Research Paper on 'Drivers Sleep detection and alarming system'

[1]Prof. Bhalerao B.L., [2]Vaibhav Suresh Borate, [3]Ravi Devidas Borate,
[4]Saurabh Natha Metkari, [5]Abhishek Milind Ghadge

[1]Asst.Professor, [2,3,4,5]Students
Dept. of Mechanical Engineering
S.B. PATIL College of engineering
Vangali, Maharashtra, India.

Abstract- **An embedded system is a special-purpose system in which the computer is completely encapsulated by or dedicated to the device or system it controls. Unlike a general-purpose computer, such as a personal computer, an embedded system performs one or a few predefined tasks, usually with very specific requirements. Since the system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product. Embedded systems are often mass-produced, benefiting from economies of scale. Driver drowsiness system is used to detect the drowsiness. Drowsiness is the main reasons of accident. Safe driving is a major concern of societies all over the world. Thousands of people are killed or seriously injured due to drivers falling asleep at the wheels each year.**

It is essential to develop a real time safety system for drowsiness related road accident prevention. There are many methods for detecting the driver drowsiness. Driver fatigue is a significant factor in a large number of vehicle accidents. It includes the measurements of physiological features like EEG, heart rate, pulse rate, eyelid movement, gaze, head movement and behaviours of the vehicle, lane deviations and steering movements.[3] After long hours of driving or in absent of alert mental state, the eyelids of driver will become heavy due to fatigue. The attention of driver starts to lose focus and that creates risks for accidents. These are typical reactions of fatigue, which is very dangerous. Recent statistics estimate that annually1,200 deaths and 76,000 injuries can be attributed to fatigue related crashes. These accidents can be controlled by development of technologies for detecting or preventing drowsiness. A real time monitoring system, to insure accuracy in detecting drowsiness of the driver and that will work in both daytime and night time conditions is required.

Keywords: **construction, working, details, view, analysis.**

INTRODUCTION

INTODUCTION TO INTERNET OF THINGS (IOT)

The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these objects to connect and exchange data. Each thing is uniquely identifiable through its embedded computing system but is able to inter-operate within the existing Internet infrastructure.

The IOT allows objects to be sensed or controlled remotely across the network infrastructure, creating opportunities for more direct integration of the physical world into the computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. When IOT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, virtual power plants, smart
homes, intelligent transportation and smart cities.

"Things", in the IOT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, cameras streaming live feeds of wild animals in coastal waters, automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring, or field operation devices that assist fire-fighters in search and rescue operations, Legal scholars suggest regarding "things" as an "inextricable mixture of hardware, software, data and service".

These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices. The applications for internet connected devices are extensive. Multiple categorizations have been suggested, most of which agree on a separation between consumer, enterprise (business), and infrastructure applications.

The IoT is a giant network of connected "things". The relationship will be between people-people, people-things, and things-things. The new rule for the future is going to be, "Anything that can be connected, will be connected.

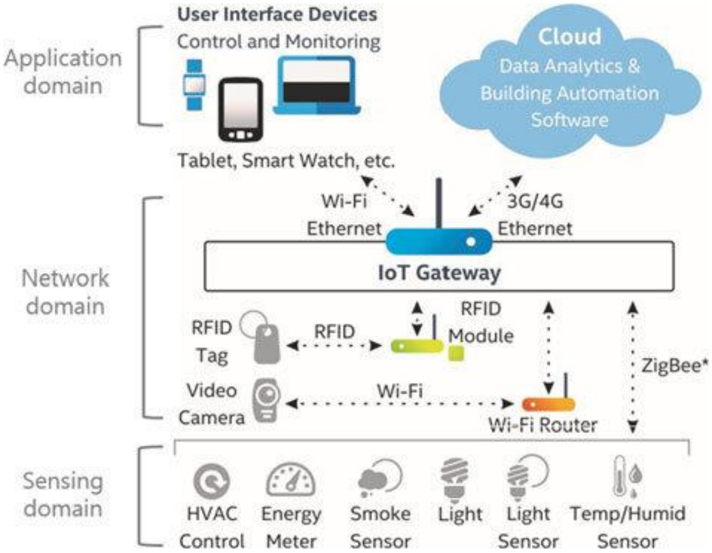


Fig IOT Gateway

SYSTEM DESIGN IMPLEMENTATION

System block diagram is comprise of: Eye blink (IR): related to sleep detection and alert the driver with the components used in the proposed operation are Eye blink length and frequency, Power supply, Buzzer, LED ARDUINO (UNO), Relay Module, DC as shown in Figure 1.4. The main component is Arduino Uno which is an ATmega328 based microcontroller (MC) that performs all functions related to controlling the embedded system circuit. The blinking module works by illuminating the eye area with infrared light, and then detecting changes in scattered light using an image transistor and a separation circuit. Each of the components is described below.

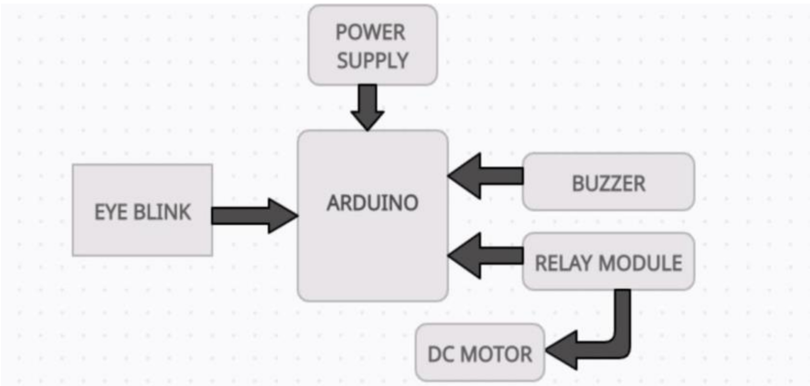


Fig Schematic Block Diagram.

Research Questions

The following questions guided my thinking during the initial stages of the project:
1. How much weight of this system?
2. Will it stable for long time?
3. What are the advantages of this system?
4. How sustain and reliable for every day?
5. What issues need to be considered when designing, making and testing a part and system?

These questions led to the following project objectives:
1. To research Arduino Uno:
a) How do Arduino Uno work?
b) How have Arduino Uno been used in system by others?
2. To test the model check Arduino Uno at every stage of its construction:
a) Does it work?
b) Does it run?
c) Can it run on long distance?
3. To make recommend actions for the design and construction of power conception.
4. To design and build a working model drivers sleep detection and alarming system.
5. To design and build an attractive model

component of this system

- Arduino Nano
- Eye Blink Sensor
- BO Motor
- 7805 Voltage Regulator
- 1000 mfd Capacitors
- 2n 2222 NPN Transistor
- In 4007 Diode
- DC Buzzer
- 470oham resistors and 1K resistor

Design and Construction

WORKING PRINCIPLE OF THE EYE BLINK SENSOR

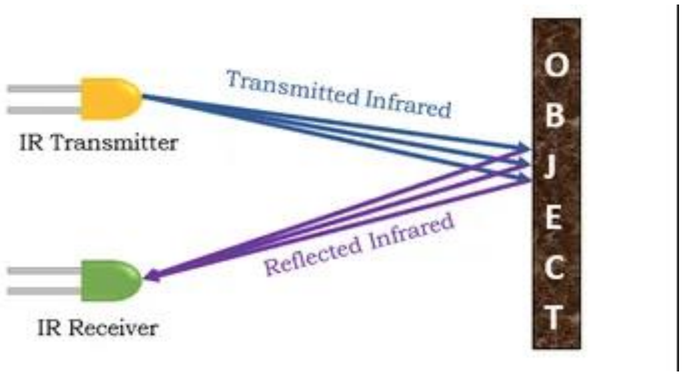


Fig WORKING PRINCIPLE OF THE EYE BLINK SENSOR

The IR sensor works based on the principle of IR. The onboard IR array contains two components, an IR Emitter and an IR Photodiode

The IR Emitter emits an IR light towards the eye. The IR Photodiode is designed to detect if the radiation of the same wavelength is reflected back and detected. If the eye is closed, the IR rays will reflect back with a larger intensity and the photodiode will detect it. If the eye is open, the IR rays will wither go into the eye or scatter across the eye thereby causing a very low intensity of reflected IR light. Therefore, by monitoring the Photodiode, we can come to a reasonable conclusion if the eye is indeed closed or not.

The module also comes with an onboard potentiometer which can be used to tune the sensitivity of the Photodiode.

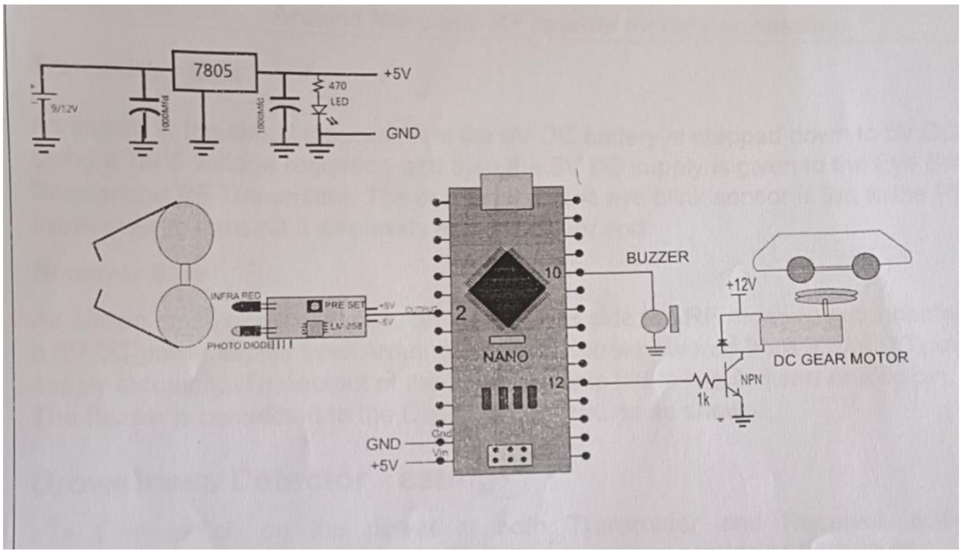


Fig. Eye Blink Car Control

WORKING OF EYE BLINK ANTI SLEEP ALARM CIRCUIT:

Driver Drowsiness Detector/ Anti Sleep Alarm consists of RF Transmitter and Receiver section.

Transmitter section: RF Transmitter and Eye Blink Sensor

Receiver section: Arduino Nano with RF receiver for data processing.

Transmitter Side

As shown in the circuit diagram, first the 9V DC battery is stepped down to 5V DC using a 7805 voltage regulator, and then the 5V DC supply is given to the Eye Blink Sensor and RF Transmitter. The output pin of the eye blink sensor is fed to the RF transmitter to transmit it wirelessly to the receiver end.

Receiver Side
As shown in the circuit diagram, on the receiver side the RF receiver is connected to a 5V DC power supply from Arduino. The Arduino is powered from a 12V DC power supply externally. The output of the RF receiver is fed to the Arduino Analog pin. The Buzzer is connected to the Digital pin of Arduino as shown.

Drowsiness Detector Testing

- First switch on the power in both Transmitter and Receiver sides by connecting the battery provided. Ensure power is coming at both ends.
- Wear the Sunglass having eye blink sensor, you will observe the motor running (that means when you have open eyes the vehicle is moving).
- Try blinking your eyes. Now the buzzer will get activated and beeps to give t alert alarm and simultaneously the motor stops which means the vehicle h stopped.

Arduino Uno

```
#define SENSE 2
void setup ()
{
pinMode(SENSE, INPUT);
pinMode(10, OUTPUT);
 pinMode(12, OUTPUT);
pinMode(LED BUILTIN, OUTPUT);
}
void loop ()
{
If (digitalRead(SENSE))
{(delay(1500);
digitalWrite (LED_BUILTIN, LOW);
pinMode (10, HIGH);
 digitalWrite(12, LOW); }
else
{ digitalWrite(LED BUILTIN, HIGH);
pinMode (10, LOW);
digitalWrite(12, HIGH); }
```

Drowsiness Detector Testing Methodology

METHODOLOGY

Prior to proposing a new hybrid method for the drowsiness detection, a thorough study is carried out on the existing methods of drowsiness driver detection mechanisms and they are listed at. A better hybrid version of drowsiness detection mechanism is expected to be proposed using the specifications, observations and calculations figured out in the theoretical study. Standard face detection techniques and heart rate variability analysis results were studied and they have been used to create a new fuzzy based hybrid drowsiness detection mechanism. In fulfilling this task EMGU CV (A cross platform .Net wrapper to the OpenCV image processing library), fuzzynet1.2.0 (Fuzzy Logic Library for Microsoft .Net), "Kubios HRV Analysis" software and MATLAB fuzzy tool box has been used.

General Flow of the Study and Implementation
The general flow of the research can be mainly divided into several parts. In here drowsiness detection model is proposed with the physiological and behavioral measurements of the subject. According to that the study varies mainly on these two sectors. Basic steps of the behavioral measurements are as follows, Study of behavioral techniques used to detect drowsiness.

- Video Acquisition.
- Extracting features to detect drowsiness.
- Monitoring features with time.
- Providing output based on the detected features.

Basic steps of the physiological measures are as follows, Study on physiological measures used to detect drowsiness.

- Selecting HRV analysis to detect drowsiness.
- Analyzing LF/HF ratio for test samples.
- Selecting a suitable range of LF/HF for the implementation.

Using the two input variables finally a fuzzy model has been designed to predict the driver's drowsiness level.

Eye Shut Duration as Behavioral Measurement for Drowsiness Detection.

After the thorough study of behavioral measurements to detect drowsiness, we selected eye shot duration of the driver as the behavioral measurement to detect drowsiness. To calculate the blink duration, the first thing we did was face detection. To do the face detection we use “harr cascade

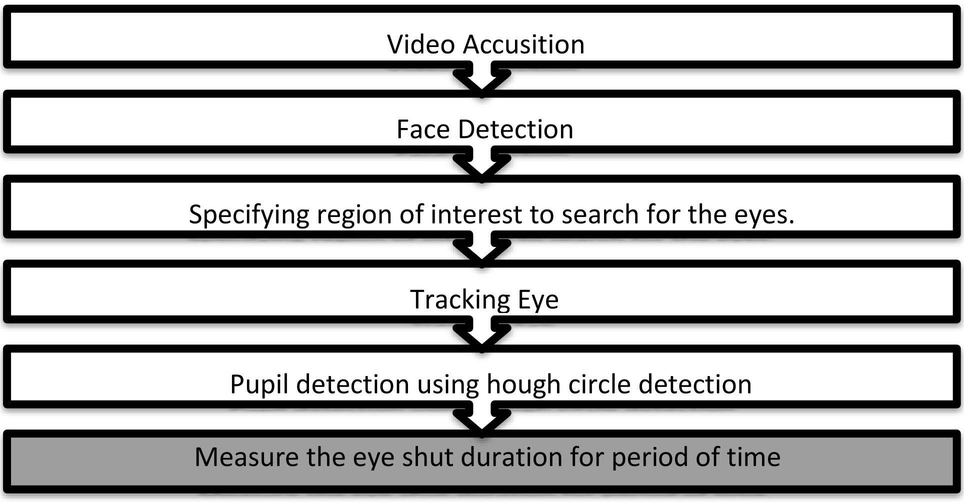


Fig. : Basic Flow of Behavioral Measure

face detection mechanism”. To detect eye in the face we use “harr eye tracking algorithm”. To detect the eye shut duration we use the Hough circle detection mechanism. The basic flow is shown in Figure 7.2.

Here the “haar face detection” and “haar eye tracking algorithm” were built in EmguCv library, and they were used to detect the face and the eye. To improve the eye searching mechanism, we give eye searching area the region of interest to search for the eyes as heuristics. This region of interest was selected by studying the normal human facial geometry.

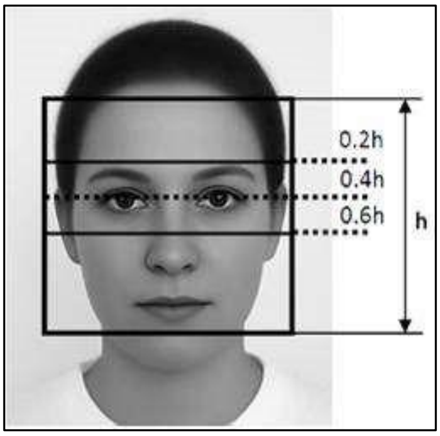


Fig. : Rules of Human Face Proportions

As shown in Figure 7.2 the human eyes are located in 0.2h to 0.6h heights from the top border of the facial area (When the total height of the face is h). This feature was used and given as
an input to the eye detection algorithm [7]. After detection of the eye, to detect the eyes open or shut the Hough circle detection was used. When the eye is in the open state iris can be detected by Hough circle detection. To improve the detection mechanism canny filters were used.

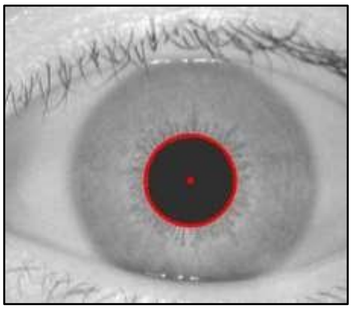


Fig. : Iris Detection Using Hough circles

When the eye lids are closed no iris is detected and this is used to calculate the eye shut duration. For every 50 frames of the input video, number of frames which eye lid is closed is recorded and it was taken as the input to create the fuzzy input for the system.

Heart Rate Variability (HRV) as Physiological Measurement for Drowsiness Detection

After thorough study on physiological measurements for drowsiness detection, Heart Rate Variability was selected to detect to detect drowsiness of the driver. Heart rate variability (HRV) is the physiological phenomenon of variation in the time interval between heartbeats. It is measured by the variation in the beat-to-beat interval. Other terms used include: "cycle length variability", "RR variability" (where R is a point corresponding to the peak of the QRS complex of the ECG wave; and RR is the interval between successive Rs), and "heart period variability". Methods used to detect beats include: ECG, blood pressure, ballistocardiograms, and the pulse wave signal derived from a photo plethysmograph (PPG). ECG is considered superior because it provides a clear waveform, which makes it easier to exclude heartbeats not originating in the senatorial node. The term "NN" is used in place of RR to emphasize the fact that the processed beats are "normal" beats. When analyzing HRV there are mainly three methods of analyzing.

Time Domain Analysis

These are based on the beat-to-beat or NN intervals, which are analyzed to give variables such as:

- SDNN, the standard deviation of NN intervals. Often calculated over a 24-hour period.
- SDANN, the standard deviation of the average NN intervals calculated over short periods, usually 5 minutes.
- RMSSD ("root mean square of successive differences"), the square root of the mean of the squares of the successive differences between adjacent NNs.
- SDSD ("standard deviation of successive differences"), the standard deviation of the successive differences between adjacent NNs.
- NN50, the number of pairs of successive NNs that differ by more than 50 ms.
- pNN50, the proportion of NN50 divided by total number of NNs.

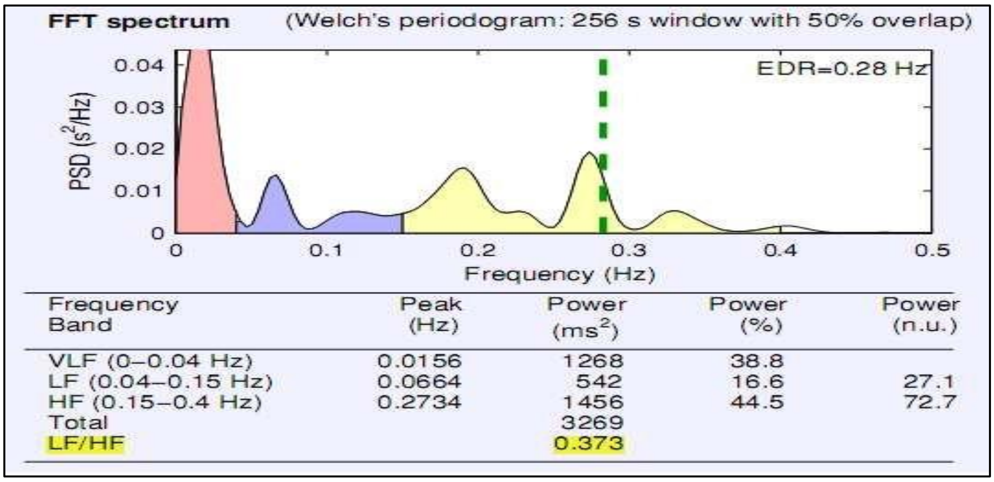
Frequency Domain Analysis

Frequency domain methods assign bands of frequency and then count the number of NN intervals that match each band. The bands are typically high frequency (HF) from 0.15 to 0.4 Hz, low frequency (LF) from 0.04 to 0.15 Hz, and the very low frequency (VLF) from 0.0033 to 0.04 Hz. Several methods of analysis are available. Power spectral density (PSD), using parametric or nonparametric methods, provides basic information on the power distribution across frequencies. One of the most commonly used PSD methods is the discrete Fourier transform. Methods for the calculation of PSD may be generally classified as nonparametric and parametric. In most instances, both methods provide comparable results. The advantages of the nonparametric methods are the simplicity of the algorithm used (Fast Fourier Transform [FFT] in most of the cases) and the high processing speed, while the advantages of parametric methods are smoother spectral components that can be distinguished independent of preselected frequency bands, easy post processing of the spectrum with an automatic calculation of low- and high-frequency power components with an easy identification of the central frequency of each component, and an accurate estimation of PSD even on a small number of samples on which the signal is supposed to maintain stationary. The basic disadvantage of parametric methods is the need of verification of the suitability of the chosen model and of its complexity.

Non Linear Analysis

Applying HRV analysis based on methods of nonlinear dynamics will yield valuable information. Although chaotic behavior has been assumed, more rigorous testing has shown that heart rate variability cannot be described as a chaotic process. The most commonly used non-linear methods of analyzing heart rate variability are the Poincare plot. Each data point represents a pair of successive beats; the x-axis is the current RR interval, while the y-axis is the previous RR interval. HRV is quantified by fitting mathematically defined geometric shapes to the data. Other methods used are the correlation dimension, nonlinear predictability, point wise correlation dimension and approximate entropy. Here in this research, we use Frequency domain analysis to detect the features drowsiness. There we acquire the results of HRV analysis done previously and also analyze some ECG measurements of sleeping subjects. (ECG data were obtained from physionet.org) [8].

When doing the analysis "Kubios HRV Analysis" software was used and the method of analyzing was Fast Fourier Transform mechanism. The Low frequency band power (LF) (Represent parasympathetic nerve system of the human body) and High Frequency band power (HF) was analyzed and found out the range of the ratio of LF/HF which relevant to the drowsiness states. Figure 4 shows the analysis window of kubios HRV software for a sleeping subjects ECG.



Frequency Band	Peak (Hz)	Power (ms^2)	Power (%)	Power (n.u.)
VLF (0–0.04 Hz)	0.0156	1268	38.8	
LF (0.04–0.15 Hz)	0.0664	542	16.6	27.1
HF (0.15–0.4 Hz)	0.2734	1456	44.5	72.7
Total		3269		
LF/HF		0.373		

Fig. 7.5: HRV Frequency Domain Analysis on "Kubios HRV

This LF/HF ratio range has been used as a fuzzy input to the fuzzy model that we prepare for the system.

Fuzzy Based Model for Drowsiness Detection

Fuzzy model prepared for the drowsiness detection system has two input variables and an output. The details of the input and outputs are as follows, we proposed a fuzzy based model for the drowsiness detection system because mainly the inputs that we use for this system are from two different measurement mechanisms. Due to that the relationship between them is not exact. Also, when considering the output, which is drowsiness levels, it's also a fuzzy value, that is we can't either Seymour have a fine line between drowsiness and wakefulness. Due to these reasons we proposed fuzzy model to detect drowsiness

Fuzzy Inputs

Eye shut duration was measured using the frames of the video. For every 50 frames of the video, number of frames which have not detected Iris has been monitored and the count has been used as an input. According to the range this inputs has been categorize into three fuzzy sets.

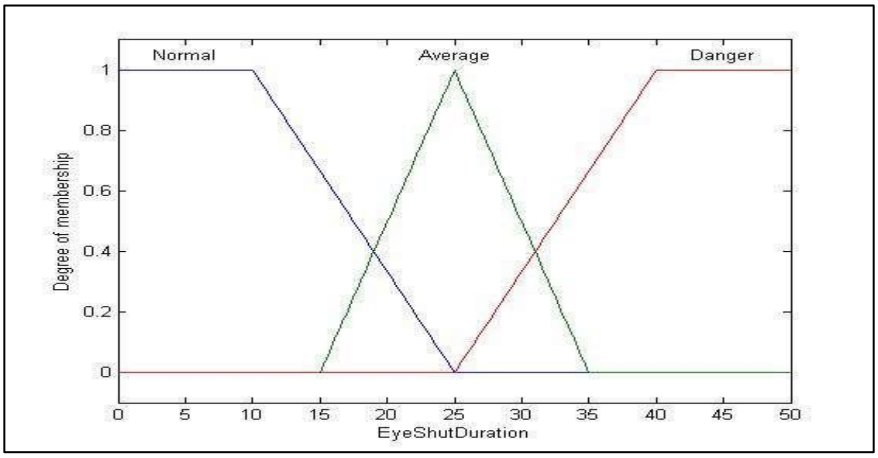


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Fig. Input Membership Function Eye Shut Duration

1. Normal
2. Average
3. Danger

HRV Analysis (LF/HF Ratio)

After the study on LF/HF ratio we obtain a range from 0.2 to 1.2 as the range which drowsiness could happen. Here the LF band is in range (0.04 - 0.15) Hz and HF band is in range (0.15 – 0.40) Hz The second fuzzy input was prepared according to this range. This input rang was mainly divided into three parts as follows,

1. Low
2. Mid
3. High

The membership function for input LF/HF Ration .

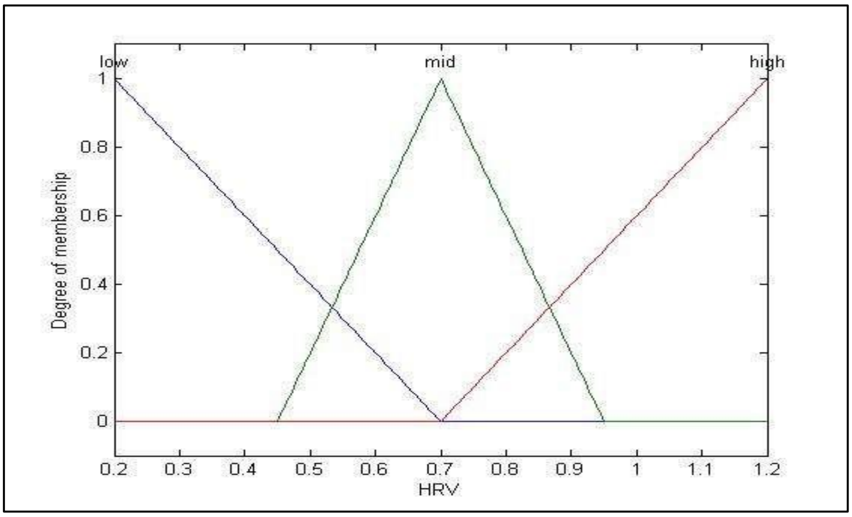


Fig: Input Membership Function

		Eye Shut Duration		
		Normal	***Average***	***Danger***
LF/HF Ratio	***Low***	Observe	Alarm	Alarm
	Mid	Good	Observe	Alarm
	High	Good	Good	Alarm

Table 7: Fuzzy Rules

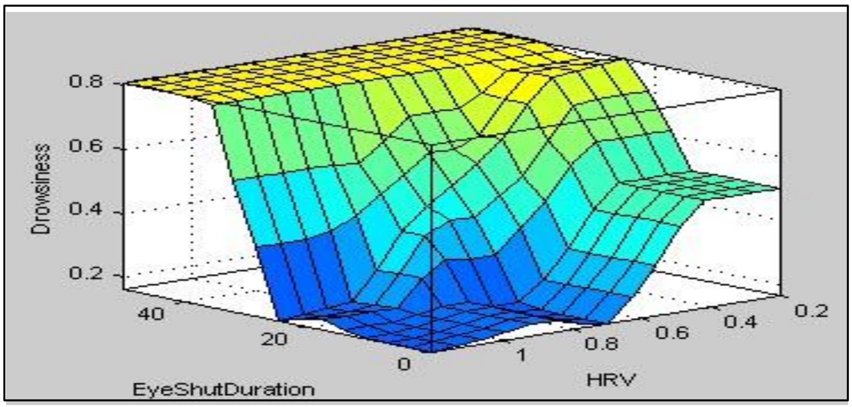


Fig. 8 Surface of the Fuzzy System

Defuzzification Process and Taking the Final Decision

To take a final decision defuzzification is needed, in here we used centroid method for defuzzification and based on the crisp output the final decision was given. Final output also has three categories they are as follows when crisp output is "X",

1. Good (When X <0.33)
2. Observe (When 0.33 <= X < 0.66)
3. Alarm (When 0.66 <= X)

Advantage And Applications

Advantage:

The various advantages of the implemented system are mentioned below

1. Detection of drowsiness
2. Decreasing road accidents
3. No need of monitoring cameras or other devices are attached or aimed at the driver.
4. This method is practically applicable.

Disadvantage:

1.Damage of senser cannot be detected.

2. One component damage whole system are not work

Applications:

The drowsiness detection system can be used for different applications. One of them is heavy vehicles for example trucks, since the drivers of trucks have long driving periods. It can also be used for commercial vehicles. Many people use public transport facility for travelling. For their safety this system can be used in public vehicles. Heavy things are lifted by using cranes and transporting them to other places. So for overloaded cranes and mobile cranes this system can be used to avoid accidents related to drowsiness.

RESULT AND DISCUSSION

The results of this experiment can be mainly divided into three subcategories, which are results from the physiological measurements, results from the behavioral measurements and result from the overall system.

Results from Physiological Measurements

Before developing a model to detect the drowsiness, to select the suitable values for the LF/HF ratio relevant to drowsiness previous researches was studied and from the results of those researches we acquire a range of LF/HFratio for the drowsiness. There the selected range of LF/HF ratio to observe was 0.1 to 1.0 [9]. According to the pilot range we observed ECG records of sleeping subjects using Kubios HRV analysis software. These ECG records were obtained from “physionet.org”. [7] There we analyze the ten different ECG signals taken while sleeping. From the analysis, we obtain that most drowsy subjects show LF/HF ratio between 0.3 and 0.5. According to the results we modeled the fuzzy input membership function varies from 0.2 to 1.2 LF/HF ratios. Figure 15 shows the basic analyzing window of the Kubios HRV analysis software.

Fig. Kubios HRV Analysis Interface

Results from Behavioral Measurements

The basic face detection was done using haar face detection mechanism and Figure 10 show the basic detection of the face and facial features when eyes are open.

Here in Figure 10, the basic face detection is shown by pink color squire. Then the region of interest to search for the eyes, that obtain from the basic rules on human face proportions are shown in yellow frames. Also in green the detected iris using Hough circle detection mechanism are shown.

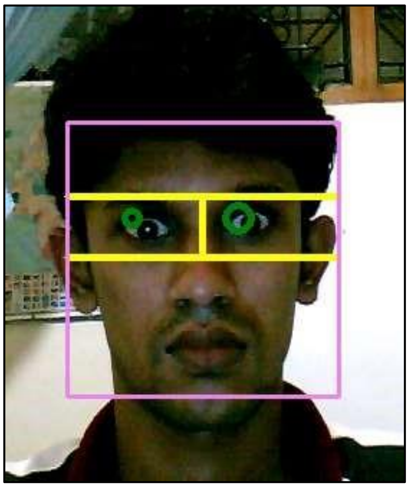


Fig.10.1: Basic Feature Detection (Open Eyes)

The Figure 11 shows the feature detection when the eyes are close which imply the drowsiness. There face is detected but iris is not detected. Frames in this stage are used as the data frames for the system. That is video frames which didn't detect iris are counted and given as the inputs to the system.

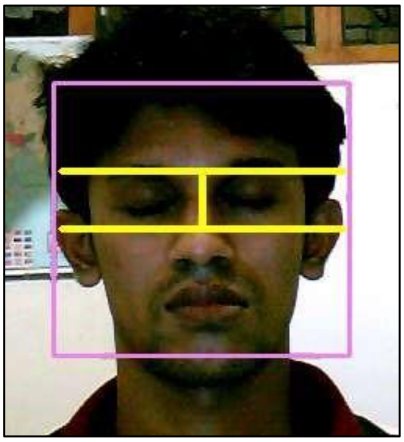
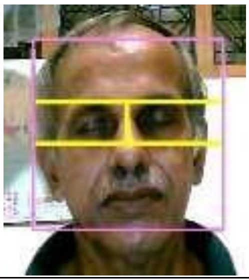
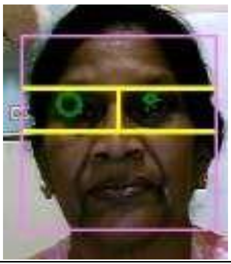
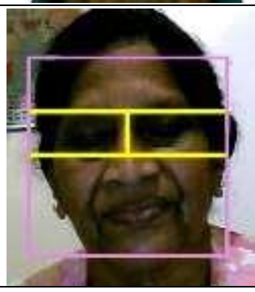


Fig.10.2: Basic Feature Detection (Close Eyes)

The detection was tested on subjects from various ages both male and female and achieved 100% success results in detecting facial features. Couples of test results are shown Table 2

Open eyes	Close eyes
	
	

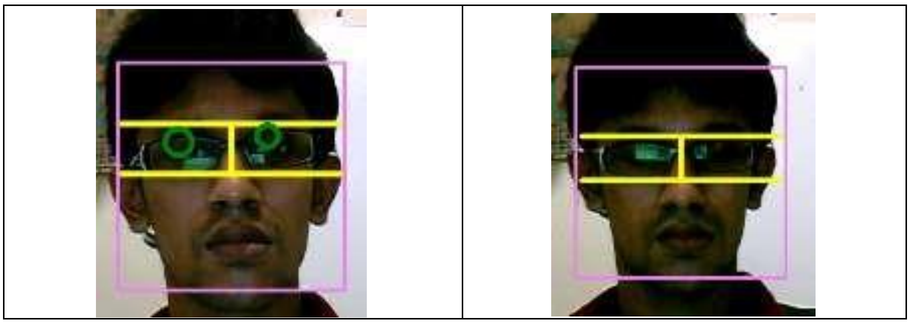


Table 1: Test Results for Facial Recognition

Also the testing was done with the subjects with spectacles. The results were not as good as the subjects without spectacles. The system was unable to detect eyes in most of the cases with spectacles. The main reason for this is reflections on the surface of the spectacles.

Implemented System

The system was implemented using C# language, EmguCv framework and fuzzynet 1.2.0 library. The system acquires real time video using a web camera. The system provides an input field to insert the LF/HF ratio as the input. This input is given manually because the system is not design to take ECG data real time. The user interface of the system is shown in Figure 12

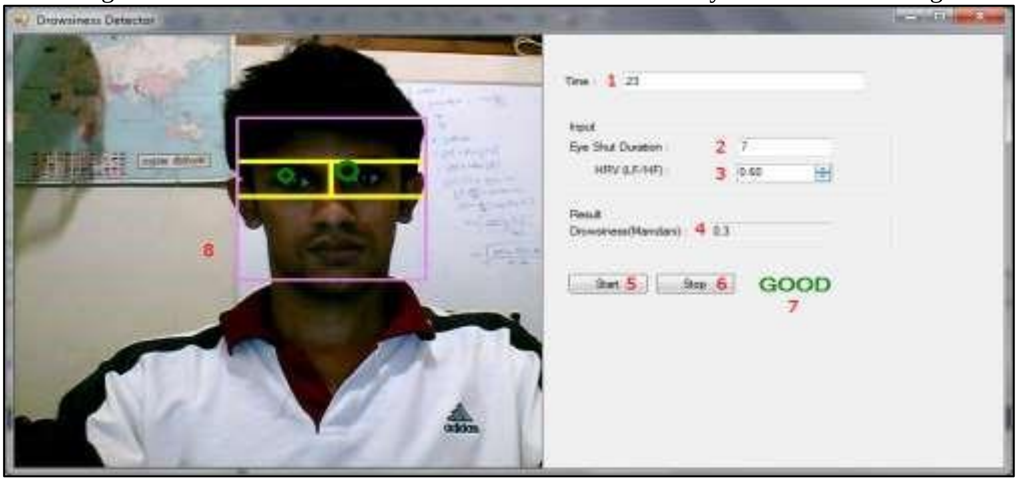


Fig.10.3: User Interface of the System

The function of the each element in Figure 12 is as follows

1. **Timer:** Show video captured time in seconds
2. **Eye Shut duration :** Number of frames that eye has been shut in previous 50 frames is shown
3. **LF/HF Ratio :** Data input area for the LF/HF values
4. **Crisp output :** Crisp output value from the fuzzy system
5. **Start Button :** Push to Start the drowsiness detection
6. **Stop Button :** Push to stop the drowsiness detection
7. **Output :** A label that show the State of the driver
8. **Video :** The input video and detected components are shown in this

Basic Functionality

- This implemented system acquire real time video input from the web cam and detect the eye closed time in every 50 frames and save it in "2" text field.
- LF/HF ratio need to be entered to the in Numeric up down field "3".
- To start monitoring start button need to be pressed and from then onwards system calculate inputs and output the condition of the driver in label "7" and the crisp output from the fuzzy model is displayed in "4" text field.
- To stop the detection stop button need to be pressed

The implemented system detects drowsiness in real time and gives the output. This implementation is only to demonstrate the functionality of the fuzzy model that we proposed. The implemented system also tested with subjects from various age levels and the also the system has tested on various lighting conditions.

The systems works perfectly in day light, but in the night conditions performance is lacking due to the limitations of acquisition of behavioral data from the webcam. But since this model is a hybrid model using the physiological measurements the system could still function. This has not been tested real time because this system is not implemented to take real time inputs on HRV data.

Discussion

The fuzzy based model for drowsiness detection which we proposed works remarkably fine with the webcam and the external input of LF/HF ratio. One of the key objectives of this study is to provide more cheap but effective drowsiness detection system and with the model that we provided it can be achieved. Also these results prove that hybrid method to detect drowsiness is robust to the environmental issues such as lighting conditions. However this project does not provide any hardware implementation other than the web cam due to that the exact cost for implementation this system cannot be estimated.

Conclusion and Future Scope

- As for the software part, we fulfilled our goal successfully. The detection algorithm could not only work effectively and accurately at daytime, but also at night.
- The Eye portion extraction is smooth and in real time with no delays on the microcontroller. In addition, there is a bonus function in the software part –detection with glasses. For the Arduino board, we achieved two major difficulties.
- First, we were not able to power up the board with any commercial chargers initially, including the ones for Iphone, for Assume or the USB charger on car. But later we added DC POWER battery to power our board and used the power supply we designed to charge the battery to solve the problem. The power supply unit basically completes all its design requirements.
- By adding the extra USB battery stage, the problem of powering the entire microcontroller and alarming system has been solved. Moreover, the alarming system works as we supposed.
- The voltage ripple of the power supply unit can be mitigated by applying more resilient capacitor components. It is apparent that the overall project success is not derived from one team member's mind but the keen coloration within our group.
- Each part is indispensable and every team member made the great dedication on the completion of this design project.
- The driver drowsiness and alcohol detection system is used to detect the drowsiness of the driver and also detects the alcohol consumption of driver.
- If there is drowsiness or consumption then the motor of the car gets slowed down and the buzzer sounds until the eyes get opened.
- The values of alcohol and the blink rate will be displayed in the serial monitor of the Arduino IDE. This proposed system helps in finding drowsiness and alcohol detection using Arduino.
- This helps in avoiding many accidents. Further we extend this project by using webcam to detect the drowsiness of the driver.

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