ME-366

Electromechanical System Design

Project Report on

Accident reduction system design

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Abstract

Reasons for accidents are numerous. Among them, driver's drowsiness is one of the main cause. As driving is a continuous process, it creates fatigue. Drowsiness is a common phenomenon for drivers while driving for a long distance and duration. Accidents become inevitable. Drunk drivers are another cause for accidents. This project focuses on detecting driver's drowsiness and also on detection of alcohol. With alcohol detection system, vehicle would not start in presence of alcohol on driver. If the driver is detected drowsy, speed of the vehicle would be decreased gradually as well as starting an alarming system to notify the driver. Driver's drowsiness is detected based on head motion. Speed control has been prototyped using DC motors. Alarming system will notify the driver if he is drowsy or distracted. As the speed of the vehicle will be reduced sensing drowsiness, accidents can be prevented for these cases in an efficient way. This system can also notify whether the driver is distracted while driving. To detect head motion, a head mount has been devised. Thus sensing the driver's head position and notifying according to the data collected.

Acknowledgement

We are really grateful to Dr. A K M Monjur Morshed (Professor, Department of Mechanical Engineering, BUET) and Md. Rakib Hossain (Lecturer, Department of Mechanical Engineering, BUET) for guiding us throughout the project.

Contents

1 Introduction

Road accidents have been increasing rapidly in Bangladesh during last two decades causing a vast amount of social & economic loss in terms of fatalities and property damages. Everyday around eight persons die in road traffic accidents. At least 4,284 people were killed and 9,112 others injured in road accidents across the country in 2017[1]. A total of 3,412 people died and 8,572 others injured by this in 2016. The number of accidents increased by 15.82% and death increased by 25.56% in 2017 compared to 2016[1]. As many as 6,686 people lost their lives and 8,600 were injured in a total of 4,891 road accidents in 2020. But only these numerically shocking statistics may fail to reflect the social tragedy related to each life lost in road traffic accidents.

Reasons behind the increased number of accidents and casualties include drunk driving, driver's drowsiness, reckless driving, over speeding, overloading, overtaking, violating laws, illegal and dangerous competition, long-time driving without break, use of drug and alcohol, incompetency of the driver, hazardous road, lack of proper design and construction of the road, lack of safety measures, lack of road maintenance, poor implementation of traffic rules and regulations, lack of awareness among the people, locally-made mechanized vehicles etc.

But driver's drowsiness, drunk driving, over speeding and reckless driving are mainly responsible for accidents now-a-days. That's why we tried to develop an economic system to propose as a solution to this national problem.

The objectives of developing an accident reduction system were:

1. Distracted driving is the most common cause of road accidents around the world, resulting in more crashes every year than speeding, drunk driving, and other major accidents causes. We used MPU-6050 six degrees of freedom 3-Axis Gyroscope and Accelerometer Module to make sure that the driver doesn't do multi-tasking while driving. It will help to reduce the possibility of accident due to drowsiness.

2. If the driver is drunk, he/she will be warned by an audio device. We used MQ-3 Alcohol sensor for this purpose.

3. When driving at a speed beyond the maximum speed limit, there will be an alert and we designed a prototype for controlling vehicle's speed using L298N motor driver.

We used ARDUINO IDE along with MPU-6050 gyro-sensor, MQ-3 Alcohol senor, L298N motor driver for developing the system. To avoid faulty design, we simulated the system using PROTEUS PROFESSIONAL and SOLIDWORS.

2 Literature review

Many researches have been conducted on driver's drowsiness detection based on different criterion. The following measures have been used widely for monitoring drowsiness:

- Vehicle-based measures
- Behavioral measures
- Physiological measures[2]

There have been complex researches as well as researches using simple technologies. Among complex works, main focuses were to increase the accuracy of data analysis through modern technology and methods e.g. image processing, openCV[3], data analysis, machine learning[4] and many more.

Physiological measures are simpler to detect and researches have been done in this genre in different fields and detecting different phenomenon e.g. detection of eye blink using sensors[5], EEG based detection[6], head motion detection using IR sensor[7] etc. Eye blink sensor is mounted on a goggles which hampers the eye sight as the sensor is to be close to eyelid to detect eyelid movement. EEG based detection of drowsiness has a much accurate result.

One thing to remind is the system has to be economic for generalizing this useful project to all.

Study shows that there is a direct relation of drowsiness with head motion[8]. Using gyrosensor(MPU6050) head movements can be navigated. And using previous research data regarding the relation between head motion and sleepiness, this project discuss a system that can detect driver drowsiness in an efficient and economical way.

To implement our idea of speed control, DC motor and L298 has been used. As the gyrosensor detected drowsiness it sends a signal to Arduino controller and predefined code checks the threshold and on drowsiness detection the motor slows down.

Accidents due to drunk driving is a big problem throughout the world. We wanted to address it by developing an economic and reliable system. Some great research and development have already done on this topic. We were really motivated by this paper[9]. The Author concluded that, as MQ-3 alcohol sensor has a great sensitivity within 2 meters. So, we can use it for safely detecting driver drowsiness due to drinking irrespective to the size of the vehicle.

This paper[9] describes a breathalyzer based on Arduino Uno and virtual instrumentation to prevent drunk driving by self-testing. The embedded system was connected to the car's electronic system which will disable the engine ignition system when the driver is found drunk. This paper[9] really motivated us to incorporate a speed control system along with driver's drowsiness detection.

As the pandemic situation was going on, equipment collection for the project became challenging though it was managed somehow but there was lacking of some extra equipments, which hampered the project a little. The mounting for the gyrosensor to place it on the driver's head could not be managed and in lack of soldering iron it became challenging to set the sensor properly as it's pins were separate. Trial and error process became difficult, though it was done manually then. To mount the gyrosensor glue gun and breadboard has been used, which solved the problem a lot.

3 Design and Methodology

3.1 Problem statement

To fulfill the project's goal, a system has to be designed that can detect the head motion of the driver and control the speed of the vehicle according to the result. Another criterion was to detect alcohol presence (upto a threshold) from driver's breath and if the result is positive then lock the vehicle and do not start until the driver comes to normal. A system schematic is shown in **Figure 01:** ***System schematics.***

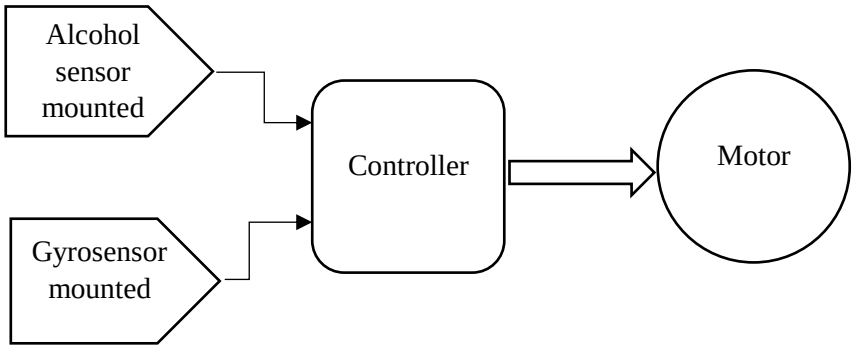

Figure 01: System schematics.

3.2 Design requirements

3.2.1 Components required

- Arduino Uno
- MPU6050 (Gyrosensor)
- MQ3 (Alcohol sensor)
- L298
- DC motors
- Alarming components (Buzzer, LEDs)
- Prototype Vehicle model

And other miscellaneous equipments.

3.3 Design Images and Schematics

3.3.1 Driver's drowsiness detection

The controller is connected with gyrosensor and the sensor is mounted on a breadboard. This breadboard is used as the mounting for the sensor in lack of a soldering iron the planned mounting could not be managed though a solidworks

model for the mounting was designed shown in **Figure 2:** ***Mounting for Gyrosensor (solidworks design)***.

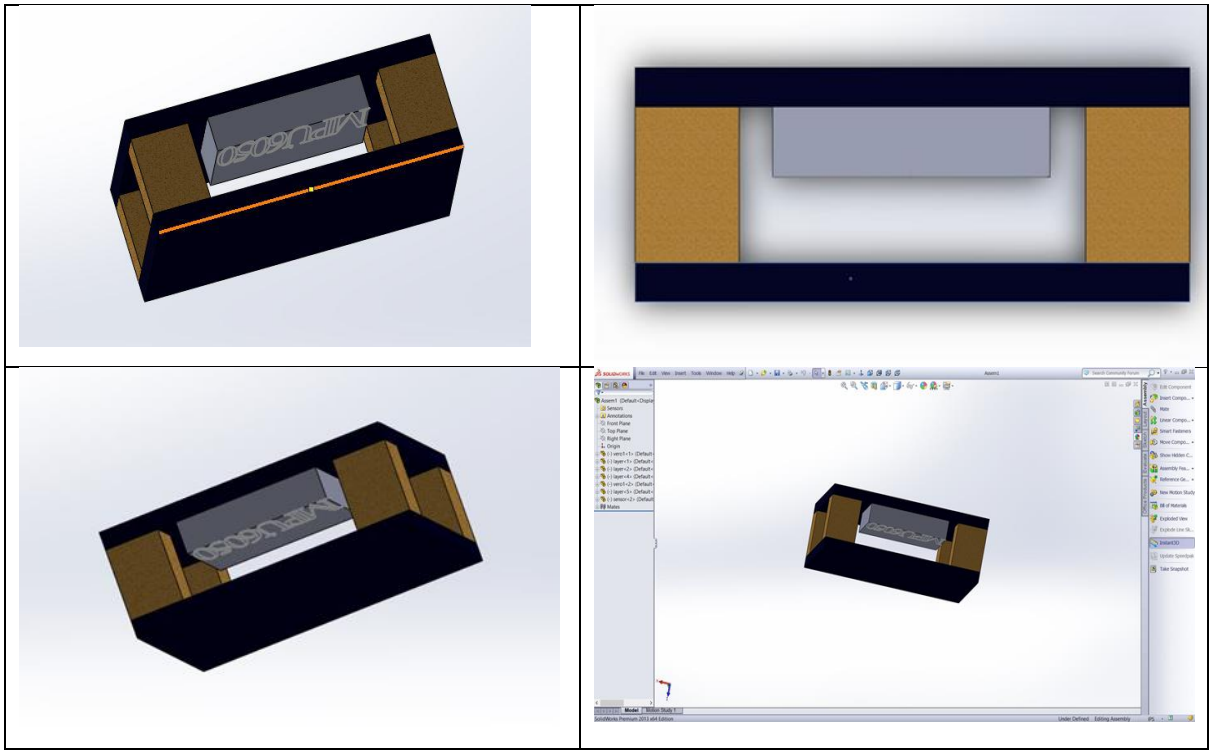

Figure 2: Mounting for Gyrosensor (solidworks design).

3.3.1 Speed control of DC motor

A prototype vehicle was also designed using solidworks. This prototype was only for showing the concept of speed control in this project. The 3D model is shown in **Figure 3*: 3D model for prototype vehicle***.

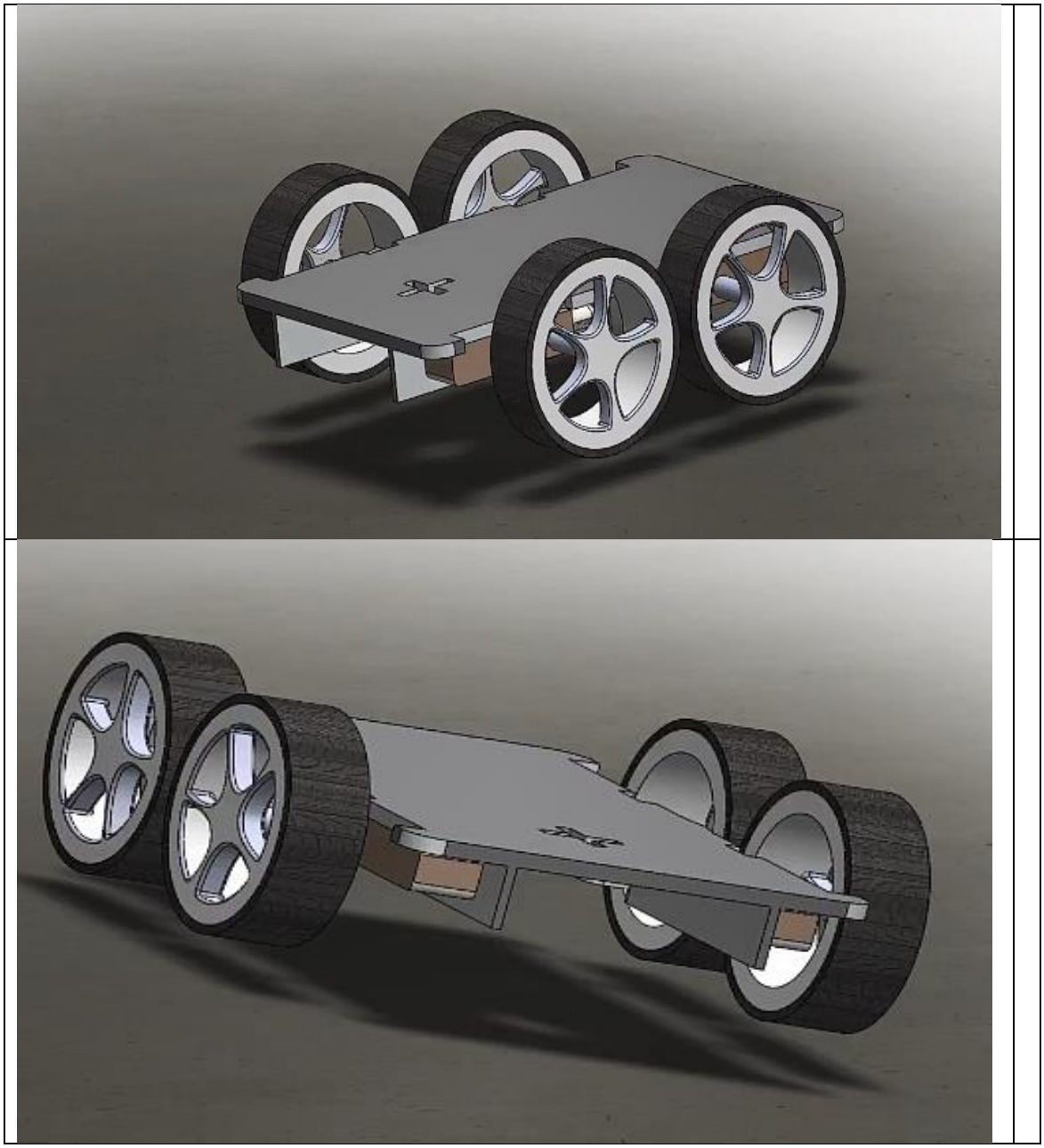

Figure 3: 3D model for prototype vehicle

3.4 Design Parameters selection

3.4.1 Driver drowsiness detection

In detecting driver drowsiness, MPU6050 gyrosensor has been used, head motion can also be detected using IR sensor and Accelerometer. But they are bulkier and more difficult to handle than gyrosensor, moreover, gyrosensor has small dimension (9mm*9mm) and it has 3 axis accelerometer in it. Its flexibility for this project is higher than IR sensor. So, Gyrosensor has been used in detecting head motion of the driver.

3.4.1.1. Gyrosensor circuitry and analysis

A proteus simulation has been done for simulating the project. Which is shown in **Figure 4:*MPU6050 connection in proteus.***

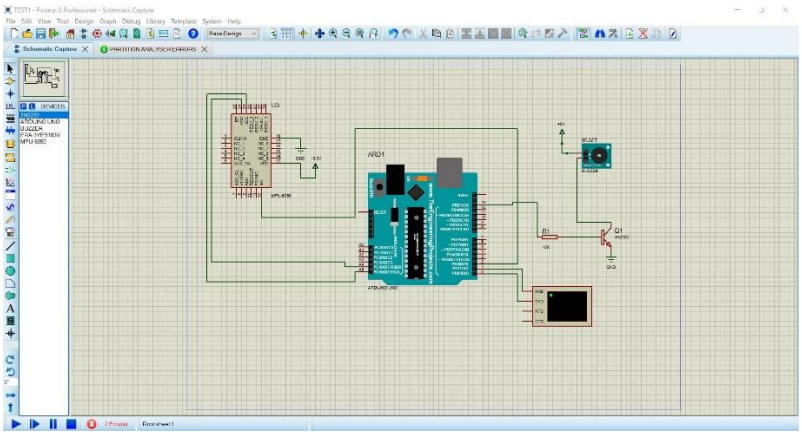

Figure 4:MPU6050 connection in proteus.

3.4.2 MQ3 – Alcohol detection

An investigation was carried out to testify the presence breath alcohol by using MQ-3 Alcohol Sensor. The Arduino microcontroller acts as a heart and core of the whole system which control the operation. The MQ-3 Alcohol Sensor detects the alcohol concentration of exhaled breath of the driver, transmits the data to Arduino. The working range of MQ-3 sensor is within 0.04 mg/L to 4 mg/L. The legal limit of breath alcohol is 0.4 mg/L in most of the case[10]. It has high sensitivity for alcohol and small sensitivity for Benzene.

When alcohol is present in the air, the sensor's conductivity increases along with rising gas concentration a simple circuit converts the change of conductivity into corresponding output signal of gas concentration.

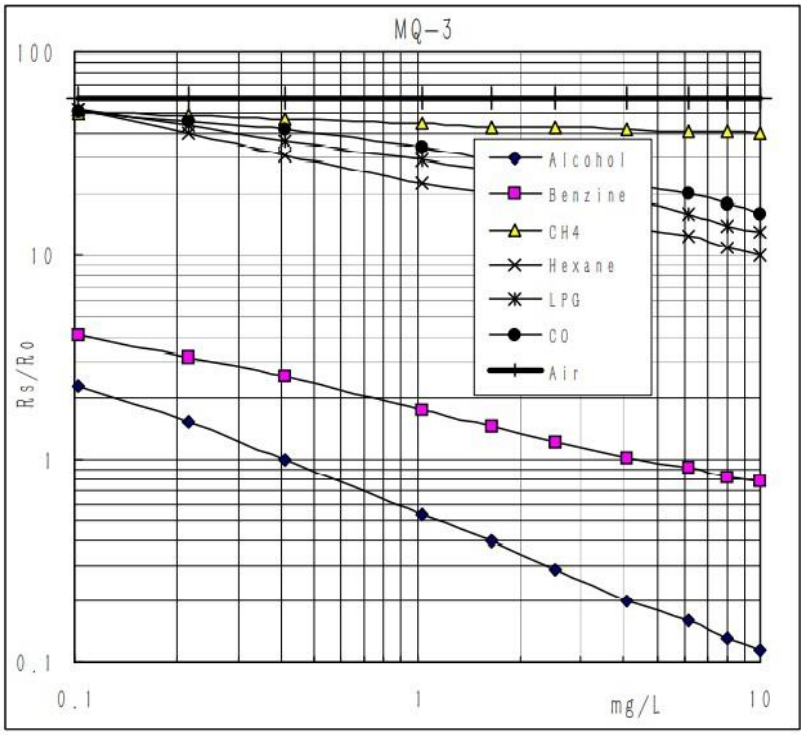

Figure 5: Sensitivity characteristics of MQ-3 for various gases Temp: 20℃

Resistivity of MQ-3 differs with various types and concentrations of gases. So, while using this sensor, sensitivity adjustment is very essential. It is proposed to calibrate the detector for 0.4mg/L (approximately 200ppm) of Alcohol concentration in air and to use value of Load resistance about 200 KΩ. While calibrating, the proper threshold point for the gas detector should be predetermined. The temperature and humidity influence must be considered as well.

3.4.2.1. MQ-3 circuitry and analysis

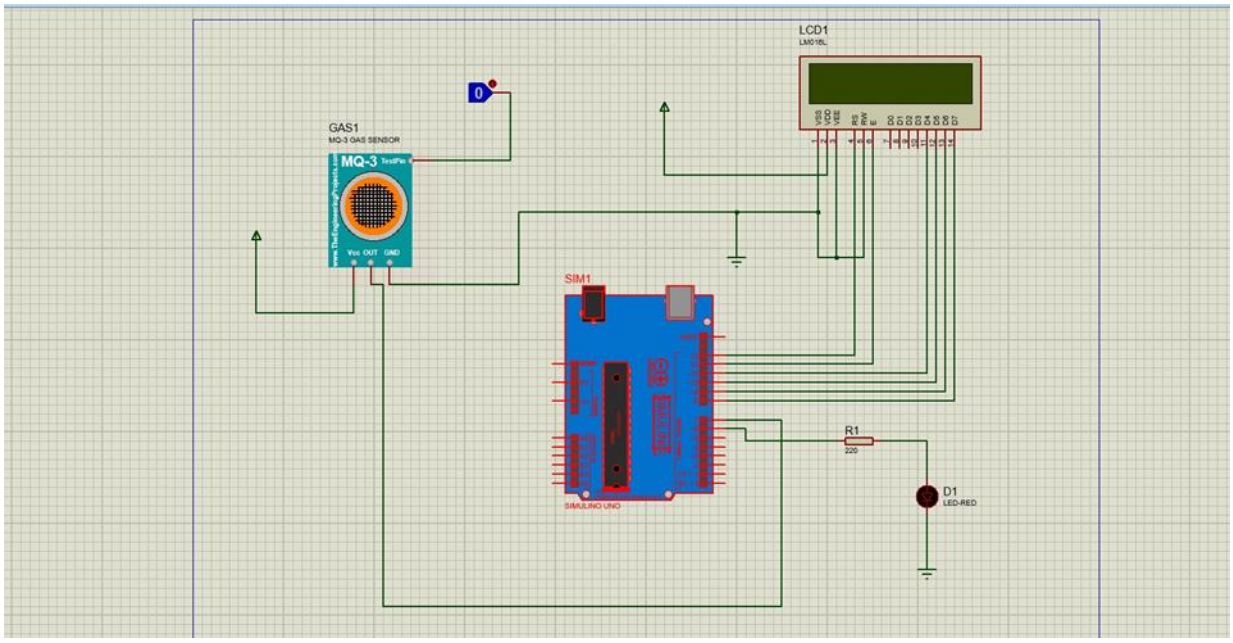

Figure 06: Circuit diagram for detecting drunk driver using MQ-3 Alcohol senor

It has simple drive circuit and long life moreover it is inexpensive. Power supply required is 5V, it has three pins for output (analog as well as digital), ground and VCC. **Figure 06***: Circuit diagram for detecting drunk driver using MQ-3 Alcohol senor* shows the circuit diagram of MQ3 Alcohol sensor embedded with Arduino.

3.4.3 L298 and Speed control of DC motor

Here we use L298N motor driver for controlling DC motor speed by changing supply voltage. L298N is a dual H bridge motor driver which can control speed and direction of two to four DC motor at a same time. Pulse width modulation (PWM) signal is sent through enables A enables B pin to control speed of motor.

3.4.3.1. PWM (Pulse Width Modulation)

PWM or pulse width modulation is a technique which allows us to which allows us to adjust the average value of voltage that's going through an electronic device by turning on and off the power at a first rate. The average voltage depends on the duty cycle or the amount of time the signal is on versus the amount of time signal is off in a single period of time.

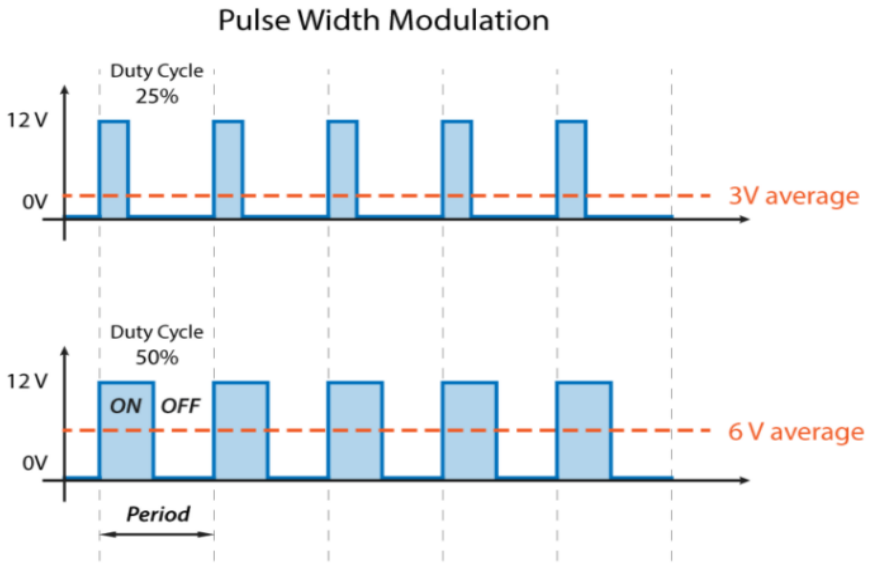

Figure 07:Pulse Width Modulation signal.

So, depending on the size of the motor we can simply connect Arduino PWM output to the base of the transistor or the gate of a MOSFET and control the speed of motor by controlling the PWM output.

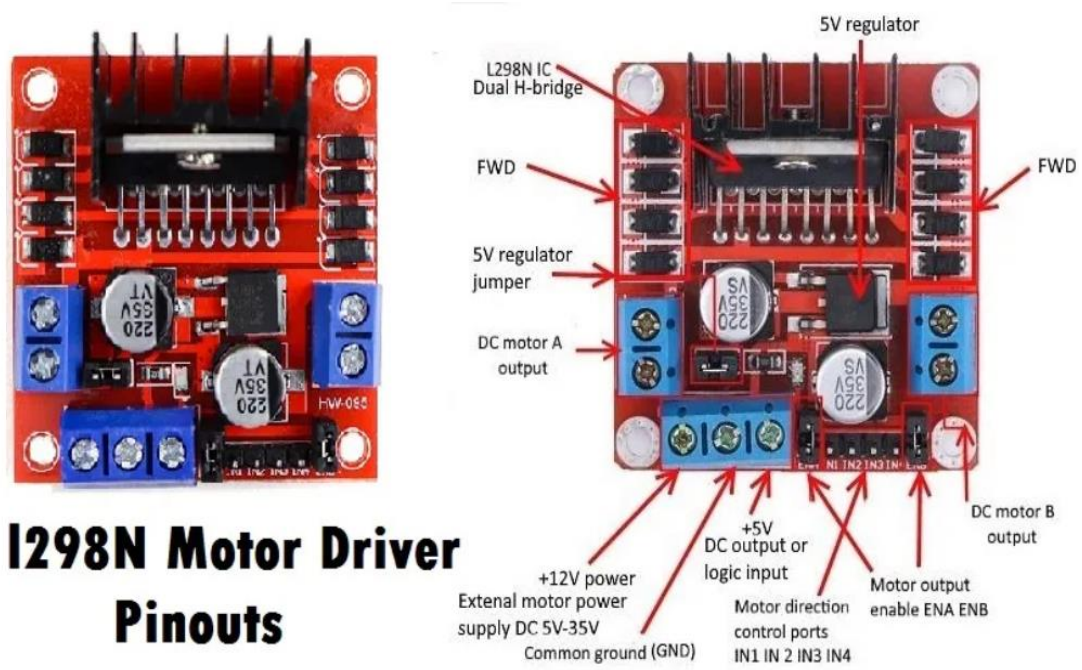

Figure 08: L298 motor driver.

3.4.3.2. Simulation and Connection

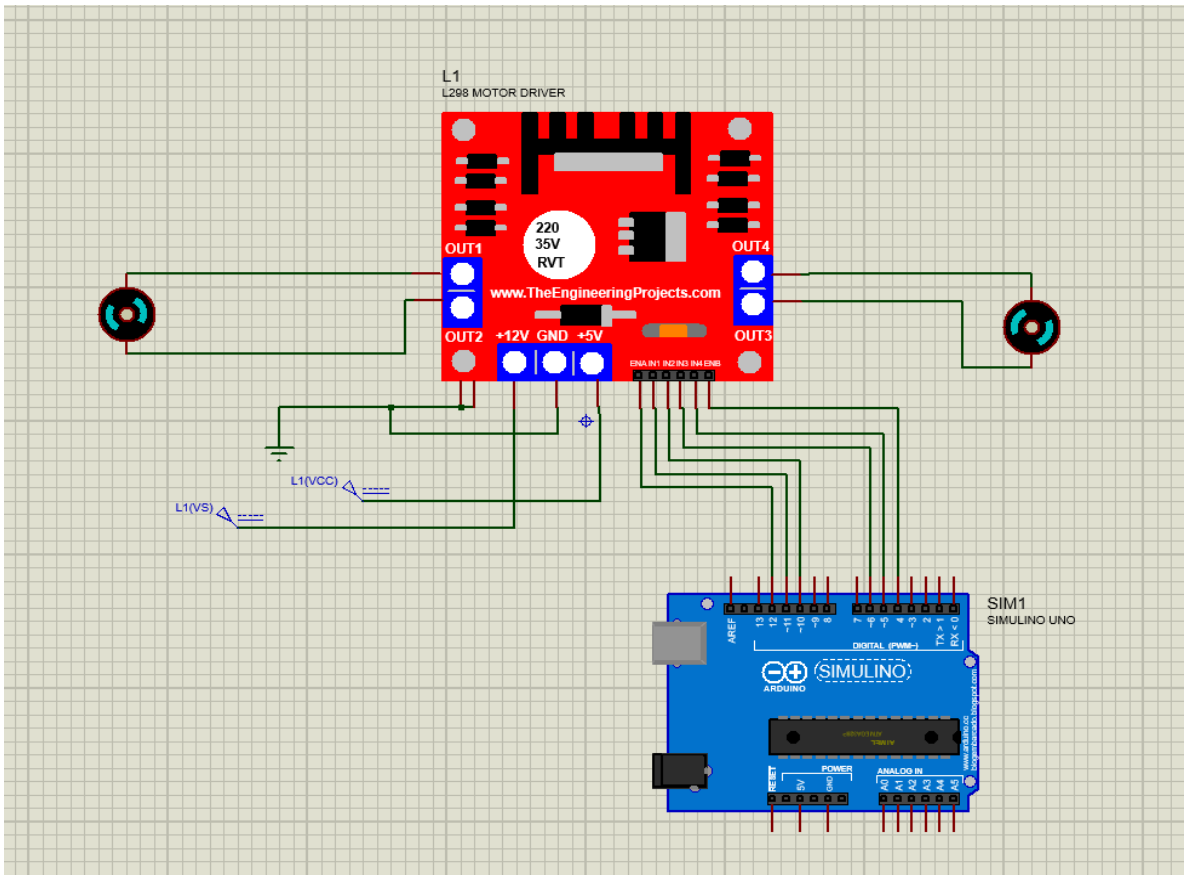

Figure 09: L298 proteus simulation.

3.5 Equipment Assembly

3.5.1 MPU6050

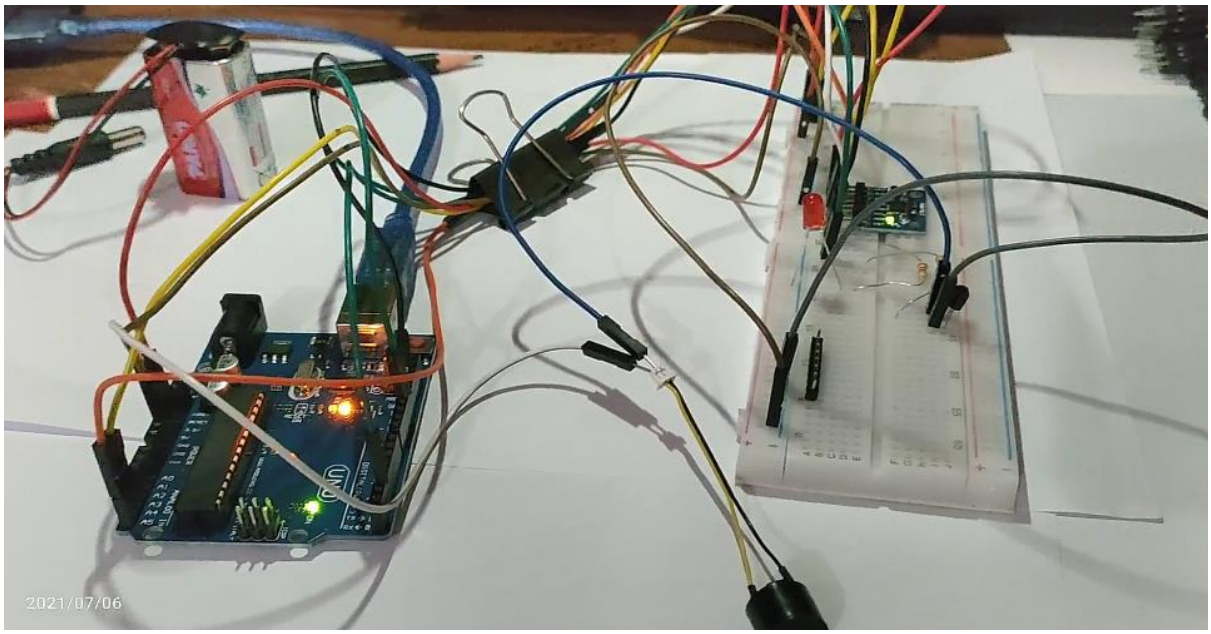

Figure 10: MPU6050 connection

Figure 10*: MPU6050 connection* shows the connection of gyrosensor. It's a test connection. There is a buzzer and LED for alarming. The axis along the length of the breadboard assumed as x axis for the gyroscope. Left side is the front of the driver and right side is the back of the driver. The gyroscope is to be mounted on driver's head. The small square shaped sensor placed on the breadboard is the gyrosensor. It has a small LED which turns on when 5V is input and indicates the activeness of the sensor. If the driver tilt his head towards his front side(left side in **Figure 10*: MPU6050 connection***) more than +50 degree (with respect to the perpendicular plane along the length of the breadboard) for more than 1.5 second, the buzzer and LED turns on and send alert as fast as the driver is asleep. Same thing happens for leaning back (-50 degree) for 1.5 second. Threshold for the angle that dictates the sleepiness of the driver has not been taken arbitrarily. A study[8] shows the relationship between head leaning angle and drowsiness. A result from this study shown in **Figure 11*: Head movement with sleepiness*.**

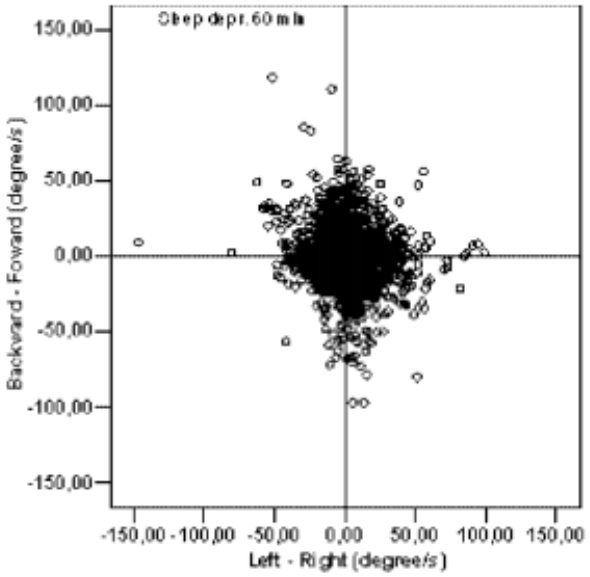

Figure 11: Head movement with sleepiness[8]

Figure 11 shows head movements in a drowsy state. From this figure the high frequency data is +50 to -50 degree, which have been used in this project.

3.5.2 MQ-3: Alcohol detection

We calibrated the system according to the source. When the sensor detected a concentration higher than the threshold set on Arduino code, system turns the buzzer on. At the same time, a 'Drunk Alert' message was shown to the display and started continuous blink in-blow out of a LED. **Figure 12*: Arduino based drunk driver system***. shows the Arduino operated drunk driver detection system.

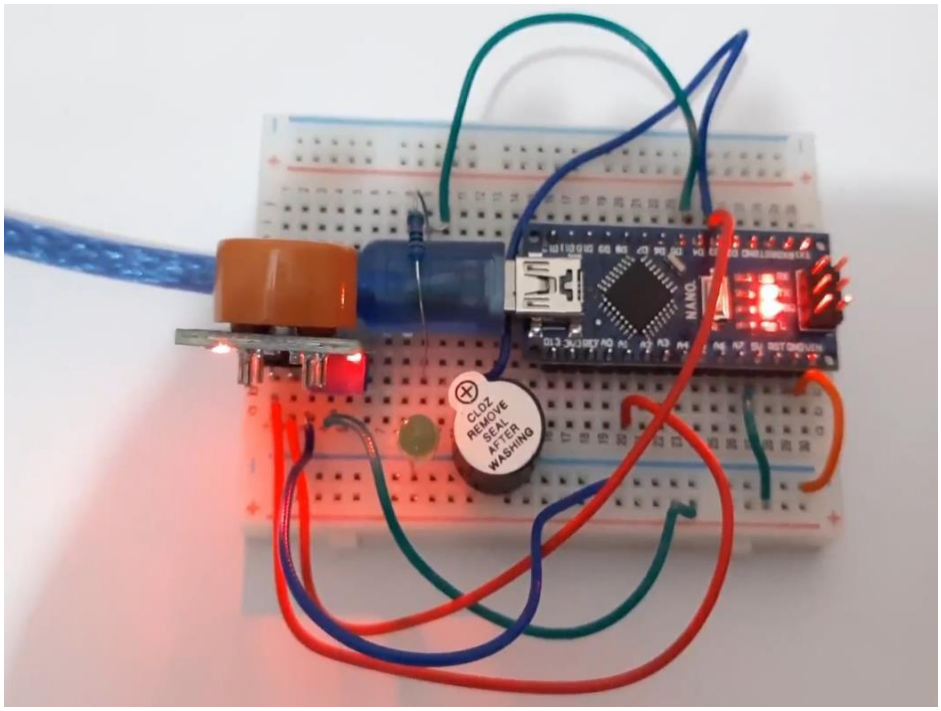

Figure 12: Arduino based drunk driver system.

3.5.3 L298 based speed control of DC motor

Two DC motors have been used for this prototype. These are connected to Arduino through L298. The integration is shown in **Figure 13***: DC motor control with L298.***.**

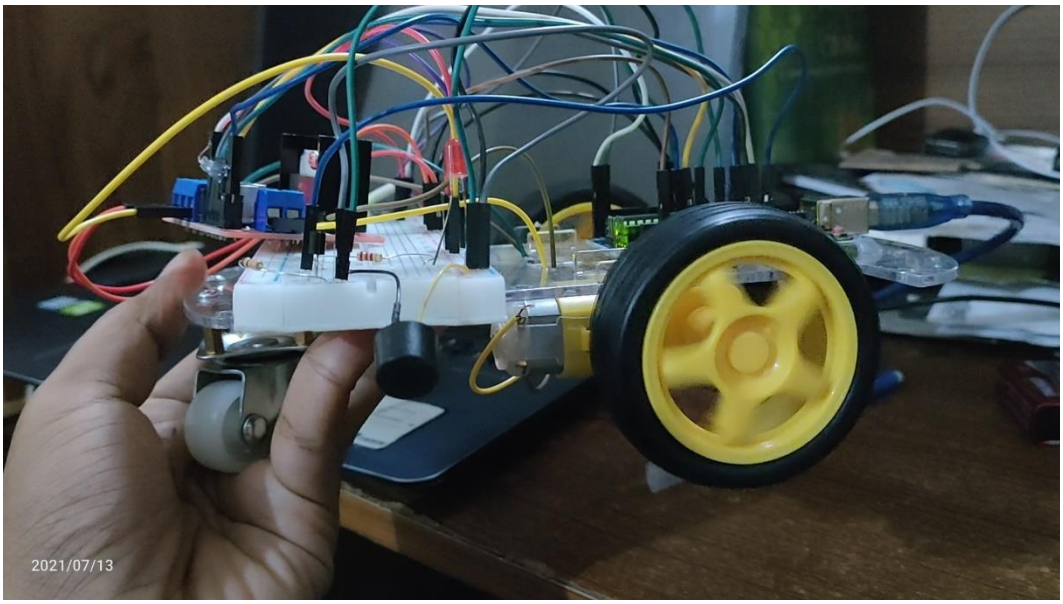

Figure 13: DC motor control with L298.

3.5.4 Final Integration

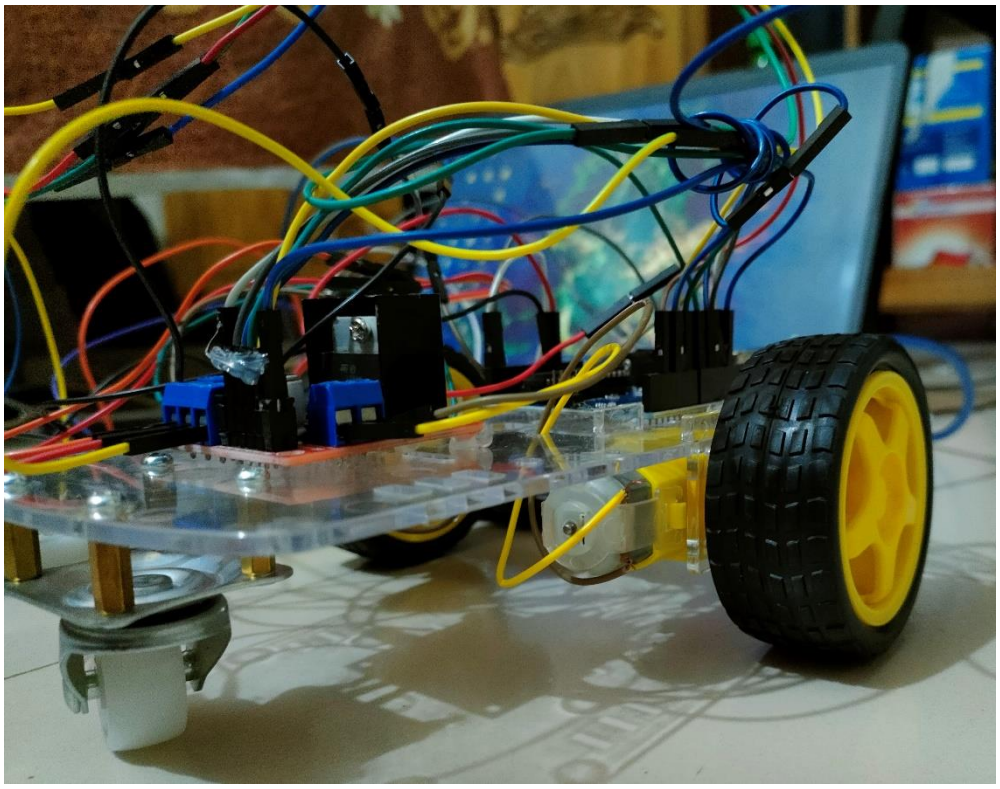

Figure 14: Final Assembly

Figure 14*: Final Assembly* showing the prototype of the vehicle to show the speed control. It is embedded with drowsiness detection system discussed in section **3.5.1**. When the gyrosensor data goes out the optimum values, the alarming system start buzzing and the speed of the motor decreases. The speed is reduced (not fully stopped) to avoid accident and also to avoid the effect of inertia.

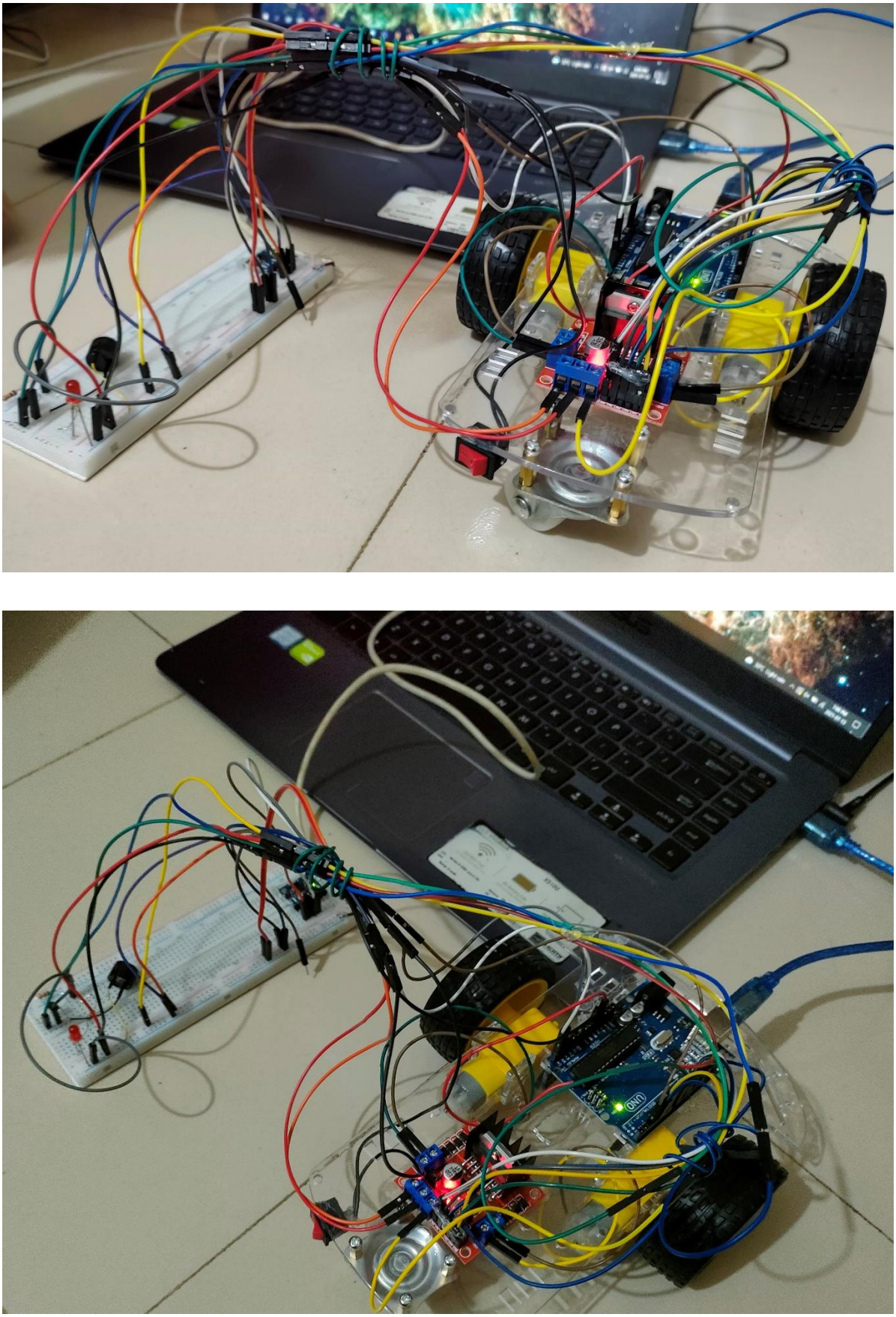

Figure 15: Final Assembly for the accident reduction system prototype

4 Calculation

As our main goal was to design an accident reduction system design & no calculation is associated with this. It depends on many factors. We try to design a prototype which shows a system where speed is controlled from reflection of human based measurements.

As motor speed formula

$$\omega = \frac{V_T}{k\varphi} - \frac{R_A}{(k\varphi)^2}\tau_{ind} \ldots\ldots\ldots (1)$$

If we keep constant R_A and k constant and choose two voltage sources V_{T_1} and V_{T_2} for which speed of motor is ω_1 and ω_2 respectively.

Now, if $V_{T_1} > V_{T_2}$ then from equation 1 it can be obtained that $\omega_1 > \omega_2$.

When accident reduction system is designed one factor are kept to constant as this system associated with many factors. All factors cannot be overcome.

Accident Modification Factor

$$AMF = 1 + 0.106(\frac{L_c}{L})(\frac{5730}{R_c})^2$$

Here,

AMF = Horizontal curve radius accident modification factor

L_c= horizontal curve length (mile)
R_c= Curve radius (ft)

Crash Reduction factor,

CRF = 1- *AMF* [11]

5 Result and Discussion

Here our project run successfully by detecting drowsiness through gyroscopic sensor which we cannot calibrated due to un available of soldering iron in this pandemic situation. Tilting angle was kept here -50° to +50°.After a certain time drowsiness is detected.

For controlling speed motor after getting response whether driver is sleepy or drunk an output displayed on speed of dc motor whose speed was controlled by varying supply voltage although we can control speed by changing flux and changing armature current flowing through field windings. For changing speed of motor by changing supply voltage depending on the human based behavior we use L298N motor driver. L298N is a dual H bridge motor driver which controls speeds and direction of 2 to 4 dc motors at a same time.

From enable A&B pin of module a PWM signal is passed through which speed of motor is controlled based on the condition.

Here alcohol sensor detects presence of alcohol which limit is from 25 to 500 ppm. Beyond this concentration level this sensor cannot detects the presence of alcohol. As alcohol is not available to us so we use perfume here for our purpose. Now it may arise a problem such if a driver uses body spray before driving then our system will give a message. To overcome this problem sensitivity of sensor can be changed maintaining with the concentration level of body spray that usually we used.

After many days of use sensor may not able to show accurate data as precession value is changed. Also, sensitivity needs to be changed based on the requirements. This problem can be overcome by following suitable way. Noise filters can be used to increase precession. For changing sensitivity of sensors series parallel arrangements can be used. Band pass filter, amplifier can also be used in order to change sensitivity of sensors.

6 Conclusion

Accident reduction is a huge work and there are vast ways to improve the design. An effective solution is provided to develop a system for vehicles which will sense the level of alcohol present in the breath of the driver and the controller IDE will respond accordingly. By implementing this design, a safe journey is possible by decreasing the accident rate due to drunk driving. The control system will serve the benefit of cost economic, small volume and high reliability. This

project emphasizes on just driver's drowsiness, one of the major cause. Our main goal was to design a prototype which shows a system where speed is controlled in any case of driver drowsiness, whether he is drunk or sleepy. Sensors used in this project are of high accuracy and shows fast reflex. The cost was economic. Though there were difficulties in integration of parts due to this pandemic situation, we have finished 90% of our project, only mounting of equipments were hampered a bit.

7 Reflection on learning

This electro mechanical project helps to give knowledge work done practically & also inspires to do more thing like this in future.

To complete this project, we introduced with some new software like Arduino for coding needs to run this project, proteus for electrical simulation to check whether the design run or not practically.

To complete Cad model which is our only part of mechanical design we have to use solidworks which is very interactive and so interesting to complete any 3D design.

To apply theoretical knowledge practically in real life scenario and observe what problem arise when working practically and how to overcome them to get expected output.

Though there was a difficult situation for us to do this project due to this pandemic, we have tried our best and worked as a team.

8 Future works

This model can be improved by correlating physiological measurement (ECG, EMG, EEG etc.) with both vehicles based & human based measurement which will make this model more accurate and reliable.

This model can be improved incrementally by using other parameters like blink rate, yawning, state of the car etc. If all these parameters are used, then we can improve the accuracy by a lot.

By controlling Steering Wheel Movement (SWM) we can improve the accuracy of this system. Using an angle sensor mounting on the steering column, driver's steering behavior is measured. When drowsy, the number of micro-correlations on the steering wheels reduces, compared to normal driving.

Accidents can be prevented caused due to sudden heart attack of drivers of drivers by adding a sensor to track the heart rate.

LBP (Local Binary Patterns) technique can be used here which have aroused increasing interesting image processing. This technique is mostly used for detecting emotions on the face like happiness, sadness, excitement etc.

Same model and techniques can be applied for various other uses like NETFLIX and other streaming services can detect when the user is asleep and stop video accordingly. It can also be used in application that prevents user from sleeping.

By sensing obstacle at a certain distance adding a sonar sensor integrating with our proposed system.

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youtube links:

https://www.youtube.com/watch?v=I7IFsQ4tQU8&t=463s&ab_channel=HowToMechatronics

https://www.youtube.com/watch?v=9rNZLVkrop4&ab_channel=ElectronicClinic

Physical Demonstration Video links

1. https://buetedu-my.sharepoint.com/:v:/g/personal/1710035_me_buet_ac_bd/EYIB7Rw-DyZOpUM_Ty7ZqbQBaxBEu3J1Ks0DcEty_o7lmA?e=EHec5w
2. https://buetedu-my.sharepoint.com/:f:/g/personal/1710043_me_buet_ac_bd/Ei2B1koJ8HpMi7Qa1rnBuQwB0IpvhcZe00SGxbzEALdh9Q?e=XdSTgf