Smart helmet system with accident safety gears and bike tracking mechanism using non IOT methods

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Abstract. The road accidents across the world have been increasing every year. Due to this, safety of a rider has become a major concern. It is observed that bike accidents in south Asian countries are in majority as compared to other class of vehicles. Most of these bike accidents are due to rider’s negligence. The intension is to circumvent the negligence of the rider and fatal injuries. In this regard, the Arduino microcontroller system is developed which does not allow the rider to start the bike until the main rider and pillion rider wears the helmet. It is also necessary that the main rider is not drunk and is sober to start the bike which is detected in the helmet. In case of an occurrence of the bike accident, the concerned members of the rider and emergency services are notified with text message and real time location to avoid last minute casualties. If the rider exceeds the speed limit, audio warning alert will be given to the main rider through the speakers in the helmet. The provision for alternate method to start the bike is given to the rider in limited access to avoid misuse of the system in case the helmet is lost. The bike is made trackable in case of lost or not found.

1. Introduction

India is a vast country and road transportation is serving as the backbone of the country, from cargo to connecting cities, towns and villages. On the other hand, road safety has also become a major concern as the road accidents have led to causality and serious injuries. These accidents are mostly caused due to over speeding, hit and run, drunk and drive and many more reasons. As per the government reports of India in the year of 2017, number of accidents caused are 4,64,910 which has further led to 1,34,796 fatal accidents out of which 1,47,913 were killed and 4,70,975 were injured including the pedestrians and other victims of the accident[1].The accidents caused in the year 2014 to 2017 in India as projected by the government can be seen in Table 1.
Table 1. Accidents projected by the government of India in the year 2014 to 2017.

| Year | Accident caused | Total victims |
|------|-----------------|---------------|
|      | Total Fatal     | Killed Injuries |
| 2014 | 4,89,400        | 1,25,828 1,39,671 4,93,474 |
| 2015 | 5,01,423        | 1,31,726 1,46,133 5,00,279 |
| 2016 | 4,80,652        | 1,36,071 1,50,785 4,94,624 |
| 2017 | 4,64,910        | 1,34,796 1,47,913 4,70,975 |

Looking at the data collected, it is evident that the severity of these accidents towards fatality is a major concern and the main motivation to contribute towards the safety of the rider and reduce the probability of the accidents. Table 2 and Table 3 provides the data on the number of accidents caused and the type of vehicles causing it in the year 2016 and 2017 as per the Indian government reports [1][2].

Table 2. Accidents projected by the government of India for the type of vehicle in the year 2016.

| Type of vehicle                  | 2016          |
|----------------------------------|---------------|
|                                  | No of accidents | Victims causalities | Victims injured |
| Motor Bikes                      | 1,62,280      | 44,366             | 1,53,060        |
| Auto-rickshaw                    | 31,400        | 6,767              | 39,680          |
| Cars, jeeps and taxis            | 1,13,267      | 32,599             | 1,25,773        |
| Buses                            | 37,487        | 12,088             | 50,686          |
| Trucks, Tempo and tractors       | 1,01,085      | 39,504             | 91,784          |
| Other motor vehicle              | 13,225        | 5,886              | 11,607          |
| Non-motor vehicles               | 4255          | 1,728              | 3,799           |
| Others                           | 17,583        | 7,847              | 18,235          |
| Total                            | 4,80,652      | 1,50,785           | 4,94,624        |

Table 3. Accidents projected by the government of India for the type of vehicle in the year 2017.

| Type of vehicle | 2017          |
|-----------------|---------------|
|                 | No of accidents | Victims causalities | Victims injured |
| Motor bike      | 1,57,723      | 44,092             | 1,48,907        |
| Auto-rickshaw   | 29,351        | 6,762              | 35,682          |
| Cars, jeeps and taxis | 1,13,737   | 31,183             | 1,23,156        |
| Buses           | 32,145        | 10,651             | 44,330          |
| Trucks, Tempo and tractors | 92,818   | 37,505             | 87,453          |
| Other motor vehicle | -     | -                  | -               |
| Non-motor vehicles | 6,376     | 2,798              | 4,39,528        |
| Others          | 32,760        | 14,922             | 26,455          |
| Total           | 4,64,910      | 1,47,913           | 4,70,975        |

In Table 2 and 3, the projected data for motor bike accidents have been way more and fatal than any other class of vehicle[1][2].
The motor bike accidents are in majority mostly due to rider’s negligence and the negligence can be in the form of rash driving, over-speeding, consumption of alcohol and riding and losing attention from the road while talking on phone. The fatalities of accidents are more due to avoiding safety rules and gears like seat belts and helmets. To avoid this negligence from the biker’s side, the safety gears for the riders are also developed.

1.1 Solution for the addressed problem
A system is developed where the rider is not allowed to start the bike until the main rider and pillion rider (if present) wears the helmet. The detection of the pillion rider is made by using a switch at the back seat of bike where he sits. The main rider must undergo the alcohol consumption test, which is also a criterion to start the bike which is performed through his helmet. In-case the bike exceeds the specified speed limit while riding, an audio waring alert through the speaker inside the helmet of the main rider is heard to caution him. If the rider meets with an accident, an immediate message alert with real time location is sent to the concerned members of the rider and emergency services as registered in the system, to provide immediate medical assistance and avoid last minute casualties[9]. The main rider can connect his phone to the helmet to attend hands free emergency calls which avoids the risks of him handling the phone and losing the balance of the bike hence leading to accidents.

1.2 Increasing the reliability of the system
In-case the bike is lost or not found, the provision for tracking the bike offline is also provided[13]. If the helmets are lost or tampered, the provision for an alternate method to start the bike is also seen. The rider can unlock and start the bike by sending a text message through the rider’s phone to the bike. This provision is limited to the rider, say about twice a week/day to avoid the misuse of this feature.

2. Design of sub-system
The developed system has been categorized into three sub-systems namely.
- Bike unit.
- Main rider helmet unit.
- Pillion rider helmet unit.

The bike unit will be communicating with the main rider unit and the pillion rider unit serially (UART) via Bluetooth[11]. The main and pillion rider helmet is powered by the rechargeable battery or solar panel mounted on top of the rider’s helmets[5]. The Bike unit can be powered on by the bike battery during the time of execution.

![Block diagram of Bike Unit and Hardware connections of the Bike Unit.](image-url)
2.1. Bike Unit
The bike unit as in Figure 1 (a) consists of a main Arduino Uno microcontroller. Further this microcontroller is embedded with GPS module, GSM module, 2 x HC-05 Bluetooth modules (interface with main rider’s helmet and pillion rider’s helmet), IR sensor (to check the speed of the bike), ignition switch, switch (pillion rider detection), 16x2 LCD (display messages) and accelerometer (detecting accidents).

2.2. Main rider Helmet Unit
The main rider helmet unit as in Figure 2 consists of a main Arduino Nano microcontroller. This microcontroller is embedded with MQ-3 gas sensor (for alcohol detection), rechargeable battery or solar unit (to power on the system), speakers (providing audio speeding caution), Bluetooth headset (to pair with the phone to receive calls), HC-05 Bluetooth module (to interface with the bike unit) and over-head switch (for riders detection).

![Figure 2(a). Block diagram of main rider Helmet Unit and (b) Helmet with all the components of the Helmet Unit.](image-url)

2.3. Pillion rider Helmet Unit
This Pillion rider helmet unit as shown in Figure 3 consists of a main Arduino Nano microcontroller. This microcontroller is embedded with HC-05 Bluetooth module (to interface with the bike unit), rechargeable battery or solar unit (to power on the system) and over-head switch (for riders detection).

![Figure 3. Pillion Rider Helmet Unit](image-url)
3. Methodology to Develop the System

The bike unit is the central part of the system, which handles all the protocols and actions needed for the system. The microcontrollers in main rider helmet and pillion rider helmet will be serially communicating with the microcontroller present in the bike unit through the HC-05 Bluetooth modules. The configuration of the Bluetooth is performed by ‘AT’ commands. The Bluetooth modules in the bike unit is configured to ‘AT+ROLE=1’ and acts as the master. The Bluetooth modules in main rider helmet and pillion rider helmet is configured to ‘AT+BIND=slave address’ and acts as the slave. This enables and establishes the serial communication between the bike and the helmet units. The bike unit is simultaneously communicating serially with the GSM module. For configuring the GSM module, ‘AT’ commands are used. To send a text message, the GSM module is configured to ‘AT+CMGF=1’. To send a text message to the specific mobile number, the GSM module is configured to ‘AT+CMGS=77XXXXX209’ (‘X’ denotes the designated phone number). In order to receive the incoming text message, the GSM is configured to ‘AT+CNMI=1’.

3.1. Assurance of main rider wearing helmet

Once the main rider wears the helmet, the switch present over-head is active, and the main rider helmet unit is powered on by the rechargeable battery. The battery is charged manually with charging adapter or with the help of solar power panel. After powering on the helmet unit, the serial communication between the bike and main rider helmet unit is accomplished via HC-05 Bluetooth module. When the connections of the Bluetooth are established, it detects and assures the main rider helmet worn and the ignition switch will be active to start the bike. In case the helmet is removed, the over-head switch is inactive and ignition switch is disabled[4][10].

3.2. Alcohol consumption test of the main rider using MQ-3 gas sensor

The alcohol consumption test is carried by MQ-3 gas sensor. This sensor pins are connected to Arduino Nano microcontroller in the main rider helmet unit. The sensor is present inside the main rider’s helmet near the mouth. Once the main rider wears the helmet the gas sensor monitors for any alcoholic gases from the mouth of main rider[3]. The threshold of the MQ-3 gas sensor is set to 0.04mg/L. If the rider is drunk and crosses the threshold, the signals are sent to bike unit through Bluetooth and ignition switch is disabled [15].

3.3. Assurance of Pillion rider wearing helmet

If the pillion rider is present, the detection of pillion rider is done by the detection switch present at the rear seat of the bike. Once the pillion rider presence is detected, pillion rider helmet worn assurance is required to start the bike. This assurance is obtained when the over-head switch inside the helmet is turned on when it is used. This whole unite is powered on by the rechargeable battery. The Battery can be charged manually or with the help of solar power panel. Once the unit is powered on, the Bluetooth connection is established between the pillion rider helmet unit and the bike unit. Therefore, the ignition switch is active to start the bike. Only when section A, B and C follows the protocols, the ignition switch turns ON. When any one protocol fails, the ignition switch turns OFF.

3.4. Accident alert system using accelerometer, GPS and GSM modules

This working takes place inside the bike unit. The accident detection is initiated by MEMS accelerometer sensor (ADXL35). The accelerometer monitors the change in the axis of the bike during the fall of the bike. If the speed of the bike is above 30kmph and if there is change in the axis of the bike beyond 60° (which indicates the fall), accident of the bike is hence sensed at that speed[12]. Once the accident is detected, the GPS module fetches the current co-ordinates of the location and GSM module will send a
text message to the concerned members of the rider and emergency service as registered in the GSM module. The text message contains the GPS location of the rider’s accident spot [14][7].

3.5. Detection and audio alerting system using IR sensors and speakers
The speed of the bike is monitored by the IR sensor, placed near the rotating wheel. If the speed of the bike exceed above 80 kmph, a signal is sent to the main rider helmet unit, the main rider hears an audio alert inside the helmet as ‘bike is speeding up please slow down’ for three times. The frequencies of the audio are captured by the Arduino Nano microcontroller in the main rider helmet unit. The same frequencies are transferred to the speakers present in the main rider helmet unit, hence cautioning the rider on over speeding. While transferring frequencies of audio to the speakers, the pulse code modulation technique is used.

3.6. Attending hands-free emergency phone calls using Bluetooth headset module
The left speaker and the right speaker are connected to a Bluetooth headset module. This module is placed in the helmet of the main rider. This can be extended to the pillion rider’s helmet as well. The rider can pair his mobile phone to the headset module to attend emergency calls hands free through a push button on the side of the helmet shown in Figure 4. The intension of this feature is to avoid rider’s distraction from road which results in an accident when he receives phone calls while riding the bike by stuffing the phone through the helmet.

![Figure 4. Hands-free phone call attending using push button blue-tooth headset.](image)

3.7. Bike tracking using GPS and GSM
In case the bike is lost or not found, the provision for tracking the bike is provided. The rider can send the bike tracking text message to the GSM module present in the bike. On receiving the tracking message in the bike unit, the GPS module fetches the current co-ordinates of the bike and sent to the rider’s mobile number through the GSM module in the form of a text message [6][8]. This way, the rider tracks his bike in case of theft or lost.

3.8. Alternate method to start the bike using the GSM module
In case the helmet is lost or tampered, the need to use the bike and start the bike using an alternate non smart helmet is still possible. This is achieved by using the GSM module. The rider sends a text message from his phone to the GSM module in the bike unit to unlock the bike. On receiving the unlock text message by the GSM module, the ignition switch is made active to start the bike. This provision is allowed by giving limited access to avoid the misuse of the system.
4. Working Model and Results

The system was tested on a motored-wheel. The results were observed on a 16x2 LCD display. The LCD display is also used as an instruction set for the riders. The responsive text message is received from the bike unit to the mobile phone.

4.1. Unlocking the bike by wearing helmet

Before starting the bike, instructions for wearing the helmet is displayed on the LCD screen to the main and pillion rider (if present) as shown in Figure 5. Unless, the rider wears the helmet, the ignition switch is inactive and the bike is locked. Once the helmets are worn by the riders, the bike will be unlocked as shown in Figure 6 and the ignition switch is made active.

4.2. Alcohol consumption test of the main rider

The MQ-3 gas sensor is placed near the mouth of the main rider inside the helmet as shown in Figure 7. If the main rider is drunk, the sensor detects the alcoholic gases and the bike is locked and the ignition switch is inactive as shown in Figure 8.

Figure 5. Instructing the riders to wear the Helmet

Figure 6. Indicating the main rider to start the bike

Figure 7. MQ-3 gas sensor inside the helmet near the mouth.
4.3. Speed check and audio alert
The speed check performed on a motored wheel where the audio warning alert inside the helmet as well as the display provided on the LCD screen as shown in Figure 9 when the speed of the vehicle exceeds 80kmph.

4.4. Accident alerting system
The concerned members of the rider are alerted on the accident occurrence once the system detects the change in the axis of the bike above 60\(^\circ\) and speed of the bike above 30kmph. The concerned members of the rider receives a text message as shown in Figure 10 with real time location of the accident spot.

4.5. Bike tracking system
For tracking the bike, rider sends a text message ‘getgps’ from his phone to the GSM module present in the bike unit. A real time location of the bike is sent back to the mobile phone of the rider from the GSM and GPS module in the bike unit as shown in Figure 11.

4.6. Alternate method to start the bike
The ‘unlock’ text message is sent from the rider’s phone number to the GSM module as shown in Figure 12. On receiving the unlock message, the bike will be unlocked, and the ignition switch is active to start the bike. The LCD displays the unlock status of the bike as shown in the Figure 13.
5. Future Work and Developments

Many additional features can be added to this smart system. This prototype can be brought to the market as a product and implemented on any bike. Internet of things can be introduced to this system along with mobile applications developed for live tracking the bike. The rain sensing wipers can be added to the helmet system for the visibility during riding in the rain. The voice assistance for locations can be added inside the helmet of the main rider for assisting the rider on directions while riding for hassle free and avoid distractions from the road.

6. Conclusion

Smart helmet system safeguards the riders of the bike by providing protective gears before starting the bike. It also ensured that the main rider is not drunk to start the bike which helps in monitoring the negligence of the rider and hence reducing the bike accidents and forces the rider to abide the government rules of ‘drunk and riding’. The system also helps in preventing the fatal accidents caused by over speeding by cautioning the main rider by an audio alert system. In case of an unexpected occurrence of the bike accident, the accident location is tracked, and medical services are intimated to avoid last minute casualties. To prevent the distraction from the road while talking on the phone, the emergency calls can be received by hands-free push button Bluetooth system embedded on the helmet. In case of the smart helmet tampered or lost, a provision of an alternate method to start and use the bike is provided for a limited period of time till the user purchases a new smart helmet. This system provides a full proof to reduce the fatal accidents of the bike by 80% and able to provide the medical assistance at the earliest to reduce casualties.

Acknowledgments

This research was supported by IEEE Yesist12 Age of Innovation 2019 and secured ‘First place’ at the national level competition with all paid trip by IEEE to participate at the International level IEEE Yesist12 Age of Innovation competition at Stamford University, Thailand, 2019.

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