IoT-Based Driver Drowsiness Detection and Traffic Collision Avoidance System Using Raspberry Pi for Intelligent Transportation and Road Safety Applications

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ABSTRACT

The rapid change of technology and infrastructure has made our lives more easier. The new technology has also increased the traffic hazards and road accidents take place frequently which causes huge loss of life and property because of the poor emergency facilities. The accident detection and avoidance will provide an optimum solution to this drawback. As a detection method, have developed a system that uses image processing technology to analyze images of driver's face and eyes taken by using Raspberry pi, in that webcam is connected. Diminished alertness is detected on the basis of the PERCLOS, a scientifically supported measures of drowsiness associated with slow eye closure. For health monitoring of driver , making wearble device which will give the heart beat of the driver. With signals from an ultrasonic sensor ,a severe accident due to an obstacle can be recognized. When a vehicle meets with an accident, the ultrasonic sensor detects the signal and immediately sends it to microcontroller alert message through the GSM module and also sends an Email to emergency help team or rescue team. This project is useful in detecting the drowsiness state and avoid the traffic collision by means of Raspberry pi and ultrasonic sensor.

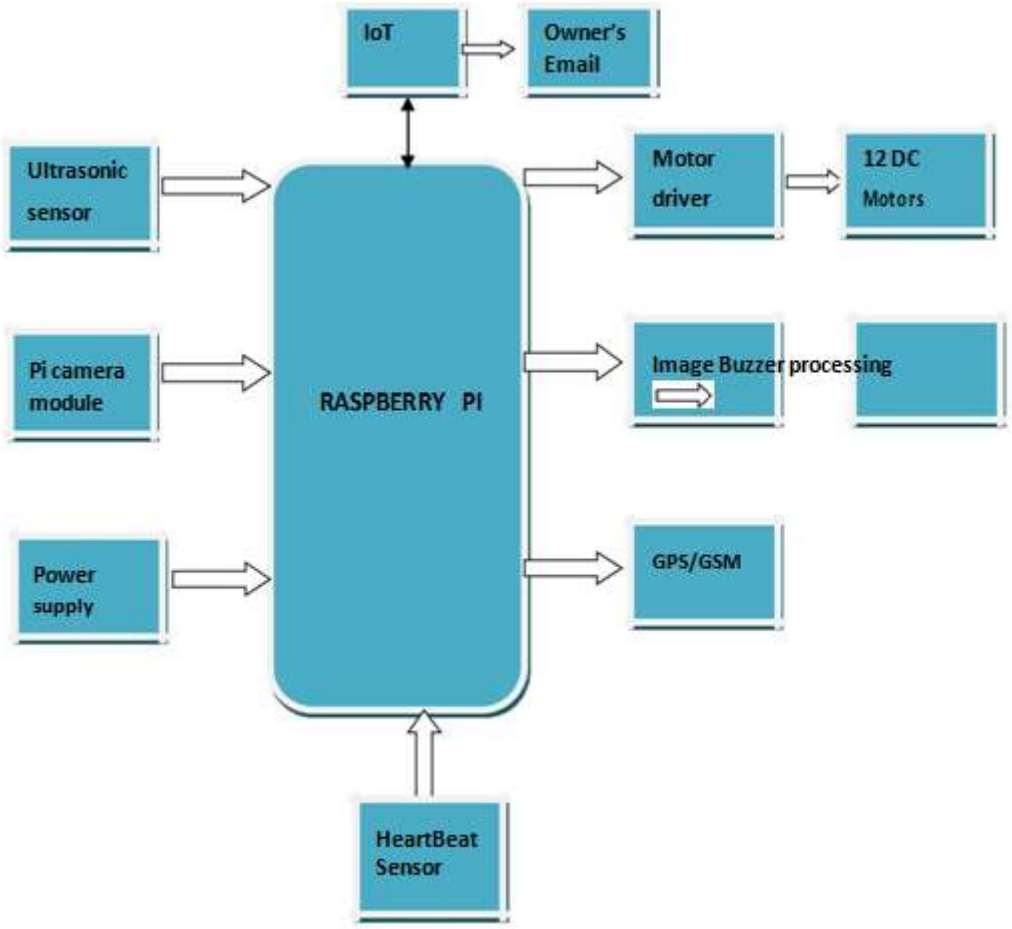
KEYWORDS*:* Image processing, PERCLOS, heartbeat monitoring, ultrasonic sensor, Raspberry pi, Email.

1. INTRODUCTION

The road transportation increases year by year, since india is one of the developing countries, where the road crashes is more than the critical limit. The ever increasing number of traffic accidents in india due to the drowsiness of drivers. The statistics show that every year 1.24 million people die in road accident around the world. Yannis T.H was presented a review of The Effect of Traffic and Weather Characteristics on Road Safety, he observed that the effect of traffic flow seems to have a linear relationship with accident rates, eventhough some studies suggest non-linear relationship with accidents.[2] The several reports show that the number of traffic accidents in India are due to a diminished driver's vigilance level that suffer the driver's abilities of perception, recognition, and vehicle control to a marked decline so that which leads serious danger to their own life and lives of other people.[1]. For this reason, monitoring the drivers level vigilance and alerting the driver of any insecure condition is essential to accident prevention. Many reports have been contributed in the literature on developing active real-time image based fatigue monitoring systems. But most of them focus on only a single visual cue such as facial expression, eyelid movement, head orientation etc.to characterize the driver's state of alertness. When the system relying on a single visual cue,the required visual features can't be required accurately.[1]We can provide accurate characterization of a driver level of vigilance by combining all those visual cues. So that it is our aim that simultaneous extraction and use multiple visual cues be reduce the uncertainty and resolve the ambiguity present in the information from a single source. The system we propose simultaneously ,non-intrusively and real time can be monitor several visual behaviours that typically characterize a person's level of alertness while driving. The parameters due to fatigue computed from the visual cues are combined to form a fatigue index that could be reliably, accurately, and consistently characterize one's vigilance level. The main objective of this project is to promote the idea that can be implemented in large scale in long run to facilitate better safety standards for vehicle and provide effective way for achieving better results in future. The main objectives are:

- To develop a non-intrusive system which can detect the drowsy state of driver by image processing technique.
- To develop a heart beat monitoring system.
- To develop a traffic collision avoidance system using ultrasonic sensor.

2. OVERALL SYSTEM DESIGN



Our system uses an algorithm to locate , track, and analyze both the driver's face and eyes.Fatigue monitoring starts with extracting visual parameters typically characterizing a person's level of vigilance.This is accomplished via a computer vision system.The paper presents a system to detect the driver's drowsiness.In addition to this,we propose advanced collision avoidance system is introduced which detects the presence of obstacle in front of the vehicle and alert the driver accordingly.This system implants ultrasonic sensor for detection purpose of real time moving and stationary object under all weather environment.The overall developed system consists of following elements:

1. Raspberry Pi: Here we use Raspberry Pi Model B+ that incorporates a number of enhancements and new features.There will be improved power consumption, increased connectivity, and greater IO are among the improvements to this powerful, small, light weight ARM based computer. Python is a main programming language.It performs a processing of the input video stream so to compute the level of fatigue of the driver.

2. Pi Camera module: It is used to for capturing the video in real time and monitoring a stream of faces and eyes. This is a high definition camera module connected with the Raspberry Pi. It also provides high sensitivity , low crosstalk, and low noise image capture in an ultra small and light weight design.The camera module connects to the Raspberry pi board.

Ultrasonic sensor: Ultrasonic sensors measure the distance using the properties of its sound waves. The sensor is used for detecting the range information of the object.The horizontal and vertical distance are noted by the camera for a fixed field , so the sensor detects the accurate distance of the object in the sensors range .Angle of vision is found ,thereby measuring the distance of obstacle.The main task of obstacle avoidance is to control the vehicle in a non collision position and to move in a obstacle free path.This is a very compact,highly sensitive and low power consumption device.

4.Heartbeat sensor: For health monitoring of driver , making wearable device which will give the heartbeat.The heartbeat sensor is designed to give digital output of heartbeat when a finger is placed on it.When the heartbeat detector is working ,the digital output can be connected to microcontroller directly to measure the Beat per Minute (BPM) rate.

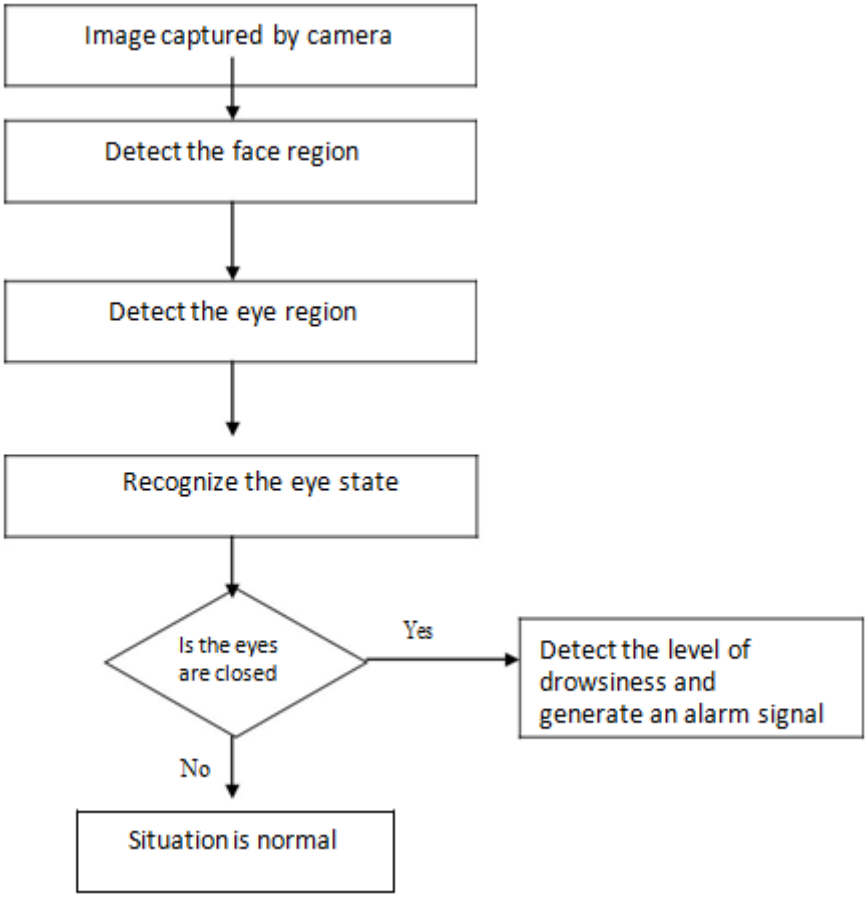
5. Motor driver: L293D is a dual H-bridge motor driver integrated circuit which serves as a vital element in the system. Motor drivers act as current amplifiers since they take a low current control signal and provide a higher current signal.The higher current signal is used to drive the motors.In its common mode of operation ,the two DC motora can be driven simultaneously,both in forward and reverse direction.

6.Buzzer: When the drowsiness index exceeds a prespecified parameter or when the signal falls below the specified threshold it activates an alarm signal.To alert the driver loud alarm is buzzed indicating that he is in drowsy state and is dangerous to drive in this state and that he must take a break.

7. GPS/GSM: A GPS/GSM tracker utilizes either the Global Positioning System satellites or Global System for Mobile Communication to determine the precise location.GSM is used to send and collect data from a central unit. GPS can't communicate with a central unit but receives information about a location from satellites.

A. Real time and non-intrusive driver fatigue monitoring

The system performs processing of the input image so to compute the level of fatigue of the driver .The analysis is based on the calculating the number of frames of the data where the driver eyes are closed.The algorithm is described as follows:



1. We first capture the face image of the driver using a web camera located inside the vehicle .
2. After that we have to segment only the face region and exclude the background portion.

• After detecting the face region , we should detect the eye region ,use eyes are the decision parameter to determine the drowsiness of the driver.
• When recognize the eye state,if the eyes are closed,detect the level of drowsiness and generate an alarm signal.If the eyes are open , the situation is normal

The system uses driver's face movements and eye loacations to determine the state of the driver's eyes and if drowsy. The system will be able to work under low lighting condition with the help of a webcam installed on the dashboard. The system performs a processing of the input image stream so to compute the level of fatigue of the driver. The analysis is based on the calculating the number of frames of the data where the driver eyes are

closed. The result of the processing is sent to the alarm based, which activate an alarm signal when the drowsiness index exceeds a prespecified parameter.

Drowsiness detection system is designed to use a camera sensor on the front of the driver thatis connected to an application. The sensor will detect the condition of driver continuously, especially in the eye, when the eye is considered sleepy then the application will immediately sound an alarm to wake the driver.Power is supplied to the system camera is used to monitor the status of the driver . We are using the Raspberry Pi processor and alarm is beeped when system send the signal.

Here use canny edge detection . It is a popular edge detection algorithm.and is multistage.The following steps are described below:

Step 1: Noise reduction
Since edge detection is susceptible to noise in the image ,first step is to remove the noise in the image with a Gaussian filter.

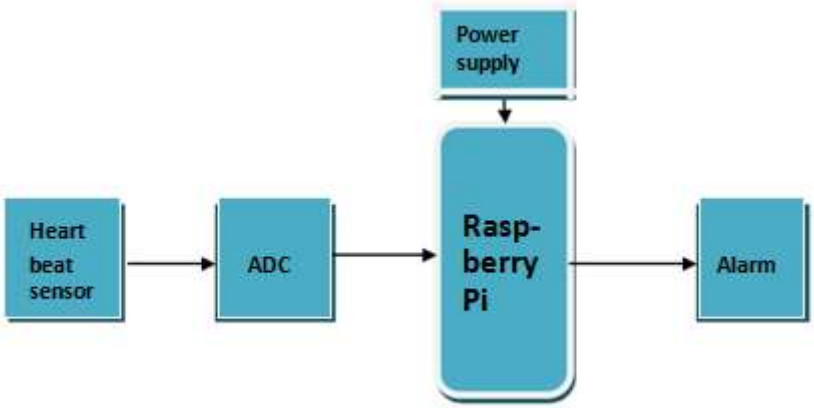
Step 2: Finding intensity gradient of the image
Smoothened image is then filtered with a sobel kernel in both horizontal and vertical direction to get first derivative in horizontal direction (Gx) and vertical direction (Gy) from these two images ,we can find the edge gradient and direction of each pixel as follows;

$$\text{Edge Gradient}(G) = (Gx^2 + Gy^2)^{1/2}$$
$$\text{Angle} = \tan^{-1} (Gy/Gx)$$

Step 3: Non-maximum suppression
After getting gradient magnitude and direction ,a full scan of image is done to remove any unwanted pixels which constitute the edge. For this,at every pixel, pixel is checked if it is local maximum in its neighbourhood in the direction of gradient.

Step 4:Hysteresis Thresholding
This stage determines which all edges are really edges and which are not. For this, we need two threshold values minVal and MaxVal.Any.Edges with intensity gradient more than maxVal are sure to be non edges ,it is discarded. Those edges which lie between these thresholds are classified into edges or non edges based on their connectivity to “sure edge ”pixels, they are considered to be part of edges. Otherwise they are discarded .

B. Heartbeat monitoring system
For health monitoring of driver, making wearable device ,which will give the heart beat. The heartbeat sensor is designed to give digital output of heartbeat when a finger is placed on it.The digital output can be connected to Raspberry Pi directly to measure the Beat Per minute (BPM) rate.



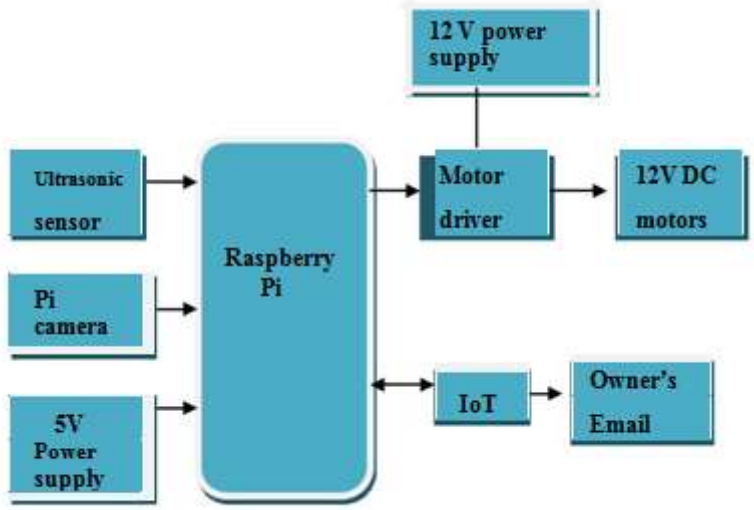
The normal heart rate keeps varying from person to person. Generally for adults the normal heart rate is within the range of 60 to 100 beats per minute. But the heart rate could be elevated because of stress, anger or other emotional behaviours as our heart tries to pump oxygen to increase our energy. While sleeping the normal heart rate of adults drop till 24 bpm, however for people of around 80 years old the sleeping heart rate could be 14 bpm. The data is collected via the heart rate sensor. An ADC is connected from the sensor and the data converts

from analog to digital signal. This signal is given as input to the Raspberry Pi.A threshold minimum heartbeat is set on the code .

The heartbeat from the sensor is compared with the threshold heartbeat. If the heartbeat recedes below the minimum heartbeat rate the buzzer will be turned on showing that the driver may be drowsy. The condition of the driver is considered as normal if the heartbeat is above the threshold value, the buzzer will be off. The pulse rate is the number of times the arteries to expand and contract in one minute as a response to the heartbeat. The number of pulses are equal to the heart rate because heart contraction causes an increase in blood pressure and Pulse in the arteries. Measuring the pulse is synonymous to measuring the heart rate.

C. Vehicle collision avoidance system using raspberry PI

The vehicle collision avoidance system and obstacle detection is one of the important factor in the automative field. This system detects an obstacle in front of the vehicle, alarms the system and moves away. Camera is used for detecting the moving or stationary objects.



The ultrasonic sensor is enclosed with this system to compute the distance of real time moving and the stationary object. The distance between the vehicle and the obstacles is measured by the ultrasonic sensor and the object detection done by the camera. Most of the vehicles enable an alert feature to function as a safety measure. In proposed work, advanced collision avoidance systemis introduced which detects the presence of obstacle in front as well as in blind spot of vehicle and alert the driver accordingly. For this an ultrasonic sensor is implemented for detection purpose of real time moving and stationary object under all weather environment.

Recentl,ultrasonic sensors and radar sensors are used for obstacle detection technique in vehicles. The ultrasonic sensors are planned to be used as these sensors are able to measure the close distance. This system is needed to be designed especially for Indian standard scenario at mostly highway side and traffic zone area where the number of accidents has take place. The objective of our system is to make a smart system that will operate fully automatically for handling the drowsy driver detection problem. For our system, when obstacle is detected as it is connected with IoT,it will send an email to the android device of the authorized owner.

In this system we use following hardwares and software:

a. Raspberry pi,2Model B

A small computer chip which have the capability of laptop and user for many applications in real time.It is a low power consumption device,low cost product for network engineers and software developers for developing applications.

b. Camera

The camera is used to capture image may be a USB webcam.Resolution up to 5megapixel used for clear image.Image resolution upto 640*480 and with frame of 30. It is easy to plug and play camera in the board.

c. Ultrasonic sensor

These sensor measure distance using properties of sound waves.The sensor is used for detecting range.The horizontal and vertical information distance noted by camera for a fixed field.The working of sensor is done by

transmitting and receiving soundwaves through device.The frequency is produced back in form of echo when object comes ahead.Time between sound wave and echo received is then calculated ,then in turn distance can be measured.

d. L293D MOTOR DRIVER

It is a dual H- bridge driver integrated circuit.Motor made to operate with sufficient conditions. Drivers act as current amplifiers since they take a low current control signal and provide a higher current signal.The higher current signal is used to drive the motors .L293D contains two H bridge driver circuits.,two DC motors can be driven simultaneously , in its common mode of operation both in forward and reverse direction.It is very easy to use and available in standard size.

e. Software – OPEN CV

A library made by Intel which consists of functions used for computer vision.C++ and python language are supported in Open CV ,these run on windows ,Linux OS,etc.Open CV run on variety of platforms .Python is a programming language that is here we used.

3. RESULTS AND DISCUSSIONS

Fatigue and drowsiness leads to particular states in which driver's facial changes such as eyes ,head and face are detected for determining the drowsy state. Hence IoT can revolutionize the way embedded systems interact and respond for variety of applications especially in case of drivers by monitoring the state of their drowsiness for a quick ,safe and effective response for a safer road travel enables large amount of data acquisition for taking accurate decisions over the emergency conditions. A non –intrusive system to localize the eyes,face and monitor fatique was developed. Information about the head and eyes position is obtained through various self developed image processing algorithms such as HARR cascading method .During the monitoring ,the system is able to decide if the eyes are opened or closed. When the eyes have been closed for too long ,the alarm signal is issued .

The following results were made:

1. Image processing achieves highly accurate and reliable detection of drowsiness continuosly without any fail.

2. Image processing offers a non – intrusive approach to detecting drowsiness without the annoyance and interference.

3. A drowsiness detection system developed around the principle of image processing judges the driver'salertness level on the basis of continous eye closures.

4. A drowsiness detection system can be achieved by using a heart beat sensor allows wheather the driver is drowsy or not.If the heart rate exceeds a threshold value ,can be determined as he is drowsy otherwise the alarm is turned off.

5. The vehicle collision avoidance system and obstacle detection can be achieved by using ultrasonic sensor. For this system,when obstacle is detected as it is connected with IoT ,it will send an email to the android device of the authorized owner.

4. CONCLUSIONS

The road safety is one of the grand challenges in India facing today.There are many ways to enhance the road safety. According to Transport Accident Commission ,about 20% of fatal road accidents are caused by driver drowsiness or fatigue. Therefore it is essential to design and implement an embedded system in vehicles that can anlayze, detect and recognize the driver's state.The main of this project is to detect and recognize different drowsiness states using image processing algorithms and heartbeat monitoring system. This project also introduces the vehicle collision avoidance system using ultrasonic sensor .

The Image processing and sensors offers a non intrusive approach to detecting drowsiness without the infuriation and hindrance and involves highly accurate and consistent detection of drowsiness. A non intrusive system developed judges the driver's alertness level on the basis of continous eye closures and heart rate monitoring system. Also we contribute a system that is traffic collision avoidance system using ultrasonic sensors ,which detects any obstacle infront of the vehicle and allows a completely IoT based driver drowsiness detection system. The project includes improvement of its flexibility to changes in ambient brightness, attainment of a more compact system design and assurance of consistency.

REFERENCES

[1] S. G. Klauer, T. A. Dingus, V. L. Neale, , and J. D. Sudweeks, “The impact of driver inattention on near -crash/crash risk: An analysis using the 100-car naturalistic driving study data,” National Highway Traffic Safety Administration, DC, DOT HS, vol. 810, 2006.
[2] T. Akerstedt, G. Kecklund, and L. H¨orte, “Night driving, season, and the risk of highway accidents.” Slee, vol.24, pp. 401– 406, 2001.
[3] J. Connor, R. Norton, S. Ameratunga, E. Robinson, I. Civil, R. Dunn, J. Bailey, and R. Jackson, “Driver sleepiness and risk of serious injury to car occupants: Population based control study.” British Medical Journal, vol. 324, pp. 1125– 1129, 2002.
[4] J. Horne and L. Reyner, “Vehicle accidents related to sleep: A review.” Occupational and Environmental Medicine, vol. 56, pp. 189–294, 1999.
[5] L. M. Bergasa, J. Nuevo, M. A´ . Sotelo, R. Barea, and M. E. L. Guille´n, “Realtime system for monitoring driver vigilance,”IEEE Transactions on Intelligent Transportation Systems, vol. 7, no. 1, pp. 63–77, 2006.
[6] C. Papadelis, Z. Chen, C. Kourtidou-Papadeli, P. Bamidis, I. Chouvarda, E. Bekiaris, and N. Maglaveras, “Monitoring sleepiness with on-board electrophysiological recordings for preventing sleep-deprived traffic accidents.” Clinical Neurophysiology, vol. 118, no. 9, pp. 1906–1922, September 2007.