Non-Invasive Alcohol Detection for Drunk Driving Prevention

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***Abstract*: This prototype aims to prevent the drivers who are not in the condition to drive and prevent them from any mishaps. This research proposes the development of a portable prototype which can be installed in a vehicle that can perform a quick check on driver's intoxication before starting the engine. In this prototype, a two-step mechanism ensures that the driver is not under alcohol influence and will be able to drive without any difficulty. Firstly, the driver has to place his/her finger on the Heart Rate sensor, if the heart rate is below the threshold value then the engine will ignite right away. However, if the heart rate exceeds above a certain threshold, the alcohol sensor will check the driver's Blood Alcohol Concentration (BAC). If the sensor detects alcohol it will prevent the vehicle from starting and send alerts to the emergency contacts of the driver.**

***Keywords*: Heart Rate/ Pulse Rate, Intoxication, Heart Rate sensor, Alcohol sensor, Blood Alcohol Concentration (BAC).**

1. Introduction

Alcoholic beverages are being increasingly used in societies which are creating positive and negative; short-term, long-term, social, medical and cultural impact. Drunk driving is a punishable offence in and a strictly followed one. The only exception being permission to a limited amount of blood alcohol concentration (BAC).

The connection of alcohol with automobile accidents is fairly well established. It has been found that the probability of involvement in serious crashes increases dramatically for blood alcohol concentration (BAC) beyond 0.08 g/100 ml [1]. People under alcoholic impairment not only pose a threat to themselves but also to other people in the vicinity. According to the estimates of the World Health Organization (WHO), it is estimated that there are 2 billion alcohol users in the world, which it reflected into a potential increase of diseases and economic costs. Traffic accidents have become, over the years, a public health issue, as well as causing fatalities, leave sequelae of varying degrees between the survivors and adverse effects between the members of their families. Among numerous factors, driving under the influence (DUI) of alcohol is highlighted [2].

Fatal accidents caused by alcohol-impaired driving continue to attract social attention across all parts of the world, including countries like Japan, USA, India, etc. In Japan, in 2007, the fatal accidents caused by alcohol-impaired driving occupied more than 8% of the whole fatal accidents, and the fatality rate of the accidents caused by DUI was 9.4 times higher than that of other traffic accidents [3-5]. In 2014, 9967 people were killed in drunk driving crashes, accounting for nearly 31% of all traffic-related deaths in the USA [6].

On a survey that has been done recently, said that nearly 70% of road accidents occur due to drunken drive, with a range of 44% to 67% in small cities in India [7]. A total of 76,446 people died in 211,405 road accidents nationwide due to alcohol consumption between the years 2008 and 2017.

The influence of physical exercises and alcohol intake over the spectra of PPG signal has been investigated and it is found that aspects of the PPG signals can be altered by alcohol intake [8]. In daily physical activities, humans require energy to carry out all activities. This energy can be obtained through the consumption of food and beverages, including food and beverages containing alcohol. Besides this, consumption of alcohol in large amounts can cause respiratory failure and death [9]. This amount of alcohol can be fatal and needs to be kept in check.

Several methods have been developed to easily measure the gases in exhaled breath and non-invasively detect alcohol in the blood. To prevent errors when using an alcohol interlock, it is necessary to avoid false detection due to other gases, such as ambient air [10-11].

Although the non-invasive monitoring of biomedical information is generally inferior to invasive monitoring in terms of sensitivity, resolution, and reproducibility, non-invasive monitoring is definitely useful in the analysis of biomedical signals from the point of view of bio-informatics [12].

Also, non–invasive detection of BAC is less time consuming which is an important aspect in today's world. Hence, the proposed system makes use of various sensors for detection of alcohol content through a non-invasive process.

2. System Model

The proposed prototype system has a two-step working procedure which ensures the drunkenness of a person even before he/she starts to drive the car. This will prevent them from causing any fatalities possible.

The primary step involves obtaining the heartbeat and blood oxidation levels of a person. The heart rate for a normal adult lies between 60 – 100 beats per minute (bpm). If the heart rate of the person lies in the normal range, he/she will be considered safe to drive and can drive away safely. In case the heart rate turns out to be higher than the normal range, it'll act as an alarming signal, and the system proceeds towards the next step.

The second step is taken by the system, which initiates the alcohol detector installed within to measure the alcohol content in the person's blood through a breath test. This will determine whether the person is fit to drive or not.

The alcohol detector ensures whether the person has consumed alcohol or not because a person's heart rate can increase from various physical activities too. If low and legal alcohol levels are found, the car ignition will be turned on. Otherwise the car ignition will be turned off to prevent the person from driving under the influence.

Finally, a warning message will be sent to the person's family to notify them about the person so they can receive immediate assistance.

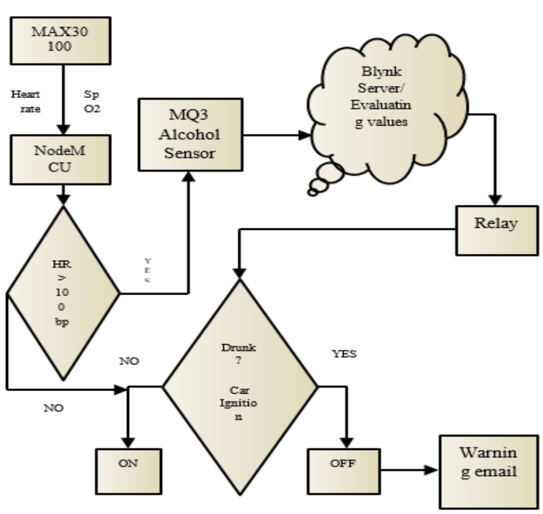

Fig. 1. Block diagram of the proposed model

3. Components

In order to design the proposed system, components such as microcontrollers and sensors were installed to fulfill the required objectives and produce desired results. The various components used are:

A. NodeMCU

NodeMCU is an open source IOT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espress if Systems, and hardware which is based on the ESP-12 module. The term NodeMCU by default refers to the firmware rather than the development kits. It is responsible for the collection of data from the sensors and processing the data for determining the sobriety of the driver.

B. MAX30100

The MAX30100 is an integrated pulse oximetry and heart-rate monitor sensor solution. It links two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals. The project uses this sensor to detect the heart rate and blood oxygen saturation of the driver with modest power consumption.

C. MQ3 Alcohol Sensor

It is a low-cost semiconductor sensor which can detect the presence of alcohol gases at concentrations from 0.05 mg/L to 10 mg/L. The sensitive material used for this sensor is SnO_2, whose conductivity is lower in clean air. Its conductivity increases as the concentration of alcohol gases increases. It has high sensitivity to alcohol and has a good resistance to disturbances due to smoke, vapor and gasoline. This module provides both digital and analog outputs. This sensor is used for detection of alcohol concentration in driver's breath if necessary. It provides the system fast response time and high sensitivity.

D. Arduino IDE

The Arduino Integrated Development Environment (IDE) is a cross-platform application that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards. The integration of the NodeMCU along with MAX30100 and MQ3 Sensors was done using the Arduino IDE.

E. Blynk Server

It is responsible for all the communications between the smartphone and hardware. It is an easy to use application that can effectively display the results on the smartphone. It helps the system to notify when the sobriety of the driver is inconclusive.

4. Working

The proposed prototype is connected to the Arduino IDE which uploads and runs the programs required to get the whole system running. The first and foremost thing is to have the driver to put his/her finger on the pulse oximeter sensor MAX30100. The device has two LEDs, one emitting a red light, another emitting infrared light. For pulse rate, only the infrared light is needed. Both the red light and infrared light is used to measure oxygen levels in the blood. This is the main function of the MAX30100: it reads the absorption levels for both light sources and stored them in a buffer that can be read via I2C.

When a person consumes alcohol, their heart rate increases rapidly, i.e., when the heart pumps blood, there is an increase in oxygenated blood as a result of having more blood.

As the heart relaxes, the volume of oxygenated blood also decreases. By knowing the time between the increase and decrease of oxygenated blood, the pulse rate or heart rate is determined. For a drunk person, this pulse rate is higher than the normal pulse rate range (60 – 100 bpm).

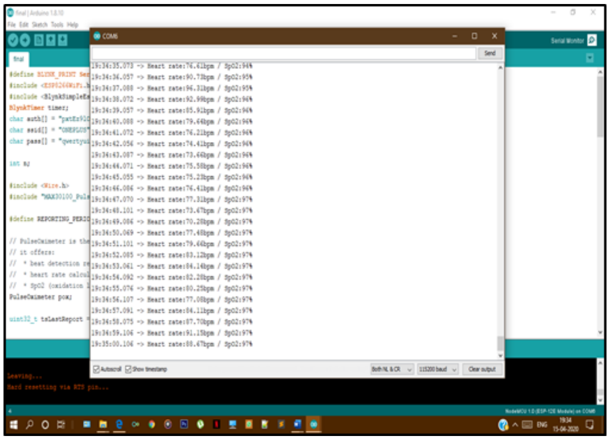

Fig. 2. Heart Rate in the normal range (60 – 100bpm)

The pulse oximeter sensor measures the heart rate and blood oxidation levels (SpO2 levels). If the pulse rate of the person lies in the normal range, it will mean that he/she is in normal condition and hasn't consumed alcohol. This information will be passed on to the system relay through a microcontroller, NodeMCU. The NodeMCU also connects to the MAX30100 sensor and alcohol sensor MQ3. The relay, which is connected to the car ignition, controls the ignition button. It turns the ignition on so the driver can drive away.

But if for any reason, the pulse rate of the person shows an increase above the normal range, i.e., more than 100 bpm, it becomes a critical moment.

The NodeMCU initializes the alcohol sensor MQ3. This device is highly alcohol sensitive and can easily detect the presence of alcohol in a person's breath. It has a really fast response time.

The person has to breathe onto the sensor for the alcohol test. As soon as the person breathes, the sensor will act up to measure certain values. The sensor is integrated with the Blynk application server, which displays calculated values by the sensor. These sensor values reflect the approximated trend of gas concentration in the breath vicinity. The MQ3 sensor has a built-in variable resistor that changes its value according to the concentration of the gas. If the concentration is high, the resistance decreases, and if the concentration is low, the resistance increases.

Since the MQ3 is highly sensitive to alcohol, if the concentration values are lower, i.e., in the range 100-500, then it is a safe range for the alcohol concentration in the breath. The person is considered safe to drive.

This data is fetched back to the NodeMCU which passes the information to the relay, which turns the car ignition on so the person can drive away. If the concentration values are higher, i.e., greater than 600, it does become an alarming situation as the alcohol concentrations are high, showing that the person is highly drunk and is unfit to drive. This information is passed on to the relay via NodeMCU and it forces the car ignition to be turned off to prevent the person from driving.

On high concentrations, the Blynk displays a message saying high alcohol concentrations have been detected. After this, a warning email is sent to the person's emergency contacts regarding his health. This way the person can receive assistance from the people listed in his emergency contacts.

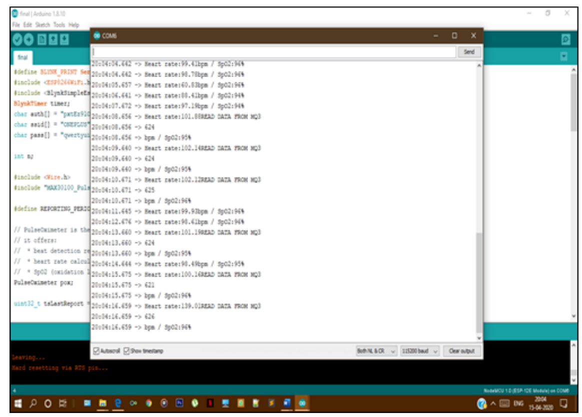

Fig. 3. Heart Rate above normal range/ MQ3 initialized

This system is a cheap and easy to build prototype capable of measuring pulse rates and detecting any alcohol content to prevent a person from driving under the influence. This will prevent not only the driver but also the people around him from causing any harm.

5. Results

Since the amount of oxygenated and deoxygenated blood changes with each breath, in MAX30100, the optical IR and Red LED combined with a photodetector, are brought to use by giving different values to represent the redness of the skin. Fig. 4. shows the IR (BLUE) and Redness (RED) values.

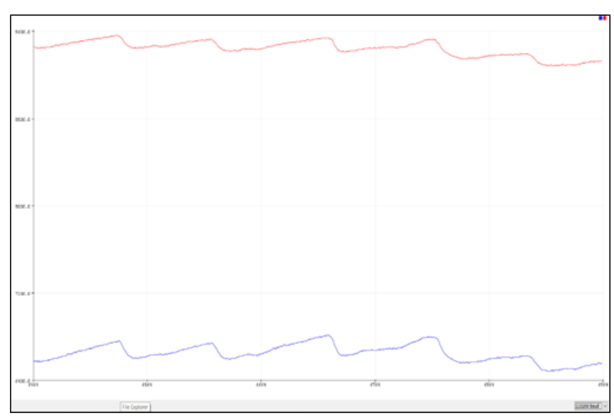

Fig. 4. IR and Redness values from MAX30100

The normal pulse rate of a person, without consuming

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any alcohol lies between 60 – 100 beats per minute. MAX30100 takes the fingerprint and measures the heart rate, first in the normal condition. Fig. 5. shows the pulse rate when the person is in normal condition.

When the pulse rate increases, i.e., it goes above 100 bpm, the MQ3 is initialized. Now, depending upon the alcohol concentration, the MQ3 measures and returns an analog value which represents the alcohol concentration in the air. The more the analogous value, more is the concentration of alcohol in the air.

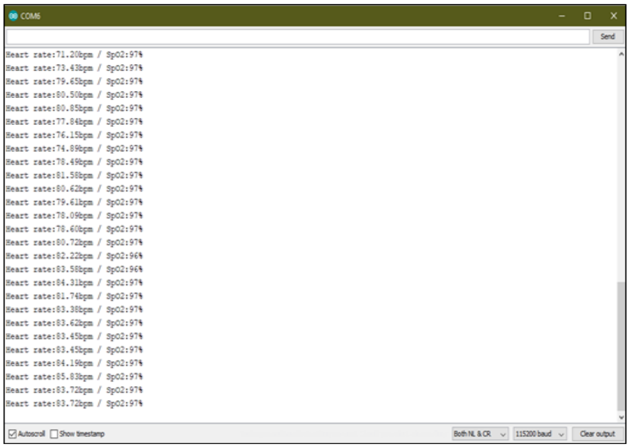

Fig. 5. Pulse Rate in normal condition

In Fig. 6., at high pulse rate, the initialization of MQ3 is shown which detects alcohol concentration in a deodorant (an alcohol-based product), which contains 95% alcohol, when a small amount of it is exposed to the MQ3 alcohol sensor.

These analogous values are displayed on the Blynk application. We can clearly see that even on using small amounts, the sensor is able to detect easily and shows intermediate values for every second that the pulse rate is above 100bpm.

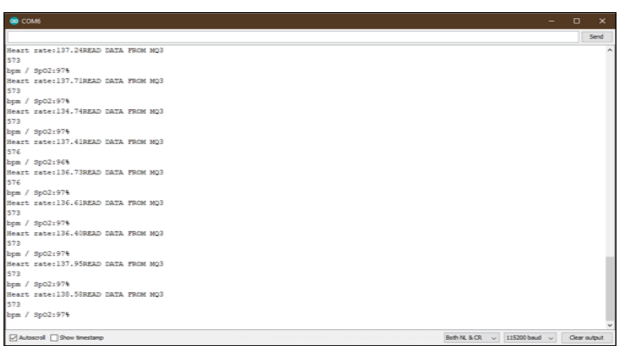

Fig. 6. MQ3 shows intermediate analog values for every second that the pulse rate is above 100bpm

Since, the alcohol concentration is intermediate (400 - 600), it does not show an alarming message in Fig. 7.

When the alcohol sensor was exposed to a large amount of deodorant gas, the alcohol concentration was found to be so high that it crossed the 600 mark, which clearly indicates high level of alcohol. Hence if the person does drink above the legal limit, they will get caught by this sensor. Fig. 8 shows high pulse rates and the values detected by MQ3.

Fig. 7. Intermediate analog values from MQ3 on Blynk app

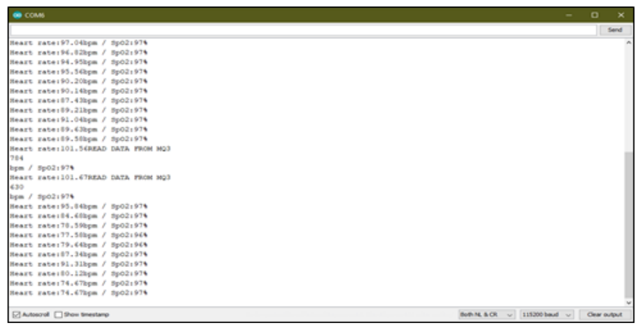

Fig. 8. High pulse rates and high alcohol concentration

Fig. 9. Analog value of high alcohol concentration

Since, the value of alcohol concentration crosses the 600 mark, we can easily say that it not a safe condition to drive in. Hence, to keep the driver from driving, the relay is turned off and a warning mail is sent to the driver's emergency contact to provide them immediate assistance, in Fig. 10.

The content of the warning can be anything regarding the situation of the driver. Its main purpose is to alert the people concerning the driver.

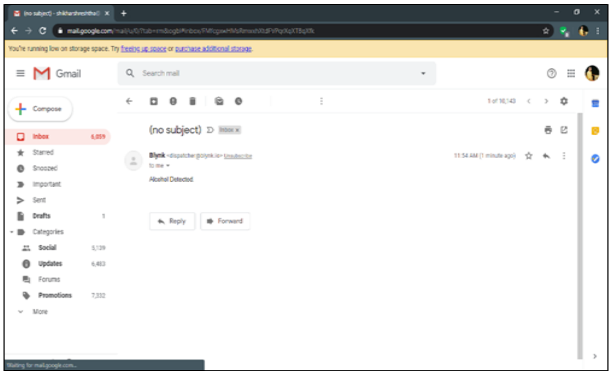

Fig. 10. Warning email sent to alert the driver's emergency contacts

We can clearly see that the proposed prototype is successfully able to measure the pulse rate of any person, and the alcohol sensor gives fast response and detected concentrations of alcohol in the air around it. Table 1. shows the overall time taken by the prototype model to complete the whole measuring and detection process.

Table 1
Time taken by the prototype for the complete process

Operation	Least Time Taken
Compilation and uploading of the code on NodeMCU	60 seconds
Pulse Rate Measurement	2 – 4 seconds
Alcohol Concentration Detection	1 second

6. Conclusion

In the proposed model research, we exploit the relation between the heart rate of a person and blood alcohol content. We know that a person's heart rate can increase on consumption of alcohol and this is the main focus of this research. But a person's cardiac behaviour can also change while performing various physical activities like exercising, running or other sports related activities. To fully ensure that the increase in heart rate is due to alcohol, we have also installed an alcohol sensor.

When the heart rate was in the normal range, the alcohol sensor was not initialized which means that the person is sober. As soon as the heart rate was more than the normal range, the alcohol sensor was initialized, and on exposing the sensor to the deodorant containing ethyl alcohol, it easily detected the alcohol content and displayed high values which means the amount of alcohol is really high. Upon detecting high content of alcohol, the system immediately sent a warning email, which is to notify the person's relatives.

The large amount of time taken in the verification of code in Arduino IDE is a major drawback to this model. The time efficiency can be improved by taking less complicated sensors and a faster microcontroller than NodeMCU. Further, in the MAX30100 sensor, the SCL and SDA pins are pulled-up via 4.7k ohm resistors to 1.8V. This means it does not work well with microcontrollers with higher logic levels. The solution is to remove the resistors from the board and attach external 4.7k ohm resistors instead.

Also, the MQ3 alcohol sensor only gives the approximate values of alcohol concentrations in the air near it. More accurate and sophisticated readings can be obtained by consulting the sensor datasheet or by using other accurate sensors.

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