Journal of Ergonomics

Poursadeghiyan, J Ergonomics 2017, 7:1
DOI: 10.4172/2165-7556.1000e165

Editorial Open Access

Road Safety by Presenting a Model for Facial Dynamic Anthropometry in Detecting Driver Drowsiness

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Received date: Dec 20, 2016; **Accepted date:** Dec 26, 2016; **Published date:** Dec 30, 2016

Introduction

Driver's reduced alertness due to fatigue and monotony of road is a major cause of road accidents and thus a crucial factor undermining road safety across the world [1,2]. It has been reported that in America, from 1989 to 1993, this issue has been the cause of about 500,000 crashes leading to 1550 deaths and 4000 severe injuries [3]. Research has shown that driver's reduced alertness is the cause of about 12.4 billion dollars annual damage to US economy [4,5], is the primary or contributing cause of about 20% of road accidents in Britain [6], and also the main cause of road accidents in Japan [8,9] and France [10]. It has been estimated that this issue is the cause of 25% of accidents worldwide [11,12], and plays an even bigger role in the less developed countries and the ones with less effective enforcement of road and transport regulations.

Road safety in Iran too is severely undermined by this issue, which, combined with low quality roads and vehicles, make Iran the country with fifth highest rate of deathly road accidents in the world [13]. It has been reported that in Iran, road accidents account for 27.8 % of deaths (20 times more than the global average) and are the primary cause of unintentional death of children and the second most important cause of death after cardiovascular conditions [13,14]. It has been estimated that in Iran, road accidents cause 1 death every 19 minutes and 1 critical life-long injury every 2 minutes. In addition, they damage Iran's economy by about 6 billion dollars per year, which is equivalent to 5% of its GDP. In Iran, victims of road accidents are mostly low or middle-income citizens. According to reports, of 20,068 unfortunate Iranian victims of road accidents in 2011, 5888 were killed on urban roads, 12,232 on suburban roads, 1803 on rural roads (145 unknown cases) [15]. In the same year, road accidents were the cause of 216,207 severe injuries among Iranian men and 81,050 severe injuries among Iranian women. Fatigue and sleep disorders in driver can lead to road accident by causing the driver to fall sleep or by reducing his alertness and the speed of his reflexes [13].

Drowsiness Detection Methods

There are two groups of drowsiness detection methods: supervisory methods, and methods that are based on vehicle movements. Supervisory methods monitor the driver's physical signs by sensors and cameras and send the recorded data to a computer that uses them to estimate the driver's drowsiness or alertness. These methods have simple mathematical, biological and engineering foundations and are easier to develop, but the high cost of available measuring equipment and the fact that they annoy and distract the driver have limited the prospect of their use in real world. These methods may use three types of sensor to achieve their purpose: physiologic sensor, driver performance sensor, and vehicle response sensor. In the first approach, which is currently regarded as the best method, changes in physiological signs can be measured by EEG, ECG, and EOG. Table 1 presents a summary of vehicle response and driver performance sensors and features of each approach.

In driver performance monitoring, a camera detects the driver's drowsiness. Driver's drowsiness can also be inferred from driving performance and vehicle control behavior e.g., the motion of steering wheel, patterns of acceleration or braking, speed, transverse momentum, and lateral shift. To use these methods, data and patterns must be calibrated for the condition of driving, driver, and vehicle [16]. Currently, this method is regarded as the best approach to drowsiness detection, but displeasure of drivers by the presence of sensors still remains an issue. An alternative method that can circumvent this issue is to monitor the blinks of driver's eyes and infer his drowsiness accordingly [17]. According to research, drowsiness has detectable effects on driver's manner of sitting as well as facial features, most noticeably on the eyes, mouth, and orientation of the head, which can be tracked by a camera and an image processing application developed for this purpose [12]. The features that can be tracked to predict drowsiness include longer blinks, higher rate of blinking, and slow movement of eyelids, closed eyes, repeated nodding, yawning, staring, inclined head orientation, and inactivity of the head, which all can be monitored by an appropriate machine vision apparatus without annoying the driver [18]. The previous works in this line of research have had many breakthroughs in tracking the eye movements and interpreting them for the purpose of detecting drowsiness; thus eye-tracking is by far the most successful approach for this purpose. Eye-tracking schemes put particular emphasis on the metrics and frequency of blinking, closure of eyes, and gaze direction [19].

Performance of a drowsiness detection scheme to estimate the driver's alertness and ability to control and maneuver the car and thus avoid an accident depends largely on the ability of its software application to track and detect eye movements in the provided sequence of images. The suggested criteria for evaluation of alertness through eyes include the duration of blinking, frequency of blinking, and PERCLOS (percentage of eye closure over the pupil over time). In contrast to the first criterion, PERCLOS measures the drowsy and slow closure of eyelids instead of blinks [17,20].

Citation: Poursadeghiyan M (2017) Road Safety by Presenting a Model for Facial Dynamic Anthropometry in Detecting Driver Drowsiness. J Ergonomics 7: e165. doi:10.4172/2165-7556.1000e165

Method name	Advantages	Disadvantages
Based on physiological measures (particularly EEG)	By using brain waves, drowsiness can be efficiently and accurately detected	It is not realistic, because to get these signs, electrodes should be attached to the body, which is unpleasant or annoying for driver
Based on vehicle-based measures (vehicle performance)	Lane tracking, vehicle steering wheel changes, the number of lane crossings, and the distance from the front can be used in detecting	Having restrictions against some changes, including vehicle type, driver experience, road topology, road quality, and ambient light and on the other hand the processing of these methods require a considerable time to analyze the driver behaviors that cause to not recognize of micro-sleep
Based on behavioral measures (image processing)	In drowsiness, sensible en in appearance and thchanges can be seen in appearance and face of people, and the most important changes are in eyes, head, mouth, and sitting posture. By taking picture of driver and helping image processing techniques, signs of drowsiness can be extracted	Sudden changes in head, eyes and changes in light intensity can decrease the percentage of drowsiness detection
Combined method (expect-intrusive) Based on behavioral and vehicle-based measurement	In this method, infrared radiation is used for imaging, which allows imaging at night without disturbing driver	This method requires different categories in terms of image processing and status of eyes and face

Table 1: Common methods of evaluating drowsiness and their advantages and disadvantages [21].

Presentation of model

According to the results presented in Table 1 of the proposed model in the following Figure 1, the result of work on driving simulator will be offered. In this method, changes in the position of facial features, which are represented in the histogram of facial dynamic anthropometry, are extracted from a sequence of images and are utilized to assess the state of driver's facial appearance [22]. Thus, this method can be considered as an integrated version of previous methods developed in this field, which are mostly based on a single criterion, particularly eye-movement. As a result, this method can maintain its performance even when driver wears glasses or when eye measurements are not sufficiently conclusive. This method can be evaluated in a driving simulator by the objective criteria such as Standard Deviation of Lane Position (SDLP), Steering Wheel Movement (SWM), and subjective criteria such as Karolinsca Sleepiness Scale (KSS) and Observer Rating of Drowsiness (ORD) [23,24].

Proper implementation of this method may be able to prevent many avoidable catastrophes due to driver's fatigue and drowsiness, and save many lives in Iran as well as other countries suffering from high rates of road accidents.

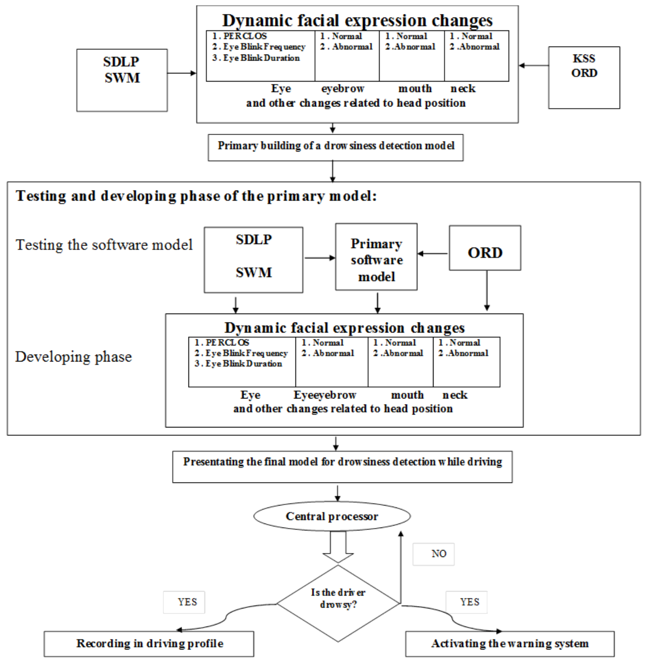

Figure 1: Presentation of model.

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