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Intelligent Helmet System for Enhanced Rider Safety

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A B S T R A C T

In recent years, the number of two-wheeler vehicles has significantly increased, leading to a rise in accident frequency. Unfortunately, a major portion of fatalities in these accidents can be attributed to two main factors: individuals not wearing helmets and cases of drunk driving. Another critical factor contributing to the severity of these accidents is the delayed reporting and admittance of victims to hospitals. To address this issue, the development of a device capable of detecting accidents is essential. Upon detecting an accident, this device should promptly send a message to emergency contacts, providing them with the precise location of the incident.

Keywords: Smart Helmet, Accident detection, Arduino, SoC, MQ3.

1. INTRODUCTION

At 29.2 per 100,000 people, India has the second-highest reported global rate of road traffic injury mortality [1]. The following six states—Uttar Pradesh, Maharashtra, Madhya Pradesh, Karnataka, Rajasthan, and Tamil Nadu—contribute up to half of all road fatalities in the nation [2]. Maharashtra with a population share of 9.1% has reported the highest number of accidental deaths (58,242), contributing nearly one-seventh (14.7%) of total accidental deaths reported in the country. Among these accidents, a significant portion can be attributed to two key factors - not wearing helmets and lack of timely medical attention [1][2]. The mandatory use of helmets has been proven effective in reducing head and facial injuries associated with motorcycle accidents, regardless of the rider's age or the type of crash, including those involving other motor vehicles [3]. To address this issue, the development of a device that can reduce fatalities caused by two-wheeler accidents by mandating helmet use is essential. Smart helmets have been introduced to incorporate advanced technologies, such as accelerometer, alcohol sensor and various wireless communication systems, to enhance the protection of riders. Additionally, if there is an accident, the helmet should provide immediate medical assistance.

2. WORKING

Smart helmets consist of mainly two modules: Helmet side and Vehicle side. Both modules consist of an Arduino nano.

The helmet side module consists of the following components:

- Alcohol sensor (MQ3):
  - ➢ Specifications: Concentration Range = 25 - 500 ppm (parts per million)
  - ➢ Function: detection of alcohol level in human breath.
- Force Sensing Resistor (FSR):
  - ➢ Specifications: Minimum resistance = 120 ohm.
  - ➢ Function: To detect if a person has worn the helmet or not.
- Accelerometer (ADXL335):
  - ➢ Specifications: 10,000 g shock survival.
  - ➢ Function: To detect tilt angle of the helmet.

- Vibration sensor:
  - ➢ Function: To sense vibrations of the helmet during an accident.
- RF transmitter:
  - ➢ Specifications: Operating Range: 100 Meters
  - ➢ Function: To transmit data to the receiver.
- Bluetooth Module (HC-05):
  - ➢ Specifications: Frequency = 2.4 Ghz
  - ➢ Function: To transmit data to the android phone.
- Battery:
  - ➢ Specifications: 7.2V, 2500mAh
  - ➢ Function: Power Supply
- Voltage Sensor:
  - ➢ Specifications: Voltage detection range: 0.0244 to 25
  - ➢ Function: Power Supply

Similarly, the vehicle side consist of following components:

- Servo motor:
  - ➢ Specifications: Operating speed = 0.1 s/60 degree.
  - ➢ Function: To control the opening and closing of the flap above the keyhole.
- RF receiver:
  - ➢ Function: To receive data from the transmitter.

The working of the system consists of two parts:

- Unlocking vehicle
- Accident Detection.

3.1 UNLOCKING VEHICLE:

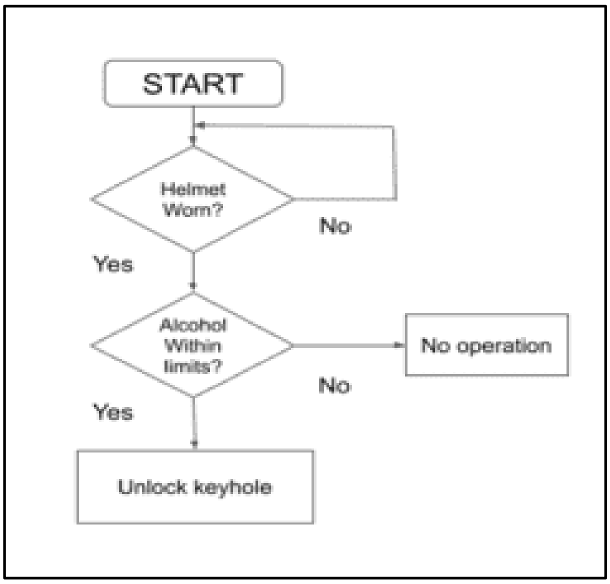

Figure *1*: Flowchart of unlocking vehicle

- The conditions to unlock the vehicle are as follows:
    a) Helmet is worn
    b) Alcohol consumption is within limits
- At the very first stage, the smart helmet is to be switched ON.
- Then using the android app, a Bluetooth connection between the helmet and the phone is established.
- As soon as the helmet is worn by the rider, the FSR is triggered. The arduino then receives this signal from FSR and it turns on the transistor, which switches ON the Alcohol Sensor.
- The alcohol sensor then stays ON for a duration of 20 seconds to detect whether the alcohol consumption of the rider is within limits. If the alcohol concentration is below the legal limit, it sends a signal to the Arduino on the vehicle side using RF.
- This actuates the servo outside the keyhole which then allows the rider to insert the key into the keyhole and start the vehicle.

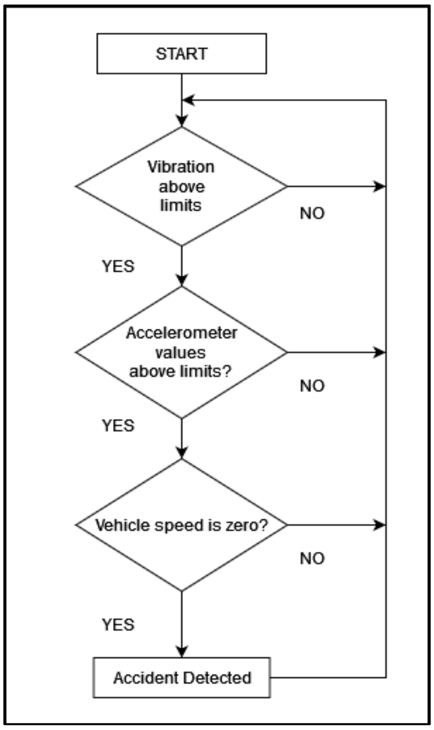

Figure 2: Flowchart of accident detection

3.2 ACCIDENT DETCTION:

- Accidents are detected using the vibration sensor and the accelerometer. For an accident to be detected three conditions are to be satisfied:
    a) Vibrations are above a threshold value.
    b) Accelerometer values are above the limits.
    c) The speed of the vehicle is zero after condition (a) is satisfied [5]
- Considering the following conditions, if the accident is detected, then the Arduino sends triggering signals to the android phone using the Bluetooth module. The messages containing the location of the accident are sent to the contacts, registered by the rider in the app.

4. EQUATIONS

4.1 BATTERY DISCHARGE TIME CALCULATIONS:

$$Discharging\ time\ = \frac{Battery\ capacity\ in\ mAh}{Total\ current\ consumption}$$

Considering,

i) Total battery capacity = 2500mAh

ii) 80% of total battery capacity = 2000mAh

iii) Total current consumption = 250 mA

Hence,

Discharging time = $\frac{2000}{250} = 8\ hours$

4.2 BATTERY SOC CALCULATIONS:

Considering,

i) Lower voltage limit = 7.2 V

ii) Upper voltage limit = 8.4 V

$$Battery\ Percentage\ = \frac{100}{1.2} * VSR\ -\ E$$

Where Error (E) = 600 and VSR = Voltage Sensor Reading.

5. IMPLEMENTATION:

The position of the components are as follows:

Figure 3: Positioning of alcohol sensor on helmet

a) Alcohol sensor: The alcohol sensor is placed near the mouth of the driver.

c) PCB: The PCB is mounted inside the left cushion of the helmet.

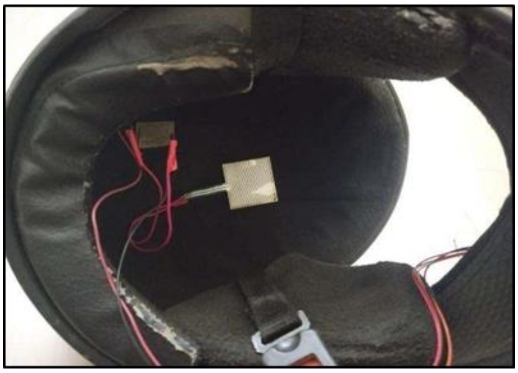

Figure 4: Positioning of FSR in the helmet

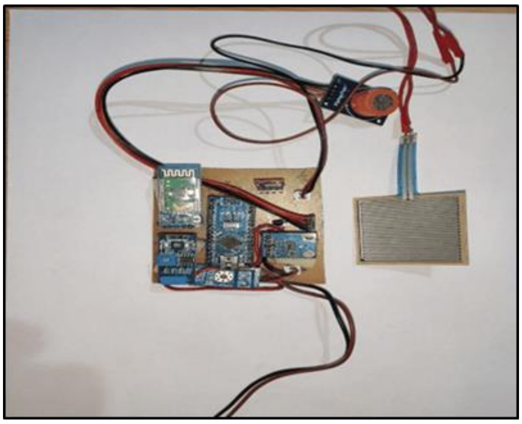

Figure 5: PCB (helmet side)

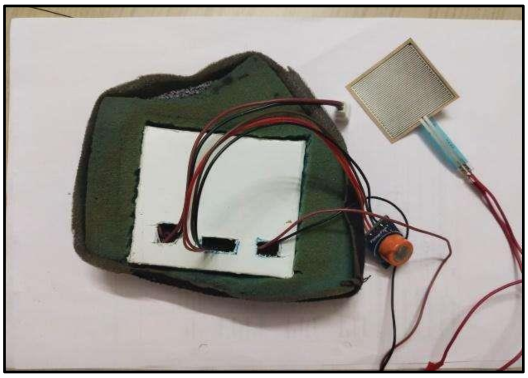

Figure 6: PCB placed in left cushion

d) Battery: The battery is mounted outside the helmet

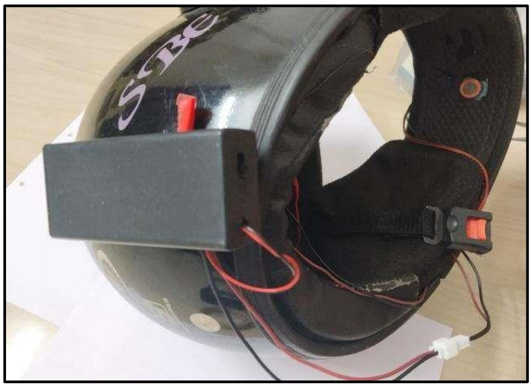

Figure 7: Mounting of battery on the helmet

e) Servo Motor: The servo motor is mounted near the keyhole of the vehicle.

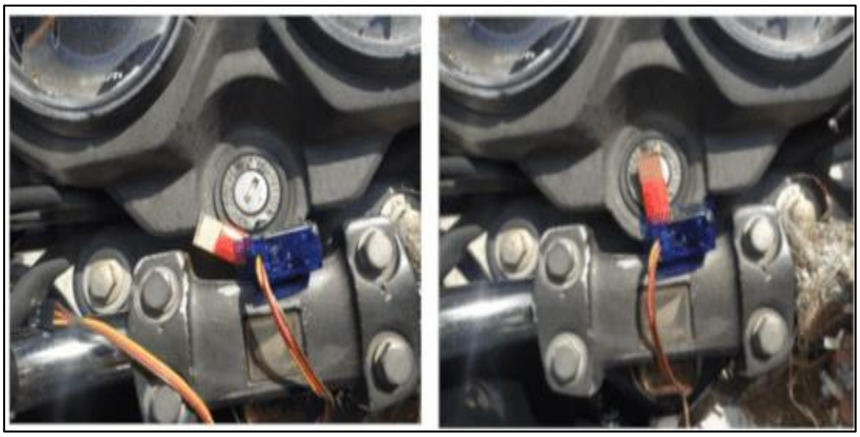

Figure 8: Mounting of servo motor on handlebar

6. ANDROID APPLICATION

The Android app, developed using Android Studio, is designed to be installed on the driver's phone. The app is used to establish a connection between the phone and the smart helmet. The helmet is equipped with an HC05 module that enables communication with the app.

Once the app is installed and the connection is established, it continuously stores the GPS coordinates of the rider at regular intervals. This information is crucial for accurately identifying the rider's location in case of an emergency. When the Arduino Nano detects a significant impact or abrupt motion, it sends a message with the value '1' to the Android app

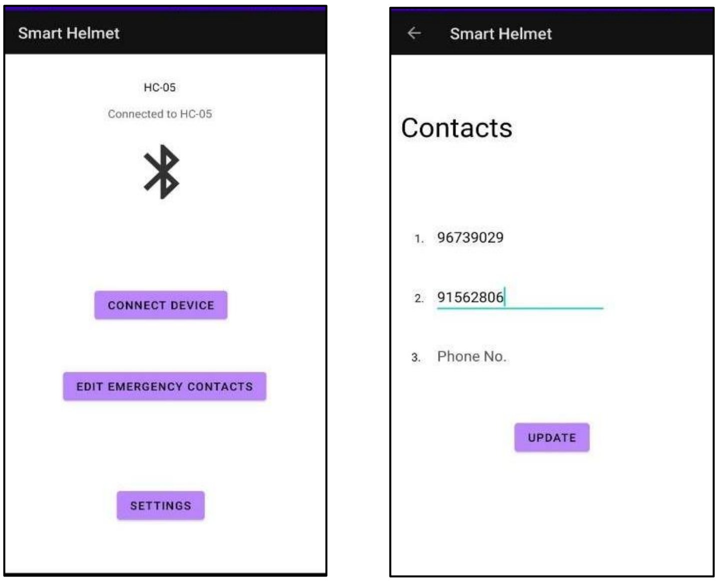

Figure 9: Android app

Upon receiving this signal, the app sends an alert message to the emergency contacts specified by the rider. The alert message includes the precise location coordinates of the accident, obtained from the stored GPS data.

6.1 ADDITIONAL APPLICATION FEATURES

Some optional features are implemented in the system which are:

- System mutes the phone calls received to the driver while riding the vehicle.
- System sends a message containing last location and low battery alert message to the first preferred number registered by the rider.
- Battery SoC (State of Charge) is calculated from the voltage sensor, which is displayed on the app.

7. FUTURE SCOPE

- A solar PV module can be mounted on top of the helmet, this can be used to charge the battery.

- Voice over GPS navigation system inside the helmet can be implemented.
- A mic and speaker can also be added inside the helmet to communicate over a phone call.
- A limit on the vehicle speed can be set, based on the alcohol consumption of the rider.
- A list containing the contacts of ambulances near the location of the accident can also be included in the emergency message.

In case the phone is damaged during the accident, a cloud monitoring system can be used. The cloud monitoring system continuously receives the rider's location from the app. If the data is not received after a particular time, then it will send an emergency message to contacts.

8. CONCLUSION

The smart helmet design prioritizes rider safety by implementing mandatory helmet usage and preventing the rider from operating the bike if either of two key safety rules is violated: not wearing a helmet or exceeding the permissible alcohol consumption limit. The proposed system acts as a preventive measure. Additionally, in the event of an accident, it aids in the effective management of the aftermath. By sending an SMS to the family members and friends containing the biker's location, prompt medical attention can be provided to the victims, ensuring their well-being.

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