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COMPUTER VISION SYSTEM FOR DETECTION OF PASSENGER SLEEPING STATE FOR ADVANCED DRIVER ASSISTANCE SYSTEMS

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ABSTRACT

The goal of this research is to develop an in-vehicle computerized system able to warn the driver, to assess the passenger's state of sleeping in order to avoid affecting the driver psychologically and induce drowsiness. This new feature proposed for Advanced Driver Assistance System might increase car safety by mitigation or avoidance of accidents.

KEYWORDS: computer vision, passenger fatigue detection, Advanced Driver Assistance System

1. Introduction

Every year in Europe more than 40000 casualties and 1.3 million injuries are caused by car accidents [1]. The advances in passive safety have reached their limits regarding consumption conditions, as traditional materials are used for manufacturing safety components. Also, passive safety has limits concerning speed due to the huge amount of deceleration to human body. The safety potential of further improvements in passive safety features is limited. However, Advanced Driver Assistance Systems (ADASs) have the potential to significantly reduce the number of road accidents, mitigate and moreover reduce accident casualties and victims. An ADAS is a vehicle control system that uses different sensors (e.g. camera, radar, laser, vision) to improve traffic safety by assisting and warning the driver in potentially dangerous traffic situations. Nowadays an ADAS can even autonomously intervene in case of dangerous situations.

There are many ADAS systems [2–9] concerning issues such as traffic sign recognition, forward collision warning, lane warning departure, parking assistance, etc. Nearly 80 percent of all crashes involve driver inattention or sleepy state [10].

Drowsiness appears in situations of fatigue and it may be produced by several factors such as sleep disorders, medications, and even the fact that the right passenger is sleeping during a long, especially night, drive, as stressed by psychological studies [1].

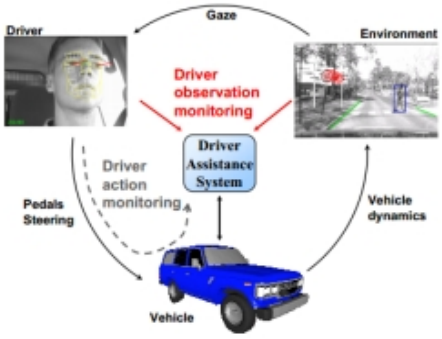

Fig. 1. *Principle of driver drowsiness warning systems* [11]

It has been revealed that drowsiness causes between 10% and 20% of traffic accidents with casualties and injured drivers [12]. Other authors [13] estimate that 30% of all traffic accidents have been caused by drowsiness. According to recent road safety surveys, fatigued driving is a common cause of accidents in Canada.

The main concern related to drivers falling asleep is their high crash rate. Fatigue and sleepiness are typically shown in the driver's facial expression and affect eye movement, gaze orientation, and head and body movement (Fig. 1). Such visual cues are analyzed by various computer vision techniques for the detection of fatigue [13-19]. There are research groups dealing with occupant posture analysis but only for airbag activation and not for detection of sleepiness.

Starting from a psychological study [1], this paper proposes a new feature for ADAS, aiming for the real-time detection of sleep onset in a fatigued passenger. Sleep onset is one of the most important consequences regarding high causalities as shown by statistics all over the world.

One of the reasons for driver sleep onset is the co-driver state of sleep. Therefore, unlike previous related work, we separate the issue of driver sleep onset from the right passenger sleep onset and we consider a major influence the physiological state of fatigue of the right passenger (co-driver in case of truck transport). This allows us to formulate our approach as an event-detection problem. Real-time performance is achieved by focusing on a multiple visual cue (eye-state, movement, face position), and by a custom-designed template-matching algorithm for passenger state detection.

The system proposed offers a non-invasive and low-cost alternative to electrode-based measures of fatigue. The approach proposed tracks eye and body motion from video data acquired with one camera placed on the dashboard of the car. In terms of simplicity, the hardware architecture is similar to another approach mentioned above concerning driver sleep detection. However, their scope lies in monitoring the visual attention of the driver, which is different from occupant fatigue.

The proposed algorithm is designed for on-line data processing: when detecting that the occupant is sleeping, it will activate a warning audio alarm to inform the passengers in the car.

2. Technique proposed

Experimental results were acquired using the Logitech C170 placed on dashboard as webcam (Fig. 3), and the Acer NoteBook 1.6 GHz with 1 GB RAMas processing unit. The video sequences were acquired at 20 frames per second. The proposed approach was implemented in Microsoft Visual C++ and OPenCV library. Figure 2 shows the general algorithm to detect passenger sleeping state. While preliminary tests have shown that the proposed approach works well in the in-vehicle environment, all results reported here have been obtained using offline video.

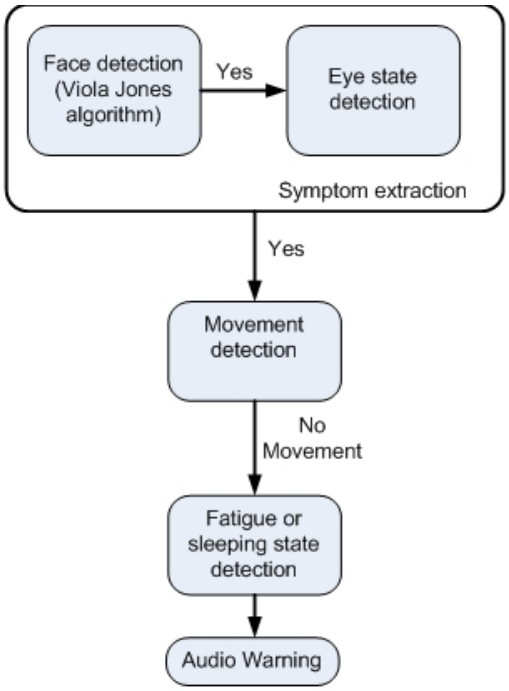

Fig. 2. *General algorithm used for passenger sleeping state*

The well-knownViola-Jones face detection algorithm is used for face detection, and once face is detected, the last 100 seconds are considered for movement detection in order to decide if the passenger is sleeping. The Viola-Jones machine learning-based approach is concerned with face detection using a number of training samples. This algorithm benefits from using algorithm for object detection, which uses very simple features named Haar-like features. In this algorithm, many numbers of Haar-like features are extracted from the image samples, and a number of effective features are selected using AdaBoost algorithm. The data base for training was used from OpenCv library. Due to the simple extracted features and selection of the best features, this algorithm is relatively fast and robust. Compared to the case of driver sleeping detection, the passenger detection is an easier task as the warning may be delayed dozens of seconds whereas in the first case 2 or 3 seconds is the upper limit to avoid an accident. The developed system monitors the driver's body position in the car and quantifies the body movement by a position into the space (x,y), a head yawn. We also quantify the level of closed eye vs open eye by taking into consideration the degree of modification for a period of time (100 seconds) (Fig. 4 and Fig. 5). The more the driver is moving his body, including his head, the higher the head activity variable. When the variable indicating body

movement is zero, the detection of closed eye for more than 60 seconds and head yawn position, a gentle sound alarm is issued.

Fig. 3. *Positioning of the web camera on dashboard*

Fig. 4. *Face detection and eye opened detection*

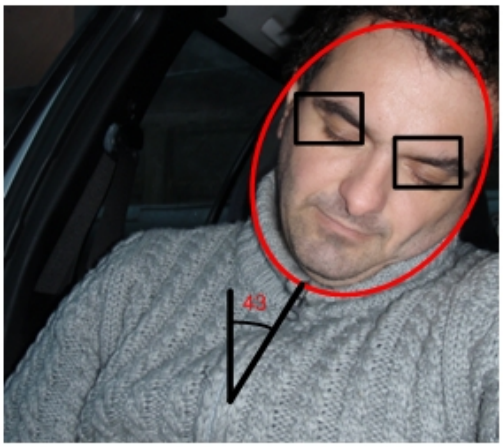

Fig. 5. *Face detection and eye closed detection*

The proposed approach also features an on-line calibration step in order to improve eye detection and allow the user to adjust the parameters of the proposed system.

Table 1. *Statistics concerning detected features*

No of video sequences	50 – total 3h
Open Eye detection	85%
Closed Eye detection	60%
Face detection	90%
Movement detection	30%
Sleeping state detection	3%

Real-time performance was achieved by focusing on several visual cues (face detection, eye-state, body movement).

4. Conclusions

The present study has shown the potential use of a new ADAS feature – monitoring car occupant sleeping state in order not to psychologically affect the driver. Computer vision technique as a tool to assess the passenger sleeping state is a very effective non-intrusive solution. The presented method is an alternative feature to the driver sleeping on state detection and further enhances driving safety and also improves ADAS features. This represents a significant advance in the application of computer vision to ADAS.

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