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Transport Device Driver's Assistance Vision Systems

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Abstract

The purpose of this paper is to review solutions whose task is to actively correct decision-making processes of the vehicle's driver on the basis of information obtained from the surroundings and the presentation of a tool that makes it possible to react to the changes of the psychophysical condition of the driver. The system is implemented by the Matlab application environment on the basis on the image activated by a webcam.

Keywords: driver, vehicle, driver assistance systems, vision systems, safety devices

1. Introduction

In 2002, the European Union (EU) formed the e-Safety working-group to encourage the producers to implement intelligent safety systems. The e-Safety website gives the statistic that more than 1,2 million people were injured in road accidents in the EU in 2005, and over 40.000 killed. Analysis of accidents shows that as much as 93% is caused by human error [8]. Traffic accidents involving pedestrians were the second most common type of traffic accidents in the European Union in 2009.

Each year around 10 million people fall victim to traffic accidents, of who 3 million sustain grave injuries. In the European Union 15.000 people sustain grave injuries in traffic accidents involving pedestrian and as many as 7.000 are killed. That is why the reduction of the number of collisions resulting in death is a priority when designing safety solutions [8].

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On the 20th of July 2010 the European Commission has adopted a document concerning the improvement of road traffic safety: *Road Safety Programme 2011-2020*. The document aims to cut road deaths in Europe in half in the next decade. Numerous initiatives aimed at improving the safety of vehicles, road infrastructure and the education of road users will be carried out in the EU and member states [8]. One of the ways to decrease the number of accidents, especially of those resulting in death, is to develop systems that will assist the driver's skills and take over driving functions in the case of the lack of required psychophysical properties. These functions are implemented with the use of, for example, optoelectronic solutions.

Modern systems that assist the driver's skills work in real time, thanks to which the driver's reaction time to the changes in the surroundings depends on his motor skills and reflex. Wheeled vehicles are being equipped with intelligent vision solutions that are a logical complement or extension of existing active and passive safety solutions. The task of intelligent visual systems is to correct decision-making processes of the driver on the basis of information obtained from the surroundings. Intelligent vision-based systems have task based correction of decision operator making process on information obtained from environment [1,2].

2. The review of Optoelectronic Solutions Assisting the Driver

Among the most important optoelectronic systems used in vehicles are solutions that assist the driver in maintaining the proper trajectory of the vessel by analysing and processing the image containing information about the current position of the vehicle in relation to the traffic lane. The system is implement via optoelectronic devices installed in the front of the vehicle that activate the image containing information about the vehicle's coordinates in relation to the centre line. The driver's assistant analyses the road in front of the vehicle checking whether the vehicle is on an acceptable traffic lane or whether the change of a traffic lane is a conscious and safe action taken by a driver.

When the vehicle changes the lane without the direction indicator turned on, warnings for the driver are activated. According to the European Commission this system helped to prevent 14.000 accidents in 2009, although only around 7% of all currently manufactured vehicles are equipped with it. This system is installed in premium-class vehicles under the working name *Lane Departure Warning System* (LDWS) and it significantly improves safety in the case of a rapid decline of the driver's psychophysical condition [1,4].

A vehicle with LDWS is equipped with a camera placed in the front, near the radiator grille or in the rear-view mirror depending on the manufacturer and the adapted solution. Figure 1 shows an example of the view of the vehicle's surroundings from the camera placed over the rear-view mirror.

The image obtained by the optical system is analysed by an appropriate algorithm which basically consists of three steps. The first one indicates objects that can indicate a correct trajectory of the vehicle. By design these objects are the centre lines painted on the road. This step is based on the detection of the edges defined as the extremes of the image (Fig. 2). The next step is to identify the points that have been classified as traffic lanes and to form lanes with a proper curvature depending on the curvature angle of the turn of a moving vehicle. During the third step, it is checked whether the vehicle has a proper position in relation to the road and a smooth analysis of the image and the generation of new directives in real time is enabled.

Fig. 1. A view over the road from camera based on LDWS system [1]

Shadows, indistinct centre lines, tire marks on the roads, holes and crash barriers that divide the carriageways may cause an incorrect interpretation of the image and thus incorrect work of the programme. Manufacturers are working on the solution that would make it possible to integrate the system into the steering system so as to save the time needed by the driver to react when danger is detected [1,3].

A loss of concentration while driving is a cause of many collisions that may result in running into the rear of the preceding car. Such situations usually take place when vehicles are moving in column or when the preceding vehicle decelerates rapidly. Car producers have developed a solution which by installing appropriate tools in a vehicle watches over and maintains a safe distance from the preceding vehicle. The system is called Adaptive Cruise Control (ACC) and about 3% of currently produced cars are equipped with it. It is estimated that this system prevented

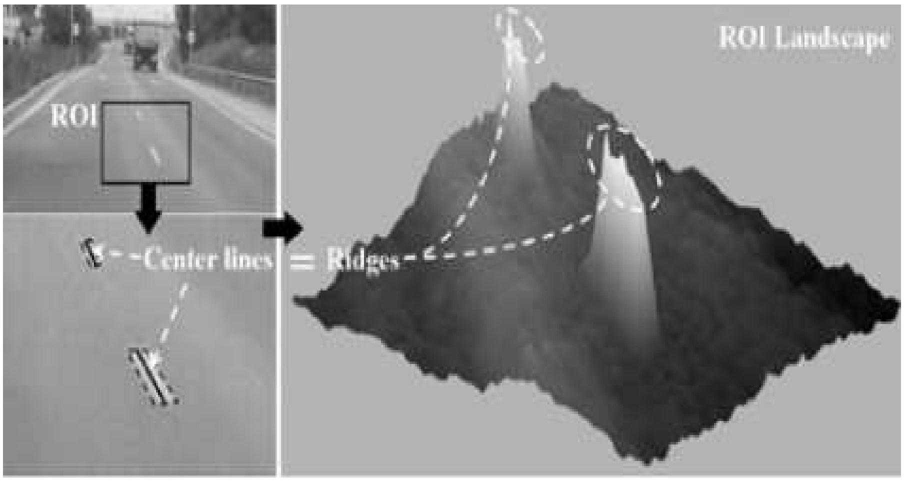

Fig. 2. Detected traffic lanes [1]

about 4.000 car crashes in 2009 [1]. The ACC system uses either radar (Fig. 3) or lidar (a combination of laser and a telescope). Both methods are used to calculate the distance to the vehicle in front. The system calculates the distance by measuring the time the signal emitted by the radar needs to reach an obstacle and return. The system is unaffected by weather conditions, which significantly improves safety during fog, downpour or snow but can cause the driver to trust the system too much and prevent him from adjusting speed to conditions on the road [1,2,3].

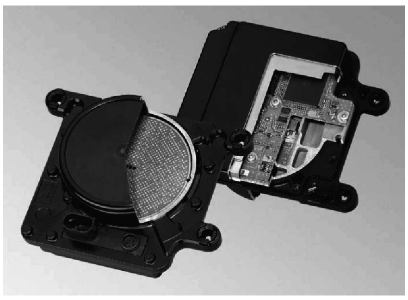

Fig. 3. Example of a 77-GHz radar used by Continental company in Adaptive Cruise Control systems [1]

Solutions with a working name *Pedestrian Protection Systems* (PPSs) are tasked with assisting the driver in situations when a pedestrian, without prior indication, steps in the way of the vehicle [9] – Fig.4. The information about a pedestrian's position are processed by: a vision system directed at the surroundings of the vehicle, a dedicated digital environment which analyses the image, a procedure algorithm, whose purpose is to detect a pedestrian in the vicinity of the vehicle and to make a decision in dangerous situations and systems that show the results to the driver and/or autonomously correct his actions.

Fig. 4. The Pedestrian Protection System used in BMW cars [7]

Pedestrian identification does not always proceed in exactly the same way because of physical differences among people and their position in relation to the vision system of the vehicle [1,4,9,10].

3. A System that Reacts to the Changes of the Driver's Psychophysical Potential

A large number of devices assisting the driver cause the loss of concentration and as a result a rapid decline of psychophysical condition which may manifest itself as fatigue and drowsiness. According to police statistics more than 1,7% of all accidents on Polish roads in 2009 were caused by driver drowsiness and fatigue [8].

This information led to work aimed at enabling the real-time tracking of changes of the driver's psychophysical properties whose visible symptom is, for example, fatigue that may result in the driver falling asleep behind the steering wheel. It was assumed that the driver's tiredness manifests itself in the changes of his field of view. The change in the field of view caused by the closing of eyelids is a measure of the decline of the driver's psychophysical condition (with the use of accepted calibration) which is subsequently an object of registration in an online system and of feedback in the form of a signal for the driver or his automatic assistant.

The constructed driver's registration system was developed under the assumption that the costs should be kept to the minimum and with consideration of the limits of the environment [5]. The following were used in the development of the project: Creative Live Notebook VF0470 web camera (sensor), Matlab ver. 7.5.0 application (analysis and processing of the image) and Acer Aspire 3620 laptop (analysis and processing of the image and registration and presentation of results). Figure 5 show the algorithm of the work of the developed driver fatigue registration system.

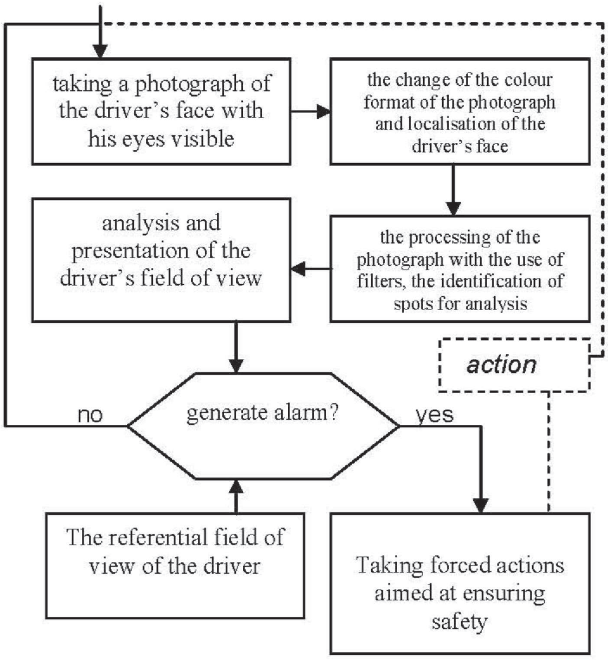

Fig. 5. Algorithm of the developed driver's tiredness registration system

The image is registered by a camera integrated with a toolbox *Image Acquisition Tool* of Matlab application, which makes a photograph in the resolution of 320×240 in RGB (*Red Green Blue*) format. The image is input into the environment of Matlab application. By utilizing the appropriate function of the application the format of the photograph is changed in order to isolate features needed in the further analysis of the image. The application finds the driver's face and marks it with a red rectangle whose dimensions depend on the physical features of the driver's face and its distance from the camera. The fragment of the image containing the most important information (the driver's eyes) is framed. The image undergoes analysis whose aim is, ex definitione, to isolate the image's features in a numerical or symbolical form. To this end the grey-level values chart containing information about the driver's field of vision is used. Using the chart allows the isolation of data that makes it possible to assess physical features of the face and to determine whether the driver's eyes are closed or open. Appropriate interpretation of the chart is the key to the correct analysis of the driver's face.

Figure 6 shows an example of an analysis of the chart. Number 2 indicates the darkest spots whose values, depending on the illumination of the face, range from 130 to 140, which corresponds to darker colours. By design the darkest spots on the driver's face are his eyes. Number 1 indicates the brightest spot on the face, namely the nose. If we were to perform a more in-depth analysis, we could also notice other features of the driver's face. The purpose of the analysis of the chart is to isolate the coordinates of an eye. This way complete information about the coordinates of the driver's eyes was obtained.

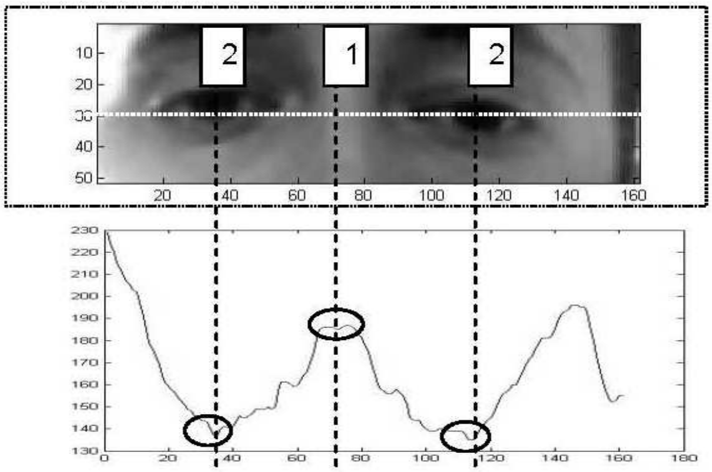

Fig. 6. Characteristics of the changes of the field of view shown on the grey-level chart

In the subsequent part of the programme further processing of the image aimed at eliminating noise, distortions and deficits resulting from application of low-quality and low-resolution camera takes place. To this end appropriate filters, whose work is shown on Fig. 7, are used.

The image, prepared in this manner, is indexed with a suitable value threshold that depends on the illumination of the driver's face. The application remembers mean values of the grey-level of the image and dynamically selects the indexing threshold so as to eliminate the influence of light on the results of the analysis of the image. Figure 8 shows an example of an image of a pupil of an open eye.

After the matrix has been indexed, all its elements are summed up. If this sum is lower than the value required by the application, a message "Watch out! You are

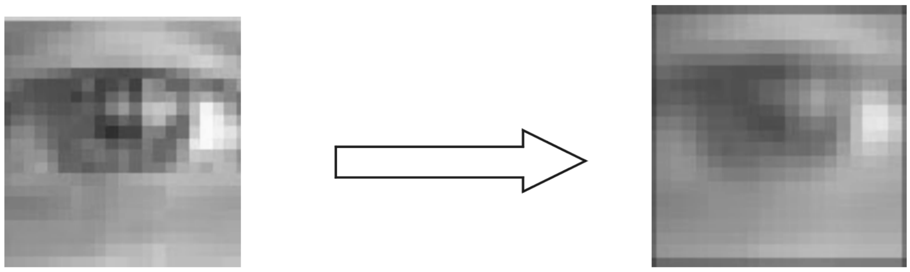

Fig. 7. The effect of the work of the filter

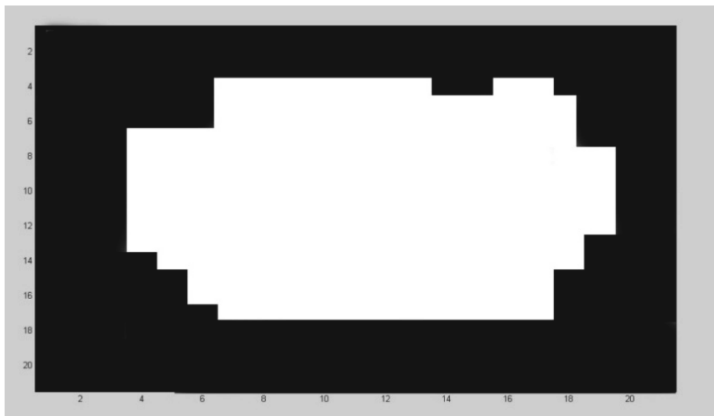

Fig. 8. An indexed image of a pupil of an open eye

falling asleep." is projected, its action is stopped and warning triangle is projected on the control panel of the application. However, if the sum of the elements of the indexed matrix is bigger than the required value, a message "You can continue driving" is projected.

The control panel is divided into five parts, numbered as shown on Figure 9. The first part shows an image of the face with eyes, after a prior analysis. Second part of the panel contains the controls: "start", "*Stop*" and "reset". The "start" button starts the application and the process of taking photographs, whereas the button labelled "*stop*" stops the process of taking photographs, as well as the application's operation. The "reset" button deletes messages and images in the windows. The third part of the control panel is divided into two parts in which the photographs of the right and left eye, still undergoing analysis, are shown. In the fourth part the messages that inform about the application's results and potential errors are shown. Lastly, in the fifth part of the panel visual signs informing about the results of the analysis and the errors in the application's work are shown.

4. Summary

This paper contains a description of selected active type assistance systems improving safety in wheeled vehicles. Much focus was given to selected intelligent vision systems that are developed in modern systems due to the fact that they work as an integrator of existing solutions and improve the driver's automatic assistant.

This paper also contains a presentation of a successfully tested driver fatigue registration system which is manifested in the tendency to fall asleep while driving. The presented application which is actively integrated with vehicle's control systems makes it possible to improve their safety.

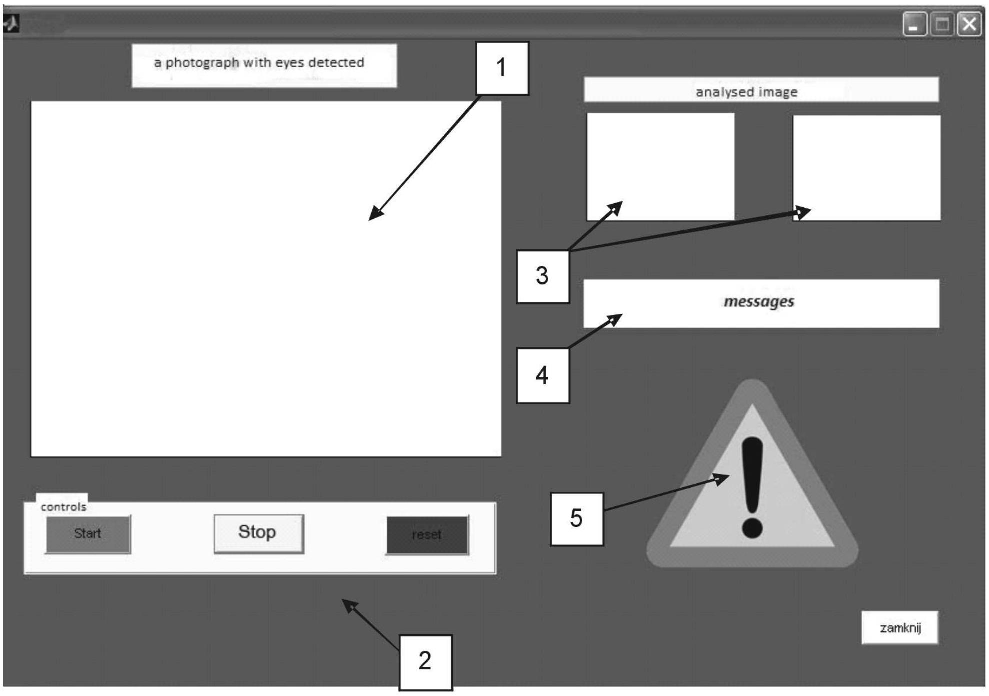

Fig. 9. Interface of the Matlab environment used for the analysis and the display of the driver's tiredness: 1 – a display of a photograph of the driver's face, 2 – a control panels used for controlling the interface, 3 – a display of the driver's field of view, 4 – messages about the driver's psychophysical condition, 5 – a display of warning signs for the driver

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