



Research Article

A Smart Helmet for Accident Detection and Response for Emergency Communication

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Abstract

Road Traffic Accidents (RTA) have been a major cause of death and life-threatening injuries globally. The delay in Emergency Response Services (ERS) has heightened the number of death casualties in the event of motorcycle accidents. To address these life-threatening issues, the Smart Helmet for Accident Detection and Res communication device (SHADR) was developed to automatically detect accident, notify the registered emergency contact about the incident and disclose the location of the incident. This concept is designed for rural communities where motocycling activities are predominant. The design was actualized by deploying an accelerometer to detect accident, a load sensor to define when the helmet is being worn, GPS module to ascertain the exact location of the incident, GSM module for call activation and delivering short message service (SMS) of the emergency immediately after the incident has occurred. It leverages the user the opportunity to register the emergency contact by sending information as a coded text to the SHADR. This therefore eliminates the need for interface components and reduces the power consumption level of the device. The outcome of the design implementation demonstrated an efficient operation, with a fast response time for the GPS and GSM communication. Its major contribution stems from the fact that the response time was adequate since it was not affected by network delays and failures associated with communication systems in rural communities. It is a cost effective device which operates with minimum power consumption, the SMS delivery time was adequate and the call functionality was good, at minimum network connectivity. The implementation of SHADR on motorcyclists will greatly reduce casualties from road traffic accidents, provide more data for road traffic studies and give more confidence to road users. Future improvements will require the implementation of this device using 5G technology to improve communication speed and reduce latency for emergency services in urban communities.

Keywords

Accelerometer, Accident Detection, Emergency Response, GPS Module, Load Sensor, Microcontroller, Smart Helmet

1. Introduction

Road traffic accidents are among the leading causes of death globally, with motorcyclists being the most affected since major parts of their body are exposed. Helmets have helped to reduce the fatality of these accidents but there are

still substantial records of death incidents as a result of little or no emergency response as at the time of the incident. It has become pertinent that helmets need to be improved on with respect to its design and fabrication, not just to reduce accident

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fatality, but to aid automatic emergency response services. There have been advancements in smart helmet technology, current study shows a major limitation in the ability of the device to operate on stand alone, without incorporating technologies such as; Bluetooth to phone connection dependency etc. Although this dependency will help to improve the reliability, portability and mobility of the system. Furthermore, some smart helmets are not locally manufactured, they are not affordable, while others have a complex implementation process which does not capture the peculiarities of the region of deployment. This calls for modelling of an affordable, efficient and standalone smart helmet to actively protect the lives of motorcyclists. The smart helmet for accident detection and response (SHADR) like other smart helmets basically integrates key components such as the sensors, GSM and GPS modules to detect accident, call emergency contact and send the location of the accident [1].

The absence of a cost-effective, standalone, and easily implementable solution for real-time accident detection and fast emergency response leaves motorcyclists at the risk of delayed assistance thereby increasing the likelihood of death or long-term injury.

2. Review of Related Works

The importance of safety cannot be over emphasized in our everyday life as it extends beyond motor cycling activities with the use of innovative rescue systems [2]. The Smart Helmet for Accident Detection and Response presents itself as a device that serves as a solution to emergency medical response. The safety developmental process and rescue measures has evolved over several decades deploying various technologies, components and designs. In the work presented in [3], an intelligent system embedded within a smart helmet to ensure the rider's sobriety and helmet use was analysed. Major highlight of the work showed the application of RF communication for seamless interaction between the helmet and the bike by adding a physical and practical layer to safe usability of the device. However, the requirement for helmet-to-bike communication introduces a reliance on multiple modules, thereby increasing the system's complexity and vulnerability to power-related issues, while also elevating the risk of multiple points of failure. [4] and [5] introduced a "Shelmet," which is a self-sustaining smart helmet designed to enhance the safety of the cyclist. It uses a low-power Bluetooth module to interface with an IR camera on the two wheeled vehicle and the rider's smartphone. This system, due to the additional function may introduce complexities and increase the chances of multi point failures. [6, 7] considered another approach to accident prevention by integrating alcohol detection with vehicle immobilization. This method demonstrated the ability of the helmet to curb accidents specifically caused by drunk drivers. [8] presented a prototype of a smart helmet that effectively addressed key safety issues such as helmet usage and speed. The inclusion of pothole and speed bump detection is particularly innovative,

enhancing the rider's safety particularly on poorly maintained roads. [9] and [10] proposed a system that combines accident prevention and detection with real-time monitoring. The inclusion of RFID (Radio Frequency Identification) technology for verifying a valid driver's license adds an extra layer of security, but the system could be limited by poor network performance. [11] considered a smart helmet for accident detection by utilizing image processing algorithms with raspberry pi camera and pressure sensors embedded in the helmet. A significant set back adopting this approach lies in the fact that, the use of cameras and large development modules does not give room for a compact design.

Vashisth R. designed a built-in Black Box for accident analysis as a standalone feature that enhances the helmet's utility [12]. Nevertheless, the inclusion of a wide array of sensors and modules, are beneficial for its functionality but results in a complex design with difficulty in trouble shooting. The study in Khan et al and Sneha et al designed a smart helmet that uses IR sensor to determine when a user is wearing the helmet. This system is wirelessly connected to the ignition circuit on the motorcycle such that, the motorcycle engine cannot be activated unless the helmet is worn [13, 14]. A significant drawback to this approach is the difficulty that may arise in case of an emergency. [15] and [16] described a smart helmet that can detect when the helmet is properly worn as well as monitor for signs of alcohol consumption. It also includes the use of accelerometers to detect crashes, of which alerts are immediately sent to the registered emergency services in real-time. The review carried out in [17] and [18] highlighted the integration of various sensors, such as accelerometers and breath analyzers, to detect accidents and alcohol consumption. The complexity of the system stems from the fact the level of alcohol intake was not ascertained from the study. Although the aforementioned systems are also prone to having more points of failure.

The work in [19] presented a smart helmet designed to address common causes of motorcycle accidents, such as drunk driving and drowsiness. The work further incorporated a vibration detection device to sense harsh impacts in accident scenarios. [20] and [21] presented the design of a solar powered smart helmet for bikers incorporating the fact that the bike is not likely to start unless the rider wears the helmet. The paper further checked the consciousness of the rider by determining the rider's head position. This approach may prove to be unreliable particularly when there is poor radiance from sunlight leading to a false or no alarm system. In [22] a Piezo-electric sensors was used within the helmet to determine the severity of trauma using electrical signals and additionally defining a predetermined threshold.

Gamage et al and Khule et al focused on describing alcohol intake as the major cause of accident [23, 24]. The work was geared towards preventing users from operating their motorcycle ignition once they are detected to have taken alcohol. A key limitation of this device lies in the difficulty in adopting to a technology that will hinder or change a person's lifestyle.

[25] and [26] developed a Smart Helmet designed to detect drowsiness in riders by monitoring their heartbeats and tracking their location via GPS module. In Maganti et al [27] the importance of timely accident detection with a Support Vector Machine (SVM) model to provide an effective safety solution was highlighted. The system's ability to improve detection accuracy through continuous data training is particularly advantageous. However, the reliance on machine learning models necessitated a consistent stream of data to maintain and improve accuracy, which could be difficult to sustain in real-life scenarios. [28] crafted an integrated smart helmet that performs accident detection and emergency communication. A significant contribution is the clear segmentation of the helmet which enhances its modularity. The use of IoT-based smart helmet aimed at accident prevention through alcohol detection and helmet usage verification was discussed extensively [29]. The work deployed sensors to ensure the rider's sobriety and helmet use thereby enhancing the safety of individuals. Kumar

et al and Mohd et al proposed a smart helmet design focused on crash detection and emergency response [30, 31]. In the work, GSM technology was used for sending alerts to ensure timely response to report of accidents related issues.

The use of cloud device and IoT technology for accident detection was discussed to show how cloud services can reduce latency and improve the response time [32].

3. Materials and Method

3.1. Design Methodology

The SHADR with many functions and good efficiency of operation is made possible by integrating various sensor, modules and communication systems. These system all work together to share and process data to achieve a desired result. The block diagram of the SHADR is presented in Figure 1.

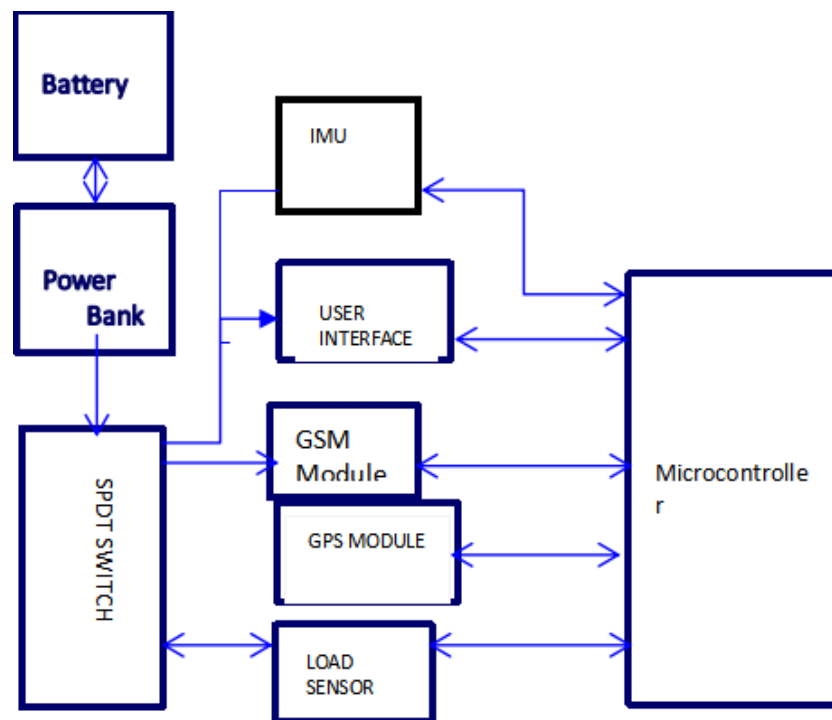


Figure 1. System Block Diagram.

3.2. Principle of Operation

The ATMEGA328P 32bit microcontroller serves as the brain of the system. It interfaces with all other components, processing the data and controls the entire system depending on the algorithm embedded within it. To detect when the helmet is worn by a user, an HX711 load sensor with a programmed force threshold was used. The accident detection feature was handled by the MPU6050 MEMS module, whereby acceleration was used as a parameter for detecting

accident. This module has a detection range of up to 16g of acceleration and is programmed to have a threshold which will be considered as accident occurrence. The location feature of the SHADR was achieved with the use a NEO-M8N GNSS module which uses data collected from four different satellites to obtain the accurate location of the user. This information is stored constantly in the microcontroller. The GSM module is the communication module that allows the helmet to make an emergency call and send SMS. It was also used to register the emergency contact to be called in case of an emergency. A TP4056 power bank module was integrated in the helmet to

provide a constant 5V power supply for all the components, it also charges and monitors the battery level. Two 2000mah lithium ion batteries were used to store and provide power for the entire system. An SPDT switch was used to either connect/disconnect the full circuit to 5V power supply.

Finally a tact switch was also used to provide an interrupt

to the system. When the button is activated, the whole algorithm halts and at that moment, the user is allowed to register the emergency contact on SHADR through SMS. The integration of these components and their work flow is illustrated in the system flowchart in Figure 2.

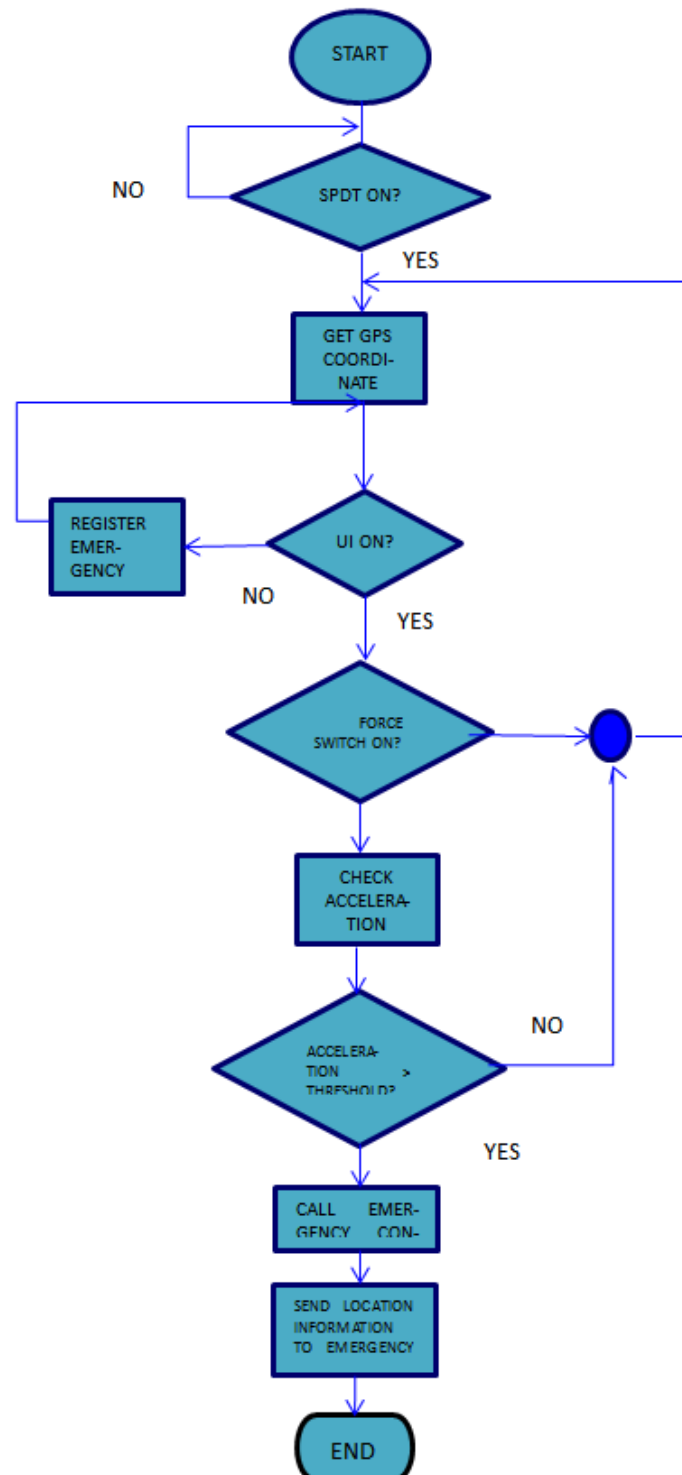


Figure 2. Flow chat of smart helmet for accident detection and response device.

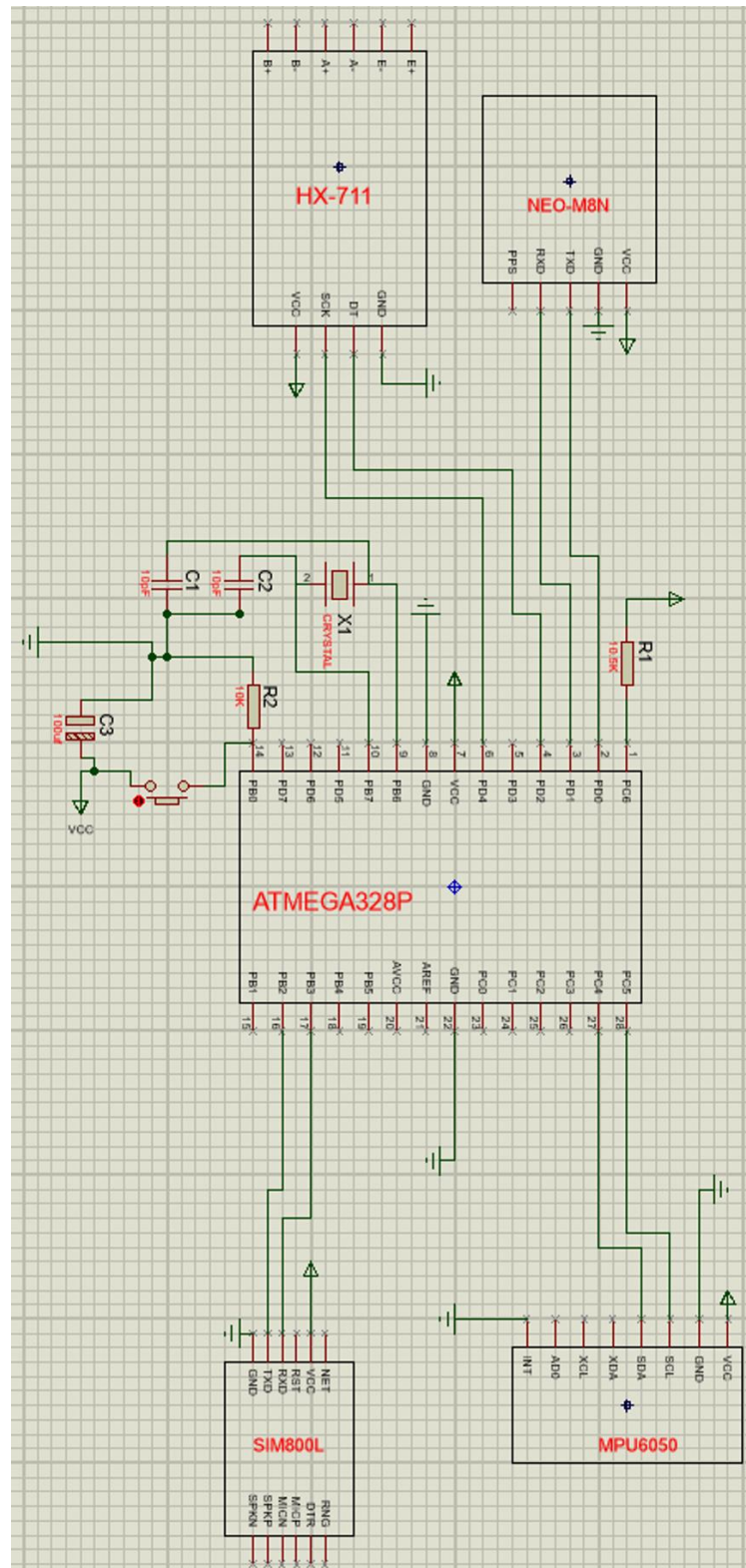


Figure 3. Circuit diagram of the Smart helmet for accident detection and response.

3.3. Shadr Software Algorithm

1. Initialize Components:

Set up digital pins for the GPS, GSM, load sensor, accelerometer, and UI.

Initialize communication protocols (Serial, GSM, I2C).

Load emergency contact number from EEPROM.

2. Setup MPU:

Establish communication with the MPU6050 sensor.

Configure gyroscope and accelerometer settings for desired

sensitivity.

3. Main Loop:

Check for Emergency Number Update:

If UI button is pressed, listen to detect incoming SMS.

Extract emergency number from SMS, if present, and update EEPROM.

Read GPS Data:

Continuously read data from the GPS.

If location data is updated, store latitude and longitude.

Generate Google Maps link for the location.

Check Load Sensor:

Measure weight using the load sensor.

If helmet is detected as worn (reading $\geq$ threshold), turn on load indicator.

Monitor Helmet Status:

Record and process accelerometer and gyroscope data to calculate forces and rotations.

If either g-force or rotation exceeds preset thresholds, enter an alert state.

4. Alert State:

Flash acceleration indicator as a warning signal.

Emergency Response:

Call the emergency contact number.

Send SMS with Google Maps location link.

5. Functions:

sendSMS: Send an SMS message to the registered specified phone number.

call: Make a call to the emergency contact.

recordAccelRegisters: Read accelerometer data and calculate g-forces.

recordGyroData: Read gyroscope data and calculate angular velocities.

processAccelData & processGyroData: Process raw data from accelerometer and gyroscope, scaling to meaningful units.

6. End of Loop: Return to step 3 to continuously monitor helmet status.

3.4. Design Analysis

The SHADR uses a more accurate and energy efficient method of accident detection by measuring the acceleration of a body and detects accident by comparing this acceleration to a certain threshold. In this design analysis, the mathematical modeling and derivations for accident detection with MPU6050 accelerometer, wear detection using HX-711 load sensor, GPS positioning and the power supply is considered.

3.4.1. Linear Acceleration

The MPU6050 accelerometer was programmed to measure the total acceleration vector of SHADR (G_p), which is mathematically represented as:

$$G_p = g + a_r \quad (1)$$

Where; G_p is the total accelerometer output along x, y and z axis can be represented as a function of their vectors:

$$G_p = [G_{px}, G_{py}, G_{pz}] \quad (2)$$

g is the gravitational acceleration vector in SHADR's frame of reference, and can be represented as:

$$g = [g_x, g_y, g_z] \quad (3)$$

The linear acceleration used to detect accident with the SHADR is represented as a_r . The linear acceleration vector (a_r) (eqn (1)) is also represented as:

$$a_r = [a_{rx}, a_{ry}, a_{rz}] \quad (4)$$

The gravity component (g) is removed from the total acceleration output to determine the true acceleration:

$$a_r = G_p - g \quad (5)$$

Considering eqn (5), the respective components of the true acceleration is given as;

$$a_{rx} = G_{px} - g_x \quad (6)$$

$$a_{ry} = G_{py} - g_y \quad (7)$$

$$a_{rz} = G_{pz} - g_z \quad (8)$$

The magnitude of the linear acceleration is determined by applying Pythagorean theorem to equation (6), (7) and (8) to obtain:

$$|a_r| = \sqrt{a_{rx}^2 + a_{ry}^2 + a_{rz}^2} \quad (9)$$

$|a_r|$ has its unit in g, where $1g = 9.8 \text{ ms}^{-2}$ used to determine the existence of an accident.

If the helmet is kept flat and stationary at time $t = 0$, the total accelerometer output will be:

$$G_p = [0, 0, 1g], g = [0, 0, 1g], a_r = [0, 0, 0]$$

At the event of a collision, $t = 0.1s$, helmet experiences a sudden forward deceleration ($a_{rx} = -2g$).

The total accelerometer output becomes

$$G_p = [(-2g), 0, 1g]$$

With the helmet still at a flat position, $g_x = 0, g_y = 0, g_z = 1g$

To determine the linear acceleration, gravity is subtracted from the total acceleration (G_p):

$$a_{rx} = G_{px} - g_x = -2g - 0 = -2g \quad (10)$$

$$a_{ry} = G_{py} - g_y = 0 - 0 = 0 \quad (11)$$

$$a_{rz} = G_{pz} - g_z = 1g - 1g = 0 \quad (12)$$

The magnitude of the linear acceleration becomes:

$$|a_r| = \sqrt{(-2g)^2 + 0^2 + 0^2} = 2g \quad (13)$$

The linear acceleration can also be expressed in ms^{-2} by:

$$|a_r| = 2 \times 9.8 = 19.6ms^{-2}$$

3.4.2. Load Sensing

The HX-711 sensor is a load cell that produces significant electrical signal when there is an applied force and this electrical signal is amplified by the HX-711 amplifier with a 24bit ADC. The load cell is a combination of 4 strain gauges connected in a Wheatstone bridge configuration. When a force is applied, the Wheatstone bridge produces a differential output voltage proportional to the applied load, this can be represented mathematically as:

$$V_{out} = V_{exc} \cdot S \cdot \frac{\Delta R}{R} \quad (14)$$

Where: V_{exc} is excited voltage applied to the bridge (5v).

S: Sensitivity of the strain gauge (in mV/V per unit strain).

ΔR : Change in resistance of the strain gauge due to the applied load.

R: Nominal resistance of the strain gauge (e.g., 350 Ω).

The HX-711 amplifies the small differential voltage V_{out} with a programmable gain (G).

$$V_{adc} = G \cdot V_{out} \quad (15)$$

G can be set to values 32, 64, or 128, for example,

For $V_{out} = 1mV$ and $G = 128$, then:

$$V_{adc} = 128 \times 1mV = 128mV. \quad (16)$$

After the amplification stage, the amplified output is now converted to a digital form (D) using the HX-711 24 (n) bit ADC and can be mathematically expressed as:

$$D = \frac{2^{23} \cdot V_{adc}}{V_{ref}} \quad (17)$$

To determine the weight on the load sensor, its important to note that the digital output is proportional to the applied load (W), with a constant of proportionality (k) which is the load sensitivity expressed as:

$$W = k \cdot D \quad (18)$$

The value of (k) can only be determined through calibration. This is done by applying two known weights (W_1, W_2) to the load cells. Recording their digital outputs (D_1, D_2) and using these values to compute k:

$$k = \frac{W_2 - W_1}{D_2 - D_1} \quad (19)$$

The model and derived equations are utilized to achieve the load sensing.

Given that $V_{exc} = 5v$, $S = 2mV/V$ at full scale, $G = 128$, $V_{ref} = 5v$ and a full-scale weight (W_{max}) = 10kg. The value of D can be determined.

At full-scale load:

$$V_{out} = V_{exc} \cdot S = 5v \times \frac{2mV}{V} = 10mV \quad (20)$$

$$V_{adc} = G \cdot V_{out} = 128 \times 10mV = 1.28v. \quad (21)$$

HX-711 converts the V_{adc} to a 24-bit digital value:

$$D = \frac{2^{23} \times V_{adc}}{V_{ref}} \quad (22)$$

$$D = \frac{8,388,608 \times 1.28}{5} = 2,147,483.$$

This illustrates how the HX-711 sensor was analyzed and programmed to determine the weight applied to suit the working principle of the SHADR.

3.4.3. Power Supply

The SHADR is able to work with strict power requirements which requires stability of supply and long supply hours. The design for the power supply was made bearing in mind the power requirement of the individual components on the SHADR.

3.4.4. Power Requirements

- 1) MPU6050 Accelerometer: Voltage = 3.3v, Current = 3.5mA, Power = $3.3 \times 0.0035 = 0.01155$ watts
 - 2) HX-711 Load Sensor: Voltage = 5.0v, Current = 1.5mA, Power = $5.0 \times 0.0015 = 0.00495$ watts
 - 3) NEO-M8N GPS MODULE: Voltage = 3.3v, Current = 40 mA, Power = $3.3 \times 0.04 = 0.132$ watts.
 - 4) SIM800L GSM: Voltage = 4.0v, Current = 20mA (idle), 2A (peak transmission), Power = $4.0 \times 0.02 = 0.08$ watts. Peak Power = $4.0 \times 2 = 8w$
 - 5) ATMEGA328P MICROCONTROLLER: Voltage = 5.0v, Current = 18.0mA, Power = $5.0 \times 0.018 = 0.09$ watts.
- Average Current (I_{avg})mA = $3.5 + 1.5 + 40 + 20 + 18 = 83mA$
- Peak Current: (I_{peak})mA = $3.5 + 1.5 + 40 + 2000 + 18 = 2063mA$
- Average Power: (P_{avg})mW = $11.55 + 4.95 + 132 +$

$$80 + 90 = 318.5mW$$

$$\text{Peak Power: } (P_{peak})mW = 11.55 + 4.95 + 132 + 8000 + 90 = 8238.5mW$$

The required battery capacity C was determined by taking the product of the average current and the desired time, assuming the system is designed to have a runtime of 24hrs.

$$C = I_{avg} \times t = 83mA \times 24 = 1992mAh.$$

$$C = 1992mAh.$$

For the value of the battery capacity calculated, 408mAh was used in the design to account for inefficiencies in the system. The design of the SHADR was made to have redundancies, account for errors and inefficiency in the system. It is also worthy of note that cost-efficient design was adopted in this work.

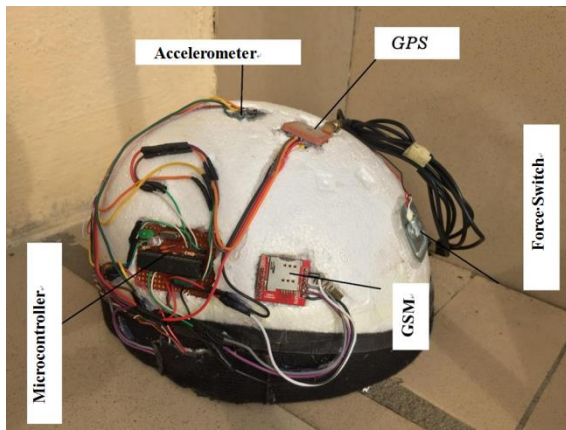


Figure 4. Internal architecture of the SHADR.

4. Results and Discussions

The implementation and test results for the SHADR system is discussed and presented. Each component of the system—accident detection, force switch, GPS tracking, GSM communication, and power supply—was built and tested to ensure functionality, reliability, and performance under real-world conditions.

To detect an accident, the system was programmed to monitor acceleration data from the MPU6050 accelerometer module. The Atmega328p microcontroller received acceleration values in real-time and compared them against a pre-set threshold. Any value exceeding this threshold was considered to be an indicator of a sudden impact, potentially signifying an accident.

4.1. Test Setup and Procedure

The accident detection module was tested using simulated

accident scenarios. A helmet with the embedded SHADR system was accelerated to make forceful impact and the average reading was collected on a serial monitor.

Threshold for Detection: The threshold was set at 1.5g, where 'g' represents gravitational force.

Sampling Rate: With the MPU6050 having an I2C data sampling rate of 1KHz, the interval between the samples is: $\frac{1}{1000} = 0.001 \text{ seconds} = 1 \text{ ms}.$

Therefore, data was sampled at 1ms intervals. The image in Figure 5 displayed the helmet on its reference position of $[x, y, z] = [0, 0, 1]g$. The helmet was accelerated in the y direction and collided on the wall to simulate an accident. The accelerometer readings were taken through the microcontroller to an Arduino IDE serial monitor.



Figure 5. Acceleration Test.

4.1.1. Force Switch Design and Testing

A force switch was designed using load cells to detect when the helmet is being worn or subjected to a significant force. The load cell was connected to the Atmega328p through an HX711 amplifier to increase signal sensitivity.

4.1.2. Testing Setup and Procedure

The force switch was tested by applying incremental force to verify detection accuracy and the data was viewed through a serial monitor.

Threshold Force: 10 N was set as the threshold.

Calibration: Load cells were calibrated using known weights for accurate readings.

4.1.3. GPS-based Location Tracking

The GPS tracking module, integrated with the NEO-M8N GPS, provided real-time coordinates. The GPS module was tested for accuracy in providing latitude and longitude of the incident region.

4.1.4. Testing Setup and Procedure

Testing was conducted in known location to validate GPS accuracy. Coordinates were logged in and compared alongside known location.

Test Locations: Tests were conducted in open environments.

4.1.5. GSM Communication Module Testing

The GSM module, based on SIM800L, enables the SHADR system to send SMS alerts and make emergency calls. Testing involved verifying SMS delivery time, call functionality, and network connectivity.

4.1.6. Testing Setup and Procedure

SMS and calls were tested by sending alerts to a designated emergency number.

SMS Delivery Time: Measured in seconds from initiation to reception.

Table 1. Accelerometer Results Sample Data and Results.

Test No.	Peak Acceleration (g)	Detected Accident?	Detection Time (1ms)
1	0.89	No	1
2	1.24	No	1
3	1.62	Yes	1
4	3.42	Yes	1

Table 2. HX-711 Load Sensor Results Sample Data and Results.

Test No.	Applied Force (N)	Switch Activation?
1	5	No
2	18	Yes
3	12	Yes
4	8	No

Table 3. NEO-M8N GPS Signal Results Sample Data and Results.

Test No.	Latitude	Longitude	Accuracy (m)
1	4.887079	6.917638	3
2	4.887058	6.917585	4
3	4.887079	6.917638	2
4	4.886987	6.917644	3

Table 4. SIM800L GSM Signal Results Sample Data and Results.

Test No.	GSM Signal (dB)	SMS Delivery Time (s)	SMS Delivery Success	Call Connection Success
1	-60	4	Yes	Yes
2	-80	3	Yes	Yes
3	-90	5	Yes	Yes
4	-100	6	No	No

4.2. Discussions

4.2.1. MPU6050 Accelerometer

The accelerometer was tested for its reliability in detecting accidents and its detection time. From the results on Table 1, it was observed that the accelerometer was reliable enough not to trigger until the measured acceleration is greater than its programmed threshold. From the tabulated results, acceleration values of 0.82 and 1.24 could not flag off the accident alert as they were below the threshold value of 1.5g. It can also be observed from the table, that for acceleration values of 1.62 and 3.42, accident alert were flagged off in the microcontroller. This is a good indication that the SHADR can reliably detect accident with minimal errors.

4.2.2. HX-711 Load Sensor

To create a force switch that will accurately detect when a user is putting on the helmet. A load sensor was used for this purpose, of which the required results were obtained. The HX-711 load sensor was tested for its reliability in detecting if a user is putting on a helmet. From the tabulated results in Table 2, it can be observed that, for force values of 5N and 8N, the force switch was not activated. This is because these two values were lower than the programmed threshold of 10N. For

the force values of 12N and 18N, the force switch were activated, showing good sensitivity.

4.2.3. NEO-M8N GPS Module

The GPS feature of the SHADR was tested for accuracy by obtaining the values of the longitude and latitude and comparing it with known values to measure its accuracy. Table 3 indicated that the GPS module gave a good performance with accuracy not less than 3 meters. Looking at these data, it can be concluded that the position detection was achieved.

4.2.4. SIM800L GSM Module

The GSM module was tested to ascertain its responsiveness to communication at different signal strengths. From the tabulated result on Table 4, it can be deduced that signal strength of -100 is not able to activate the GSM module to call or send SMS. A graph in Fig 6 is also provided for better visualization.

The outcome of the entire test process was compared with the performance of the work in [27]. Very significant improvement in performance was seen in the SHADR showing minimal response time, compact and affordable device with less power consumption.

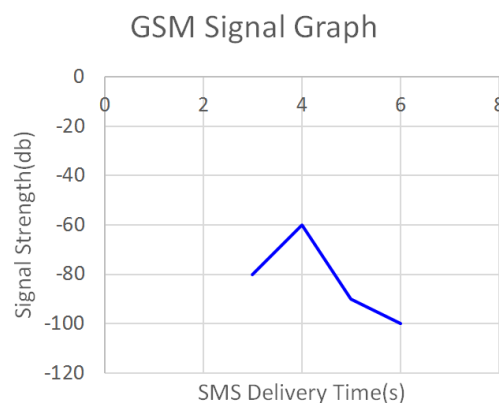


Figure 6. Graph of signal strength against SMS delivery time.

5. Conclusion

In this work, it has been demonstrated that smart helmets can effectively enhance rider safety through intelligent accident detection and automated response systems. By combining sensor technology, GPS, and GSM communication, SHADR offers a practical solution to mitigating delays in emergency responses for motorcyclists involved in accidents. The work considered practical design analysis deploying critical features such as, impact detection, wearer identification, prompt alert and global user interface to achieve the feasibility

of the design implementation for motorcyclists. SHADR's approach which is a combination of relevant hardware and its associating algorithms, addresses a clear gap in existing smart helmet technology. This is demonstrated with the switch activation showing good sensitivity, timely accident detection (recorded in seconds), adequate SMS delivery time, good call functionality, all operating maximally at minimum network connectivity.

Moreover, this work is a prototype which provides insight for applications in rural communities where cyclist operations are predominant. Future work should consider deployment at urban areas where modern network connectivity are deployed

while mitigating issues of latency and other form of interferences that could cause delay and false alarms.

Abbreviations

ESR	Emergency System Response
SHADR	Smart Helmet for Accident Detection and Response
GPS	Global Positioning System
GSM	Global System for Mobile Communication
RTA	Road Traffic Accident
RF	Radio Frequency
SMS	Short Message Services
IoT	Internet of Things
SVM	Support Vector Machine
UI	User Interface
SPDT	Single Pole Double Throw
EEPROM	Electrically Erasable Programmable Read-Only Memory
RFID	Radio Frequency Identification

Author Contributions

Ifeoma Benardine Asianuba: Conceptualization, Formal analysis, Supervision, Writing – review & editing, Validation, Funding

Udeolisa Augustine Chukwudalu: Data curation, software, Methodology, Funding, Investigation

Ofagbor Michael: Formal Analysis, Investigation, Funding, Methodology, Investigation

Conflicts of Interest

The authors declare that there are no conflicts of interest in the entire work.

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