50 meters per second. For recognition, only key frames are useful, and compression settings produce those only one such frame each 50 meters, not each 1,67m as the nominal frame rate suggests.

Other features to which consumers pay attention, are motion detection, capability of night vision (IR mode), possibilities of position and speed recording (GPS based), zoom and programmable serial shots. .

Obviously, exact date and time stamps are also important. In particular, in the case of an accident, the time stamp may be used to determine the state of a traffic light. Motion detection, in turn, may be used to start recording, e.g. automatically when the vehicle is started – or if there is some unauthorized manipulation taking place.

In the context of research on further development of the RETINA system, the GPS-capability of a DVR is a key feature. While in the case of a stationary observer unit, the identification of the camera gives the exact position of a sighted vehicle, in the case of mobile observers all positions are relative to vehicle. Any image from such a source needs to be amended by exact position and speed information of said unit. For average users, the speed information is essential, e.g. to prove that limitations were respected by the owner. When it comes to an accident, the location of the event usually is recorded also otherwise. For application in a tracking system, mainly the triple of time, position and vehicle ID is essential and needs to be transmitted as fast as possible to the OP-Center of the system. There, by collection of such triples from all available sources, sequences concerning sightings of one and the same object can be combined in order to approximate – and if wanted even extrapolated.

It should be mentioned that speed measurement of an observer car is included in the functionality of all standard DVRs. However, none of the currently available models is capable of telling the speed of objects in the field of vision of the device.

The extreme high rate of introducing new accessories on the market of electronic gadgets makes each collection of models obsolete before an article is printed. So we do not attempt to make our review complete or last second up to date. However, one last trend should be mentioned: head mounted action cams are becoming more and more popular and might be considered a further source of useful image data. For the time being, we abandon this thought, having in mind weight and power limitations and risks as e.g. water or dirt on the lenses.

For this article, and the analysis of the suitability of the considered DVR models as data sources for the RETINA system, may be disregarded. For instance, LCD-displays, their size, user interfaces and the like features essential for the customers convenience are of no concern at the present stage of the study. Also the presence of audio recording functionality, microphones or accelerometers plays no role in our considerations.

The GPS module mentioned above gives the possibility to assing travelled route to recorded file and monitor its speed. The informations are necessary for running the system properly because knowing the coordinates and the time of recorded event, chosen distinctive feature recognition of wanted vehicle, the prediction of its further route is possible.

Accelerometer – also known as *g-sensor* – is a sensor, which is used to measure acceleration. During sudden overloads blocks the possibility to overwrite the file on recorded image in the moment of its development.

The most commonly used inputs and connectors in video recorders are HDMI, USB, AV and microSD input. HDMI and AV connectors help to transfer the image from the video recorder to a TV or computer screen. USB allows to communicate with the computer and tablet. MicroSD slot allows to expand the memory. Video recorders with wireless data transfer are rare, but when connecting with available inputs of for example mobile phone/tablet/notebook – devices with mobile network – there is a possibility to adjust DVRs software for wireless transmission in the real-time. Unfortunately, companies that produce video recorders currently being discussed, do not share the programming code with the public. This makes the modification attempts impossible. In that case there a need to program the device.

However, there are available video recorders used for wireless connection for example with mobile phones, are using Bluetooth or Wi-Fi technology. With these devices it is possible to display the recorded route on phones screen.

Software installed on the phone for model Black Vue DR500GW-HD is BlackVue Viewer for Windows v2.032 – its task is to help to process the video material and connect it with the GPS parameters. That way route parameters are automatically marked on Google maps.

Non of the above models are capable to transfer those informations in the real time through the mobile phone network. Though this is a problem, which can be solved by programming given devices properly. It is therefore true that there are devices that meet the requirements of video recorders, considered in the concept study of the mobile observation units of the RETINA system.

2. ANALYSIS OF CHOSEN RESULTS OF EXPERIMENTAL RESEARCH

Besides the analysis of the equipment also experimental study are discussed. Mobile observation point (LC2U) was equipped in Rollei DVR-110, fig.2. It is characterized by the following features: resolution Full HD 1920x1080, codec/format H.264/mov, angle of vision 1300 , screen size 2,4", writing speed 30fps, supports SDHC cards – up to 32GB, built-in GPS module.

Fig. 2. *Car DVR used for experimental research [15]*

A vast video material was recorded (more than 1435km, 1434 min.), representative for certain situations: driving on national road, driving on highways, night and day driving, in bad or good visibility.

Simulations (results were shown in [5,8,12]) were based on unmistakable assumption and 100 percent effective observation. Empirical research should verify this assumption and then the evaluation of the ability to use the equipment which is commonly available such as DVR in the system that i being developed. It's functional principles were closely described in [7,12].

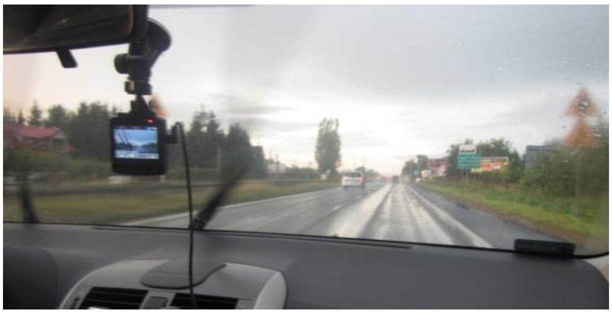

Fig. 3. *Setup of the research equipment*

According to fig. 2, 30GB of files in *mov. format was recorded also with the data concerning vehicles position (GPS coordinates in *nmea. files). *Mov. files were processed for extraction certain frames, which were rated in terms of their suitability for extracting alphanumerical data.

Series of frames taken from the footage shows their limits of usefulness in the search of the road vehicle according to its distinctive feature, the registration plate, in chosen road and weather conditions.

Rating of visual data usefulness from mobile sources is described below.

Cases of city driving must be distinguished. Also driving on the national road and highways. Here the favorable factors are slow driving (up to 20km/h), little gap and small DVR bias angle in relations registration plate and brightness. Above cases can be seen in fig. 4, 5 and 6.

Fig. 4. *Driving in urban conditions – roundabout entrance*

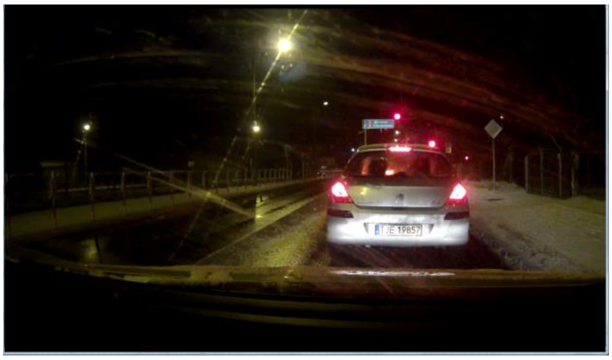

Fig. 5. *Registering the chosen feature at low speed of both objects and the mobile observation point (LC2U)*

Fig. 6. *Tests on a highway*

Fast driving makes view difficult because of bigger distance from another vehicle. In those conditions the most convenient situations, where the footage analysis is possible are the vehicles overtaking maneuvers that are moving towards the observer, and also passing cars from the opposite direction. The problem that occurs in that kind of circumstances lies in the angle increase exactly at the time when the gap reaches minimum, what leads to deteriorate the possibility of reading the license plate.

Fig. 7. *Overtaking in good weather conditions*

On a highways the observations of vehicles moving from opposite direction are almost impossible, fig. 6. However on national roads those observations are more common. In this case the speed of closing vehicles sum up, which helps to reduce the observation time and also jump between specific .mov file frames is substantial, fig. 8.

Often there is no optimal frame registered during the 50km route: on one frame the distance is still too long, on the other the angle is adverse, like in the case of urban driving on fig. 9.

Fig. 8. Research conducted on a national road

Fig. 9. Adverse angle of the research station from the license plate

Empirical research lead us to following conclusions: popular DVRs do not have the capability to provide an observation in the medium range. The vast majority of shots cannot be used in discussed objectives, because of bad weather conditions for example, which is represented by each frames in fig. 10,11,12,13.

Fig. 10. Tunnel (unfavorable light)

Fig. 11. Rain (unfavorable weather conditions)

Fig. 12. Snow (unfavorable weather conditions)

Fig. 13. Night (unfavorble light)

The total observation time was 1434 minutes = 86040 seconds. Average recording speed of the images taken from the DVR is 30 frames per second. So, more than 2,5 million frames were analyzed, of which only 20 thousand allowed accurate license plate reading. Therefore, participation of the frames with visible plate is at the level of 1%. The conclusion is that the usage of DVRs as the mobile sources of information in the RETINA system does not come with good results.

The possibility of installing immobile observers (I2CU) to generate photos/videos precisely during the optimal visibility, for example thanks to radar support or the induction loop, is a great benefit for systems efficiency.

CONCLUSION

The RETINA system is designed to observe road vehicles movement. For that type of tasks recognition of the license plates was explained in [4].

The advantage of a system which is based on immobile observation units is high quality of received material. The disadvantage is bypassing the familiar points by searched vehicles with ease, which in the case of mobile distracted observation points is impossible to accomplish. But the main disadvantage of the most popular DVRs is the low number of pixels per license plate area. In experimental studies only small number of recorded frames allowed to identify a vehicle based on the license plates.

The above conclusions show us that there is a need to develope the concept of the stationary observation points, while monitoring changes that occur in the most recent DVRs.

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Zastosowanie wideorejestratorów jazdy w systemie poszukiwania pojazdów drogowych

W Zakładzie Telematyki Transportu UTH Rad. opracowywany jest system, który na celu ma monitorowanie ruchu pojazdów drogowych na podstawie wybranych cech. Dane wizualne podlegające analizie pochodzą z sieci punktów obserwacyjnych. Badane są dwa warianty jednostek: stacjonarne punkty (I2CU – czyli Intelligent Interconnected Camera Unit)oraz mobilne (LC2U – Low Cost Camera Unit).W niniejszym artykule przedstawiono rozważania nad obecnie dostępnymi urządzeniami – wideorejestratorami jazdy, mogącymi stanowić źródło informacji optycznej w przypadku ruchomych punktów LC2U. Opisano również badania empiryczne, przeprowadzone przy pomocy wybranego modelu.

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