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Ear Based Driver Drowsiness Detection System

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Abstract: *Driver drowsiness is one of the most common reason for the road accidents. Sleep disorders causes the fatigue of driver and this results in the increasing number of road accidents. Nowadays about 30% of road accidents is caused due to the alertness of the driver. In order to reduce the accidents related to the driver drowsiness it is necessary to frame a system which accurately detect the drowsiness of the driver. By detecting the drowsiness level and providing a warning to the driver the accidents can be avoided. This paper describes a method which detects the driver fatigue accurately in real time and to provide a warning signal. In this paper Raspberry pi 3 module is used to detect whether the driver is fatigue or not using EAR method. Raspberry pi is used because it is faster to retrieve images from the camera and fast enough to detect a driver's feature in real time. In this paper a technique to detect driver drowsiness using of Open CV (open source computer vision), raspberry pi and image processing is presented.*

Keywords: *Drowsiness, Open cv, Face detection, Eye detection, HOG, EAR.*

I. Introduction

Drowsy driving is becoming one of the most important cause of road accidents. According to many surveys around 30% of road accidents is due to the driver fatigue and the percentage is increasing every year. Drowsiness can be due to the adverse driving conditions, heavy traffic, workloads, late night long drive etc. Lack of sleep, absence of rest, taking medicines are also causes for drowsiness. When driver drives for more than the normal period fatigue is caused and the driver may feel tiredness which will cause driver to sleepy condition and loss of consciousness. This results road accidents and death of driver or serious injuries and also claims thousands of lives every year.

Drowsiness is a phenomenon which is the transition period from the awake state to the sleepy state and causes decrease in alerts and conscious levels of driver. It is difficult to measure the drowsiness level directly but there are many indirect methods to detect the driver fatigue. Driver drowsiness detection can be measured using physiological measures, vehicle based measures, behavioural measures. Physiological measures includes the measure of brain wave, heart rate, pulse rate, and using the physiological signals like ECG (Electrocardiogram), EOG (Electrooculogram), EEG (Electroencephalogram) etc. Though this method measures the drowsiness accurately but it requires a physical connection with the driver such as placing several electrodes on head, chest and face which is not a convenient method and also discomfort for the driver in driving condition. Vehicle measures includes deviations from lane position, pressure on acceleration pedals, movement of the steering wheels, etc. These are constantly monitored and any change in these which crosses a threshold indicates a probability that the driver is drowsy. Behavioural measures monitors the behaviour of the driver, which includes the yawning, eye closure, eye blinking, head pose, etc. These are monitored through a camera and these drowsiness symptoms are detected. Behavioural state detection system helps to detect the drowsy driving condition early and avoid accidents. In this paper real time drowsy detection is used which is one of the best possible method to detect driver fatigue early. Real time driver detection system using image processing captures driver eyes state non- intrusively using a camera and raspberry pi is used for this.

II. Literature Survey

Drowsiness detection can be mainly classified into three aspects such as:-

1. Vehicle based measures.
2. Physiological measures.
3. Behavioral measures.

Vehicle based measures is one of the method which is used to measure driver drowsiness. This is done by placing sensors on different vehicle components, which include steering wheel and the acceleration pedal. By analysing the signals from the sensors the level of drowsiness can be determined. Commonly using vehicle based measures for detecting the level of driver drowsiness are the steering wheel movement and the standard deviation in lateral position. A steering angle sensor which is mounded on the steering of vehicle is used to measure the steering wheel movement. The number of micro-corrections on the steering wheel reduces compared to normal driving when the driver is drowsy [1]. Based on small SWMs of between 0.5° and 5°, it is possible to determine whether the driver is drowsy and thus provide an alert if needed [2]. Another vehicle based measure used to measure the drowsiness of driver is SDLP. Here the position of lane is tracked using an external camera. The main limitation of this method is that it dependent on external factors such as road markings, lighting and climatic conditions. Therefore, these driving performance measures are not specific to the driver's drowsiness [3].

Physiological measures are the objective measures of the physical changes that occur in our body because of fatigue. These physiological measures can be utilized to measure the fatigue level and can provide alert for the drivers. These physiological changes can be simply measured by respective instruments such as electrocardiogram (ECG), electrooculography (EOG), electroencephalography (EEG) and electromyogram (EMG). Electrocardiogram is one of the physiological measures which can be utilized to measure the fatigue of driver. Here ECG electrodes are used to collect ECG signals from the body which provides the critical parameters related to Heart Rate (HR), Heart Rate Variability (HRV) and respiration rate or breathing frequency. Each of these are related to drowsiness [4]. Electroencephalography (EEG) is one of the most reliable physiological measures for drowsiness detection. EEG electrodes are placed at correct place and get data from brain. After preprocessing the data, which is acquired from the EEG electrodes can be divided into different frequency bands. The preprocessing involves artifact removal and filtering. Commonly used frequency bands include the delta (0.5–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), beta (13–30 Hz), and gamma (greater than 30 Hz) bands [5]. Power spectrum of EEG brain waves is used as an indicator to detect the drowsiness of the driver. Here, EEG power of the alpha, theta bands increases and the power of the beta bands decreases. The EEG based drowsiness detection is not easily implementable. Because the driver has to wear an EEG cap while driving a vehicle. These devices are being distractive and this is the main disadvantage of this method.

Behavioral changes take place during drowsing like yawning, amount of eye closure, eye blinking etc. In normal condition the rate of yawning will be less. When the driver is in fatigue the rate of yawning will be far higher than the normal. So by observing this yawning rate we can detect whether the driver is in fatigue or not [5]. In eye closure method the count of eye blink of the driver is measured for obtaining the condition of the driver. The average duration of a normal eye blink is 0.1s to 0.4s. That means, in one second the eye will blink at least 2 or 3 times. This is observed for a few seconds. When the driver is in fatigue the count will be far less compared to the normal condition. Thus we can detect whether the driver is in fatigue or not [6]. The main techniques used for eye blink detection are Eye Aspect Ratio (EAR) method and Template Matching method. The Ear method is done by calculating a quantity named EAR. In normal condition the value of EAR is almost constant. If the driver is in fatigue the EAR value will be approximately near to zero. Thus we can detect whether the driver is in fatigue or not. In template matching method, the detected eye is converted to a template. And this template is stored. Each frame that we have obtained is matched with this template. Thus we get a correlation value in the form of a matrix. If the correlation value is high the corresponding frame is perfectly matched with the threshold template. And if this value is less, then the frame is not matching with the template. Thus we can detect whether the driver is in fatigue or not [6-7].

III. Driver Fatigue Detection System

The driver fatigue detection system consist a colour camera which is mounted on the dashboard of the car. The camera captures the images of the driver. These images are used to face detection and eye detection.

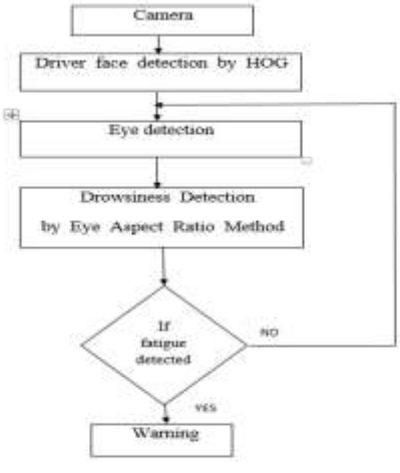

Fig .1 Flow chart of driver fatigue detection system

3.1 Face Detection

Fig.1 shows the process of driver drowsiness detection. The face is detected using a camera. Continues observation of the condition of driver's face is taken by the camera. This is converted to different frames. First of all the face is detected using a technique called Histogram Oriented Gradient (HOG).

3.1.1 Histogram Oriented Gradient (HOG)

Histogram Oriented Gradient (HOG) is a technique which is used in computer vision and image processing for the purpose of object detection. The technique basically deals with the gradient orientation in specified portions of an image. In this, the local object appearance and shape within an image can be acquired by the distribution of intensity and edge directions.

The image is divided into small connected regions called cells, and for the pixels in each cell, a histogram of each gradient directions can be compiled. The cells can either be rectangular or radial in shape, and the histogram channels are evenly spread over 0 to 180 degrees or 0 to 360 degrees depending on whether the gradient is "unsigned" or "signed". For obtaining changes in illumination and contrast, the gradient strengths must be locally normalized, which requires grouping the cells together into larger, spatially connected blocks. These blocks can be two: rectangular R-HOG blocks and circular C-HOG blocks. HOG descriptors may be used for object recognition by providing them as features to a machine learning algorithm. Here we are using R-HOG blocks to detect the face of the driver.

HOG is used for characterizing a local region which is in need for further processing.

3.2 Eye Detection and Drowsiness Detection

From the face, the eyes are detected for further processing to detect whether the driver is in drowsiness or not. In this, we are specially characterizing the eyes from the face.

A real time algorithm to detect eye blinks in a video sequence from a camera is used in this proposed system. Recent landmarks detectors exhibit excellent robustness against a head orientation with respect to a camera, varying illumination and facial expressions. In this project, the landmarks are detected precisely enough to estimate the level of the eye opening. The proposed algorithm therefore estimates the landmark positions, extracts a quantity which is known as the eye aspect ratio (EAR) for characterizing the eye opening in each frame.

3.2.1 Eye Aspect Ratio (EAR) technique

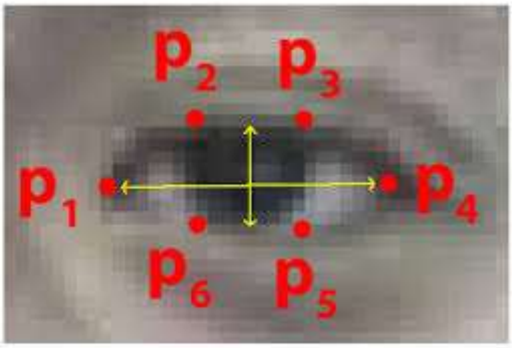

Fig .2 Landmarks obtained in EAR

In this technique, we are using different landmarks to detect the opening and closing of eye. This landmark detectors that capture most of the characteristic points on a human face image.

The eye blink is a fast closing and reopening of a human eye. Each individual person has a little bit different pattern of blinks. The pattern differs in the speed of closing and opening of the eye, a degree of squeezing the eye and in a blink duration. The eye blink lasts approximately 100-400ms. From the landmarks detected in the image, we derive the eye aspect ratio (EAR) that is used as an estimate of the eye opening state.

For every video frame, the eye landmarks are detected. The eye aspect ratio between height and width of the eye is computed. From the fig. 2 P1,P2,…,P6 are the landmarks on the eye.

$$EAR=\frac{||P2-P6||+||P3-P5||}{2||P1-P4||} \qquad (1)$$

where P1,…..,P6 are the 2D landmark locations on the eye. The EAR is mostly constant when an eye is open and is getting close to zero while closing an eye. Since eye blinking is performed by both eyes synchronously, the EAR of both eyes are taken and it is averaged.

After getting the EAR value, if the value is less than the limit for 2 or 3 seconds the driver is said to be drowsy. The buzzer connected to the system performs actions to correct the driver abnormal behavior.

IV. Conclusion

Driver Drowsiness Detection was built to help a driver stay awake while driving in order to reduce car accidents caused by drowsiness. This paper was concerned with drowsy drivers and their potential to cause car accidents. . The driver fatigue detection system calculates drowsiness level from the driver using a combination of Raspberry Pi 3 Model B and Camera. Raspberry Pi 3 Model B is a processor to calculate whether or not a driver is drowsy. At the same time, it retrieves images from the camera, which is fast enough to detect a driver's features in real time. The system uses open source software called as open cv image processing libraries, the captures images are processed in this. Raspberry pi and open cv makes the overall system to a low cost drowsiness detection system.

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