FATIGUE RECOGNITION SYSTEM USING IMAGE PROCESSING

Deepika Narayanan, Vignesh Sridharan

Georgia Institute of Technology

ABSTRACT

Driver drowsiness is a major safety concern, especially among commercial vehicle drivers, and is responsible for thousands of accidents and numerous fatalities every year. The objective of this project is to develop a non-invasive system for detecting the closing of eyes of a person driving an automobile and provide an alarm indication thus preventing road accidents from occurring. Live video relay of the driver's eyes is processed using Image Processing in MATLAB to detect whether the eye is closed for more than a fixed duration thus indicating conditions of fatigue, alcohol consumption etc. The system proves to be more accurate and safe compared to the existing sleep detection system developed using Infrared Sensors and Micro-processors.

Index Terms— Viola-Jones, Edge thresholding, Segmentation

1. INTRODUCTION

With the ever increasing population and usage of automobiles, there is an increase in the number of fatalities as well. There are a number of reasons that can be attributed to this astonishing statistic, a few of primary concern being Fatigue, Alcohol Consumption and Sleep Deprivation. Fatigue is often the cause of serious automobile crashes. About 17 percent of all fatal crashes in the USA could be attributed to tired drivers (the American Automobile Association (AAA), USA, 2010). In 20 % of all crashes, drowsiness is a contributing factor. (NHTSA, USA, 2006). 5 – 25 % of all collisions are caused by the driver falling asleep. (Volkswagen AG, several studies, Germany, 2005). Fatigue was the second most frequent cause of serious truck collisions on German highways. (Federal Highway Research Institute BASt, Germany, 2003). Considering the available statistics, importance of drowsiness detection systems is unavoidable. Existing systems impose a severe hardware overhead and experience reliability and accuracy issues. The main objective of this paper is to design and implement a noninvasive fatigue recognition system that is able to detect drowsiness of drivers, and provide an alert. This will prevent many accidents and save countless lives, reducing the high cost of damage caused due to accidents. The rest of this paper is organized as follows: Section 2 provides a detailed survey of different drowsiness detection methods. In Section 3, overview of the proposed system is presented. Then in Section 4, experimental results are presented. Finally, conclusion will be explained in Section 4.

3. SURVEY OF RELATED METHODS

Drowsiness detection techniques, with respect to the parameter type used for detection, can be categorized into two categories: (1) Intrusive methods, (2) Non-Intrusive methods. In intrusive methods, an instrument is connected to the driver and then recorded values are checked. Although these invasive approaches been highly accurate, it causes disruption to the person and hence their acceptance rate is low. According to [6], there are mainly four detection variants for driver drowsiness detection –

- Steering pattern monitoring
- Vehicle position in lane monitoring
- Driver eye/face monitoring
- Physiology measurements

Some papers that address these methods were surveyed

In [1], R R Jadhav et al developed an embedded system based on prototype vision system for the real-time monitoring of a driver's vigilance. It is based on a hardware system for a real-time acquisition of driver's status using an active IR illuminator and the implementation of software algorithms for the real-time monitoring of the fatigue level of a driver. The visual parameters employed were the PERCLOS, eye closure duration and blink frequency. In this paper, drowsiness is identified using eye blink count. The alcohol consumption is also verified during the starting process of the vehicle using Android Bluetooth. In [2], the authors employed machine learning to data-mine actual human behavior during drowsiness episodes. Automatic classifiers for 30 facial actions from the Facial Action Coding system were developed using machine learning on a separate database of spontaneous expressions. The various metrics were passed to learning based classifiers such as Adaboost and multinomial ridge regression. In [3], Mortazavi et al focused on in depth analysis of different driver-vehicle control variables, e.g., steering angle, lane keeping, etc. that are correlated with the level of drowsiness. This is implemented in its first step by installing sensors in various parts of the vehicle such as steering and accelerator. Methods based on driver performance are implemented in its first step by installing sensors in various parts of the vehicle such as steering and accelerator. The results showed that drowsiness has a major impact on lane keeping and steering control behavior. Despite these methods that have relatively good accuracy, this technique is not practical due to its high cost. In [4], Mohammad Amin Assari et al proposed an approach to use facial expressions to detect drowsiness. There are many challenges involving drowsiness detection systems. In this paper, a new method is proposed which implements a hardware system based on infrared light. In the proposed method, following the face detection step, the facial components that are more important and considered as the most effective for drowsiness, are extracted and tracked in video sequence frames. In [5], the author discusses the method to estimate a driver's fatigue through steering motion. Several methods are known to estimate driver's fatigue. In this paper, the Chaos theory was applied to explain the change of steering wheel motion. If there is

Chaos in the motion, a strange trajectory called attractor can be found by applying the Takens' theory of embedding. In [7], the authors investigated various physiological associations with fatigue to try to identify fatigue indicators. The current study assessed the four electroencephalography (EEG) activities, delta (δ), theta (θ), alpha (α) and beta (β), during a monotonous driving session in 52 subjects (36 males and 16 females). Performance of four algorithms, which were: algorithm (i) $(\theta + \alpha)/\beta$, algorithm (ii) α/β, algorithm (iii) $(\theta + \alpha)/(\alpha + \beta)$, and algorithm (iv) θ/β, were also assessed as possible indicators for fatigue detection. Results showed stable delta and theta activities over time, a slight decrease of alpha activity, and a significant decrease of beta activity ($p < 0.05$). All four algorithms showed an increase in the ratio of slow wave to fast wave EEG activities over time. Algorithm (i) $(\theta + \alpha)/\beta$ showed a larger increase. The results have implications for detecting fatigue. Thus, countermeasure device is currently required in many fields for sleepiness related accident prevention. This paper intends to perform the drowsiness prediction by employing Support Vector Machine (SVM) with eyelid related parameters extracted from EOG data collected in a driving simulator provided by EU Project SENSATION. The dataset is firstly divided into three incremental drowsiness levels, and then a paired t-test is done to identify how the parameters are associated with drivers' sleepy condition. With all the features, a SVM drowsiness detection model is constructed. But the existing method using IR sensors has a lot of disadvantages. It is susceptible to other bands such as sunlight or headlight of other vehicles and hence is prone to erroneous behavior. Additional eye-wear is required which causes discomfort. Long-term exposure to IR rays can cause Photo-Keratitis which is a condition in which there is swelling of the cornea and other retinal problems.

4. OVERVIEW OF PROPOSED SYSTEM

The project started with detecting the eyes of a static image stored in the computer and determining if the eyes are drowsy or not. The block diagram for the proposed method is as given in Fig. 1. The proposed method is as explained as follows –

(1) The face is segmented from the input image. Face detection is done through Viola Jones algorithm as explained in [2].

(2) The built in object detector function CascadeObjectDetector [3] is used to detect and crop the eye region.

(3) The image is converted to grayscale and complemented for further processing.

(4) This image is segmented using edge based thresholding. Thus, the image is converted to a binary image such that the iris region of the image is segmented efficiently which makes further analysis easier.

(5) Circles are found in the resulting image using Hough transform. The presence of circles of appropriate size indicates the presence of iris in this image, indicating that eyes are open. If no appropriate circles are found or if the number of circles found are less than two, then it indicates that the eyes are closed.

The next step of the project was to perform the same on a live video feed obtained by either using an external USB operated camera or by using the built-in webcam. The first step towards implementing this, is to first identify the webcam drivers installed and then configure the webcam to obtain the necessary video feed. The associated webcams were identified by using the imaqhwinfo() function. Then, the above steps proposed for static images is applied to the video relay also. This is achieved by visualizing the live video feed as individual frames and processing each frame distinctly. If the eyes are closed for a specific duration of time, then an alarm is generated, warning the driver. This can be improved by interfacing an audio amplifier and speaker to produce a warning sound or can be interfaced with a vibrator to produce a vibration.

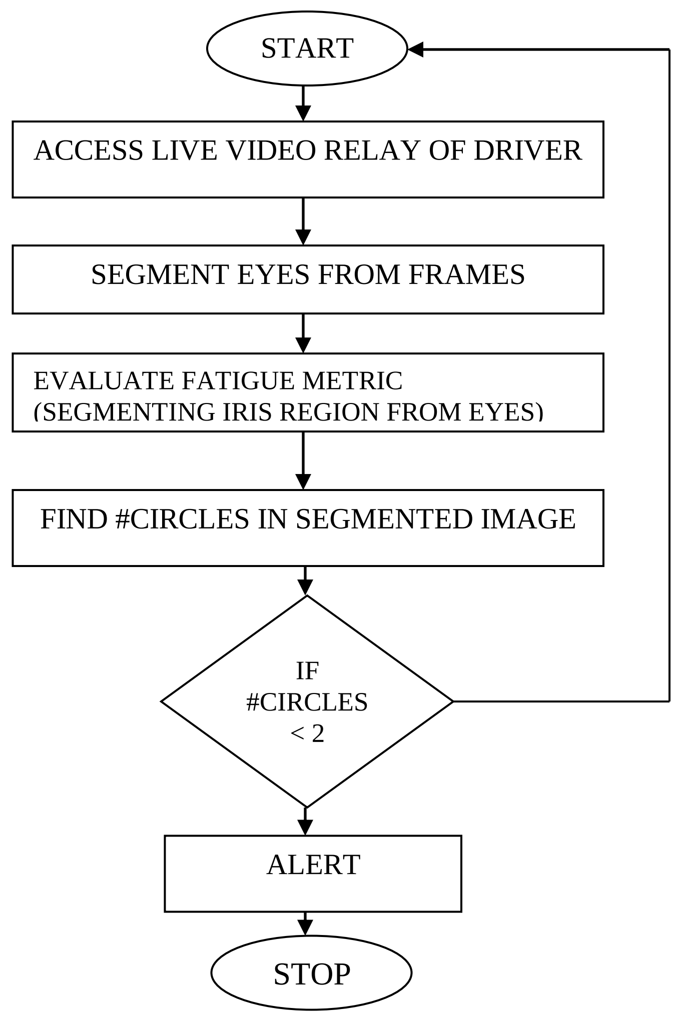

Fig.1 Flow diagram of Proposed System

5. RESULTS AND DISCUSSION

In this section, the results of the proposed method are discussed and evaluated. The simulations are carried out on a live video relay. Figure 2 and 3 shows the results for the non-fatigue condition and the fatigue condition respectively. Table 1 shows a detailed assessment of the System performance under different test cases.

Table-1 Assessment of Results

Test Case	Expected Output	Obtained Output	Result
Detecting and tracking face	Face detected and tracked	Face detected and tracked	Pass
Detecting features	Eyes detected	Eyes detected	Pass
Eyes open|close	Non-fatigue|Fatigue alert	Non-fatigue|Fatigue alert	Pass
Illumination-Low|Fatigue	Alert(100%)	Alert(<100%)	Fail
Illumination-High|Fatigue	Alert(100%)	Alert(100%)	Pass

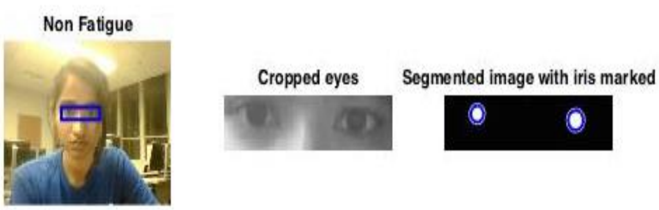

Fig. 2 (Left to Right) (a). Original image with eyes marked (b). Cropped eyes (c). Segmented image with Iris marked.

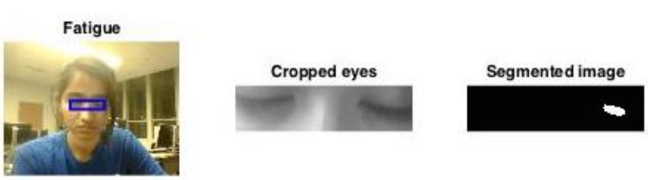

Fig. 3 (Left to Right) (a). Original image with eyes marked (b). Cropped eyes (c). Segmented image with iris marked

It can be seen that the system accuracy and robustness is limited solely by the surrounding illumination. The accuracy varies with varying background lighting.

7. CONCLUSION

The sleep detection system proposed has a specific set of advantages over the existing method and proves to be more efficient and economical in comparison. Although there is a constraint on the quality of the camera required for processing the live video feed, this method offers a non-invasive system for sleep detection. An improvement over the existing method, this system is indeed a feasible and easily implementable alternative. It eliminates all the hardware overhead imposed by sensor-based systems thereby making it easily deployable for commercial applications. The accuracy of this method of eye detection is based on the sensitivity of the camera. It is found to have a direct relationship with the accuracy. The greater the accuracy needed, the better quality of webcam has to be used.

8. REFERENCES

[1] R. R. Jadhav , Mayuri H. Godse , Supriya P. Pawar , Pallavi M.Baravkar, “Driver Drowsiness Detection and Vehicle diagnostics using Android Bluetooth”, *International Journal of Innovative Research in Electrical Electronics, Instrumentation and Control Engineering*, Vol. 3, Issue 3, 2015.

[2] Esra Vural, Müjdat Çetin, Aytül Erçil Gwen Littlewort, Marian Bartlett, Javier Movellan, “Machine learning system for detecting driver drowsiness”, http://people.sabanciuniv.edu/mcetin/publications/vural_DSPinCars07.pdf.

[3] A. Mortazavi, A. Eskandarian , R. A. Sayed, “Effect of drowsiness on driving performance variables of commercial vehicle drivers”, *International Journal of Automotive Technology*, Volume 10, Issue 3, pp 391-404, 2009.

[4] Mohammad Amin Assari , Mohammad Rahmati , “Driver Drowsiness Detection Using Face Expression Recognition “, *IEEE International Conference on Signal and Image Processing Applications (ICSIPA2011)*, http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6144162

[5] Yoshihiro Takei, Yoshimi Furukawa, “Estimate of Driver’s Fatigue through Steering Motion”, http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1571404

[6]http://www.sae.org/events/gim/presentations/2012/sgambati.pdf

[7] Budi Thomas Japa, Sara Lala, Peter Fischerb, Evangelos Bekiarisc, “Using EEG spectral components to assess algorithms for detecting fatigue” *Expert Systems with Applications*, Volume 36, Issue 2, Part 1, Pages 2352–2359, March 2009.