CS-308-2016 Final Report

Drowsiness Detector

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Table of Contents

Abstract

Product Overview
We have built a product which can warn driver if he feels drowsy while driving. This will help prevent accidents which could have also led to death of many people. This will be a small box with two sensors and a buzzer. Heart rate sensor can be attached to finger of the driver. Eye blink sensor can be worn as spectacles by the driver, also possible to wear on top of driver’s glasses(if any).

When a driver will feel drowsy , the pulse rate sensor will sense that the pulse of the person is dropping. Also the rate at which eye blinks and the duration of eye blinking will increase. Thus our system will raise an alarm warning the driver that he is unhealthy to drive

Introduction

Sleep deprivation affects driving as much as (and sometimes more than) alcohol. It has been estimated that approximately 20% of vehicle accidents have sleep deprivation as a cause.According to the National Sleep Foundation’s 2005 Sleep in America poll, 60% of adult drivers – about 168 million people – say they have driven a vehicle while feeling drowsy in the past year, and more than one-third, (37% of 103 million people), have actually fallen asleep at the wheel! In fact, of those who have nodded off, 13% say they have done so at least once a month. Four percent – approximately eleven million drivers – admit they have had an accident or near accident because they dozed off or were too tired to drive.

The National Highway Traffic Safety Administration conservatively estimates that 100,000 police-reported crashes are the direct result of driver fatigue each year. This results in an estimated 1,550 deaths, 71,000 injuries, and $12.5 billion in monetary losses. These figures may be the tip of the iceberg, since currently it is difficult to attribute crashes to sleepiness.

Noticing the trend and studying the factors of the person sleeping few common things could be noticed like the pulse rate of the person drops , the person starts blinking eye quickly and with longer durations , there could be difference in the driving way etc. We have exploited the first two important factor. We have used sensors to determine the heart rate and eye blink duration. Using those readings we will determine if the person is sleeping or not and based upon that we will raise an alarm

This project , “drowsiness detection system” will detect that and can be installed in the cars to prevent drowsiness based accidents

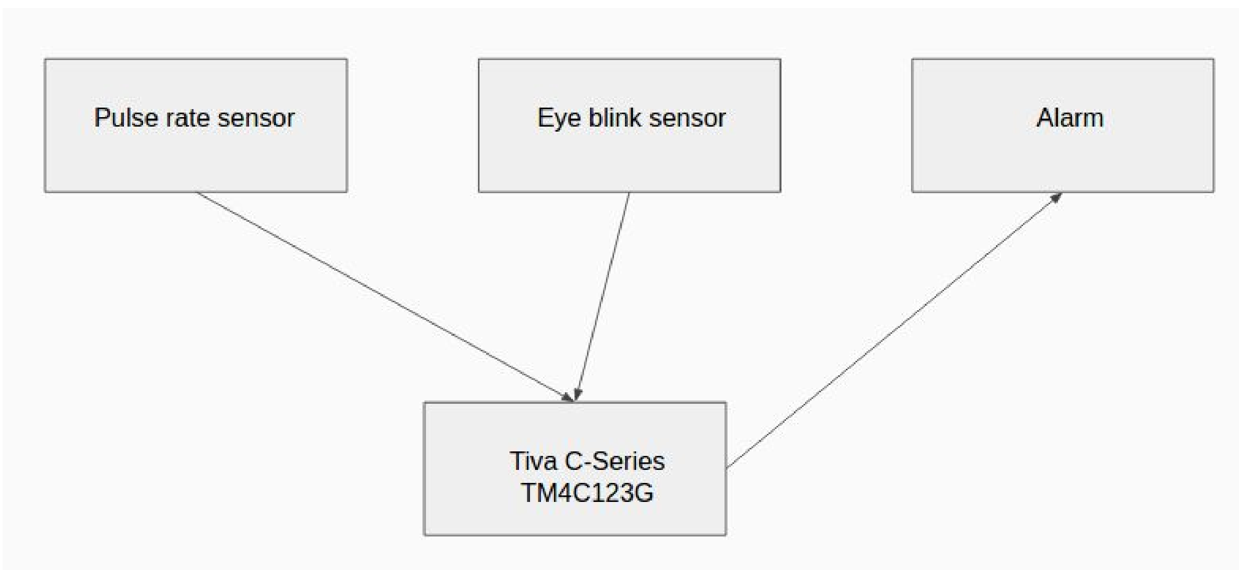
Problem Statement

The problem which we were looking to address was the huge number of road accidents, a majority of which are caused due to the driver driving in drowsy mode. So, our goal was to look into the major differences between a normal driver and a drowsy one, and so we chose to consider heart rate and eye blinks as our parameters.

Theory Behind Project

When person feels drowsy, his eyes remains closed for a longer time than normal. The heartbeat of the person also reduces. These two factors if measured properly can be used to predict if the person is feeling sleepy or not.

System Design



Tiva board will receive signals from pulse rate sensor and the eye blink sensor. After processing raw values of the signals, it will decide whether the person is drowsy or not. If found drowsy, it will fire the alarm.

Requirements

Hardware Requirements

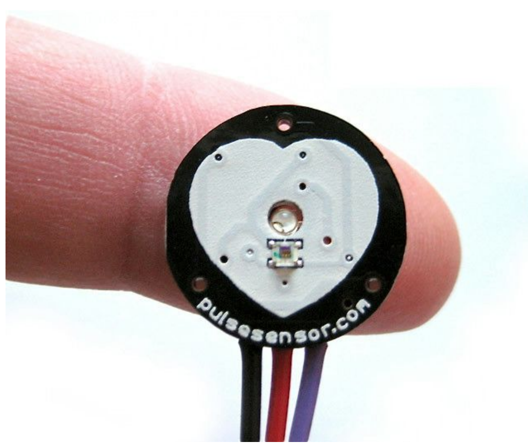
1. Tiva Board (Microcontroller)
2. Pulse rate sensor
3. TCRT5000 (IR Sensor)
4. Buzzer
5. Hot glue
6. Velcro
7. Wires

Software Requirements

The only software required is **Code Composer Studio**

Sensor Details and Processing Algorithms

Pulse Sensor



How it Works

Heartbeat sensor works on a very basic principle of optoelectronics. All it takes to measure your heart rate is a pair of LED and LDR and a microcontroller.Doctors measure our heart rate manually.The pulse is felt due to the expansion and contraction of blood vessel when blood enters and leaves it. Our heart does this around **72 to 84** times a minute for a healthy person.

In order to detect the pulse we will pass light (using an LED) from one side of the finger and measure the intensity of light received on the other side (using an LDR). Whenever the heart pumps blood more light is absorbed by increased blood cells and we will observe a decrease in the intensity of light received on the LDR. As a result the resistance value of the LDR increases. This variation in resistance is converted into voltage variation using a signal conditioning circuit usually an OP-AMP. The signal is amplified enough to be detectable by the microcontroller inputs. The signal given to the microcontroller input will look somewhat like shown in the image above in a oscilloscope. The microcontroller can be programmed to receive an interrupt for every pulse detected and count the number of interrupts or pulses in a minute. The count value of pulses per minute will give you the Heart rate in bpm (Beats Per Minute).

This is called **PPG (PHOTOPLETHYSMOGRAPHY)**. The PPG can also be used to monitor breathing and other circulatory conditions.Additionally, *the shape of the PPG waveform differs from subject to subject, and varies with the location and manner in which the pulse oximeter is attached*.

More details about the sensor can be found at the given link
https://www.sparkfun.com/products/11574

The sensor was purchased from the given link
http://www.ebay.in/itm/111930676180?ssPageName=STRK%3AMEWNX%3AIT&_trksid=p3984.m1439.l2649

Algorithm to Get Heart Rate from the sensor data

The algorithm for processing the data as a walkthrough of arduino code is given at this link
http://pulsesensor.com/pages/pulse-sensor-amped-arduino-v1dot1

Then input sensor values were ranging from approximately 1500 to 3500 , as shown in the graph in working (Fig 2). The main logic is to calculate the Inter Beat Interval (IBI) by measuring the pulses. It's hard to measure peak as there could be another smaller peaks far lower than the average value so we follow the following step to calculate the interbeat interval

1. Measure the average sensor input for first beat and mark it as threshold.
2. Whenever the input crosses the threshold , we mark it as a beat. Use the second beat to measure approximate interbeat interval
3. Use the approximate interbeat interval and threshold to calculate the subsequent beats.
4. For error removal we have done things like , ignoring readings for 250 milliseconds as the pulse rate can't be 240. Then the beat time will be a valid beat time only if more than 60% of the previous beat interval. This will basically remove

all the errors due to physical data and maintaining the continuity between beat intervals

Now the Pulse rate is given by :

BPM = 60000/Inter Beat Interval in milliseconds

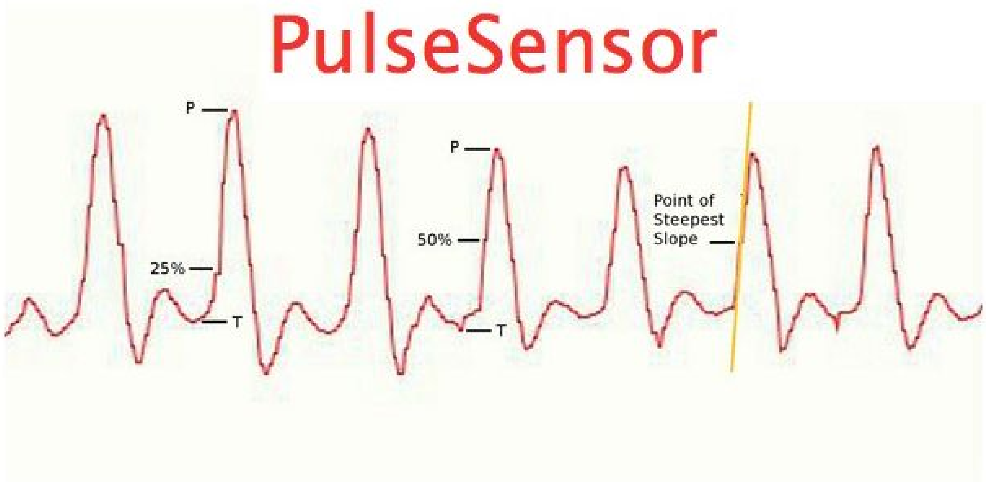


Fig 1 : The graph expected from the documentation page

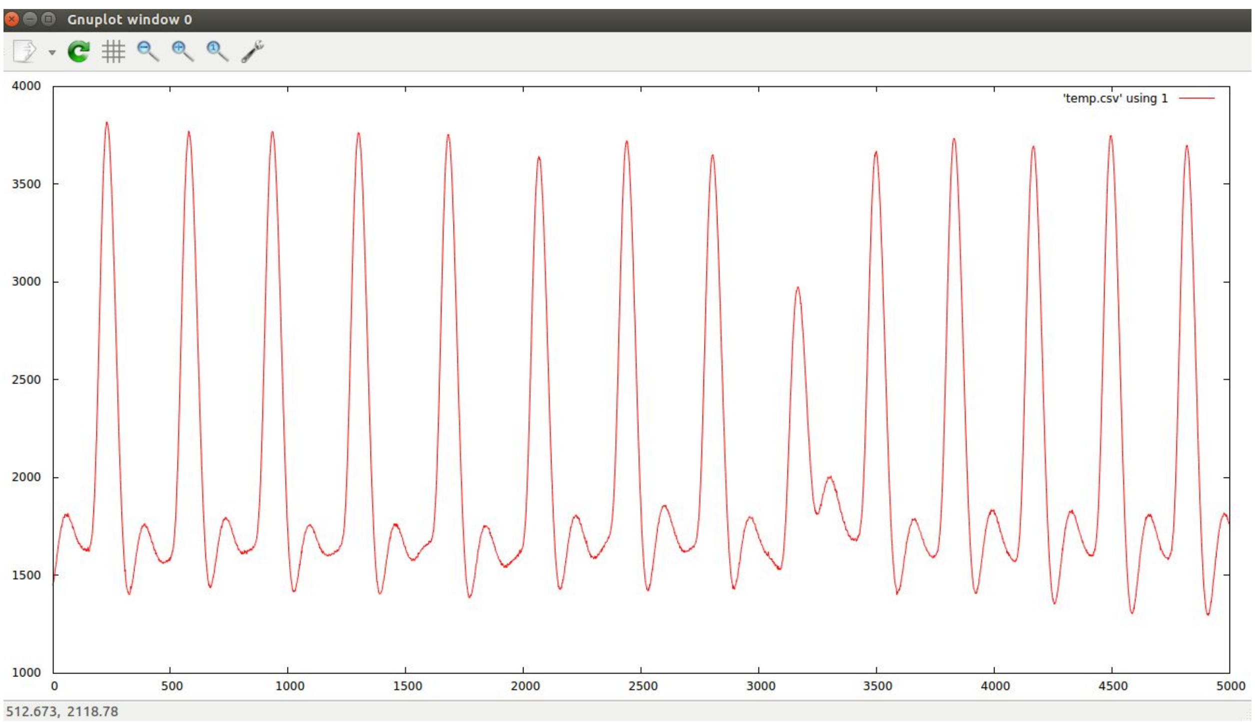
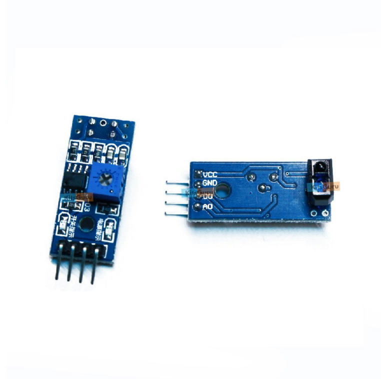


Fig 2 : The graph of pulse rate sensor achieved

Eye blink duration Sensor



How it Works

This sensor uses the fact that eyeball and eyelid reflects light differently. A normal infrared sensor can be used for the same purpose. We have used interrupts to get the value of the sensor every 2 ms. Then an algorithm written by us helps to filter the values and get correct value.

Algorithm to measure time

The first step to find if the person is blinking or not. The difference in sensor data from the open eye and close eye is close to 300-400 and the normal error for being close to 50-60. So we need to find the threshold between the higher and lower values. For that there is a process of calibration. The **calibration process** goes as:

1. Close the eyes and then press switch 1
2. After 2 seconds , open the eye and release switch 1
3. The microcontroller measures the values when the eye is closed and the eye is open and we will take the maximum and minimum of the readings in both cases and then we keep the threshold as mid of both values

Once we have the threshold , we can start measure the blinking of our eye. The measure process is simple that if the sensor is below threshold it means that the eye is close while in other case the eye will remain open. There could be errors due to electrical problems. To counter that we have kept a process or error cancelling. Whenever there is a change of state (open to close or close to open) , instead of directly changing the state , we keep a counter. If the counter exceeds 10 (20 millisecond) it means that there is actual change of state .

We take average over last 10 durations to take into account wrong values and noise.

Processing

After getting the heart rate in bpm and the blink durations in milliseconds, we have to fire buzzer in the case when the person is feeling sleepy. There can be cases when one out of two sensors doesn't work or gives opposite values. So we created a function with 0.3 weight to pulse rate and 0.7 weight to eye blink duration. Then on the basis of that fire the alarm.

$$0.3\frac{60-averageBPM}{60}+0.7\frac{averageBlinkDuration-200}{200}$$

When this value is greater than 0.1, we fire the alarm.

Other methods

To measure correct timings

Instead of keeping all the measurements in the main loop of the code , we implemented the interrupts. Assume we need time ***δ*** for processing and we need to measure samples in 2 millisecond. So

Case 1: Using loops

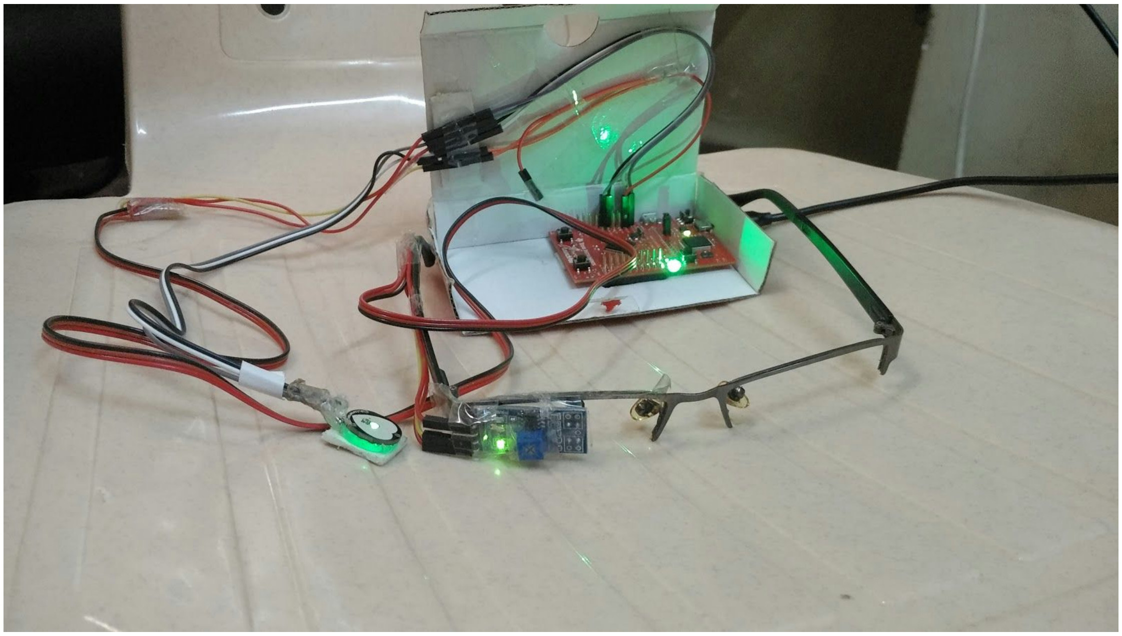
Total loop time = 2 millisecond + ***δ***

There we will get an error = ***δ***/2

Case 2 : Interrupts

Since the interrupt is set for 2 millisecond , the processing time will be in effective

Final Product and Working



1. Wear the spectacle
2. Wear the eye blink sensor on the fingertip
3. Calibrate the eye blink duration sensor
4. Buzzer will beep whenever the user feels drowsy.

Video link : https://www.youtube.com/watch?v=MdI-s5fpiKE&feature=youtu.be

Test Results

All the following tests were performed after connecting pulse rate sensor with the fingertip and attaching eye blink sensor to the spectacles.

- Test 1 : Eyes blinking slowly, pretending to be asleep
  - Eye blink rate falls down, and if pulse rate is normal alarm is raised
- Test 2 : Eyes blinking rapidly after alarm is sounded
  - Alarm stops buzzing
- Test 3 : Doing exercise and then measuring pulse rate
  - Pulse rate goes up, now if pretends to be asleep, no alarm is raised
- Test 4 : Slow breathing and measuring pulse rate
  - Pulse rate goes down by maximum 5 to 6 pulses per minute

The log of the sensor input is here :
https://github.com/prateekchandan/2016-CS308-Drowsiness-Detector/blob/master/Code/log.csv

Errors and Drawbacks

1. The heart rate sensor doesn't always give correct value. During normal time, it should give something in range 65-75. But sometimes the value drops down to 40-45 or increases to near 100 which are wrong.
2. The blink duration calculation is not error free, as many people have different blink durations. The position of the eye blink sensor is also not optimal as it is currently right in front of the eye which obstructs the view.
3. Convincing the users that the eye blink duration sensor is harmless is also a challenge. We need to verify the sensor about the harmful effects, it might cause when infrared rays are directly sent to eye for much duration.

Future Prospects

1. Reduce the size of the eye blink rate sensor such that it can be easily put on the spectacles and can also be worn by driver
2. Add vehicle based measures such as accelerometer readings or sud den steering wheel rotation and superpose on the current algorithm
3. Make a complete car safety system by including
   a. **Car vibration sensor** which detects if car is running smoothly
   b. **Parking sensor** which senses the proximity of obstacle when the

vehicle is going in reverse gear

Conclusion

1. We conclude that although the sensors are prone to external noise, the rate of eye blinks and pulse rate are good measures of drowsiness of a person.
2. And a product such as ours which utilizes those sensor values to determine drowsiness in drivers can be very useful in mitigating undesirable road accidents, which was our goal from the beginning.

References

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5. https://en.wikipedia.org/wiki/Driver_drowsiness_detection