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Certain Investigations on Development of a Non-Intrusive Fatigue Detection System

S. Vijayprasath
Assistant Professor
Department of Electronics and Communication Engineering
Kamaraj College of Engineering and Technology
Virudhunagar, Tamilnadu, India
E-mail: vijayprasath.research@gmail.com
Tel: + 91 4549 278791; Fax: +91 4549 278172

R. Sukanesh
Professor, Department of Electronics and Communication Engineering
Thiagarajar College of Engineering
Madurai, Tamilnadu, India

S. Palanivel Rajan
Assistant Professor
Department of Electronics and Communication Engineering
Kamaraj College of Engineering and Technology
Virudhunagar, Tamilnadu, India

Abstract

Drowsy driving behavior plays a significant and hazardous role in transportation issues. Recent Statistics acquired from numerous databases shows that drowsy driving is a crucial cause of road accidents which does not have an efficient real time solution to work in dynamic environment, till now. This proposed work presents a non-intrusive solution for drowsiness detection by means of detecting the physical measures and detects the Perilous driving behavior by Inquisition on facial expressions. This paper combines two main physical measures which are eye state detection and then yawning detection which also includes face detection face detection, eye detection and mouth detection to identify the drowsy driving behavior.

Keywords: Image Processing, Drowsiness detection, Matlab.

1. Introduction

Drowsy driving is a serious problem that leads to thousands of automobile crashes each year. Drowsiness is defined as a state of decreased awareness or alertness associated with a desire or tendency to fall asleep. Drowsiness is believed to be a major factor in 20 per cent or more of road crashes. The World Health Organization has revealed in its first ever Global Status Report on Road Safety that more people die in road accidents in India than anywhere else in the world, including the more populous China. Calling road fatalities an "epidemic" that will become the world's fifth biggest killer by 2030, the report said while rich nations had been able to lower their death rates, these were sharply on the rise in the third world.

According to the National Highway Traffic Safety Administration, drowsy driving is a factor in more than 100,000 crashes, resulting in 1,550 deaths and 40,000 injuries annually According to the industry reports, drowsy driving accounts for about 50,000 accidents every year in India and it is said that nearly 400% of accidents are due to drowsiness. So, this problem is raising echo in current scenario. People feel most drowse during the peak sleep hours between 11 p.m. and 8 a.m. Some even feel sleepy during afternoon hours especially from noon to 2 p.m. The most common symptoms of drowsiness are drooping eyelids, drifting vehicle, varying speed, repeated yawning, irrelevant conversation, and misjudging traffic signals. In order to monitor a driver's sleepiness and alert the driver in case of drowsiness, our proposed system offers an effective non-intrusive solution for a dynamic environment.

2. Previous Research

In order to afford alert on driver's drowsiness, different techniques have been offered in different domain. The analysis of drowsy driving behavior [1] is done by means of performing face detection as the basic step for eye detection [18]. In which, eyes are detected by constructing a threshold on roundness of iris and analyses the eye state for drowsiness detection [19, 20,22]. Iris obstruction by eyebrows, eyelashes, eyelids, Lightning reflections, specular reflections, Poor focus, partially captured iris, Out-of-image iris, and Off-angle iris motion may occur. Several techniques which detect fatigue based on the fuzzy fusion of blinking features that are extracted from a high frame rate video [2]. The different features used in the system have been selected by data-mining on a consistent database. Similar to this method another detection algorithm proposed proceeds from face detection and performs eye detection and calculates eye blink pattern from "Eye blink pattern detection algorithm" [3]. Indeed, the presence of glasses may affect the core components of the system including face detection, eye detection and symmetry calculation. Many applications through face detection were also developed for determining drowsiness which is based on Neural Networks (NN) where the matching algorithm needs a huge training set of face and non-face images and take a long time in execution [12, 17, 22, 26]

Determining the level of drowsiness by using eye blinking is way of detecting eye positions and measuring eyelid movements. Illumination based approaches also exist [4] which uses an infrared image that remained stable regardless of whether it was used during the day or at night. The camera lens with an infrared band-pass filter removes all visible light and only allowed infrared light in. The light source of infrared light is sunlight during the day and Infrared Light-Emitting Diodes (IR LEDs) during the night or on cloudy days. IR illumination cameras are used to detect the drowsy behavior by means of dark pupil effect. Although IR based approaches perform reasonably at night time, it was noted [Hartley, Horberry, & Mabbott, 2000] that those methods often malfunctioned during daytime under the presence of sunlight. Moreover, when eyes are closed the reflection in IR range disappears, making eye detection a difficult task. Another disadvantage of IR based approaches is the necessity of installing an IR LEDs setup. IR cameras are inefficacious under direct sunlight. The range of focusing plays a major role in heavy vehicles like buses where the distance between the driving personnel and front mirror exist. There are also techniques which [5] performs detection and tracking of driver's face, detection and tracking of the mouth contour and the detection of yawning based on measuring both the rate and the amount of changes in the mouth contour area. All these methods follow the invasive approach which involves EOG, EEG, EMG, ERG, etc. They need a physical contact with the driver to monitor driver's physiological changes as an indicator of drowsiness.

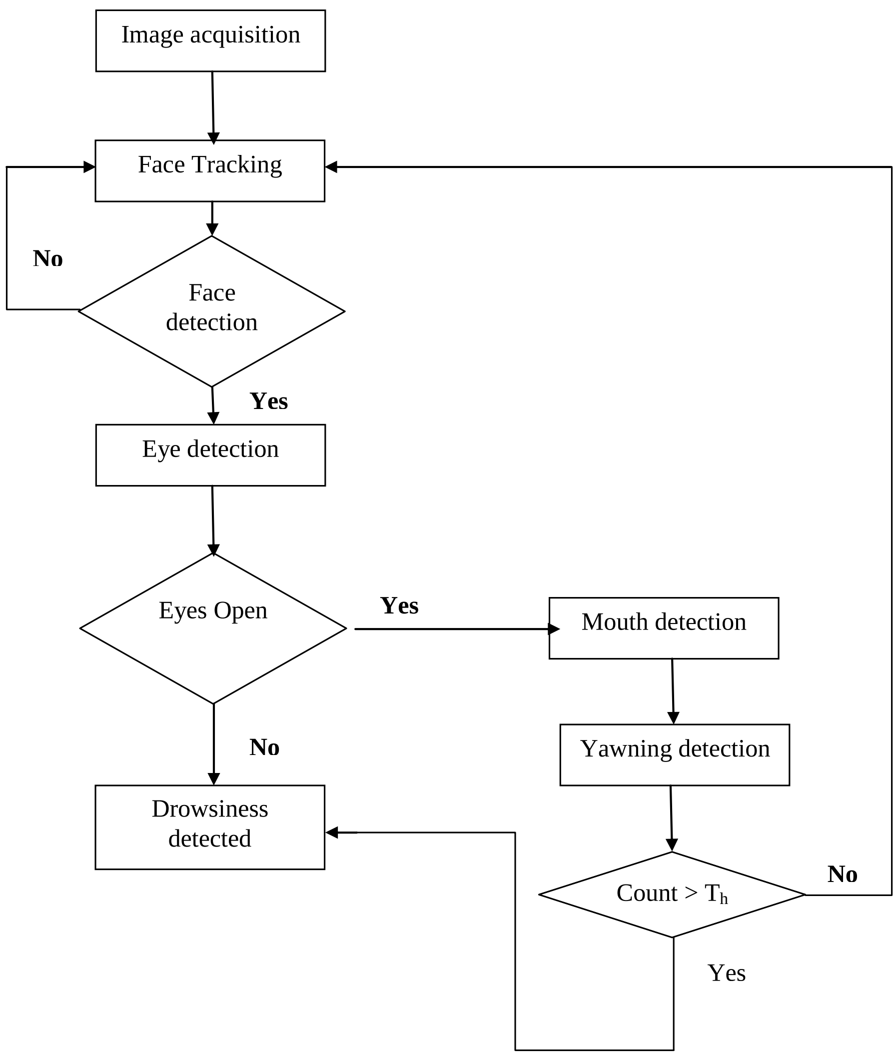
Electrodes are always connected very close to the muscle group being measured. These systems, while being the most accurate are annoying to the driver because electrodes have to be connected directly to the driver's body to measure his physiological characteristics, and accordingly detect drowsiness. Non-intrusive type of detecting drowsiness is always suited for real time analysis.

This type of system is better suited for real world conditions, since it does not distract the driver. It measures the level of alertness of the driver by monitoring steering wheel movements, braking patterns, and also tracking road lane view, facial expressions, yawning analysis, eye state analysis, head movement analysis etc.

We have proposed a new mechanism based on a simple "**3 step detection algorithm**" for face detection. This paper aims at developing a combined model for drowsiness detection mechanism. In this approach, we have analyzed two different non-invasive methods. The overall proposed work is arranged into sections as shown below. In Section 3.1 a brief description of face detection is presented. Eye detection and eye state analysis are described in section 3.2 and 3.3 defines the mouth detection and 3.4 defines the final stage of predicting drowsiness.

3. Research Method

Figure.1: Flow Diagram of the proposed work



Initial step starts with the acquisition of an image from the camera followed by face tracking, eye detection, mouth detection and drowsiness detection which is described in detail below.

3.1. Face Detection

The first step is pre-processing. It is used to calculate the integral images and lighting corrections from the scaled (scale factor is 1.2) original image. The second step is processing the frame sequences along with trained threshold values. The third step is post-processing. It clusters the adjacent detected faces to one or several rectangles to represent faces according to distance factor.

Step1: The feature window (16×16) is fixed; we need to scale the source images down to detect faces which originally are large in size. The down-sampling uses simple linear image interpolation technique with a factor of 1.2. The most important thing during this step is to calculate the integral images and the lighting corrections.

Step 2: After making integral images**,** this step is performed to find whether face pixel exist in image or not. This can be **done** by comparing it with defined threshold values.

Step3: After processing with threshold values operated onto the original source image and all scaled images, we cluster the **detected** face pixels for any adjacent scaled images to be the final detected face rectangle.

3.2. Eye Detection

After detecting the face, the location of the eyes will be detected using the duration of eye closure, Frequency of eye blinks. The first criterion is the duration of eyelid closure. It is used as a distinctive characteristic to judge whether a driver is drowsy or not. General duration of closure is 0.15 to 0.25 seconds. Low Eye blink frequency can also be brought into account in drowsiness detection. If the eyes are found closed for a certain threshold then immediately the system detects drowsiness and provides an alarm to the person. If open it proceeds to the mouth and yawning detection.

3.3. Mouth and Yawning Detection

The next step towards yawning detection is to find the location of mouth and the lips. The mouth map will then go through some post processing steps such as black and white conversion, erosion, dilation and finding the biggest connected components in the same way as the eye detection scheme. The geometrical features of the face and relative location of the mouth with respect to eyes can be exploited in this step to verify the validity of the detected mouth. Yawning detection is performed in two main steps: in the first step we detect the yawn component in the face independent of the mouth location. This component is basically the hole in the mouth as the results of wide mouth opening. In the second step we will use mouth location to verify the validity of the detected component.

3.4. Fatigue Detection

The Drowsiness is detected using Eye and Yawning detection. If the person is under the sleepy condition we use image to notify the drowsiness condition or else we use another smiley image to notify the person in active condition. In the other case if the yawning count is more than the predetermined threshold then the system detects it as drowsiness and provides an alarm.

4. Results and Discussion

Using MATLAB, you can analyze data, develop algorithms, and create models and applications. The language, tools, and built-in math functions enable you to explore multiple approaches and reach a solution faster than with spreadsheets or traditional programming languages, such as C/C++ or Java™. You can use MATLAB for a range of applications, including signal processing and communications, image and video processing and control systems.

The main reasons for performing this hypothesis testing in Matlab are

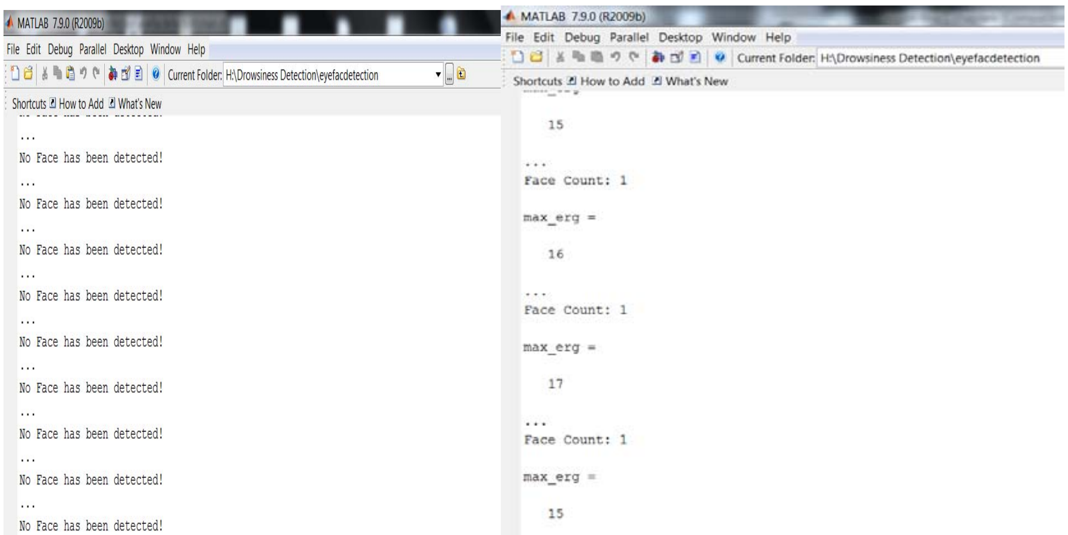
- Platform Independence
- Predefined Function

- Device-Independent Plotting
- Graphical User Interface

4.1. Face Detection

Once image acquisition has been completed our model detects the face by calculating centroid.Fig.2 shows the result that face was not detected and then shows the successful detection of facial image.

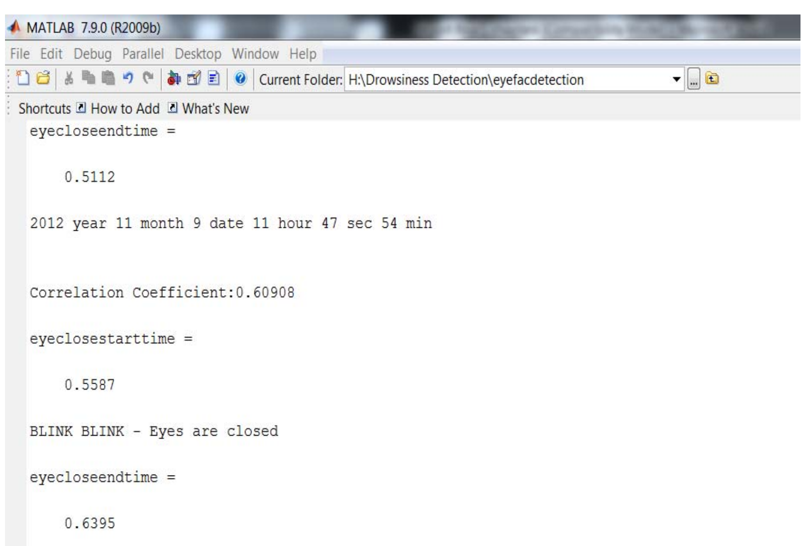
Figure 2: Face detection



4.2. Eye Detection

The results shown in Figure 3 clearly indicated the detection of eyes using boundary calculations set up in the compiler. Then correlation coefficient was compared with the threshold and drowsiness was detected. The eye opening and eye closure time were calculated and depending upon the blinks the results indicates that eyes are closed and drowsiness detected.

Figure 3: Drowsiness detection



4.3. Fatigue Detection

Figure.4: Closed eye detection with spectacles

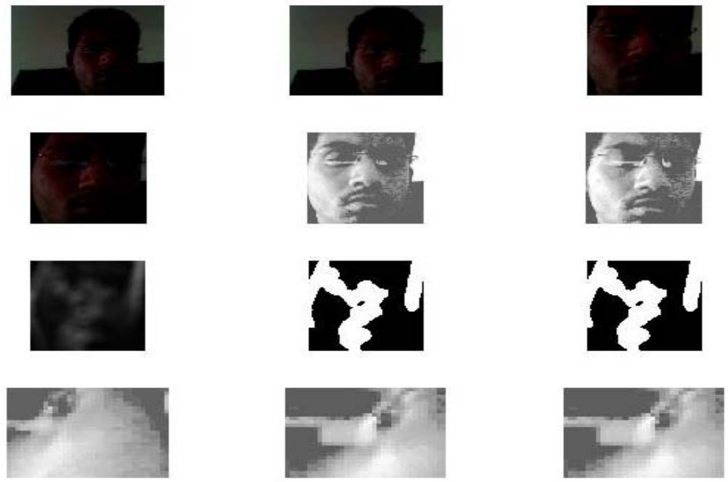


Figure.5: Open eye detection with spectacles

Figure 6: Drowsiness detection without spectacles

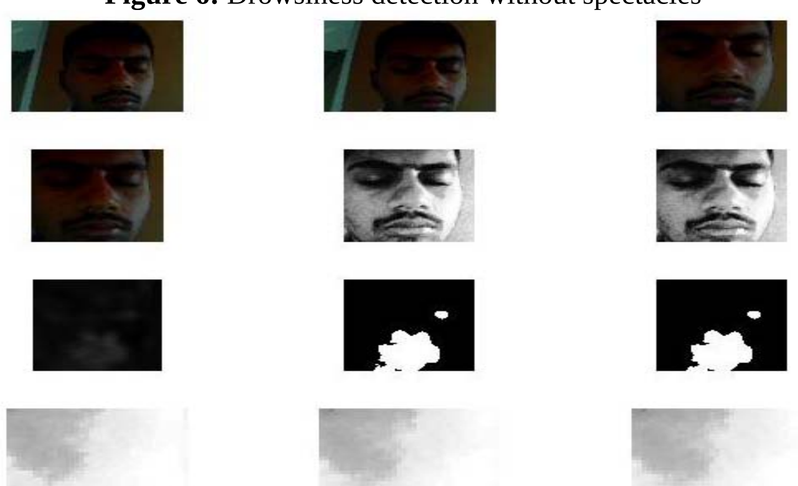
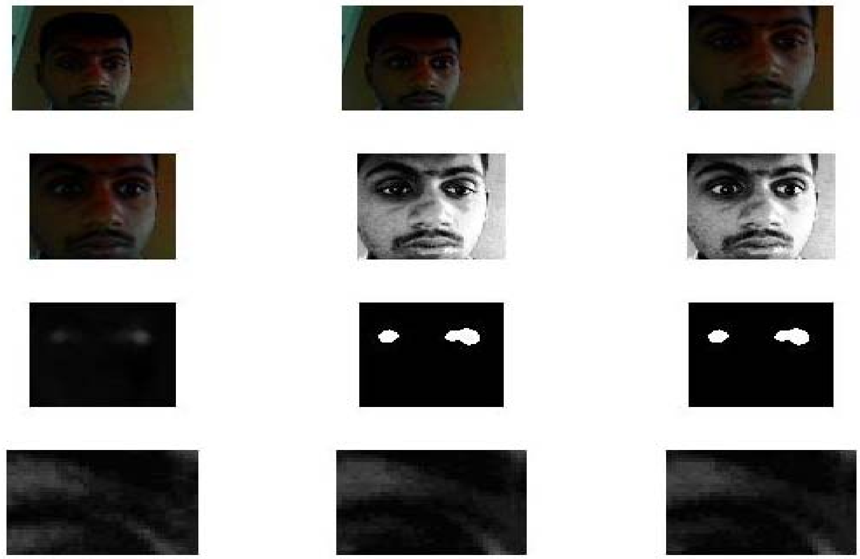
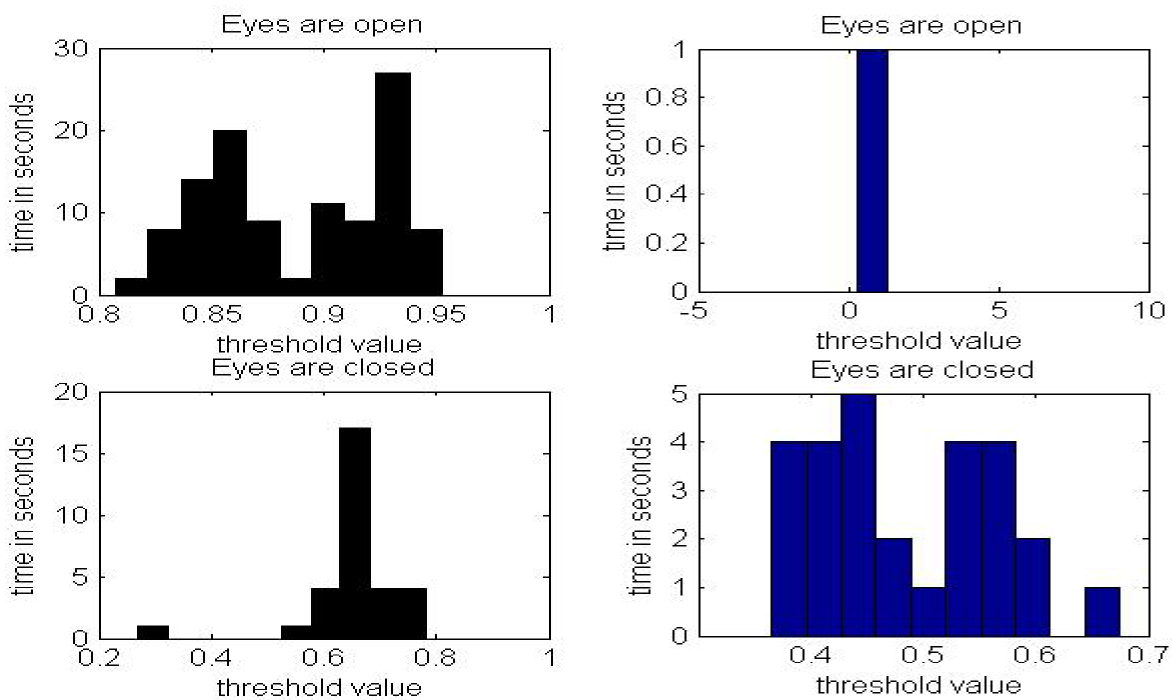


Figure.7: Open eye detection without spectacles



4.3. Graphical Representation

Figure 8: Plots for different threshold values



The results shown in figure 8 are the plots representing eye opening and eye closing characteristics for different threshold values.

5. Scope of the Research

In this research work we have investigated the driver's state of drowsiness on-line, which requires low computational and time complexity. We tried to face this requirement by using uncomplicated image processing techniques, combination of two non-intrusive metrics by means of a simple detection algorithm. Use of normal web camera, fast computation obtained from scaling factor compromise the systems performance for the sake of simplicity which is a major criterion for real time scenario.

This algorithm even works for candidates wearing spectacles and in lighting environment up to an extent. This proposed model is very cost effective i.e it can be implemented with mobile cameras which now-a-days have high pixel quality. The classification errors of the system suggest further adjustments and to avoid difficulties in over lightning conditions, this work has to be implemented with illumination compensation algorithm. In order to implement the results in a better and efficient manner, we are trying to enhance this work by combining two more non-intrusive metrics namely, head rotation monitoring and steering wheel gripping pressure.

5.1. Sample

The results shown are the images of author tested in real time.

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