VISVESVARAYA TECHNOLOGICAL UNIVERSITY
Jnana Sangama, Belagavi - 590 018

PROJECT REPORT ON

RAKSHAK – A secure riding helmet with embedded intelligence

Project submitted in partial fulfillment for the Award of Degree of
Bachelor of Engineering
in
Electronics and Communication Engineering

Submitted by

Shraddha Singh	1RN18EC148
Sumukha M	1RN18EC160
Aditya Venkata Sheshu	1RN18EC167
Vineeth Kumar Kori	1RN18EC173

Under the Guidance of
Prakash Tunga P
Assistant professor

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

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Dr. Vishnuvardhan Road, Channasandra, Rajarajeshwari Nagar, Bengaluru - 560 098
Telephone : 080-28611880/1 Website : rnsit.ac.in

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Dr. R N Shetty
Founder

Department of ECE

National Conference
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Emerging Trends in Engineering, Science and Technology

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Mrs. Ibrar Jahan M A	Dr. Rajini V Honnungar	Dr. Vipula Singh	Dr. M K Venkatesha
Co-ordinator, ECE, RNSIT	Co-ordinator, ECE, RNSIT	HoD, ECE, RNSIT	Principal, RNSIT

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Dr. R N Shetty

Founder

Department of ECE

National Conference

on

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This is to certify that Vineeth Kumar Kosi, of R N S Institute of Technology has won I Place in the Best Paper award category for the paper entitled Rakshak: A secure riding helmet with Embedded Intelligence in the IETE Sponsored Fifth National Conference on "Emerging Trends in Engineering, Science & Technology" held on June 22, 2022, Organized by the Department of Electronics & Communication Engineering.

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Department of Electronics & Communication Engineering

IEEE BANGALORE SECTION

Project Open House - 2022

Certificate of Appreciation

The project Rakshak - A secure riding helmet with embedded intelligence

carried out by Aditya Venkata Sheshu

Shraddha Singh

Sumukha M

Vineeth Kumar Kori

of VIII th semester, has been awarded the Best Project in the domain-*Signal and Image Processing/Communication Systems/Embedded Systems/AI-ML/VLSI* in "Project Open House - 2022" held on June 18, 2022.

Dr. Vipula Singh
HoD, ECE

Dr. M K Venkatesha
Principal

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Dr. R N Shetty
Founder

Department of Electronics & Communication Engineering

IEEE BANGALORE SECTION

Project Open House - 2022

Certificate of Appreciation

The project "Rakshak - A Secure riding Helmet with Embedded Intelligence"

carried out by

Aditya Venkata Sheshu,
Shraddha Singh, Sumukha M &
Vineeth Kumar Koli

of VIIIth semester, ECE has been awarded II Prize

in the "Project Open House - 2022" held on June 18, 2022.

Dr. Vipula Singh
HoD, ECE

Dr. M K Venkatesha
Principal

Acknowledgement

The joy and satisfaction that accompany the successful completion of any task would be incomplete without thanking those who made it possible. We consider ourselves proud to be a part of RNS Institute of Technology, the institution which moulded us in all our endeavors.

We express our gratitude to our Founder late **Dr. R N Shetty**, for providing state of art facilities.

We would like to express our sincere thanks to **Dr. M K Venkatesha**, Principal and **Dr. Vipula Singh**, Professor and HOD, Department of ECE, for their valuable guidance and encouragement throughout our program.

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Finally, we take this opportunity to extend our earnest gratitude and respect to our parents, teaching and non-teaching staff of the department, the library staff and all our friends who have directly or indirectly supported us.

Shraddha Singh

Sumukha M

Aditya Venkata Sheshu

Vineeth Kumar Kori

Abstract

Road accidents are increasing day by day because the riders are not using the helmet and due to consumption of alcohol. In today's world, huge number of people are dying on road accidents. By using smart riding gear, the accidents can be detected. The main target of the project is designing a smart riding gear for accident avoidance, alcohol detection, traffic sign detection and informing the rider, pollution level detection. The IR sensor checks if the person is wearing the helmet or not. The Gas sensor recognizes the alcoholic substance in the rider's breath. We intend to prevent accident and drink and drive by demonstrating the engine cutoff on the occasion of alcohol detection. This design uses solar panel, saving the energy/power sources, making it self sustainable. It also detects the traffic signs with the help of object recognition and classification using machine learning and alerts the rider, and uses a gas sensor to signify the pollution level.

If there is no sign of alcoholic substance present and helmet is used, then only the bike will start. When the rider meets with an accident, the sensor recognizes the condition of the motorbike and reports the accident. The GPS in the bike will send the location of the accident place to respective contacts.

Wearable safety equipment has been able to take an important position in the area of safety devices in a short period and is considered as a business opportunity in the field of automobile industry.

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Acronyms

GPS : Global positioning system

GSM : Global System for Mobile Communications

UART :Universal asynchronous receiver-transmitter

NMEA : National Marine Electronics Association

PWM : Pulse Width Modulation

GND : Ground

VNC :Virtual Network Computing

Chapter 1

Introduction

1.1 Project background and motivation

1.1.1 Embedded systems for wearable electronics

The purpose of embedded systems is to control a specific function within a device. They are usually designed to only perform this function repeatedly, but more developed embedded systems can control entire operating systems. Some more complex embedded systems can also perform several different functions, but these are still relatively simple tasks that do not require a large amount of processing power.A key characteristic of embedded systems is that they aren't usually programmable, so once they have been set up to perform a specific function they operate reliably and do not need to be tampered with. However, the software on some devices with embedded systems can be upgraded which means that programmed functions can be refined.

By being designed and programmed to only have one purpose, an embedded system is an incredibly reliable electronic component that does not need very much maintenance and is pretty easy to add to a device. Whilst they are a critical part of a system, they are very unlikely to malfunction and do not need reprogramming so are an essential part of many devices that are required just to function without intervention, like household appliances.

The explosive growth of the **Internet of Things** is changing our world and the rapid drop in price for typical IoT components is allowing people to innovate new designs and products at home.An embedded system may or may not connect to the internet. Traditionally, it was built for a dedicated purpose with limited connectivity with other devices. The objective was to process the real-world information from sensors in real time.While the embedded systems enable this data to be sent and often interpreted locally, the internet transmits this data to and from online (cloud) services.

So, when we want an embedded device to talk to an ecosystem (other embedded systems, cloud, internet), communication channels like WiFi, RF, 5G, LoRa, and others come into play.The 'Thing' in the IoT is an embedded system. So, in a way, embedded systems are a subset of IoT. While IoT is a newer concept, embedded systems have been available since the advent of the electronics era.IoT embedded systems have touched every facet of our life. Whether it's a modern supply chain where IIoT is enabling consumers to track their shipments in real-time or a next-generation healthcare service using IoMT to deliver critical therapies outside the hospital's walls, embedded systems have become widespread. IoT embedded systems have a tremendous amount of potential across a variety of business cases, and advanced technology development plays a significant role in this regard.

Wearable Embedded systems are cyber-physical systems that are carried from persons in their daily activities and can assist in quality of life through augmented sensing for the disabled, independent living for the elderly, and reduced healthcare costs. The implementation of wearable embedded systems is normally based on commercial available chipsets while some applications recently efforts have also focused on the development of e-textiles that will effectively disappear these systems in the person's clothes. The challenges faced with this type of embedded systems includes strict requirements for the size and energy resources together with severe constraints in computational power, while the highly variable environment due to person's movements and the body itself results to a complicated transmission channel for wireless connectivity affecting the bandwidth and the quality of communication.

1.1.2 Motivation

With the rapid increase in traffic and exponential increase in the number of accidents, there is a demand for safety, particularly in the two-wheeler line-up, notably in India, which is home to the world's largest number of motorised two-wheelers. India roughly accounts for just about one percent of the global vehicle population. However, it accounted for about six percent of the total global road accidents. In 2020, there were around 132 thousand deaths due to road accidents in India most of them being related to two wheeler riding and improper caution of road safety.Road safety is something important that has to be followed at all times to ensure the safety of the operators of a vehicle, passengers, and pedestrians. In fact, road traffic injuries are the leading cause of death among people aged between 15 and 29 years. Traffic rules and guidelines have to be set in place and strictly followed so that serious accidents and injuries can be averted.

Another key motivation factor and research area we looked into was that the demand for eco friendly items has risen dramatically with the need for more green tech products crucial for techological revolution in the modern day. Although the market for green technology is relatively young, it has garnered a significant amount of investor interest due to increasing awareness about the impacts of climate change and the depletion of natural resources. In contemporary times, it is critical to address the subject of how electronics might be made more eco friendly.

With these concerns and considerations in mind, the ever-expanding domain of embedded systems combined with IoT, as well as the growing demand for road safety and eco friendly approaches, inspires and motivates us to create our own eco-friendly, low-cost, secure, embedded wearable device for riders to use on Indian roads, ensuring their safety and comfort.

1.2 Objectives

In this project we aim to:

- Develop a safe, eco-friendly wearable equipment, integrating microcontroller and various sensors which provides a convenient and secure riding experience.
  The equipment is to have the following features:
  - Alcohol Detection
  - Identifying accidents and sending sos alerts
  - Identifying traffic signs and informing the rider
  - Pollution level detection
  - Clearing the view off rain using Wipers on visor
- Target the Indian market with increased sale volume, lower cost and increased efficiency.
- Utilize solar power to run the embedded hardware thereby ensuring eco-friendly usage of the proposed technology.
- Lend a significant helping hand in accident prevention.
- Encourage usage of helmet among the mass by attracting physical features.

1.3 Block Diagram

The figure 1.1 depicts the internal component interconnection; the orange blocks represent various sensors and other required hardware components, the green blocks represent power and related components, and the purple blocks represent the raspberry pi board, which serves as the central processing block of this system.

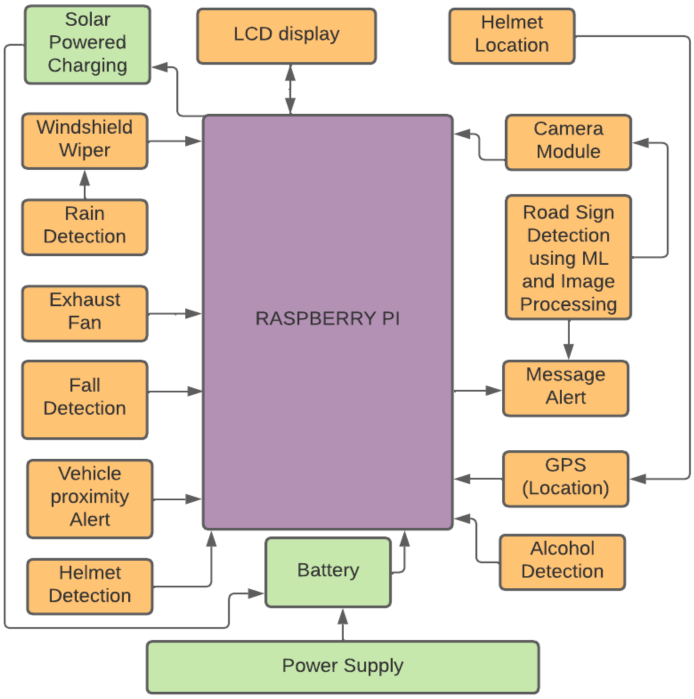

Figure 1.1: Block Diagram of Smart Riding Gear

A wide range of functions are supported by the proposed smart riding head gear. Using an infrared sensor, it first determines if the driver is wearing a helmet. It also determines the proximity of the other vehicles. The MQ3 gas sensor will detect the presence of alcohol in the rider's breath. The bike will not start unless the driver is sober and wearing a helmet. This lowers the risk of rash or inebriated driving. A smoke sensor detects dangerous gases and buzzes to inform the user. This helmet may be powered by either an external battery or a solar panel, which is both environmentally beneficial and renewable. Tilt sensor is used to measure the tilt of the helmet, to detect the accidents. The tilt data is also sent to the Raspberry Pi microcontroller, which sends an SOS to a pre-registered phone number along with the location of the rider. The riding gear incorporates an exhaust fan to minimise the heat created if the temperature rises. It has a GPS module for tracking the whereabouts of the riding equipment. This clever device also has a wiper to keep the wind shield clear when it's raining. It has one emergency SOS button that, when touched, makes the riding gear buzz and transmits an SOS alert to the registered phone number.

1.4 Applications

- Locating accident area in the case of an emergency.

- Encouraging eco-friendly and renewable energy/power sources.
- Providing safe and secure driving experience.
- Detecting Traffic signs and alerting the rider.
- Providing hands-free navigation using Bluetooth speaker and microphone.
- Preventing drunk and drive situations.
- Ensures the safety of the women during any unsafe situation.
- Preventing the accidents.

1.5 Advantages and Disadvantages

Advantages:

- Rescuing the rider at the earliest when the rider is met with an accident.
- Saving the energy/power sources, making it self sustaining.
- Traffic sign alerts to the rider in case of violation of rules.

Disadvantages:

- Ensuring the good performance of all the components in rainy weather.
- Finding suitable materials to reduce the harmful radiations emitted from the electronics components mounted on the head gear would be challenging task.

Chapter 2

Literature survey

We established this issue as the most beneficial technology in the present moment after reading several study papers based on smart helmets. The survey of few research papers are as follows:

The total number of fatalities in 2015, according to the Global Status Report on Road Safety, caused by traffic collisions has levelled off at annually 1.25 million. India has the most difficult number of accidents and fatalities from accidents in the globe. There are numerous types of areas like plateaus in mountainous terrain, and because of improperly maintained roads cause more and more accidents. More people die as a result of these accidents. Most accidents are reported, on average in the transportation industry, namely in the field of railways. Some estimates assert that only Indian highways accounted for roughly 105,000 fatalities due to accidents in 2010. Here is roughly 15% of all traffic fatalities worldwide when India only makes up 1% of the world's population vehicles. Over the course of the year, there have been a rising number of accidental deaths. a 50% growth from 2000 to 2015 in the comparing the year 2010 to the year 2000 Planning Commission of India claims that the A total of 2.5% of India's annual economic loss GDP as a result of an increase in traffic fatalities. National Crime Records Bureau claims that Ministry of Highway and Road Transportation, Law India's commission, one serious traffic accident in the nation per minute, 16 people pass away. on roadways in India every hour. Consequently, the Data Tables for the 2015 WHO Report the overall 2013 saw a certain number of fatalities in India. 238,562 road traffic deaths have been registered, with 137,572 people are believed to die in automobile accidents per year. 100,000 people were present.

Death from traffic accidents, particularly among young people, costs nations between one and three percent of their gross domestic product. national output. One of the key elements that is This number is rising as a result of the delayed reporting of the collisions to emergency facilities such the local police stations and medical facilities. As stated in , The 2030 Agenda for Sustainable Development was released in 2015. development was started with the intention of lowering the death and injury toll resulting from traffic accidents to half its number by 2024, the year [1].

In 2018, a system was proposed which was based on the Internet of things (IOT) and also keeps a continuous track of the location and the speed of the vehicle while driving. It also provides the information of helmet being placed on position. All the details can be traced by the concerned people on Internet/Mobile application [2].

Again in 2014, one more system was proposed which uses the GPS and GSM as its core technologies. Vibration sensors were placed in different sections of helmet where the chances of hitting was more, so when the rider crashes, these sensors sense and provide it to the microcontroller board, then controller extract the GPS data. When the data by different sensors goes below the minimum stress limit then GSM module automatically sends alerting message to ambulance or family members [3].

In 2014, the system was proposed which automatically checks whether the person is wearing the helmet and has non- alcoholic breath while driving. There is a transmitter at the helmet and a receiver at the bike, and switch on the inner surface of helmet to ensure the wearing of helmet. The data to be transferred is coded with RF encoder and transmitted through radio frequency transmitter. The receiver at the bike collects the data and decodes it through RF decoder. MCU controls the function of relay and thus the ignition of engine [7].

The author presented a technique for preventing bike accidents in [8]. The system is designed to lower the risk of death. To ensure that the bike rider is wearing the smart helmet, the author employs an infrared sensor. When an accident occurs, the system recognises it and uses the GSM module to relay an accident location to the nearest hospital. The GPS monitoring device detects precise position data. A three-axis accelerometer sensor is used to detect an accident.

The failure of medical assistance to reach on time is the leading cause of mortality in most accidents. No one can be notified to the ambulance in distant areas where accidents occur. The author of [9] suggests a cloud-based accident monitoring system. Motorcycle units, ambulance units, and medical centre units are the three primary units. The system's primary goal is to relay accident sites to the nearest medical facility.

Nowadays most of the countries are forcing the motorcyclists to wear helmets and not exceed the speed limit on their vehicles. Despite this, users continue to violate the rules. Various researchers have focused on employing technological solutions to address this major issue, such as the ignition not starting until the helmet is placed on the rider's head during the initial stage only [10], [11]. Other sensors can be included to help avoid accidents [12]. These techniques ensure that the rider is wearing the helmet. But there is no mechanism in place to safeguard you before an accident.

According to Nataraja K [13], a smart helmet collision avoidance system based on a sign board detecting system has been presented. The vehicle is equipped with a microcontroller and a communication system that allows a remote user to monitor it. Shikha Gupta's research [14] used a variety of sensors in conjunction with a Raspberry Pi to identify alcohol and collisions. The prototype was effective in sending the collision's GPS position as a text message to a remote user via phone. For alcohol detection, an Arduino Uno microcontroller was connected to sensors in a smart helmet [15]. This device can also tell whether the vehicle is inclined to a certain extent.

Chapter 3

System Design

This chapter illustrates the neccassary requirements and considerations for the implementation of the project work. Considering the hybrid nature of the overall system, several software as well as hardware considerations come into picture -

3.1 Hardware Requirements

The hardware components and sensors employed are as follows - The following are the hardware components and sensors used:

- Raspberry Pi
- GPS Module
- IR Sensor
- Alcohol Sensor
- Gas/Smoke Sensor
- Rain Sensor
- Servo Motor
- DC Motor Driver
- DC Motor
- Tilt Sensor
- Buzzer
- Power Supply Charging Step Up Module
- I2C LCD Display
- Solar Panels
- Lithium Ion Battery
- Mini Core-less Motor

3.2 Software Requirements

The neccassary software required involves the OS and applications that are integrated with the raspberry pi such as

- Twilio
- Thonny Python
- Raspbian OS
- Tensor Flow
- Anaconda (Python)

3.3 Description of Hardware Components Used

1. **Raspberry Pi 3 B+**
   It is a tiny computer board that comes with CPU, GPU, USB ports, I/O pins, WiFi, Bluetooth, USB and network boot and is capable of doing some functions like a regular computer. It also has wifi functionality, the dual-band WiFi 802.11ac runs at 2.4GHz and 5GHz and provides a better range in wireless challenging environments and Bluetooth 4.2 is available with BLE support. The figure 3.1 shows the Hardware model and internal components of Raspberry Pi 3 B+.

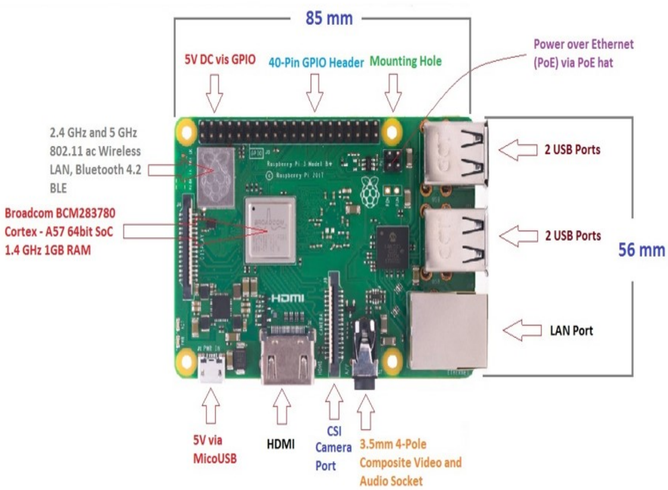

Figure 3.1: Raspberry Pi 3 B+

Pin Configuration:

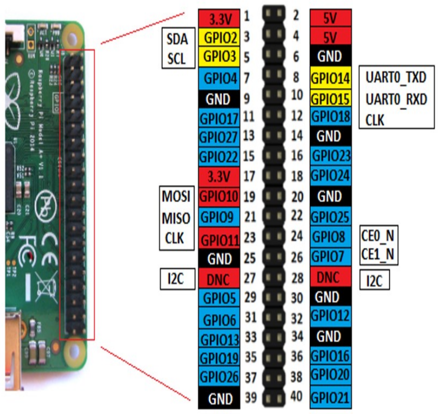

Figure 3.2: Raspberry Pi 3 B+ Pinout

The figure 3.2 shows the pinout diagram of Raspberry Pi 3 B+. It shows all the GPIO pins, power pins, SPI pins, I2C pins and UART pins.

- **Raspberry Pi 3 B+ Power Pins:** The model B+ board consists of two 5V pins, two 3V3 pins, and 9 Ground pins (0V), which are unconfigurable.

- **Input/Outputs pins:** A GPIO pin set as Input reads the signal received by the Raspberry Pi, sent by the device connected to this pin. Any voltage between 1.8V and 3.3V is read as HIGH and voltage lower than 1.8V as LOW by the Raspberry Pi. A GPIO pin set as an output pin sends the voltage signal as high (3.3V) or low (0V).
  Some specific pins are:
  PWM (pulse-width modulation) Pins:
  - Software PWM is available on all pins
  - Hardware PWM is available on these pins only: GPIO12, GPIO13, GPIO18, GPIO19

- **SPI Pins on Model 3B+:** SPI (Serial Peripheral Interface) is another protocol used for master-slave communication. It is used by the Raspberry pi board to quickly communicate between one or more peripheral devices. 5 pins are needed for the SPI communication:
  - **GND:** Connect all GND pins from all the slave components and the Raspberry Pi 3 board together.
  - **SCLK:** Clock of the SPI. Connect all SCLK pins.

  - **MOSI:** It stands for Master Out Slave In. This pin is used to send data from the master to a slave.
  - **MISO:** It stands for Master In Slave Out. This pin is used to receive data from a slave to the master.
  - **CE:** It stands for Chip Enable. We need to connect one CE pin per slave in our circuit. By default, we have two CE pins but we can configure more CE pins from the other available GPIO pins.

  SPI pins on Raspberry Pi Model 3B+:

  - **SPI0:** GPIO9 (MISO), GPIO10 (MOSI), GPIO11 (SCLK), GPIO8 (CE0), GPIO7 (CE1)
  - **SPI1:** GPIO19 (MISO), GPIO20 (MOSI), GPIO21 (SCLK), GPIO18 (CE0), GPIO17 (CE1), GPIO16 (CE2)

- **I2C Pins on R-Pi 3B+:** I2C is used by the Raspberry Pi board to communicate with devices that are compatible with Inter-Integrated Circuit. I2C has two connections: **SDA (Serial Data)** and **SCL (Serial Clock)**. They work by sending data to and using the SDA connection, and the speed of data transfer is controlled via the SCL pin.
  - **Data:** (GPIO2), Clock (GPIO3)
  - **EEPROM Data:** (GPIO0), EEPROM Clock (GPIO1)

- **UART Pins on R-Pi 3B+:** Serial communication or the **UART** (Universal Asynchronous Receiver/Transmitter) pins provide a way to communicate between two microcontrollers or the computers. TX (GPIO14), RX (GPIO15)

Technical Specifications of Raspberry Pi 3 B+:

- **Microprocessor:** Broadcom BCM2837 64bit Quad Core Processor
- **Processor Operating Voltage:** 3.3V
- **Raw Voltage input:** 5V, 2A power source
- **Maximum current through each I/O pin:** 16mA
- **Maximum total current drawn from all I/O pins:** 54mA
- **Flash Memory (Operating System):** 16Gbytes SSD memory card
- **Internal RAM:** 1Gbytes DDR2

- **Clock Frequency:** 1.2GHz
- **GPU:** Dual Core Video Core IV® Multimedia Co-Processor. Provides Open GLES 2.0, hardware-accelerated Open VG, and 1080p30 H.264 high-profile decode. Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure.
- **Ethernet:** 10/100 Ethernet
- **Wireless Connectivity:** BCM43143 (802.11 b/g/n Wireless LAN and Bluetooth 4.1)
- **Operating Temperature:** 40ºC to +85ºC

2. **U-blox NEO-6M GPS Module**

The figure 3.3 shows NEO-6M GPS receiver module which uses USART (Universal Synchronous Asynchronous Receiver Transmitter) communication to communicate with micro-controller or PC terminal. GPS receiver module gives output in standard (National Marine Electronics Association) NMEA string format. This string needs to be parsed to extract the information that we want to use. It provides output serially on Tx pin with default 9600 Baud rate.

Hardware Overview

- **NEO-6M GPS Chip:**
  At the heart of the module is a GPS chip from U-blox – NEO-6M. The chip measures less than a postage stamp but packs a surprising amount of features into its tiny frame.
  It can track up to 22 satellites over 50 channels and achieve the industry's highest level of tracking sensitivity i.e. -161 dB, while consuming only 45 mA current.
  Unlike other GPS modules, it can perform 5 location updates in a second with 2.5m horizontal position accuracy. The U-blox 6 positioning engine also has a Time-To-First-Fix (TTFF) of less than 1 second.
  One of the best features offered by the chip is Power Save Mode (PSM). This allows a reduction in system power consumption by selectively switching certain parts of the receiver on and off. This dramatically reduces the power consumption of the module to just 11mA making it suitable for power sensitive applications such as GPS wristwatches.
  The required data pins of the NEO-6M GPS chip are broken out to a 0.1 pitch headers. It contains the pins needed for communication with the microcontroller over the UART. The module supports baud rates from 4800bps to 230400bps with a default baud of 9600.

- **Position Fix LED Indicator**
  There is an LED on the NEO-6M GPS module that indicates the status of the 'Position Fix'. It will blink at different rates depending on which state it is in:
  - No blinking – it is searching for satellites.
  - Blink every 1s – Position Fix is found (the module can see enough satellites).
- **3.3V LDO Regulator**
  The operating voltage of the NEO-6M chip ranges from 2.7 to 3.6V. But the good news is, this module comes with MICREL's MIC5205 Ultra-Low Dropout 3V3 regulator.
  The logic pins are also 5-volt tolerant, so we can easily connect it to Arduino or any 5V logic microcontroller without using a logic level converter.
- **Battery EEPROM**
  The module is equipped with HK24C32 Two Wire Serial EEPROM. It is 4KB in size and is connected via I2C to the NEO-6M chip.
  The module also houses a rechargeable button battery that acts as a super-capacitor.
  EEPROM and battery together help in retaining the BBR (Battery Backed RAM). BBR contains clock data, latest position data (GNSS orbit data) and module configuration. But it is not for permanent data storage.
  The battery charges automatically when power is supplied to the module and retains data for two weeks without power.
  Since the battery retains the clock and last position data, Time-To-First-Fix (TTFF) is significantly reduced to 1s. This allows much faster position locks. Without battery the GPS is always cold-started and takes longer for the initial GPS lock.
- **Antenna**
  The module comes with -161 dBm sensitivity patch antenna for receiving radio signals from GPS satellites.
  You can snap-fit this antenna into the small U.FL connector located on the module.
  The patch antenna is great for most of our projects. But if you want to get more sensitivity and accuracy, you can also snap-on any 3V active GPS antenna.

Specifications of NEO-6M GPS Module:

- **Receiver Type:** 50 channels, GPS L1(1575.42Mhz)

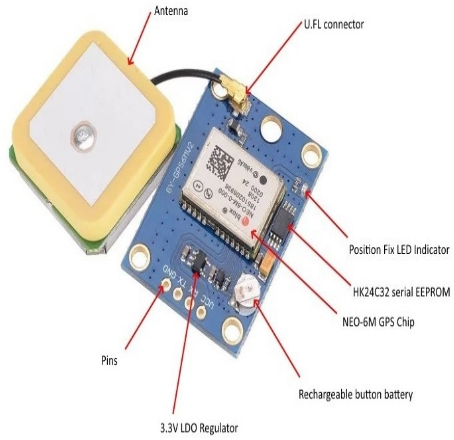

Figure 3.3: NEO-6M GPS Module

- **Horizontal Position Accuracy:** 2.5m
- **Navigation Update Rate:** 1HZ (5Hz maximum)
- **Capture Time:** Cool start: 27s, Hot start: 1s
- **Navigation Sensitivity:** -161dBm
- **Communication Protocol:** NMEA, UBX Binary, RTCM
- **Serial Baud Rate:** 4800-230400 (default 9600)
- **Operating Temperature:** -40°C to 85°C
- **Operating Voltage:** 2.7V to 3.6V
- **Operating Current:** 45mA
- **TXD/RXD Impedance:** 510 ohm

NEO-6M GPS Module Pinout: The figure 3.4 shows the NEO-6M GPS module pinout. It has total 4 pins that interface it to the outside world. The connections are as follows:

- **Tx:** Transmit data serially which gives information about location, time etc.
- **Rx:** Receive Data serially. It is required when we want to configure GPS module.
- **GND:** is the Ground Pin and needs to be connected to GND pin on the Arduino.
- **VCC:** supplies power for the module. You can directly connect it to the 5V pin on the Arduino.

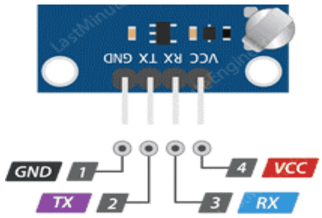

Figure 3.4: NEO-6M GPS Module Pinout

3. **HW-201 IR Sensor**

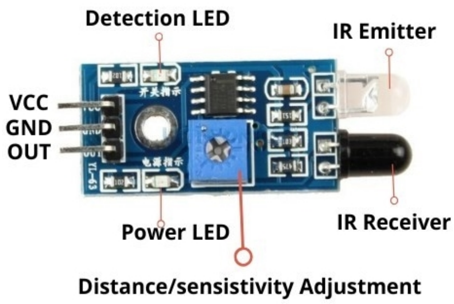

Figure 3.5: HW-201 IR Sensor

The figure 3.5 shows the IR sensor module. It consists mainly of the IR Transmitter and Receiver, Op-amp, Variable Resistor (Trimmer pot), output LED along with few resistors.

- **IR LED Transmitter:** IR LED emits light, in the range of Infrared frequency, emitting angle of approx. 20-60 degree. IR LED is white or transparent in colour, so it can give out maximum amount of light.
- **Photodiode Receiver:** Photodiode acts as the IR receiver as it conducts when light falls on it. Photodiode is a semiconductor which has a P-N junction, operated in reverse bias. Photodiode looks like a LED, with a black colour coating on its outer side, black colour absorbs the highest amount of light.
- **LM358 Op-Amp:** LM358 is an Operational Amplifier (Op-Amp) used as voltage comparator in the IR sensor. The comparator will compare the threshold voltage set using the pre-set (pin2) and the photodiode's series resistor voltage (pin3).

$$Photodiode'sSeriesResistorVoltageDrop > ThresholdVoltage$$
$$= Op - ampOutputIsHigh$$

$$Photodiode'sSeriesResistorVoltageDrop < ThresholdVoltage$$
$$= Op - ampOutputIsLow$$

How IR Sensor works?

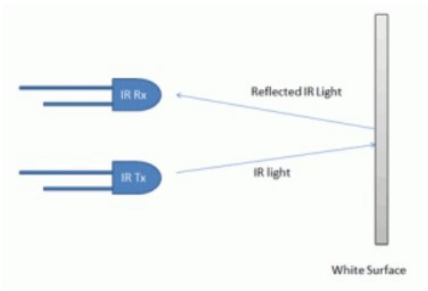

Figure 3.6: Working of IR transmitter and receiver on White Surface.

As shown in figure 3.6 and figure 3.7 , if there is an object in front of the IR sensor, the transmitted infrared waves from the IR transmitter reflect from that object and are received by the IR receiver. IR sensor gives 0 in this condition. Similarly, if there is a white surface in front of the sensor, the IR waves are reflected back from the surface(the white surface does not absorb any light).

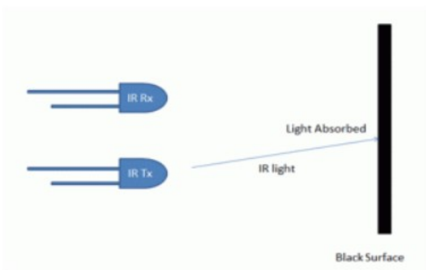

Figure 3.7: Working of IR transmitter and receiver on Black Surface.

When there is no object in front of the IR sensor, the transmitted infrared waves from the IR transmitter are not received by the IR receiver. And IR sensor gives 1 in this condition.
Similarly, if there is a black surface in front of the sensor, the IR waves are not reflected back from the surface(the black surface absorbs the light completely).

IR Sensor Module Features:

- 5V DC Operating voltage

- I/O pins are 5V and 3.3V compliant
- Range: Up to 20cm
- Adjustable Sensing range
- Built-in Ambient Light Sensor
- 20mA supply current

4. **MQ-3 Alcohol Gas Sensor**

The figure 3.8 shows the MQ-3 Alcohol Gas Sensor. It is a Metal Oxide Semiconductor (MOS) type of sensor. Its sensing is based on the change of resistance of the sensing material when exposed to alcohol. So, by placing it in a simple voltage divider network, alcohol concentrations can be detected. It can detect Alcohol concentrations anywhere from 25 to 500 ppm.

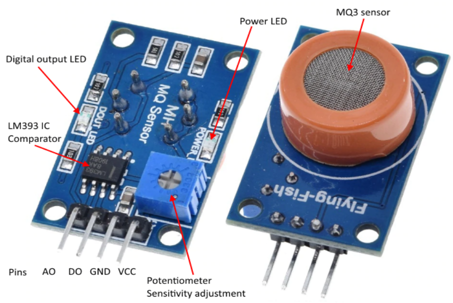

Figure 3.8: MQ-3 Alcohol Gas Sensor

The analog output voltage provided by the sensor (at A0 pin) varies in proportion to the alcohol concentration. The higher the alcohol concentration in the air, the higher the output voltage. The same analog signal is fed to a LM393 High Precision Comparator to digitize it and is made available at the Digital Output (D0) pin.

The module has a built-in potentiometer for adjusting the sensitivity of the digital output (DO). Rotate the knob clockwise to increase sensitivity and counter clockwise to decrease it. You can use it to set a threshold, so that when the alcohol concentration exceeds the threshold value, the module will output LOW otherwise HIGH.

Internal structure of MQ3 Alcohol Sensor

MQ3 is a heater-driven sensor. That's why it is enclosed in two layers of fine stainless steel mesh called an Anti-explosion network. It ensures that heater element inside the sensor will not cause an explosion, as we are sensing flammable gas (alcohol).

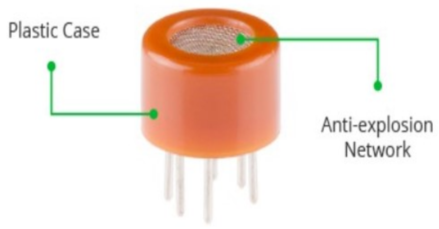

Figure 3.9: Layers of MQ-3 Alcohol Gas Sensor

The figure 3.9 shows the layers of MQ-3 alcohol gas sensor.
It also provides protection for the sensor and filters out suspended particles so that only gaseous elements are able to pass inside the chamber.

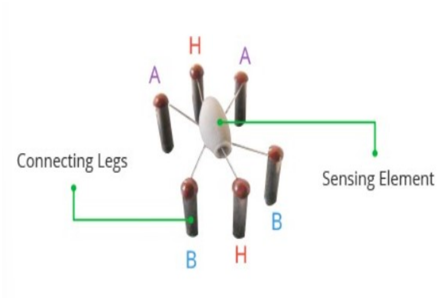

Figure 3.10: Internal structure of Alcohol Gas Sensor

The figure 3.10 shows the internal structure of alcohol gas sensor.
This is what the sensor looks like when outer mesh is removed. The star-shaped structure is formed by the sensing element and six connecting legs that extend beyond the Bakelite base. Out of six, two leads (H) are responsible for heating the sensing element and are connected via a Nickel-Chromium coil (a well known conductive alloy).
The remaining four leads (A & B) responsible for output signals are connected using Platinum Wires. These wires are connected to the body of the sensing element and convey small changes in the current that passes through the sensing element.
The tubular sensing element is made up of Aluminum Oxide (AL2O3) based ceramic and has a coating of Tin Dioxide (SnO2). The Tin Dioxide is the most important material being sensitive towards alcohol. However, the ceramic substrate only increases the heating efficiency and ensures that the sensor area is continuously heated to the working temperature.

So, to summarize, figure 3.11 shows how the Nickel-Chromium coil and Alu-

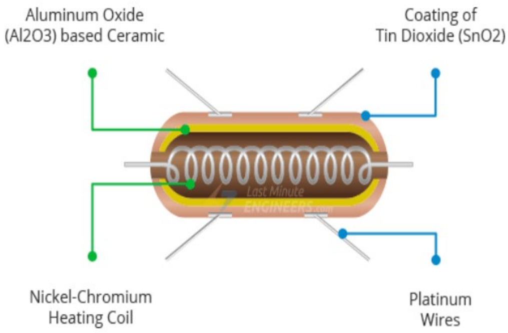

Figure 3.11: Heating System and Sensing System

minum Oxide based ceramic forms a Heating System; while Platinum wires and coating of Tin Dioxide forms a Sensing System.

How MQ3 Alcohol Sensor Works?

When SnO2 semiconductor layer is heated at high temperature, oxygen is adsorbed on the surface. In clean air, electrons from the conduction band in tin dioxide are attracted to oxygen molecules. This form an electron depletion layer just below the surface of SnO2 particles and forms a potential barrier. As a result, the SnO2 film becomes highly resistive and prevents electric current flow. In the presence of alcohol, however, the surface density of adsorbed oxygen decreases as it reacts with the alcohols; which lowers the potential barrier. Electrons are then released into the tin dioxide, allowing current to flow freely through the sensor which is depicted in figure 3.9.

Specifications of MQ-3 Alcohol Gas Sensor:

- **Operating voltage:** 5V
- **Load resistance:** 200K ohm
- **Heater resistance:** 33ohm ± 5%
- **Heating consumption:** less than 800mw
- **Sensing Resistance:** 1M ohm – 8M ohm
- **Concentration Scope:** 25 – 500 ppm
- **Preheat Time:** Over 24 hour

5. **MQ-135 Air Quality Gas Sensor**

The figure 3.12 shows the MQ-135 Gas sensor, used in air quality control equipment and are suitable for detecting or measuring of NH3, NOx, Alcohol, Benzene, Smoke, CO2. All MQ sensors have to be powered up for a pre-heat duration for the sensor to warm up before it can start working. When you power up the module the power LED will turn on, leave the module in this state till the pre-heat duration is completed.

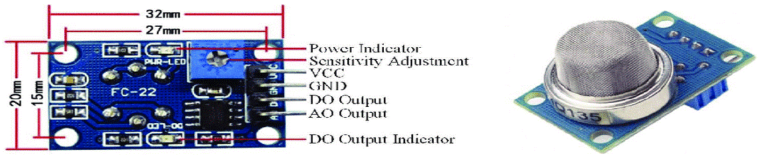

Figure 3.12: MQ-135 Air Quality Gas Sensor

Working Principle

The MQ-135 alcohol sensor consists of a tin dioxide (SnO_2), a perspective layer inside aluminum oxide microtubes (measuring electrodes), and a heating element inside a tubular casing. The end face of the sensor is enclosed by a stainless steel net and the backside holds the connection terminals. Ethyl alcohol present in the breath is oxidized into acetic acid passing through the heating element. With the ethyl alcohol cascade on the tin dioxide sensing layer, the resistance decreases. By using the external load resistance the resistance variation is converted into a suitable voltage variation.

MQ-135 Sensor Features:

- Wide detecting scope
- Fast response and high sensitivity
- Operating Voltage is +5V
- Analog output voltage: 0V to 5V
- Digital output voltage: 0V or 5V (TTL Logic)
- Preheat duration 20 seconds
- Can be used as a Digital or analog sensor
- The Sensitivity of Digital pin can be varied using the potentiometer.

6. **Water Sensor**

The figure 3.13 shows the water sensor. It has a series of ten exposed copper traces, five of which are power traces and five are sense traces. These traces are interlaced so that there is one sense trace between every two power traces. These traces are bridged by water when submerged.

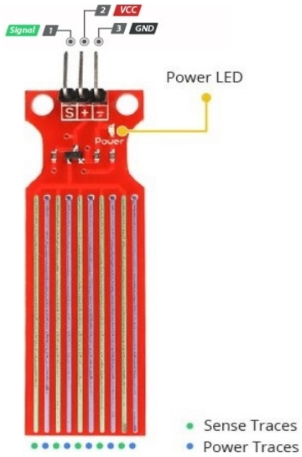

Figure 3.13: Water Sensor

Pinout of water sensor:

- **S (Signal):** It is an analog output that will be connected to one of the analog inputs on raspberry pi.
- **+ (VCC):):** This pin supplies power for the sensor. It is recommended to power the sensor with between 3.3V – 5V.

The series of exposed parallel conductors, together acts as a variable resistor whose resistance varies according to the water level. The resistance is inversely proportional to the height of the water. The more water the sensor is immersed in, results in better conductivity and will result in a lower resistance. The sensor produces an output voltage according to the resistance.

How Water Level Sensor Works?

The working of the water level sensor is pretty straightforward. The series of exposed parallel conductors, together acts as a variable resistor (just like a potentiometer) whose resistance varies according to the water level.The change in resistance corresponds to the distance from the top of the sensor to the surface of the water.The resistance is inversely proportional to the height of the water:

- The more water the sensor is immersed in, results in better conductivity and will result in a lower resistance.
- The less water the sensor is immersed in, results in poor conductivity and will result in a higher resistance.

The sensor produces an output voltage according to the resistance, which by measuring we can determine the water level.

7. **Servo Motor**

The figure 3.14 shows the servo motor. Servo is a general term for a closed loop control system. A closed loop system uses the feedback signal to adjust the speed and direction of the motor to achieve the desired result. Servo motors typically have three connections and are as follows:

- **GND:** It is a common ground for both the motor and logic.
- **5V:** It is a positive voltage that powers the servo.
- **Control:** It is input for the control system.

Working of a Servo Motor

Servo Motor consists of a DC Motor, a Gear system, a position sensor, and a control circuit. The DC motors get powered from a battery and run at high speed and low torque. The Gear and shaft assembly connected to the DC motors lower this speed into sufficient speed and higher torque. The position sensor senses the position of the shaft from its definite position and feeds the information to the control circuit. The control circuit accordingly decodes the signals from the position sensor and compares the actual position of the motors with the desired position and accordingly controls the direction of rotation of the DC motor to get the required position. Servo Motor generally requires a DC supply of 4.8V to 6 V.

Controlling a Servo Motor

A servo motor is controlled by controlling its position using Pulse Width Modulation Technique. The width of the pulse applied to the motor is varied and send for a fixed amount of time.

The pulse width determines the angular position of the servo motor. For example, a pulse width of 1 ms causes an angular position of 0 degrees, whereas a pulse width of 2 ms causes an angular width of 180 degrees.

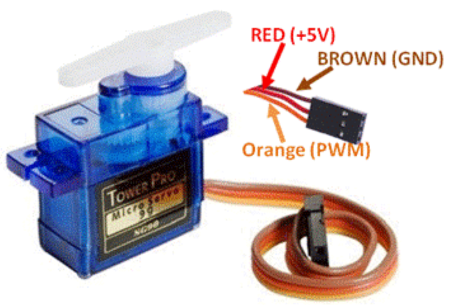

Figure 3.14: Servo Motor

You can control the servo motor by sending a series of pulses to the signal line. A conventional analog servo motor expects to receive a pulse roughly every 20 milliseconds. The length of the pulse determines the position of the servo motor.

- If the pulse is high for 1ms, then the servo angle will be zero.
- If the pulse is high for 1.5ms, then the servo will be at its center position.
- If the pulse is high for 2ms, then the servo will at 180 degrees.

8. **L293D Motor Driver IC**

The figure 3.15 shows the L293D motor driver integrated chip (IC). It enables us to drive a DC motor in either direction and also control the speed of the motor. The L293D is a 16 pin IC, with 8 pins on each side. We can use a single L293D to run up to two DC motors. L293D consist of two H-bridge circuit. H-bridge is the simplest circuit for changing polarity across the load connected to it.

There are 2 OUTPUT pins, 2 INPUT pins, and 1 ENABLE pin for driving each motor. It is designed to drive inductive loads such as solenoids, relays, DC motors, and bipolar stepper motors, as well as other high-current/high-voltage loads.

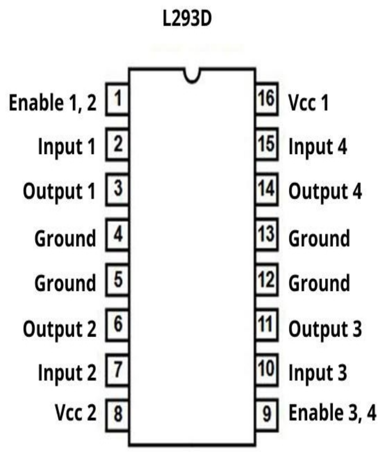

Figure 3.15: L293D Motor Driver IC

Features of IC L293D :

- Speed and Direction control is possible
- Motor voltage Vcc2 (Vs): 4.5V to 36V
- Maximum Peak motor current: 1.2A
- Maximum Continuous Motor Current: 600mA
- Supply Voltage to Vcc1(vss): 4.5V to 7V

- Transition time: 300ns (at 5V and 24V)
- Automatic thermal shutdown is available
- Available in 16-pin DIP, TSSOP, SOIC packages

9. **DC Motor**
The figure 3.16 show the DC motor. It converts electrical energy in the form of Direct Current into mechanical energy in the form of rotational motion of the motor shaft. The DC motor speed can be controlled by applying varying DC voltage; whereas the direction of rotation of the motor can be changed by reversing the direction of current through it. For applying varying voltage, we can make use of PWM technique. For reversing the current, we can make use of H-Bridge circuit or motor driver ICs that employ the H-Bridge technique.

Figure 3.16: DC Motor

Specifications of DC Motor:

- High Torque Rated Voltage Current: DC 12V
- No Load Current: 0.2Amps (Max 1.2 Amps)
- No load Power Consumption: 2.4 Watts (Max 15 Watts)
- No Load Speed: 4000RPM

10. **REES52 RC030 Tilt Sensor**
A ball tilt sensor is more of a switch that can detect basic motion, orientation or inclination. These switches are designed in such a way that a sufficient level of inclination makes or breaks the electrical connection. Such a signal can either be used as an indicator or can be used to turn something ON or OFF. The figure 3.17 shows the ball tilt sensor module.
They are small, cheap, easy to use and never wear out. Their simplicity makes them popular for use in toys, gadgets, robots, and other devices whose functioning depends on inclination. This is why they are sometimes called the "poor man's accelerometer".

Figure 3.17: Ball Tilt Sensor

How Do Ball Tilt Sensors Work?

The figure 3.18 shows Working Mechanism of Ball Tilt Sensor A ball tilt sensor is typically made up of a metal tube with a little metal ball that rolls around in it. One end of the cavity has two conductive elements (poles). The sensor is designed in such a way that a sufficient level of tilt allows the ball to roll, making or breaking an electrical connection.When the sensor is upright the ball touches the poles and makes an electrical connection. And when the sensor is tilted the ball rolls off the poles and the connection is broken.

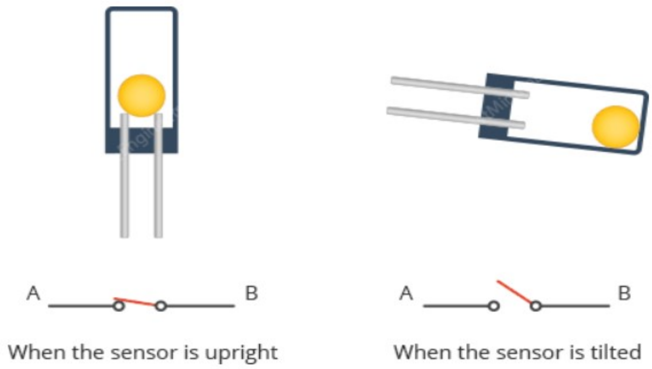

Figure 3.18: Working Mechanism of Ball Tilt Sensor

Specifications of Tilt Sensor:

- Dimensions: 5.5mm diameter & 13.5mm long
- Maximum Operating Voltage: Up to 20V
- Maximum Operating Current: 30mA
- Sensitivity Range: Movements of around 5 to 10 degrees

11. **Buzzer**

An audio signaling device like a beeper or buzzer may be electro-mechanical or piezoelectric or mechanical type. The main function of this is to convert the signal from audio to sound. Generally, it is powered through DC voltage and used in timers, alarm devices, printers, alarms, computers, etc. Based on the various designs, it can generate different sounds like alarm, music, bell & siren.

Figure 3.19: Buzzer

The figure 3.19 shows the pin configuration of the buzzer. It includes two pins namely positive and negative. The positive terminal of this is represented with the '+' symbol or a longer terminal. This terminal is powered through 6Volts whereas the negative terminal is represented with the '-' symbol or short terminal and it is connected to the GND terminal.

12. **1V-5V to 5V Power Supply Charging Step Up Module**
    The figure 3.20 shows the 1V-5V to 5V Power Supply Charging Step Up module. It is connected directly with the solar panel so that the variable DC voltage produced by solar panels due to the variations in the intensity of sunlight can be regulated to a constant 5V dc power supply.

    Specifications of Tilt Sensor:

    - Input Voltage: 1V-5V
    - Output Voltage: 5V
    - Output Current: 500mA

Figure 3.20: Power Supply Charging Step Up Module

13. **I2C LCD Display**

An LCD is short for Liquid Crystal Display. It is basically a display unit which uses liquid crystals to produce a visible image. When current is applied to this special kind of crystal, it turns opaque blocking the backlight that lives behind the screen. As a result that particular area will become dark compared to other. And that's how characters are displayed on the screen. The figure 3.21 shows the pinout diagram of I2C LCD. It consumes only two I/O pins of the micro-controller.

I2C LCD Hardware Overview:

A typical I2C LCD display consists of a HD44780 based character LCD display and an I2C LCD adapter.

Character LCD Display

True to its name, these LCDs are ideal for displaying text/characters only. A 16×2 character LCD, for example, has an LED backlight and can display 32 ASCII characters in two rows with 16 characters on each row.

I2C LCD Adapter

At the heart of the adapter is an 8-Bit I/O Expander chip – PCF8574. This chip converts the I2C data from an Arduino into the parallel data required by the LCD display. The board also comes with a small trimpot to make fine adjustments to the contrast of the display. In addition, there is a jumper on the board that supplies power to the backlight. To control the intensity of the backlight, you can remove the jumper and apply an external voltage to the header pin that is marked as 'LED'.

I2C Character LCD Pinout

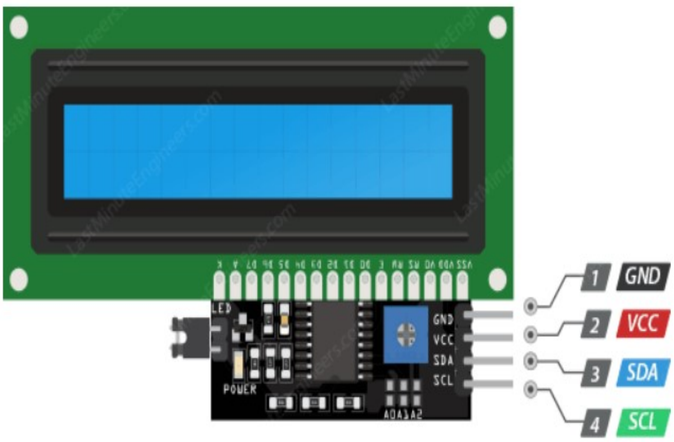

Figure 3.21: I2C LCD Pinout

- **GND:** should be connected to the ground of microcontroller.
- **VCC:** is the power supply for the LCD which we connect with the 5 volts pin on the micro-controller.
- **SDA:** is a Serial Data pin. This line is used for both transmit and receive.
- **SCL:** is a Serial Clock pin. This is a timing signal supplied by the Bus Master device.

14. **Solar Panel:**
The figure 3.22 shows the solar panel used for power supply to the whole circuit of head gear.

Specifications:

- The solar cells are encased and protected by a durable outer poly frame.
- Polycrystalline solar cells
- Max output power: 0.72W
- Max working voltage: 6.6V
- Max charging current: 110mA
- Min output power: 0.6W
- Min working voltage: 6V
- Min charging current: 100mA

Figure 3.22: Solar Panel

Applications of Small Solar Panels:

- Small Home Projects
- Science Projects
- Electronic Applications

- Charging Small DC Batteries
- Build Your Own Solar-powered Models/Toys

15. **Lithium Ion Battery:** The figure 3.23 shows the 3.7V 1000mAH (Lithium Polymer) Lipo Rechargeable Battery also known as Lipo or Lipoly batteries. They are thin, light and powerful. This battery has a capacity of 1000mAh. These are widely used in GPS, DVD, ipod, Tablet PC, MP4 Player, Power Bank, Mobile Backup Power Supply, Bluetooth Speaker, IOT and other DIY and Industrial applications.

Figure 3.23: Lithium Ion Battery

Specifications of Lipo Battery Model KP-423048:

- **Voltage:** 3.7V
- **Capacity:** 1000mAh
- **Approx Size:** 48mm x 30mm x 4.2mm

16. **Mini Core-less Motor:**
The figure 3.24 shows the mini core-less motor. This is a very small size core-less DC motor for toy or model, it could also be used on very small drone projects. It's weight is only 1gram, super light. It's free load speed can reach up to 43000rpm, which is ideally for small and light projects. The motor comes with two 12cm wires for powering up, usually you can just use some glue to mount it on your device, like PCB.

Specifications:

- **Model:** 412
- **Voltage:** 3.7V DC
- **Current:** 0.07mA
- **Revolving Speed:** 43000 round/min
- **Dimension:** 12 x 4mm

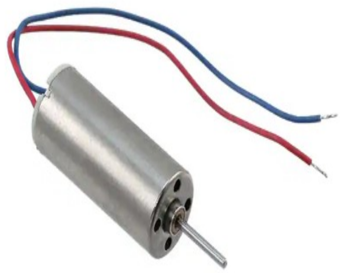

Figure 3.24: Mini Core-less Motor

3.4 Description of Software Used

1. **Twilio**

   Twilio is a modern communication API Used by developers for establishing communications. According to Twilio.com "Twilio's programmable application program interfaces (APIs) are a set of building blocks developers can use to build the exact customer experiences they want" Twilio can be used to send SMS, WhatsApp, Voice, Video, email, and even IoT, across the customer journey. All you need to do is integrate its API with your software. This facilitates developers to make easy communications between different apps. Figure 3.25 shows the main console screen of the user utilizing the API.

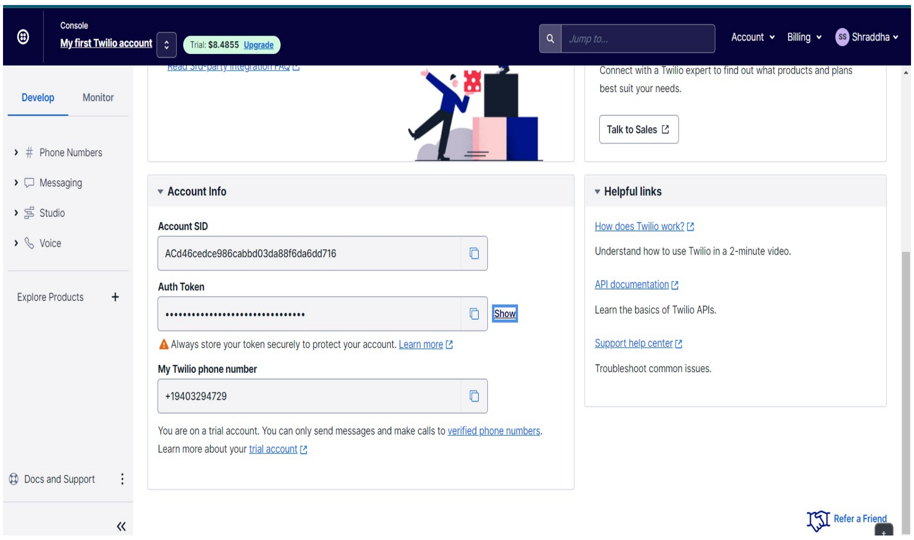

Figure 3.25: Twilio Account Details

How to Connect the Twilio API?

Integrating Twilio API to web and mobile apps is pretty simple. All you need to do is follow some simple steps, in order to do the job.

a) Get the Twilio Credentials to access the Communication API.

b) Create a Twilio Account by going on https://twilio.com/console. You can choose a Free trial from there.

c) After creating the accounts head over to the account details page and Get the API.

d) Get your Free Twilio Phone number from there so that you will be able to make calls and send messages.

e) Get Twilio Messaging SID, if you want to send SMS and MMS.

f) Find Twilio API at RapidAPI.com or go directly to the Twilio Package Page.

g) Use Your Credentials to Make Connections with Account SID and Account Token.

h) Login to RapidAPI to Access your Code Snippets.

i) Once you log in, customize Fields and Language and select the code that fits best to your project.

2. **Thonny Python**

An integrated development environment (IDE) facilitates computer programmers by integrating fundamental tools (e.g., code editor, compiler, and debugger) into a single software package. Users do not need to install the language's compiler/interpreter on their machines; an IDE provides the environment itself. Thonny is a free, dedicated IDE for Python designed for beginners. It is cross-platform and can run in Linux, macOS, Windows.

The following are some of the primary features of Thonny:

- Python 3.7 is installed by default with Thonny setup.
- Highlights syntax errors and explain scopes.
- Support code completion.
- Heap, Stack, Assistant, Object Inspector.
- Built-in debugger, simple to use as no knowledge of breakpoints is required.
- It has an easy interface to install packages. This makes it very suitable for beginners.
- It enables users to step into a function call by providing details about local variables and displaying the code pointer.

3. **Raspbian OS**

   Raspberry Pi needs an operating system to work. Raspberry Pi OS (Raspbian OS) is our official supported operating system. It is a free, open-source Debian Linux-based operating system engineered for use on Pi boards. Additionally, several ARM-based single-board computers also run Raspberry Pi OS.

   It has been officially provided by the Raspberry Pi Foundation as the primary operating system for the Raspberry Pi family of compact single-board computers. It runs on every Raspberry Pi except the Pico microcontroller. Raspberry Pi OS uses a modified LXDE as its desktop environment with the Openbox stacking window manager, along with a unique theme.
   Raspberry Pi OS's desktop environment, PIXEL, looks similar to many common desktops, such as macOS, Microsoft Windows, and is based on LXDE. The menu bar is positioned at the top and contains an application menu and shortcuts to Terminal, Chromium, and File Manager. On the right is a Bluetooth menu, a Wi-Fi menu, volume control, and a digital clock.
   Raspberry Pi OS is highly optimized for the Raspberry Pi line of compact single-board computers with ARM CPUs. It runs on every Raspberry Pi except the Pico microcontroller. Raspberry Pi OS uses a modified LXDE as its desktop environment with the Openbox stacking window manager, along with a unique theme. The default distribution is shipped with a copy of the algebra program Wolfram Mathematica, VLC, and a lightweight version of the Chromium web browser.

4. **TensorFlow**

   TensorFlow (depicted in figure 3.26) is an end-to-end open source platform for machine learning. It has a comprehensive, flexible ecosystem of tools, libraries and community resources that lets researchers push the state-of-the-art in ML and developers easily build and deploy ML powered applications.

   TensorFlow works on the basis of data flow graphs that have nodes and edges. As the execution mechanism is in the form of graphs, it is much easier to execute TensorFlow code in a distributed manner across a cluster of computers while using GPUs. It is created and maintained by Google. Ever since then, it has become one of the most popular frameworks for deep learning and machine learning projects. It has a vast library for large-scale machine learning and numerical computation.

   TensorFlow allows you to create dataflow graphs that describe how data moves through a graph. The graph consists of nodes that represent a mathematical

Figure 3.26: TensorFlow

operation. A connection or edge between nodes is a multidimensional data array. It takes inputs as a multi-dimensional array where you can construct a flowchart of operations that can be performed on these inputs.
TensorFlow provides all of this for the programmer by way of the Python language. Python is easy to learn and work with, and it provides convenient ways to express how high-level abstractions can be coupled together. TensorFlow is supported on Python versions 3.7 through 3.10, and while it may work on earlier versions of Python it's not guaranteed to do so.

Nodes and tensors in TensorFlow are Python objects, and TensorFlow applications are themselves Python applications. The actual math operations, however, are not performed in Python. The libraries of transformations that are available through TensorFlow are written as high-performance C++ binaries. Python just directs traffic between the pieces and provides high-level programming abstractions to hook them together.

High-level work in TensorFlow by creating nodes and layers and linking them together using the Keras library. The Keras API is outwardly simple; a basic model with three layers can be defined in less than 10 lines of code, and the training code for the same takes just a few more lines of code. But if you want to "lift the hood" and do more fine-grained work, such as writing your own training loop, you can do that.
Tensorflow architecture works in three significant steps:

- Data pre-processing - structure the data and brings it under one limiting value

- Building the model - build the model for the data
- Training and estimating the model - use the data to train the model and test it with unknown data

5. **Anaconda (Python)**

Figure 3.27: Anaconda Logo

The figure 3.27 shows the anaconda logo. Anaconda is a distribution of the Python and R programming languages for scientific computing (data science, machine learning applications, large-scale data processing, predictive analytics, etc.), that aims to simplify package management and deployment. The distribution includes data-science packages suitable for Windows, Linux, and macOS. It is developed and maintained by Anaconda, Inc., which was founded by Peter Wang and Travis Oliphant in 2012. It provides more than 1500 Python/R data science packages which are suitable for developing machine learning and deep learning models. Conda is an open source, cross-platform, language-agnostic package manager and environment management system that installs, runs, and updates packages and their dependencies. It was created for Python programs, but it can package and distribute software for any language (e.g., R), including multi-language projects. The conda package and environment manager is included in all versions of Anaconda, Miniconda, and Anaconda Repository.
With more than 15 million users, Anaconda is the world's most popular data science platform and the foundation of modern machine learning. Anaconda Enterprise delivers data science and machine learning at speed and scale, unleashing the full potential of our customers' data science and machine.

6. **VNC Viewer**

In computing, Virtual Network Computing (VNC) is a graphical desktop-sharing system that uses the Remote Frame Buffer protocol (RFB) to remotely control another computer. It transmits the keyboard and mouse input from one computer to another, relaying the graphical-screen updates, over a network.
VNC is platform-independent – there are clients and servers for many GUI-based operating systems and for Java. Multiple clients may connect to a VNC server at the same time. Popular uses for this technology include remote technical support and accessing files on one's work computer from one's home computer, or vice versa. VNC Viewer is used for local computers and mobile devices you want to control from. A device such as a computer, tablet, or smart phone with VNC Viewer software installed can access and take control of a computer in another location.

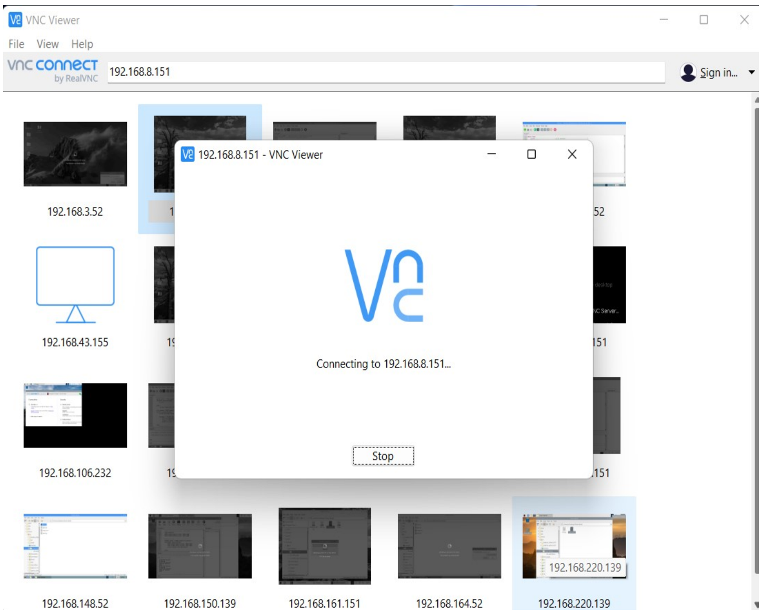

Figure 3.28: VNC Viewer Connecting with Raspberry Pi

A computer with VNC Server software installed as seen in figure 3.28 can be accessed and controlled from a different device in a different location. The software allows a broadcast of the device desktop to a secondary device with VNC Viewer installed. Connected VNC Viewer users send a request, and then (with permission) can see the same thing as the person sitting in front of the remote computer.

It is a graphical desktop sharing system that allows a user to remotely control the desktop of a remote computer (running VNC Server) from your device, and it transmits the keyboard and mouse or touch events to VNC Server, so that once you are connected, you have control over the computer you've accessed. If you're using your mobile phone, for example, you would be able to use the computer you've remotely accessed as though you were sitting right in front of it.

Chapter 4

Methodology of Project

The helmet is built of safe, lightweight materials and includes a Raspberry Pi board as well as other necessary sensors.

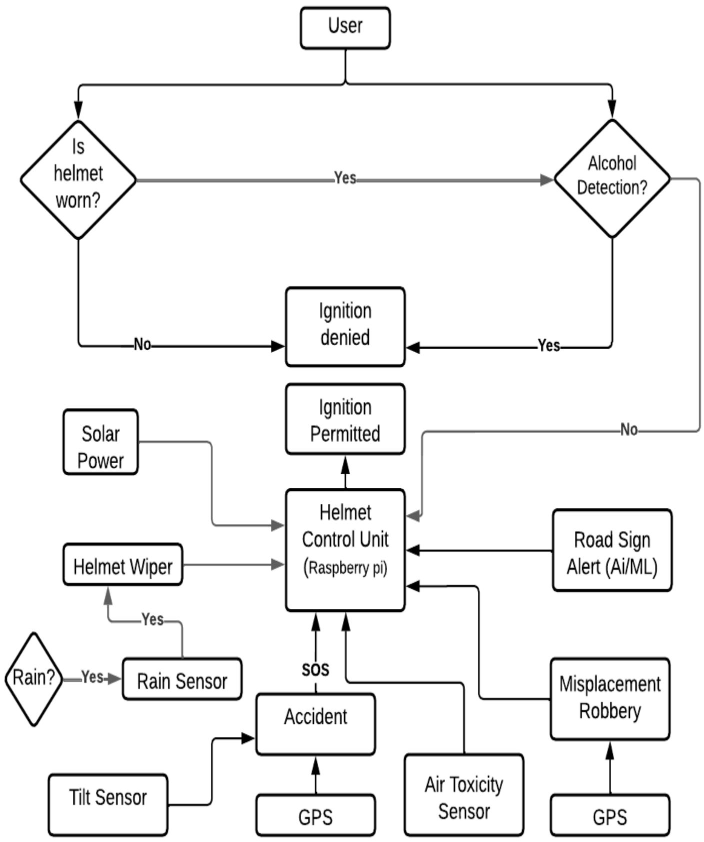

Figure 4.1: The flow of operations in Helmet Prototype

An infrared sensor monitors whether or not the helmet is being worn, with an engine switch off feature if the helmet is not being worn. On the back of the headpiece is another infrared sensor. If other vehicle approaches, this identifies them and warns the user. A buzzer sounds when another vehicle draws too close to the user, alerting him and allowing him to take the necessary precautions.

The integrated device is powered by solar panels on the top of the helmet, which are both efficient and eco-friendly. When exposed to enough light, the solar panel itself incorporates a separate charging mechanism that begins charging a lithium- ion battery implanted within the helmet. The principal power source for our circuit is the charge contained in the lithium-ion battery. Alternatively, the lithium-ion battery may be charged with a 5v DC power supply.

A fall detection function that employs tilt sensor to deliver necessary signals in the event of an accident is included. with the sensor bent at 45 degrees or more on either of the X axes indicating an accident, but otherwise unharmed. A buzzer rings when an accident is detected, and an SOS message is transmitted to the proper authorities.

In the case of an accident, other catastrophic circumstances, or even a vehicle breakdown, the user may summon assistance via a specialized switch on the helmet. When this button is pressed, the user's present location is sent to the appropriate authorities, along with an emergency call and a request for assistance.

The existence of an implanted circuit within the helmet, or unpleasant odor originating from the user's breath, or external heat from the surroundings, may create pain for the rider, with heat being the most significant issue. To address this issue, the helmet has two small exhaust fans on either side, providing airflow and rapid heat dissipation from the gadget.

When it rains, a sensor detects dampness from the environment or water particles that have fallen on it and activates a glass viper through servo motors, which cleans the visor of water particles, allowing the rider to see better in the rain.

The use of sensors to check for alcohol detection is carried out - the vehicle does not start when the alcohol threshold is exceeded. Another sensor is used to detect the degree of pollution in the environment. When the threshold is exceeded, the gadget alerts the user, and he may choose another route. A complete workflow of the above described setup can be seen in figure 4.1.

4.1 Key Features And Their Workflow

4.1.1 Solar powering the device

Solar is the fastest-growing renewable energy source in the world, increasing in worldwide capacity by an average of 40 percent every year. Many energy companies are expanding to offer solar, which is among the most energy-efficient and lucrative sources of renewable electricity on the market.

Today, solar energy companies have more options than ever for making the most out of their equipment. Harnessing the power of digital transformation with IoT can resolve common challenges associated with complex energy grids and make it far easier to manage panels and energy output. For solar energy companies, installing an IoT system will help meet customers' demands and improve overall efficiency. It is no longer a question of whether to attempt IoT digital transformation, but rather how to do it successfully.

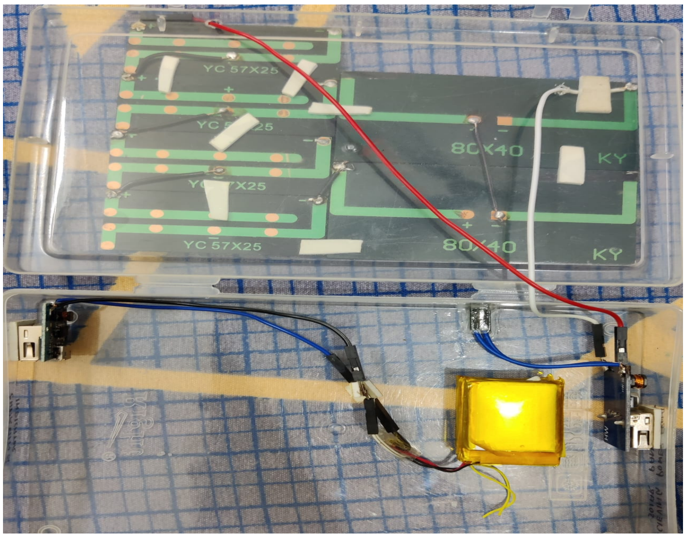

Figure 4.2: Solar Powered Circuit

As a part making our approach eco-friendly , we have incorporated our very own solar powered circuit that acts as a secondary source of power supply to the entire setup essen- tially behaving as a solar powered power bank as illustrated in figure 4.2, a solar panel, a power regulator, and a lithium-ion battery are all part of this circuit. Solar panels are mounted on the top of the helmet. When the panels are exposed to light, they begin to produce energy. This is transferred to the power regulator, which turns the solar panels' variable voltage into a constant 5 volt DC. The li-ion cell is charged with this. The lithium-ion cell is connected to a charging circuit that receives 5 volts DC and feeds it to the battery, preventing overcharging and so saving the battery from harm.

The charging circuit also allows for two-way power exchange, allowing the li-ion to be discharged and recharged at the same time. This is done without causing any damage to the battery. The li-ion cell may also be charged using standard 5v DC from the mains. There's a port for it in the charging circuit as well. The entire circuit, namely the Raspberry Pi board, is powered by the battery's output power. As a result, full eco-friendly charging is made possible.

4.1.2 Alcohol and smoke Detection

One of the main features that lead a significant helping hand in our approach to minimize the risk of accident is the incorporation of the MQ3 sensor to detect the presence of alcohol. Essentally a metal oxide semiconductor also known as Chemi-resistors,the sensing is executed as a result of the change in resistance of the sensing material when exposed to alcohol. Therefore, on placing it in a simple voltage divider network, alcohol concentrations can be detected. At the point when the objective liquor gas exists, the sensor's conductivity is higher alongside the gas concentration rising, utilizing a straightforward resistive circuit changes over difference in conductivity to the relating yield flag of gas focus.

In the same manner smoke can be detected as well, enabling a useful hardware which in cohesion with our implemented software to detect the presence of the same yields us a valuable feature that would detect alcohol presence in riders in real time as we interface the same to the raspberry pi module.

4.1.3 Rain Sensor integrated with servo motors

The rain sensor along with servo motors placed on the visor of the helmet enables the rider to effectively his route during rainy weather as it wipes out water particles and fog during difficult weather conditions . The sensing pad of the rain sensor with series of exposed copper traces, together acts as a potentiometer or a variable resistor whose resistance varies according to the amount of water on its surface.

4.1.4 Proximity alert and Accident SOS

Helping to prevent accident using embedded sensors is one of our core agendas. SOS alerts are provided as obstacles or vehicles approach within close vicinity of the riders vehicle using the proximity/IR sensor. With the simple workflow of transmitting and receiving IR waves and calculating the distance during this period (TOF-Time of Flight) we interface the sensor with a buzzer, programming it to buzz as an obstacle reaches within a certain threshold distance, close to the vehicle. Since there would exist many blind spots for a rider navigating especially through conjested areas and streets this feature lends a significant helping hand in collision avoidance and accident prevention.

We have also interfaced a GPS sensor in case of emergency acting as an SOS alert providing the location of the rider to his or her family members and other neccessary individuals such as the police. An automatic emergency call to the ambulance indicating the location of the accident through the GPS sensor can also be made possible.

4.1.5 Road Sign alert using Machine learning and Image Processing

Key concepts of image processing and machine learning come into the picture in this feature as we utilize TensorFlow in the thonny python software of the raspberry pi to include pretrained models and use them to classify and detect images such as traffic lights, road signs such as school zones, hairpin bends in order to give a preempted alert to the user acing as a warning in case of low visibility and ensuring traffic rules are followed. A Convolutional Neural Network is implemented for recognizing the signs and the model is pretrained using a custom dataset. Keras API is incorporated on TensorFlow which acts as the backend and various layers such as max pooling, flatten layer, dense layer are implemented on the squential model from keras. The key metrics taken into consideration include - training loss, validation loss, training accuracy and validation accuracy.

The training data is taken from a combination of publicly available online databases involving German and Indian road signs. The model is trained completely before giving to the individual.

4.1.6 ML Algorithm:

- Importing the necessary libraries
- Retrieving the images and their labels
- Image Transformation:
  - Resize the image
  - Convert the image to lists

- Convert the lists to numpy arrays
- Split the data set for training and testing
- Convert the labels into one hot encoding
- Build the model(adding the layers)
- Compilation of the model
- Testing the accuracy on dataset (by classifying the images)

Chapter 5

Results

This chapter illustrates the results obtained and final model developed according to the proposed design illustrated in the previous chapters

5.1 Developed prototype

The proposed design was first implemented on a flat cardboard sheet depicting all the internal wiring and circuitry as seen in figure 5.1. The central unit of raspberry pi is connected to all the necessary components that yield the required features.

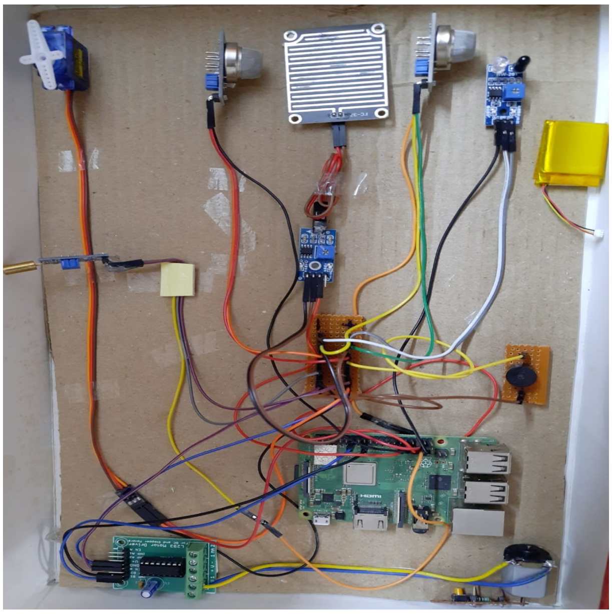

Figure 5.1: Functional Circuitry before embedding it on the helmet

The developed solar panel powered setup is also employed separately before integrating it with the overall internal circuitry. This device can be seen in figure 5.2, consisting of 6 solar panels of different sizes interfaced with the power and USB modules that indicate the charging status of the setup through the LED as shown.

The internal circuitry in figure 5.1 as well as the solar powered setup depicted in figure 5.2 is integrated together on the helmet structure which was improvised internally according to our needs to build the circuitry.

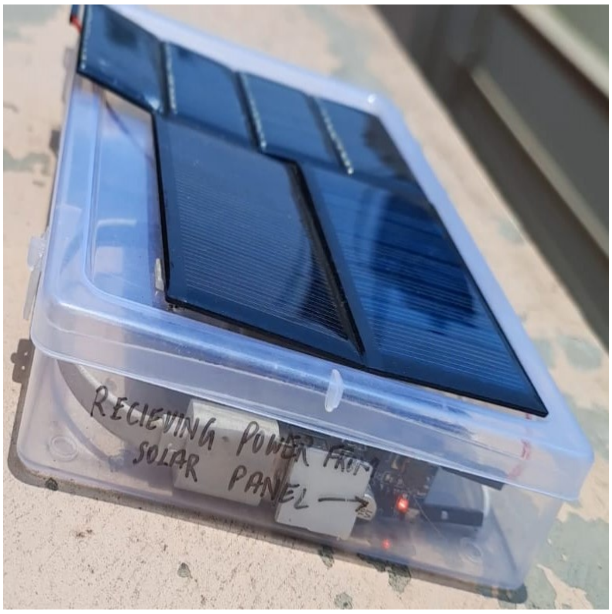

Figure 5.2: Solar panels integrated into a local power bank circuit

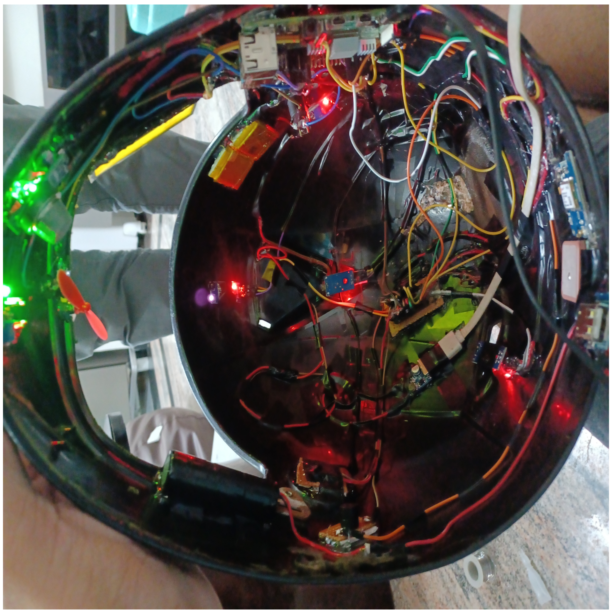

Figure 5.3: Bottom View

The internal circuitry of the helmet can seen on the inside of the helmet structure as shown in figure 5.3 depicting the bottom view of the prototype.

5.2 Integrated Software - Machine Learning for Road Sign Detection

As proposed in section 4.1.5 , the key software feature integrated with the overall helmet setup thus producing the developed prototype is the road sign detection implementation essentially using machine learning.

We have developed a machine learning model and trained datasets to successfully classify road signs, with datasets incorporated from online databases inclusive of more than 100 per sample (per road sign type). These road signs include a mix of road signs observed in both Germany and India. This feature plays an important role in assisting drivers for oncoming road signs thereby playing a significant part in road safety and reducing the chances of accidents.

The trained model after classification yielded 95 percent accuracy in classifying the road signs correctly as a variety of images including blurry, clear and low visibility images were provided for the training dataset, as shown in figure 5.4.

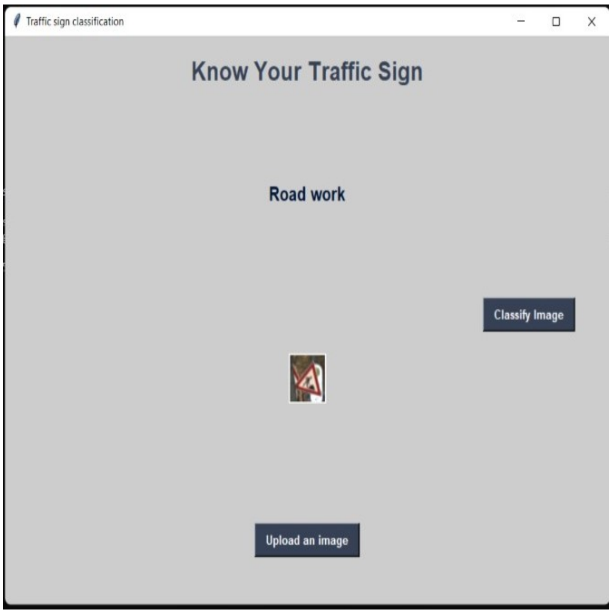

Figure 5.4: Road sign classification 1

A few more images of successfully classified road signs can be seen in the below figures 5.5 and 5.6.

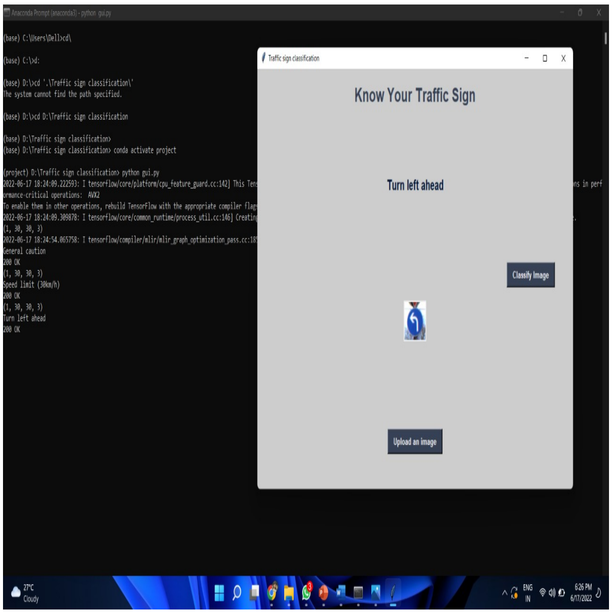

Figure 5.5: Road sign Classification 2

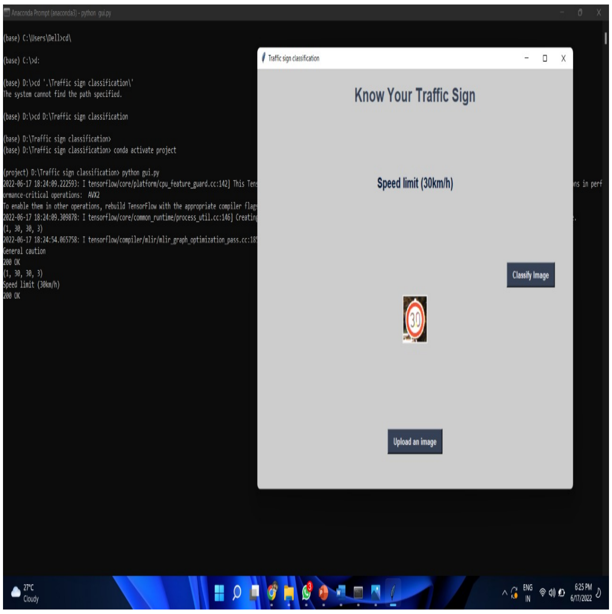

Figure 5.6: Road sign Classification 3

5.3 Final prototype

The final developed prototype integrating the internal circuitry with the solar powered setup can be seen in figures depicting the front view and top view respectively

The figure 5.7 shows the LCD display that is used to show sensor readings, an exhaust fan to remove heat and unpleasant odours, and a smoke sensor to detect environmental pollution.

Figure 5.7: Front View

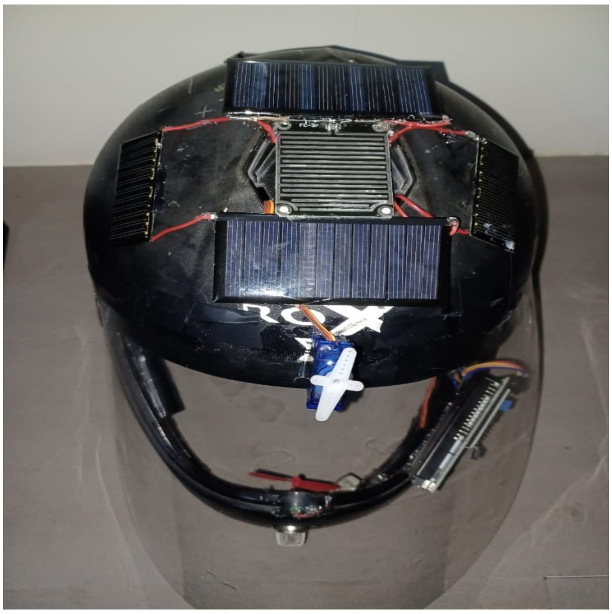

Figure 5.8: Top View

The figure 5.8 shows how the solar panels that will power the whole helmet circuit are incorporated into the upper outside portion of the helmet. Servo motor with rain sensor to improve vision while it is raining.

Chapter 6

Conclusion and Future Scope

6.1 Conclusion

Wearable safety equipment has been able to take an important position in the area of safety devices in a short period and is considered as a business opportunity in the field of automobile industry. With the increase in traffic and exponential rise in the number of accidents there is a demand for safety especially in two-wheeler line-up, in particular India being the home for large number of motorized two wheelers in the world.

The ever-growing domain of embedded systems and IoT as well as the increasing need for road safety interests and stimulates us to develop our very own, low cost, secure, embedded wearable device for riders to travel on the Indian roads ensuring safety and comfort. On developing this device we tackle these core issues and satisfy the main objective of our project which is essentially to find an alternative solution to the existing conventional riding helmets and to bring in advanced features for safety and convenience by adapting latest technology with reduced cost to suit Indian markets.
In this project we therefore have performed the following:

- Develop a safe wearable device with integrated micro-controller and sensors.
- Provide a safety , reliability and comfort to two wheeler riding
- Lend a significant helping hand in accident prevention.
- Encourage usage of efficient embedded wearable devices.

6.2 Future Scope

The proposed device and prototype has an immense scope for enhancement conisdering the overall structure, efficiency as well as coming up with a business model.

The following are some of the ideas and thoughts to increase the potential and further improve the helmet -

- The design can be combined with wireless communication technology to keep the device connected with the mobile all the time. It will help the rider to receive and disconnect the calls and use the other features like starting the navigation with just a voice command. It will add ease of communication while riding and convenient navigation.

- Integrating the helmet with the two wheeler's engine control system for improved communication.

- A holographic helmet visor can be mounted on a helmet. A transparent screen in the periphery of the motorcyclist's vision, will allow riders to keep their eyes on the road while still maintaining awareness of key riding conditions.

- Lead metal shielding can be used to make the helmet wearable without endangering the rider from radiation emanating from electronic components. Due to its high density and high atomic number, lead is very effective at shielding the body from radiation sources.

- Making the entire design waterproof to help safeguard sensitive electronics.

- The real-time data can be acquired from sensors within the helmet and transmitted to a server for further analysis. The riders can always be watched over by uploading all the real-time data to the cloud. The parents will find this function helpful in keeping an eye on their children.

- ”Find my helmet” feature can be implemented. In the event of theft or loss, this will assist the rider in locating his/her helmet.

- A complete cost effective approach and business model can be developed after thorough working considerations in order to implement a marketing strategy to introduce the developed prototype in the market.

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Appendix A

ML Code:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import cv2
import tensorflow.compat.v1 as tf
tf.disable_v2_behavior()
from PIL import Image
import os
from sklearn.model_selection import train_test_split
from tensorflow.keras.utils import to_categorical
from keras.models import Sequential, load_model
from keras.layers import Conv2D MaxPool2D Dense Flatten Dropout

data = [ ]
labels = [ ]
classes = 43
cur_path = os.getcwd()
#Retrieving the images and their labels
for i in range(classes):
path = os.path.join(cur_path,t́rain,́str(i))
images = os.listdir(path)
for a in images:
try:
image = Image.open(path + a)
image = image.resize((30,30))
image = np.array(image)
data.append(image)
labels.append(i)
except:
print(”Error loading image”)
```

```
#Converting lists into numpy arrays
data = np.array(data)
labels = np.array(labels)
print(data.shape, labels.shape)
#Splitting training and testing dataset
X_train, X_test, y_train, y_test = train_test_split(data, labels, test_size=0.2, random_state=42)
print(X_train.shape, X_test.shape, y_train.shape, y_test.shape)
#Converting the labels into one hot encoding
y_train = to_categorical(y_train, 43)
y_test = to_categorical(y_test, 43)
#Building the model
model = Sequential()
model.add(Conv2D(filters=32, kernel_size=(5,5), activation='relu', input_shape=X_train.shape[1:]))
model.add(Conv2D(filters=32, kernel_size=(5,5), activation='relu'))
model.add(MaxPool2D(pool_size=(2, 2)))
model.add(Dropout(rate=0.25))
model.add(Conv2D(filters=64, kernel_size=(3, 3), activation='relu'))
model.add(Conv2D(filters=64, kernel_size=(3, 3), activation='relu'))
model.add(MaxPool2D(pool_size=(2, 2)))
model.add(Dropout(rate=0.25))
model.add(Flatten())
model.add(Dense(256, activation='relu'))
model.add(Dropout(rate=0.5))
model.add(Dense(43, activation='softmax'))

#Compilation of the model
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
epochs = 15
history = model.fit(X_train, y_train, batch_size=32, epochs=epochs, validation_data=(X_test, y_test))
model.save("my_model.h5")

#plotting graphs for accuracy
plt.figure(0)
plt.plot(history.history['acc'], label='training accuracy')
plt.plot(history.history['val_acc'], label='val accuracy')
plt.title('Accuracy')
```

```
plt.xlabel('epochs')
plt.ylabel('accuracy')
plt.legend()
plt.show()
plt.figure(1)
plt.plot(history.history['loss'], label='training loss')
plt.plot(history.history['val_loss'], label='val loss')
plt.title('Loss')
plt.xlabel('epochs')
plt.ylabel('loss')
plt.legend()
plt.show()
```