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# Smart helmet to start the motorbike and to prevent accidents

**J Joy Mathavan[1]*, V K D Wijesekara[2], N Satheeskanth[3], W M U J Wanasinghe[4], M Maathushan[5], V V Wijenayake[6]**

[1,2,3,4,5,6,] Department of Engineering Technology, Faculty of Technology, Kilinochchi Premises, Ariviyal Nagar, University of Jaffna, Sri Lanka.

joymathavan1991@gmail.com, Kaushi.781@gmail.com, sathees117@gmail.com, jayashanthaujith@gmail.com, mathushan.mahes@gmail.com, vihangavilthera@gmail.com,

**Abstract.** Most of the motorbike riders meet a fatal end due to severe head injuries during accidents. Usually in Asian countries, riders are reluctant to wear helmets while riding motorbikes due to carelessness and negligence. This research aims at reducing the accidents that may occur due to such carelessness and at the same time, immediately report the accident to the emergency contact numbers. This research work is aimed at making the necessary conditions essential to start the motorbike. The rider needs to wear the helmet, should be free from consumption of alcohol and should take off the side stand before igniting the vehicle; failure of any one of this condition would not ignite the engine. The proposed system detects the accident occurrence as well. SMS will be sent to the emergency numbers through the GSM module. The prototype works on start mode, running mode and accident mode with different functionalities in each mode. The rider needs to clear the start on mode to ignite the engine and a smart system will continuously monitor the bike and rider in the running mode. In case of unexpected interruptions during running mode, the proposed system enters into accident mode and enables GSM to report the accident to the pre-registered phone number.

## 1. Introduction

Motorbikes serve as the means of easy transportation compared to other vehicles. At the same time, safety while riding a motorbike is also an important issue to take care of. Out of around two million reported head injuries occurring every year, it is estimated that around 28% [1] of head injuries occur during motorbike accidents. Motorcyclists are not as protected on bikes as the driver or passenger in a car. These injuries may end up in life changing injuries or even death. World Health Organisation (WHO) indicates road accident injury as the 10th ranked global cause of death in 2016, which is predicted to be the 8th in 2030 [2]. The World Health Organisation has also shown that, the use of a helmet could reduce the risk of injury by 72% and the probability of death by 39% in case of motor bike accident [2]. Motorbike accidents have become a primary public hazard, which needs to be handled in a multi-disciplinary manner. Not wearing helmets, reckless driving, ignorance of traffic rules, drunkenness while driving and absence of a protective shield are some of the most significant reasons for these deaths. Mostly, the younger generation do not worry about safety when driving motorbikes. They may not have enough practice and attitude for being a good driver. With the introduction of the open economic policy to Sri Lanka in 1977 [3], a large number of three-wheelers and motorcycles were imported. The number of registered motorcycles in Sri Lanka in 2016 was 3,699,630 [3]. It was 55% of the total registered vehicle population at that time. Sri Lanka has seen a significant increase in its motorcycle population, from 2012 to 2019. The number of registered motorcycles increased by 45% with the growth rate of

11% per year [3] in Sri Lanka. This scenario shows the significant growth of the motorcycle population in Sri Lanka. This research work is aimed at making the necessary conditions essential to start the motorbike and to report the accident to a pre-registered phone number. Proper wearing of the helmet, lifting up the side stand and non-consumption of alcohol are considered as necessary factors in this project to start the motorbike. The objective of this study is to find a smart solution to minimise the accidents and to reduce the risk of injuries and number of deaths of bikers.

## 2. Literature Review

This research work is inspired from the recommendations of medical journals, which speak about the importance of wearing a helmet while riding a motorbike. The study of Bolbol SA and Zalat MM shows that 87.1% of the motorcyclists who succumbed to death in road accidents, do not have a proper driving licence and 98.1% of them do not wear a helmet [4]. This is an alarming situation considering the developing countries including India and Sri Lanka which are congested with huge numbers of vehicles on narrow roads. K.C. Mani Kulanthayan et al in their research has stated that, in Malaysia, helmets are mandatory for motorbike riders and it has reduced the fatality rate during motorcycle crashes by 30% [5]. J. Joy Mathavan et al have described the automatic side stand lift-up system while starting the motorbike. Once the rider is on the seat and the key is turned on, the side stand would be lifted up and when the key is turned off and rider gets off the seat, the stand retrieves back to the position [6]. This system is developed in order to prevent accidents by the position of the side stand. They clearly described how the position of the side stand can cause accidents on junctions. Nataraja N et al described about starting the motorbike, if the rider is not drunk. According to their work, an alcohol sensor is fixed on the helmet, and the bike would start if the rider is not drunk. Signals received from sensors attached to the ignition system and alcohol sensor are transferred to the microprocessor, which in turn enables the ignition of the motor bike [7]. Mohd Khairul Afiq Mohd Rasli et al in their attempt to enhance the functionality of the smart helmet, have incorporated Force Sensing Resistor (FSR) and Brushless Direct Current (BLDC) fan to estimate the speed limit and alarm the rider if the pre-determined speed limit is exceeded [8]. Rashmi Vashisth et al have described E-HELMET, which is used to inhibit engine ignition if not worn and incorporated sensors which serve as alcohol detectors, speed alarming system and tollgate auto payment E Wallet [9]. But, the system of integrating with tollgates for auto payment is practically tedious to implement in developing countries. Though a number of features are available in this research work, real time implementation integrating the system with the motor bike is not illustrated in their paper. L. Kanimozhi et al developed a smart helmet system that ensures the rider remains sober throughout the journey and also to monitor his heart beat rate to detect any health abnormalities while riding motorcycle [10]. Yet, the suggested prototype needs further improvements to make sure the helmet remains in contact with riders' head throughout the journey to protect him in case of any accidents. Abhinav Anand et al described an IR (Infra-red) sensor to detect the presence of a helmet using the infra-red rays emitted from the human body, and absence of which will not ignite the motorbike engine. He has also mentioned about pre-defined speed limits to prevent over speed of vehicles and inform them, if the speed exceeds the limit. His system was designed in a way to inform nearby hospitals in case of any accident as well [11]. In an attempt to improve the security and to prevent theft of automobiles, two factor authentication was described by O. Akinsanmi et al. It works on enabling keyless entry to ignite the engine using two-factor authentication. In addition to automobile keys, voice-based authentication can also be enabled to secure the vehicle from theft. If the automobile key is lost and found by an unauthorised person, the attempt of starting the engine can be prevented by implementing this voice-based authentication [12]. The working principle here is appreciable but brings practical difficulties when it comes to voice authentication. R.M. Vithlani et al described the possibility of a biometric automobile ignition locking system. It is mentioned that the automobile ignition system can be started only if the fingerprint authentication is provided [13]. Implementing such a biometric locking system is good for the use of single person, but may result in chaos in case of automobiles which are frequently used among inmates. S. Aliyu et al in their research work described a multi factor authentication technique using combination of password and fingerprints. In case if the vehicle is stolen, the current location of the vehicle could be communicated with the user using GSM / GPS (Global System for Mobile Communications / Global Positioning System) communication module [14]. However, with the advancement of technology, if the GSM module is removed after theft or if the automobile is taken to places where there are no proper mobile networks, the target of this research cannot be achieved. Researches [12-14] concentrated much on the security of automobiles rather than motorbikes. The research works [12–14] spoke about passing the robbery information or preventing the robbery of the vehicles. Mohammad Ali et al in their research work, analysed the accident-avoidance framework, in which, the proposed algorithm automatically decelerates the automobile in case of any dangerous terrains or road curves using automatic brake and steering control of individual wheels of the automobile [15]. J J Mathavan et al also carried out research regarding the accidents in automobiles. They described an automatic door unlocking system of the vehicle in case of any vehicle fire accident [16]. Chloe et al found that, during an accident, the riders of motor bikes and drivers of automobiles tend to blame the opponents for the cause of the accident [17]. It doesn’t actually matter whether the accident involves two motorbikes or two automobiles or a motor bike and an automobile; the damage and loss is for both. Blaming the opponent after the accident will not restore the loss. Also, it hardly matters whether the accident involves two or more vehicle collisions or slip of a single vehicle. So, the best way to avoid accidents is by taking necessary precautions. Ching-Yao Chan has worked on sensor arrays during vehicular crashes. He observed the response time of those sensors for vehicular crashes happening at various speeds. His research concentrated on detecting suitable sensors for automobiles with the lowest response time with varying speeds [18]. Researches [15 - 18] are concentrated more on preventing accidents of automobiles.

Most of the required factors like starting conditions, safety while riding, informing accidents and preventing robbery are individually discussed by several authors. Individual solutions cannot solve this issue, since this subject is an interconnected matter of several factors. Eliminating one factor of accident while the others remain the same will not help to solve this problem. Therefore, the current research work is interested in solving all the available factors of accident in a single shot. The novelty of this research work resides in combining all the necessary factors for smooth and safe riding of a motorbike in a single small device, without making the existing system complex and implementing it in real time. Because, most of the research works failed to connect the solutions with the real time implementation for a developing country.

This research paper is written in way that, section one introduces the current scenario on the population of vehicles and accidents, section two describes the detailed literature review of the steps taken by different authors to solve the issue, section three describes the methodology of the solutions designed and developed in this research work to solve the above-mentioned issues, section four discuss the obtained results and the last section mention about the conclusion of this research work.

## 3. Methodology

The proposed smart helmet comprises overall functionalities as shown in Figure 1. The block diagram shown in Figure 2 shows the parts of the developed system such as alcohol sensor, IR sensor, GSM module, ignition relay, accelerometer and display. The flow diagram shown in figure 3 describes the necessary conditions to start the engine. Satisfaction of all the three conditions such as helmet worn properly, free of alcohol consumption and side stand lifted up will allow the ignition system to be activated. The flow diagram for the detection of accidents is shown in Figure 4. Once the accident is detected, a phone call and a message will be sent to the emergency number saved in the phone. The specifications of the hardware components used in the research work is shown in table 1.


**Figure 1.** Integrated system of Smart Helmet

The Smart safety helmet is developed using IR sensors and it has two separate parts: receiver and transmitter. Receiver is fixed at the motorbike and the transmitter is fixed inside the helmet. The receiver fixed at the motorbike will control the ignition switch according to the signals received from the transmitter which is fixed inside the helmet. When the rider wears the helmet and ties the belt of it up, the IR sensor detects that the rider wears the helmet and then only it'll allow the bike to start. Simply wearing a helmet without tying the belt of the helmet will not work. When the rider wears the helmet, the mini switch placed inside the helmet detects the pressure and the switch would be turned ON. The transmitter looks to find the receiver which is fixed on the motorbike dashboard. Then the transmitter emits signals from Infra-Red Light Emitting Diode (IR LED) and which would be detected by the IR receiver. Then the receiver transfers this command to the controller. The helmet worn message will be displayed in the dashboard of the motorbike as shown in figure 5. Then as the next step, the controller will check for the position of the side stand.

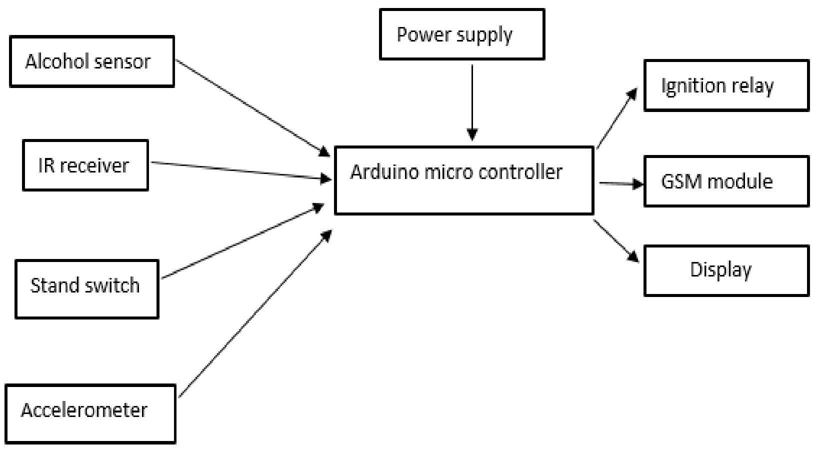


**Figure 2.** Block diagram indicating the overall function of smart helmet

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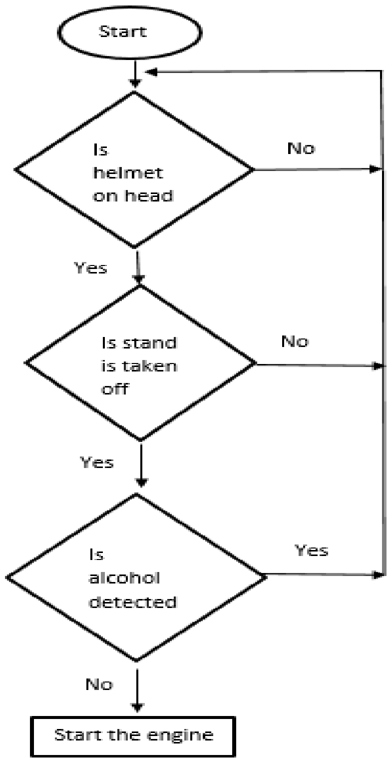


**Figure 3.** Flow diagram indicating the ignition of the engine

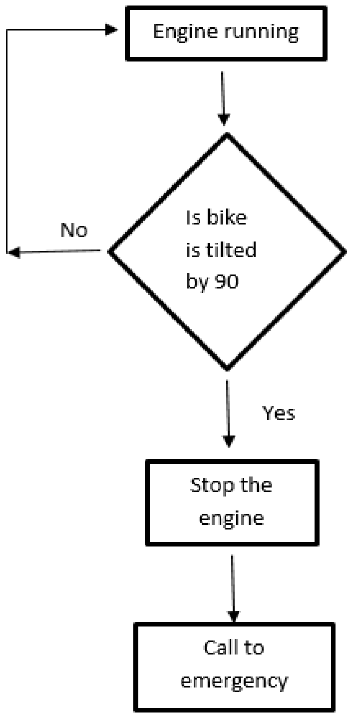


**Figure 4.** Flow diagram indicating the detection of accident

**Table 1.** Specification of the hardware components

| Hardware co components | Specifications |
|---|---|
| Arduino UNO | Microcontroller: ATmega328P<br>Operating voltage: 5V<br>Flash memory 32KB<br>Clock speed 16MHz<br>Analog I/O pins: 6<br>Digital I/O pins:14 |
| GSM module | Model type: SIM800L<br>Power supply: 3.8V-4.2V<br>SIM card socket: micro-SIM<br>Supported frequencies: Quad-band (850/950/1800/1900 MHz) |
| Relay switch | Contact rating: 10A,240VAC/24VDC<br>Max. carrying current: 14A<br>Max. switching power: 2400VA, 240W<br>Initial resistance: Max. 100mΩ at 6VDC, 1A |
| MQ 3 Sensor | Sensing resistance: 1MΩ – 8MΩ (0.4 mg/L alcohol)<br>Operating voltage: 5V ± 0.1 |

| | |
|---|---|
| | Load resistance: 200KΩ<br>Operating temperature: $20^0$C - $50^0$C |
| Accelerometer | Model type: ADXL 345<br>Power supply: 1.8V – 3.6V<br>Resolution: 13 bits<br>Sensitivity: min 232 LSB/g, max 286 LSB/g<br>Temperature range: -40 to +85℃ |
| Display | Type: HD44780<br>Operating voltage: 4.7V – 5.3V<br>Display: 2 × 16 characters<br>Pixels: 5 × 8-pixel box<br>Operating bits: 8-bit and 4-bit mode |

**Figure 5.** Detection of Helmet

Then the system detects the position of the side stand. If the stand is lifted, the toggle switch shown in figure 6 near the stand will be activated. Otherwise, the switch would not be pressed and the system would not allow the ignition of the vehicle. This scenario is shown in figure 7. In the similar way, when the side stand attached to the motorbike is released, the signals from the relay are transmitted to the controller to turn off the engine. Forgetting to lift the side stand is dangerous while taking left turns as it may hit the ground and the rider may lose his balance [6]. Once the controller detects that the side stand is lifted up, it looks for the signals from the alcohol sensor.

**Figure 6.** Arrangement to detect the position of side stand

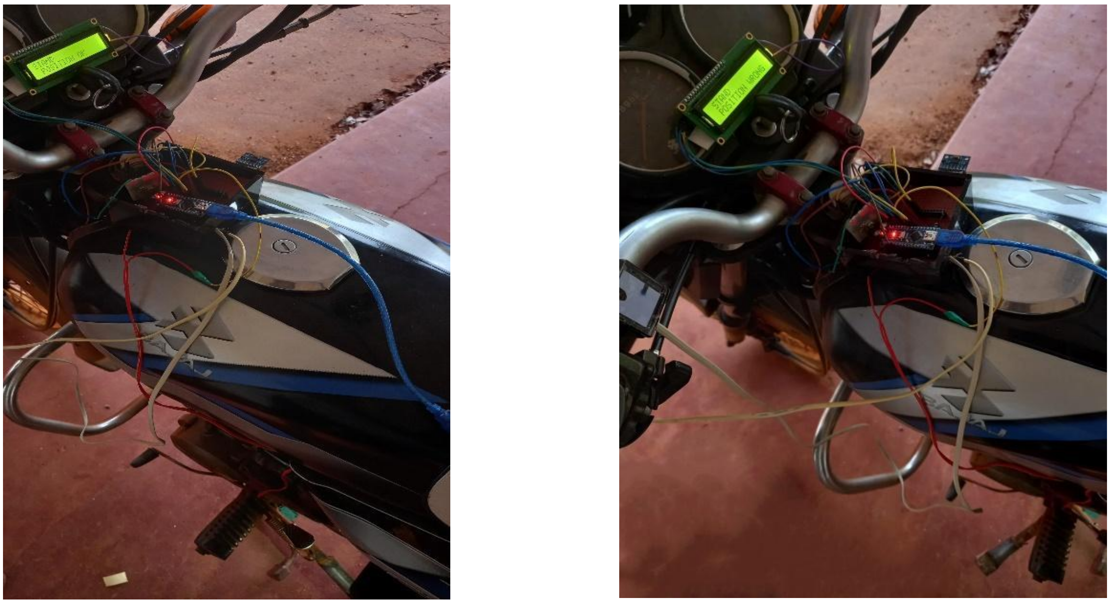

**Figure 7.** Detection of side stand

Alcohol sensor (MQ3 sensor) is also fitted inside the helmet. It will be activated if the user has consumed alcohol. Under such conditions, the controller denies the ignition of the motorbike. If the rider is free of alcohol consumption, the alcohol sensor will not be activated and the motorbike ignition system can be started and it is shown in figure 8. The combination of all the signals from helmet, side stand and alcohol detector will allow the ignition of the motor bike engine to switch to start mode.

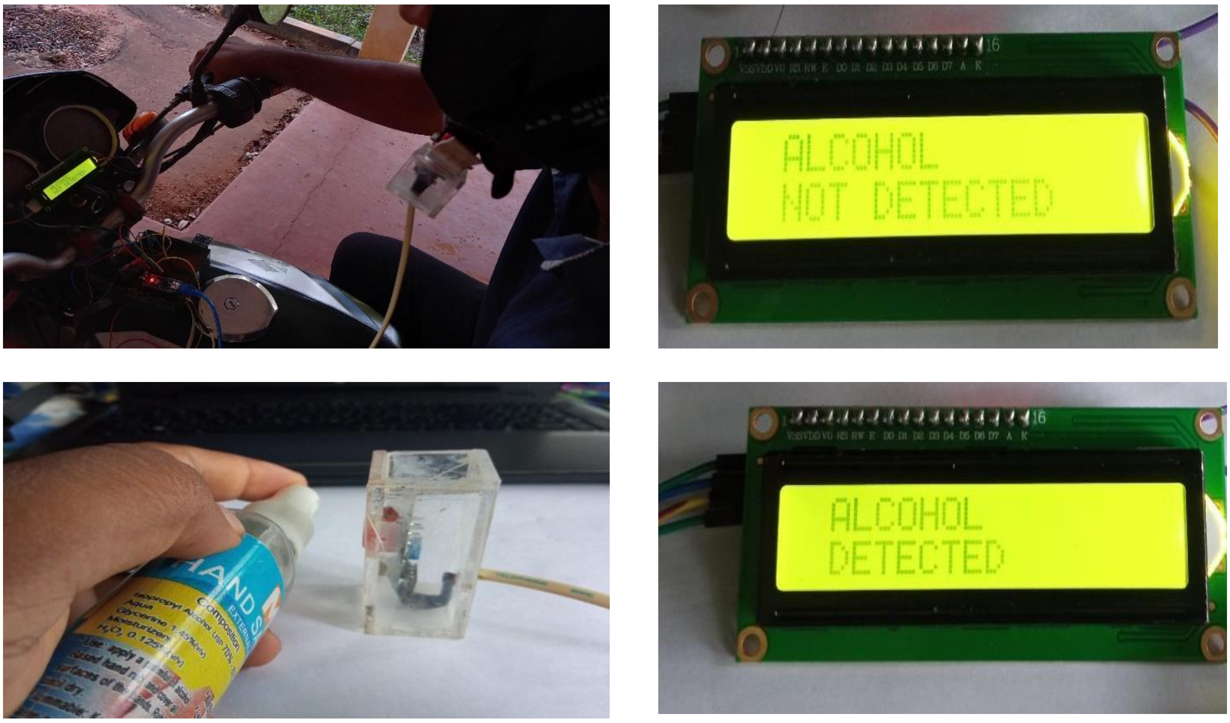


**Figure 8.** Detection of Alcohol

In running mode, a gyroscopic sensor will be monitoring the angle of inclination of the motor bike. If the gyroscope tilts above 90 degrees angle, then the accident mode would be enabled and the GSM module gets activated as shown in figure 9. The GSM module sends the message “accident detected” to the pre-registered emergency contact numbers in case of any accidents, as shown in the fig 10.


**Figure 9.** Detection of accident

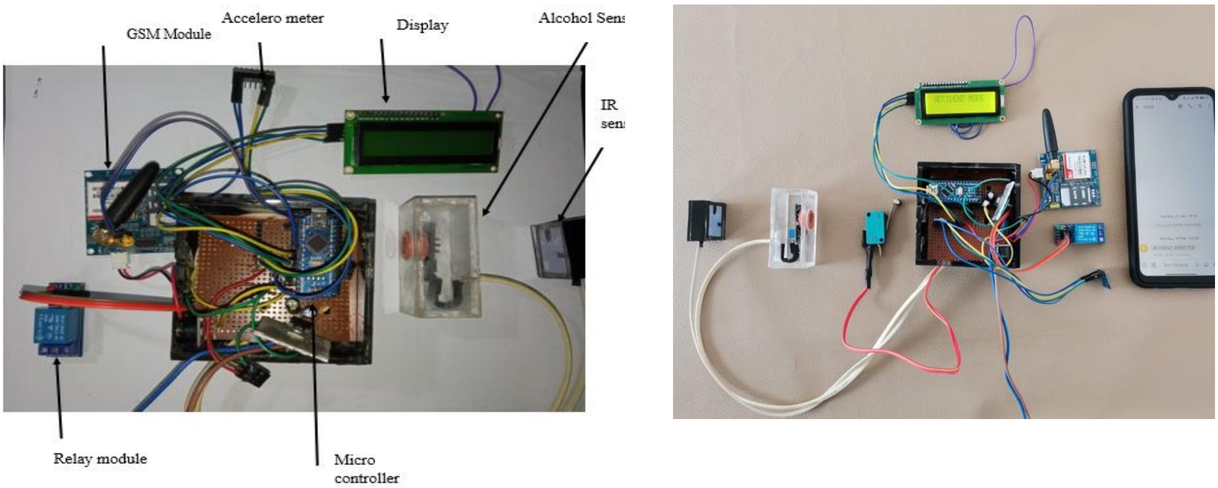


**Figure 10.** Proposed prototype for Smart Helmet

## 4. Results and discussion

The proposed smart helmet includes three modes namely Start ON mode, Running Mode and Accident mode. These three different modes of operations are designed using suitable sensors and tested in the real time environment.

In start ON mode, the controller will check whether the user has placed the helmet properly on his head and tie the belt of it, whether the side stand is taken off and whether any alcohol consumption is detected. If all these conditions are satisfied, then the controller sends signals to relay to ignite the engine. Even if any one of the above-mentioned conditions are not satisfied, relay will not be activated. Hence the engine would not be ignited.

In running mode, a gyroscopic sensor will be monitoring the angle of inclination of the motor bike. The ignition of the engine will be terminated when the bike is tilted above 90 degrees and which would be considered as an accident. 90 degrees here is a default set value. It can be customised to 60 or 70 degrees depending on user requirement. It can also be turned off if the user wants to travel to elevated terrain without getting unwanted accident alerts.

If the bike is tilted above 90 degrees, accident mode will be enabled where a message saying “accident detected” would be sent to the pre-registered phone number. This phone number can be changed time to time depending on the location where the rider is travelling. In other words, according to the place of movement of the rider, he can set the mobile number of a friend who is living nearby. So, in case of any accident, if the message is sent to that friend who is living nearby, he may arrive at the accident spot in a minimal time to assist the victim. It should not be forgotten that unnecessary delays during the arrival of emergency vehicles to and from a hospital due to traffic congestion in roads [19], may also increase the chance of life loss.

The proposed model is built and tested in a motorbike and found to work effectively. The modes of operations and emergency messages will be displayed in the Liquid Crystal Display (LCD) screen which can be fitted in the dashboard of the motorbike. Finalised prototype of the proposed smart helmet system is shown in Figure 10.

## 5. Conclusion and future scope

The smart helmet is designed and tested for real time application. All three modes of operations designed in the prototype namely Start ON mode, Running Mode and Accident modes are tested and found to work satisfactorily. Wearing a helmet, taking off side stand and negative in alcohol detection is mandatory during Start ON mode; without which the bike will not start. While riding the bike, gyro sensors will be continuously active and monitor the rider, and bike as well. In case if the gyroscope encounters an angle greater than 90 degrees, the engine will be off and will not be ignited and a message will be sent to the emergency number. This emergency number should already be set in the mobile phone.

Future scope of this project includes designing the proposed model using high-end controllers like raspberry pi and involvement in vehicle-to-vehicle communication (V2V). The automatic error detection in the vehicle and displaying those errors in the display to inform the user, integrating with the prompt audio messages are some advanced features which are currently under developing stage. Additionally, road signs are expected to be detected at a distance using image-processing software and a gentle alert can also be provided to the user while riding the bike.

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