Coma Detection and Real Time Driver Drowsiness Using Deep Neural Techniques and Computer Interaction Implemented in a Smartphone.

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Abstract.
Doctors find difficult to tell whether the patient is in coma or just unconscious for a bit. Doctors have to wait for at least 6 hours before declaring the patient in coma. Mental health of people are also affected by not getting proper sleep for which this application can be used by the doctors and professionals to check on their patients and employs respectively.
The main reason for motor vehicular accidents is the driver drowsiness. This work shows a surveillance system developed to detect and alert the vehicle driver about the presence of drowsiness. It is used a smartphone like small computer with a mobile application using Android operating system to implement the Human Computer Interaction System. For the detection of drowsiness, the most relevant visual indicators that reflect the driver's condition are the behavior of the eyes, the lateral and frontal assent of the head and the yawn. The system works adequately under natural lighting conditions and no matter the use of driver accessories like glasses, hearing aids or a cap. Due to a large number of traffic accidents when driver has fallen asleep this proposal was developed in order to prevent them by providing a non-invasive system, easy to use and without the necessity of purchasing specialized devices. The method gets 93.37% of drowsiness detections.

Keywords: Drowsiness Detection, Coma Detection, Artificial Vision, Mobile App, Face Detection.

1 Introduction

Sleeping is one of the basic needs of the human being, sleep lack causes the body to react inefficiently, reducing both reaction time and wakefulness, also produce low alertness and lose of concentration which reduces the ability to perform activities based on care that is necessary in the case of driving a car.

According to many researches drowsiness is related to thousands of traffic accidents each year, the accidents produces approximately 50% of death or serious injuries [1], as they tend to be impacts at high speed because the driver who has fallen asleep cannot brake or deviate to avoid or reduce impact. To mitigate these accidents,

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manufacturers have developed drowsiness detection systems that recognize signs of possible drowsiness, alerting the driver to their condition [2].

In the research: "A smartphone-based driver safety monitoring system using data fusion. Sensors", Lee and Chung [3] propose a method to monitor driver safety levels using a data fusion approach such as: eye characteristics, variation of biological signals, temperature inside the vehicle and vehicle speed. This system is developed as an application for an Android-based smartphone, where measuring security-related data that does not require additional costs or additional equipment. The system has an efficiency of 96% to detect that the driver is awake and 97% to detect that he is asleep. This information allows knowing the signs that shows a sleepy driver.

In work "Detection of fatigue using Smartphone aims to use a smartphone (with Android operating system or IOS) to detect fatigue in the driver" [4] Roberson and others uses the front camera of the smartphone to capture images of the driver and then uses advanced algorithms of computer vision to detect his face and eyes. Rotation and tilting of the head and blinking of the eyes are detected as indicators of fatigue. The smartphones is used to assist driver using front and rear camera [5], for drowsy driving detection system [6], for the wavelet analysis of heart rate variability and a support vector machine classifier [7], and for identification of dangerous driving situations [8].

The PERCLOS (Percent of the time Eyelids are CLOSed) metrics is used to measure drowsiness in the work "Eye tracking based driver fatigue monitoring and warning system" [9]. The system estimates with a non - parametric methods for detecting drowsiness, the vehicle steering wheel variability is considered to determine the amount of drowsiness because drivers makes variability greater as driver become more drowsy. The PERCLOS metrics for alerting driver is used in [10] to detect drowsiness in heavy vehicles, to monitor and alert the driver [11], for line departure warnings [12] and to detect drowsiness conditions in drivers [13].

The HCI systems allows to interrelate the human being with an electronic device (computer) which is capable of giving solutions to a great number of problems that can affect him. The development and use of HCI has been very important, so it must be implemented with adequate usability criteria [14] and satisfy users' needs efficiently [15]. A relevant aspect is that not only sought a simple interaction also sought to assist humans with special skills to satisfy their needs even overcoming their limitations [16-19] and can be implemented using low cost systems [20-25]. The smart phones being mass-use are actually a low-cost computer, if are used in an HCI would allow to massify its use and therefore offer greater solutions to improve the quality of life of any person satisfying their needs even if the person presents some limitation in one or more of their senses.

The objective of this work was to implement a surveillance system to the vehicular driver based on artificial vision techniques and implemented in a smartphone in order to detect and alert when the driver have drowsiness signs. To achieve this objective it was analyzed other works related with detecting drowsiness in drivers, the drowsiness symptoms in vehicle drivers; we identify the technical parameters and algorithms that allow to process signals of the state of drowsiness. In this work we present a developed drowsiness detection algorithm, the interface in which the state of drowsiness is displayed and the necessary adjust to get the correct functioning of the implemented system.

Some of the aspects that are included in this work have been considered in the investigations referred to, but it differs essentially in the use of the new systems for digital image processing in smartphones.

1.1 Drowsiness Characteristics

Drowsiness is a physiological state with a tendency to fall asleep. Technically, drowsiness is different from the fatigue that is the lack of willingness to continue performing the same activity. Fatigue occurs by performing tasks that are always performed in the same way using the same muscle groups, their repetition rate is high and are usually performed by adopting forced postures such as monitoring a screen [26]. A person may be fatigued without being drowsy, but conditions that produce fatigue such as driving cars over great distances unmask the presence of physiological drowsiness, but do not cause fatigue.

Among the effects of being sleepy we have a lowered wakefulness, reaction time, psychomotor coordination and decreased information processing. For the driver the main effect is the progressive withdrawal of attention in demands of road, traffic and signaling, which causes a low driving performance producing accidents [27]. People who are drowsy have signs like frequent blinking, rubbing eyes, repeated yawning, head tilt, and distractions are the most important among which it can mention.

1.2 Drowsiness detection methods

Detection methods are divided into two main groups: methods based on driver performance and methods based on driver status [28]. The methods centered on driver status are divided into two subgroups: methods that use physiological signals and methods that use artificial vision techniques. Figure 1 shows classification of drowsiness detection methods.

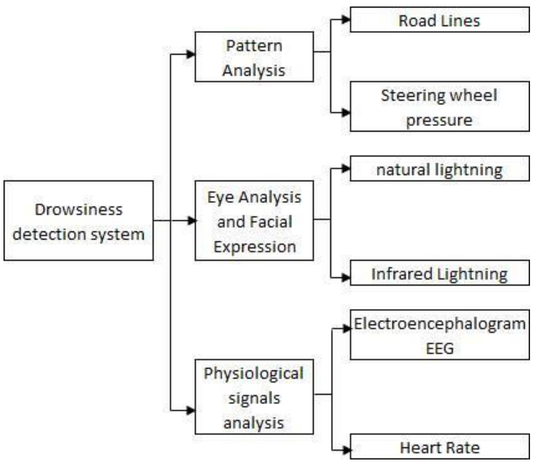

Fig. 1. Drowsiness detection methods.

The drowsiness detection using patterns analysis are generated based on measurable variables that are obtained experimentally. These variables can be speed, acceleration, braking, gear shifting, hand pressure on the steering wheel and the car's path in the road lane. This method has the disadvantage that its modeling depends on the characteristics of each car and the way of driving that is specific to each driver.

By the use of the image processing, driver states can be determined. From the image of the face it can be detected if the driver is awake or asleep. The drowsiness of the driver can be determined because the driver is trying to close his eyes [29]. This method has the advantage of not being intrusive and can be used techniques like the template pairing technique where a driver templates is defined. The technique of the behavior of the eyes, calculates the blinking frequency and the time interval of eyes closing in order to determine the rate of drowsiness.

One of the most used indexes to calculate the level of sleepiness is PERCLOS (Percent of the time Eyelids are CLOSed), which measures the percentage of time a person's eyes are closed at 80% to 100% in a period. According to a study by Walter Wierwille and colleagues [30], PERCLOS is among the most important real-time alert measures for vehicle drowsiness detection systems.

$$\text{Perclose} = (\text{Closed eyes time} / (\text{closed eyes time} + \text{open eyes time}))*100 \quad (1)$$

The Yawning technique is based on the driver's yawn frequency [29]. The opening of the driver mouth is greater when yawning than when speaking normally. The mouth is compared with a reference point experimentally obtained by the programmer and the number of times the driver has yawned is calculated to generate a drowsiness index. The analysis based on changing physiological measures use sensors that measure physiological variables of the human body to analyze states of drowsiness. These variables are the heart rate, brain activity, heart rate variability, respiration, peripheral skin temperature, and blood pressure [31].

1.3 Mobile applications in Smartphones

Smartphones are electronics devices that combines the functionalities of a mobile phone and the functionalities of a computer. The term intelligent is used commercially to refer to the ability to use as a handheld computer, sometimes leading to a replacement of a personal computer.

Smartphones are built on a mobile platform similar to the operating system of a computer, which makes it equally vulnerable to viruses. Among the basic characteristics of a smartphone we have that includes an operating system, it can send and receive calls and text messages, it has multimedia services, includes basic applications such as clock, alarm, calendar, calculator, games, digital agenda, it has internet connection, includes front and rear video cameras, it can read and edit documents, it has sensors like gyroscope, accelerometer, barometer, thermometer, etc. Google provides a set of open source visual programming interfaces (APIs) for mobile devices [32], the APIs can make face detection and tracking, barcode scanner, text recognition. The API also offers information about the state of facial features like
open eyes and smiles [33].

2 Materials and Method

This section describes different aspects of the system considered in its implementation; they include the functional requirements as well as the tools used and devices selected for system testing in different study cases.

The used algorithm processes the color information present in the image, converting it to grayscale. To determine the face in the image, the image is divided in sub regions determining whether the subregion is a face or not. The use of this algorithm means a time saving and only the subregions that contains a face are processed.

The gesture detection is done from the residual error that is modeled considering a linear combination of facial movement models. A similar model is considered to detect the position and inclination of the face. It includes a system that allows detecting facial gestures in the presence of head movement.

Figure 2 shows the flowchart of the system. The code used to implement the algorithms was created taking into account the limitations that have mobile devices like the limited content or features in the interface, slow or limited hardware and use situations. Their success in functionality is based on the way they are designed and optimized by company that owns Android.

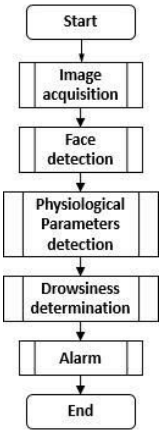

Fig. 2. Drowsiness detection methods

A system general scheme is seen in Figure 3 in which it is shown that the driver must take into account the alerts presented by the system, while the smartphone is in charge of processing the information acquired from the driver's face in real time. The main use case diagram is shown in Figure 4.

Fig. 3. General scheme of the drowsiness detection system.

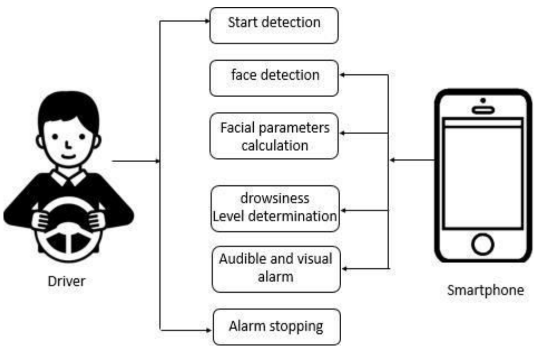

Fig. 4. Main use case diagram.

In which two buttons are presented that allow to show information regarding the situation of the driver, which is necessary for research aspects. In addition, there are indicators that shows the presence or absence of the driver's face at the interface, open eyes, left or right face tilt, left or right distraction, and yawn presence are included. Technical information is also presented with respect to the operating characteristics of the system that the user does not necessarily need to know.

Subjects: To perform the system tests, 20 drivers, 10 men and 10 women of different ages were included, each of whom was accompanied by a "co-pilot" who was in charge of managing the controlled events of sleepiness only when the external conditions in the road and close to the vehicle were safe.

The events to validate the system were the following: yawning detection, front and lateral assent of the head, left and right distraction and blinking. In the process of validating the system, the co-pilot will direct them, making the drivers repeat 10 times the test. The number of correctly detected events, false positives, false negatives, and the efficiency of the implemented system were registered.

3 Results

This section presents the results on the detection of visual indicators of drowsiness. Collecting the data set to properly evaluate the system is a challenge, this is because dangerous drowsiness events are not guaranteed to occur during daily driving for application testing.

Table 1. Detection levels for drowsiness parameter under normal conditions.

Test	Number of observations	Number of hits	Percentage of hits
Yawn detection	170	143	84.11 %
Front nodding	200	184	92.0 %
Assent of the head to the right	200	190	95.0 %
Assent of the head to the left	200	191	95,5 %
Distraction to the right	200	184	92.0 %
Distraction to the left	200	193	96.5 %
Blink detection	200	197	98.5 %

Table 1 presents the results of the detection of somnolence considering the normal operation of the system in which the responses are obtained from each of the drivers that were submitted to the addresses issued by the co-pilot who recorded the results. The level of total hits on detection represents an average percentage of 93.37%.

Table 2. Detection levels for different drowsiness parameter under special conditions.

Test	Number of observations	Number of hits	Percentage of hits
Driver with a cab	1400	1295	92.5 %
Driver with glasses	1400	1183	85.5 %

Tests Table 2 presents the results obtained by placing additional objects on the clothes of the drivers, which in this case were the caps and glasses. The average percentage of hits is 88.5%.

Table 3. Detection levels for different drowsiness parameter considering the hair covering face.

Test	Number of observations	Number of hits	Percentage of hits
Hair covering driver’s face	70	65	92.8 %
Hair not covering driver´s face	70	49	70.0 %

Table 3 presents the results obtained by considering the hair covering driver’s face.
The drivers were women and the average percentage of hits was 81.4 %.

Los resultados presentados indican la eficiencia del sistema que es de alto nivel y son comparable e inclusive superiores a otros sistemas a los que se hace referencia en el presente trabajo. Los menores niveles de acierto se presentan cuando los usuarios incluyen elementos que no permiten ser identificados los gestos de la cara de manera correcta, pero que a pesar de aquello sus niveles son satisfactorios.

The presented results indicate the efficiency of the system that is of higher level and even better than other systems referred to in this work. The lower levels of accuracy occur when users include elements that do not allow to correctly identify the face gestures, but despite that, their levels are satisfactory.

5 Conclusions

The study has shown promising results in applying the vehicular driver surveillance based on artificial vision techniques and implemented in a smartphone. The implemented system allows an efficient detection of the indicators that appear in drowsiness, as long as the measurements are carried out under the established conditions. The correct functioning of the system depends on these conditions.

The increase in the processing characteristics in smartphones made possible to develop an application of artificial vision, capable of detecting the face and visual indicators present in a person who suffers from drowsiness such as: yawning, head movements and the state of the eyes.

The symptoms that people present during the transition between awake and asleep are appearing as the intensity of drowsiness increases. The greater intensity of drowsiness means a higher loss of concentration and a lower ability of driver reaction. In development this work, the implementation of 3 levels of sleepiness allows the system to alert the driver about their condition, not necessarily at a critical level where it may have serious repercussions, rather at early levels where drowsiness is just emerging.

An HCI could be implemented using smartphones like shown in this work, which would allow massify their use and therefore provides greater solutions improving the quality of life of the people even if has specials skills.

References

1. World Health Organization. Road Safety: Basic Facts. ; 2016 (http://www.who.int/violence_injury_prevention/publications/road_traffic/Road_safety_media_brief_full_document.pdf).
2. Ji Q., Yang X.: Real-time eye, gaze, and face pose tracking for monitoring driver vigilance. Real-Time Imaging. 8(5):357-77 (2002)
3. Lee B. G., Chung W. Y.: A smartphone-based driver safety monitoring system using data fusion. Sensors. 12(12):17536-52 (2012)
4. He J, Roberson S, Fields B, Peng J, Cielocha S, Coltea J. Fatigue detection using smartphones. Journal of Ergonomics. 3(03):1-7 (2013)
5. Chang K, Oh BH, Hong KS. An implementation of smartphone-based driver assistance system using front and rear camera. In Consumer Electronics (ICCE), 2014 IEEE International Conference (pp. 280-281). IEEE (2014)
6. Xu L, Li S, Bian K, Zhao T, Yan W. Sober-Drive: A smartphone-assisted drowsy driving detection system. InComputing, Networking and Communications (ICNC), 2014 International Conference. pp. 398-402. IEEE (2014)
7. Li G, Chung WY.: Detection of driver drowsiness using wavelet analysis of heart rate variability and a support vector machine classifier. Sensors. 13(12):16494-511 (2013)

8. Smirnov AV, Kashevnik A, Lashkov I, Baraniuc O, Parfenov V. Smartphone-based identification of dangerous driving situations: Algorithms and implementation. In FRUCT pp. 306-313 (2016)
9. Singh H, Bhatia JS, Kaur J.: Eye tracking based driver fatigue monitoring and warning system. InPower Electronics (IICPE), 2010 India International Conference. pp. 1-6. IEEE (2011)
10. Grace R, Byrne VE, Bierman DM, Legrand JM, Gricourt D, Davis BK, Staszewski JJ, Carnahan B.: A drowsy driver detection system for heavy vehicles. In Digital Avionics Systems Conference, 1998. Proceedings., 17th DASC. The AIAA/IEEE/SAE 1998 Nov (Vol. 2, pp. I36-1). IEEE.
11. Grace R, Steward S.: Drowsy driver monitor and warning system. In International driving symposium on human factors in driver assessment, training and vehicle design. Vol. 8, pp. 201-208 (2001).
12. Kozak K, Pohl J, Birk W, Greenberg J, Artz B, Blommer M, Cathey L, Curry R.: Evaluation of lane departure warnings for drowsy drivers. In Proceedings of the human factors and ergonomics society annual meeting (Vol. 50, No. 22, pp. 2400-2404). Sage CA: Los Angeles, CA: Sage Publications (2006)
13. Garcia I, Bronte S, Bergasa LM, Almazán J, Yebes J.: Vision-based drowsiness detector for real driving conditions. In Intelligent Vehicles Symposium (IV), IEEE. (pp. 618-623). IEEE (2012).
14. Harshul, G., Tanupriya, C., & Praveen, K. (2017). Comparison between significance of usability and security in HCI. 2017 3rd International Conference on Computational Intelligence & Communication Technology (CICT) (págs. 1 - 4). Ghaziabad, India: IEEE.
15. Zhiqiang, X., Xuejun , Q., & Jialiang , H. (2017). A novel multimedia human-computer interaction (HCI) system based on Kinect and depth image understanding. International Conference on Inventive Computation Technologies (ICICT) (págs. 1 - 6). Coimbatore, India: IEEE.
16. Fernandez Montenegro, J., & Argyriou, V. (2016). Gaze estimation using EEG signals for HCI in augmented and virtual reality headsets. 2016 23rd International Conference on
Pattern Recognition (ICPR). Cancun, Mexico: IEEE