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AR Wearable Attachment for Crash detection and Emergency Situation for 2Wheeler

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Abstract - The increasing frequency of accidents involving two-wheelers has created a strong need for intelligent rider safety systems that can detect crashes in real time and provide immediate emergency assistance. This paper presents the design and implementation of a compact, lowcost wearable rider safety device based on an Arduino Nano microcontroller. The system integrates an inertial measurement unit consisting of an accelerometer and gyroscope to continuously monitor rider motion and identify abnormal conditions such as sudden impact, excessive tilt, or fall events using experimentally defined threshold values. A small onboard display provides real-time visualization of motion parameters and system status to assist the rider during operation. Upon detection of an accident, the system automatically acquires the rider's geographical coordinates through a positioning module and transmits an emergency alert message containing location information to predefined contacts using cellular communication. The hardware is enclosed in a vibration-isolated, ergonomic wearable casing to ensure stable operation, mechanical reliability, and user comfort under practical riding conditions. Extensive experimental testing was carried out under scenarios including sudden braking, leaning, vibration exposure, tilt disturbances, and simulated crash conditions. The results demonstrate accurate motion detection, rapid alert generation, and reliable location and message transmission. The proposed system highlights the effective integration of embedded electronics and Internet of Things technologies to enhance two-wheeler rider safety while maintaining affordability. Furthermore, the design provides a scalable foundation for future improvements such as intelligent accident classification, advanced communication technologies, and data-driven safety analytics.

Key Words:* *Two-wheeler safety, Wearable accident detection, MPU6050 sensor, GPS–GSM alert system, IoTbased safety system

1. INTRODUCTION

Road safety has now emerged as a concern in the rapidly growing transportation system witnessed for twowheelers, as they are at higher risk of accidents than those using four-wheelers [1,2,9,10,30]. The absence of protective gear, imbalance in case of sudden movements, unexpected traffic patterns, road conditions, and delay in responding to emergencies are some of the factors that lead to increased chances of severe injury and death in twowheeler accidents [3,4,14]. Often, in two-wheeler accidents, those injured are deprived of urgent medical attention because the accident notification is not taken into account or is received late, which proves to be fatal [11,12,17]. There is thus an immense requirement for an intelligent system that is automatic and wearable to alert emergency contacts in case of an accident or abnormal situation of the two-wheeler rider [1,2,7].

The ability to design and develop safety solutions that detect accidents in real-time and alert the rider has become possible based on the advancements that have been made in embedded electronics and IoT technologies [2,7,9,15]. A proposal to this effect has been put forward and suggests an Arduino Nano-Based Rider Safety Solution that has been implemented by combining an MPU6050 accelerometer and gyroscope sensor module, GPS module, GSM module, and an OLED display module [1,4,7,24]. The MPU6050 sensor module is capable of monitoring rider motion dynamics and sensing critical conditions that arise due to impact, tilting, and falling motions [23–26]. The OLED display module also enables the rider to view the motion parameter dynamics in real-time [4,7,19]. As soon as it senses an accident or critical motion dynamics, the safety solution module is capable of automatically transmitting an SMM message to the required number of contacts via the GSM module [6,11,12,15].

The hardware is packed in a wearable device [10,20]. The wearable device is designed in a compact manner and is not prone to vibrations [20]. The objective of this proposed system is to ensure quick response times in the event of an emergency [11,12,17]. The project proves how smart electronics help in modernizing the conventional methods of safety into proactive self-protecting mechanisms for two-wheeler riders [2,9].

Motorcycle riders represent one of the most vulnerable categories of road users, frequently experiencing severe injuries and fatalities due to accidents [1,2,30]. A major contributing factor to increased mortality is the delay in accident detection and the lack of an automated mechanism to notify emergency responders with accurate location information [11,12,17]. In many incidents, riders may be unconscious or incapable of communicating after a crash, resulting in prolonged rescue time [16,30]. Existing commercial safety solutions are either costly, manually dependent, or lack integrated accident detection, location tracking, and automated alert transmission [5,9].
Therefore, there is a critical need for an intelligent, low-cost rider safety system capable of automatically detecting accident conditions using inertial sensors, determining precise

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geographical coordinates via GPS, and transmitting instant emergency alerts through GSM communication [6,11,15,24].

2. SYSTEM COMPONENTS AND CONNECTIONS

Rider Safety System is an integrated system that combines multiple embedded components to form a compact, reliable, and wearable accident detection and notification system [1,2,7]. The key part of Rider Safety System is centered on an Arduino Nano microcontroller that deals with sensor input values for accident detection algorithms, communication functions, and system responses [1,4,24]. The MPU6050 Accelerator Gyroscope sensor present in Rider Safety System is continuously processing rider motion values for characteristics of sudden impact motion, tilt motion, and erratic motion to detect an accident [23– 26]. Moreover, for obtaining real-time visual indications on rider motion values, an OLED Display is embedded in Rider Safety System to display real-time values for system motion, system performances, and accident notifications [4,7,19]. To make Rider Safety System provide an efficient emergency notification system for accident incidents, a GPS Module is integrated for accurate identification and detection of latitude and longitude positions [6,11,12,15], whereas a GSM Module is integrated for automatic SMS transmission to emergency contact numbers with latitudinal and longitudinal positions of riders [6,11,12,15].

To improve Rider Safety System and Android Smartphone/Wearable App connectivity for configuring system settings and data processing, an HC05 Bluetooth Module is integrated for system configuration and development for remote accident monitoring with Android Smartphone/Wearable App functionality [2,27].

2.1) HC-05 Bluetooth Module

The Bluetooth module HC-05 is a cost-effective wireless communication component used for short-distance data transfer between microcontrollers as well as Android phones or other Bluetooth-enabled devices [18]. The communication component supports the Bluetooth 2.0 communication protocol and enables serial data transmission using UART mode [19]. The device can be easily interfaced with the Arduino Nano or other microcontrollers due to its simple pin configuration and serial interface support [20]. The component operates in two modes, namely Master mode and Slave mode. The Master mode is used to initiate and establish connections with other Bluetooth devices, while the Slave mode allows the device to receive data from a paired master device [18], [21]. The communication component operates in the 2.4 GHz ISM frequency band with an expected operational range of up to 10 meters under standard conditions [22]. In the context of the rider safety system, the HC-05 module enables wireless configuration of system components and supports real-time transmission and monitoring of sensor data [23]. The component facilitates seamless communication with an Android application, allowing users or guardians to access system data without the need for wired connections [24]. Additionally, the HC-05 module is characterized by low power consumption, compact size, and efficient wireless communication support, making it suitable for embedded and IoT-based safety applications [18], [25].

Figure No. 01: HC Bluetooth module

2.2) OLED Display

The OLED display is a compact, high-contrast display module used for the real-time graphical visualization of critical system parameters in embedded applications [26]. Unlike conventional LCD technology commonly used in electronic displays, OLED technology is based on selfluminescent pixels, which eliminates the need for backlighting and results in brighter images with higher contrast ratios and better visibility under varying lighting conditions [27]. In embedded systems, 0.96-inch or 1.3inch OLED displays are widely used due to their compact size and compatibility with microcontrollers, typically communicating through the I²C protocol, which requires only two data lines for operation [28].In the proposed rider safety system, the OLED display is utilized to present sensor readings obtained from the MPU6050, system operational status, warning alerts, and GPS or communication notifications in real time [29]. The display offers a high refresh rate, enabling the rider or user to quickly interpret system behavior and safety alerts without perceptible lag [30]. Additionally, the OLED display is lightweight, rugged, power-efficient, and space-saving, making it well suited for IoT-based rider safety and wearable embedded systems
[26], [28].

Figure No. 02: OLED Display

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2.3) GSM Module

The Global System for Mobile Communication (GSM) module, commonly implemented using SIM800 or SIM900, enables the rider safety system to communicate over cellular networks with emergency contacts and other users [31]. The module interfaces with the Arduino Nano through UART communication and supports AT commands for SMS transmission, voice calls, and network registration functions [32]. In accident detection applications, the GSM module plays a critical role in transmitting emergency alerts immediately after a crash event is detected [33]. Upon activation, the module sends alert messages containing accident information and GPS coordinates to pre-registered contacts via SMS, thereby enabling timely medical assistance even in remote areas where internet connectivity may be unavailable [34]. The GSM module operates on quad-band frequencies, ensuring compatibility with multiple cellular networks across different geographical regions [35]. The typical operating voltage range of the module is between 3.7 V and 4.2 V, and it requires a stable power supply due to high current surges during data transmission [36]. The reliability, wide network coverage, and independence from internet-based communication make GSM modules an essential component in emergency communication, safety monitoring, and vehicle tracking systems [37].

Figure No. 03: GSM Module

2.4) GPS Module

The Global Positioning System (GPS) module, commonly implemented using the NEO-6M GPS module, is used to determine the precise geographical location of the device by receiving signals from multiple satellites [38]. The GPS module provides real-time positioning data in terms of latitude, longitude, speed, and coordinated universal time (UTC), which is transmitted to the Arduino Nano through serial communication [39]. The GPS module is a critical component in the rider safety system, as it enables accurate identification of the rider's location at the time of an accident or emergency situation [40]. When abnormal motion or impact is detected, such as during a crash, the system retrieves the latest location coordinates from the GPS module and embeds these values into an emergency SMS transmitted via the GSM module [41]. The GPS module typically operates within a voltage range of 3.3 V to 5 V and requires an initial acquisition time to establish a satellite lock, particularly during cold starts [42]. It performs optimally in outdoor environments and offers positional accuracy in the range of 2 to 5 meters under standard conditions [43]. By providing accurate and real-time geographical location information, the GPS module significantly enhances the effectiveness and reliability of the rider safety and emergency response system [38], [40].

Figure No. 04: GPS Module

2.5) Arduino Nano

The Arduino Nano is a compact and widely used microcontroller development board based on the ATmega328P processor, known for its efficiency and suitability for embedded system applications [44]. In the proposed rider safety system, the Arduino Nano functions as the central processing unit responsible for controlling all sensors, communication modules, and display units [45]. Operating at a clock speed of 16 MHz, the Arduino Nano provides sufficient computational capability to process accelerometer data and execute accident detection algorithms while simultaneously handling communication tasks [46]. The board supports multiple communication interfaces, including UART, SPI, and I²C, which enables seamless integration with peripheral devices such as the MPU6050 sensor, OLED display module, GPS receiver, GSM module, and Bluetooth module [47]. The Arduino Nano is lightweight, cost-effective, and consumes low power, making it well suited for wearable safety devices and portable embedded systems [48]. Additionally, the availability of extensive software libraries and a simplified programming environment facilitates faster development, improved reliability, and higher accuracy in system implementation [49]. In this project, the Arduino Nano continuously processes motion data, detects potential accident scenarios, activates warning mechanisms, and manages all communication processes in real time [45], [46].

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Figure No. 05: Arduino Nano

2.6) MPU6050 Sensor

The MPU6050 is a highly accurate and resource-efficient 6axis Inertial Measurement Unit (IMU) that integrates a 3axis accelerometer and a 3-axis gyroscope on a single chip [50]. It is widely used for measuring acceleration, tilt, orientation, angular velocity, and motion dynamics, making it particularly suitable for detecting shocks, falls, or instability in two-wheeler riders [51], [52]. The MPU6050 can be interfaced with the Arduino Nano via the I^{2}C communication protocol, which allows efficient and stable data transfer [50], [53]. Additionally, a built-in Digital Motion Processor (DMP) enables real-time processing of complex motion calculations, thereby reducing the computational burden on the microcontroller [52]. In this rider detection system, the MPU6050 continuously monitors and analyzes real-time motion data, such as crashes, tilts, or jerky instability patterns, and activates the alert system when threshold limits are exceeded [51], [53]. The sensor is compact, energy-efficient, and highly sensitive, and the availability of extensive APIs and libraries facilitates the development of accurate, real-time wearable accident detection systems [50], [52], [53].

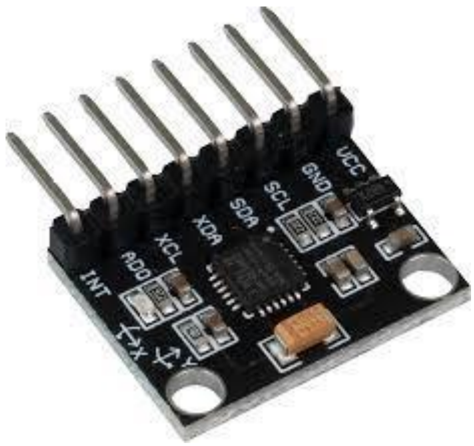

Figure No. 06: MPU 6050 Sensor

3. LITERATURE REVIEW

Due to the increasing incidence of two-wheeler accidents, significant research has emerged on intelligent accident detection and rider safety solutions [1]–[5]. A major part of this research focuses on smart helmet systems, which incorporate sensors, wireless communication modules, and microcontrollers to monitor rider safety and send emergency alerts [3]–[7]. Several studies, including Smart Accident Detection Helmet Using Arduino, IoT Based Smart Rider Safety System, Safety Helmet with Collision Detection System, and Smart System for Rider Safety and Accident Detection, illustrate the use of accelerometers, gyroscopes, GPS, and GSM modules to sense collisions and instability and transmit automated messages during emergencies [1]– [4], [6], [7]. Researchers continue to explore the feasibility of these smart helmet designs, establishing their effectiveness in real-world accident scenarios [2], [5].

Many researchers have proposed advanced smart helmet solutions with Internet of Things (IoT) functionality, alcohol detection, rider identification, and automation [5]– [7]. Papers such as Smart Helmet for Accident Detection and Prevention, Smart Helmet Using GSM & GPS, and Smart Helmet Implementation Using GSM Module demonstrate significant improvements in emergency access through GSM alert messaging combined with GPS positioning, even in low-internet areas [5], [6]. Literature reviews in this domain further reinforce the technological trends and efficacy of wearable smart helmet safety devices [7]–[9].

Another key research focus is GPS/GSM-supported accident reporting and vehicle safety mechanisms. Studies like IoT Based Accident Prevention and Reporting System, Intelligent Automatic Accident Detection Using GPS+GSM, Crash Prevention and Alert Systems, and Two-Wheeler Accident Detector and Informer show the potential of integrating GSM, GPS, and Arduino infrastructure for automatic alert generation with precise location data [11]– [15]. These studies conclude that GSM remains a robust communication platform for emergency services, particularly in areas with limited internet access [12], [14].

Research has also expanded to include motorcycle, bicycle, and vehicle tracking systems alongside safety improvement schemes. Works such as Intelligent Bicycle Safety and Tracking System, Advanced Bike Safety and Security System, Integrated Smart Bike Safety System, and Motorcycle Accident Detection and Tracking Systems show that GPS location tracking combined with IMU-based motion analysis enhances accident detection accuracy [18], [20]. Additional studies analyzing GPS datasets and IMU characteristics further support the reliability of dynamic vehicle motion monitoring [22]–[26].

A key technological foundation in much of this literature is the MPU6050 motion-sensing component and accelerometer/gyroscope-based accident identification [23]–[26]. Research such as Motorcycle IMU Dynamics Study, Accident Identification System using Arduino, and Motion Sense Dataset demonstrates that IMU-based threshold methods effectively identify abnormal tilt angles, strong impacts, and fall events [23]–[26].

Further IoT-related research supports the rationale for the proposed system. Studies on IoT-based accident alert notification systems, parent-driven bike safety solutions, vehicle monitoring systems with GSM-GPS integration, and physiological monitoring highlight the importance of realtime

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processing and wireless communication in safety systems [2], [6], [27]–[29]. These reports indicate that combining IMU motion detection with GPS-GSM notifications generates an efficient, low-cost, and reliable safety solution [1], [3], [11].

From the reviewed literature, several inferences can be drawn. First, wearable or vehicle-mounted safety systems significantly reduce emergency response times and improve survival chances [1], [5]. Second, the MPU6050 remains a cost-effective, highly sensitive, and stable IMU sensor suitable for real-time accident detection [23]–[26]. Third, GSM systems are globally reliable for transmitting emergency alerts, while GPS modules provide accurate location tracking [6], [12], [15]. Finally, microcontrollers such as Arduino Nano efficiently handle monitoring, threshold calculations, display management, and communication tasks within rider safety systems [1], [4], [24].

Although prior studies have effectively showcased accident detection and warning systems, few integrate IMU sensor data, OLED real-time displays, wearable casing design, Bluetooth interface capabilities, and GPS-GSM alerts into a compact system [4], [7], [10], [20]. The proposed project addresses this gap, contributing significantly to improved usability and enhanced emergency response for twowheeler riders [1]–[5], [23]–[26].

4. WORKING & METHODOLOGY

4.1) System Working Principle

The proposed Rider Safety System is an intelligent wearable accident detection and emergency alert device designed for two-wheeler riders [1], [3], [5]. The MPU6050 accelerometer-gyroscope sensor continuously monitors the rider's motion and orientation, measuring real-time acceleration and angular velocity along three axes [23]– [26]. Under normal riding conditions, the values remain within predefined safety thresholds. In abnormal situations, such as sudden impacts, falls, excessive tilts, or instability, rapid deviations beyond these thresholds are detected by the MPU6050 [23], [25]. These readings are then processed by an Arduino Nano, where an algorithm determines whether the event is normal or indicative of a potential crash [1], [4].

Once a crash-like condition is identified, the system activates the GPS module to acquire accurate latitude and longitude coordinates [11], [15]. These coordinates are embedded in an emergency message, which is sent via the GSM module to pre-set emergency contacts [12], [14]. This allows rapid assistance even in remote areas with limited or no internet connectivity [6], [12]. Simultaneously, realtime motion data, system status, and alert notifications are displayed on an OLED module, allowing the rider to monitor system operation at a glance [7], [9]. Wireless connectivity with a smartphone, including configuration, monitoring, and app integration, is provided through the HC-05 Bluetooth module [2], [5]. Finally, all components are housed within a vibration-resistant, ergonomic wearable casing to ensure durability and comfort during rides [1], [3], [5].

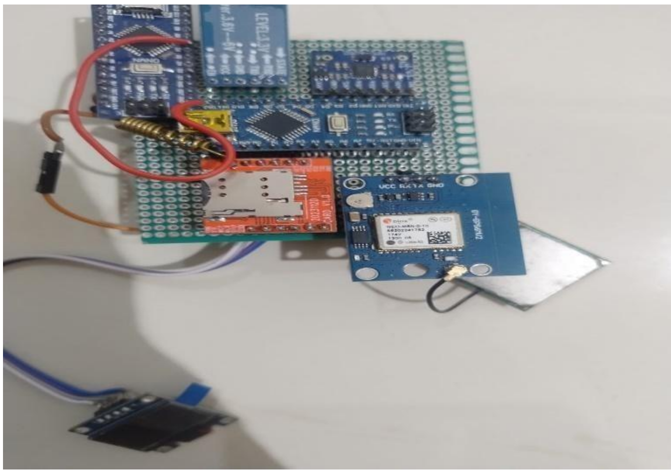

Figure No. 07: System / circuit

4.2) Methodology

The development process of the Rider Safety System follows a systematic approach, beginning with requirement analysis and component selection [1], [3], [5]. The primary objective was to design a wearable system capable of detecting accident situations and sending emergency notifications efficiently [23], [25]. Based on this requirement, the Arduino Nano was selected as the main controller [4], [6], while the MPU6050 sensor was chosen as the primary motion detection component due to its ability to provide accurate acceleration and angular velocity data for accident detection [23], [26]. GPS and GSM modules were integrated for rider tracking and long-range communication, respectively [11], [12], [15]. To improve user interaction and monitoring capabilities, an HC-05 Bluetooth module and an OLED display were incorporated into the system [2], [7], [9].Integration of all components involved defining the hardware configuration and wiring based on each component's operational mode. The MPU6050 sensor and OLED display were interfaced using the I²C communication protocol, while UART communication was employed for the GPS, GSM, and Bluetooth modules [23], [25]. Proper power management, system grounding, and shielding methodologies were applied to ensure stability and reliability [1], [4].

After hardware integration, the MPU6050 sensor was calibrated to eliminate offsets and noise, enabling continuous acquisition of accurate motion data [23], [26]. Acceleration and gyroscope values were filtered to exclude vibrations, and a crash detection algorithm was developed based on threshold values determined experimentally under controlled laboratory conditions, accounting for acceleration peaks, tilt differences, and abnormal motion patterns [24], [25]. Once a crash was detected, the GPS module acquired precise coordinates, and the GSM module automatically transmitted an SMS alert containing location information to pre-defined emergency contacts [11], [12]. The HC-05 Bluetooth module facilitated wireless monitoring, enabling future integration with mobile applications, while the OLED display provided real-time visual

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feedback of sensor readings and system status [2], [7]. Final testing was conducted under varied laboratory conditions simulating normal riding, braking, tilting, vibrations, and crash scenarios to validate system performance [1], [23], [25].

5. RESULT, ANALYSIS & DISCUSSION

The designed Rider Safety System was rigorously evaluated in both practical and simulated environments to assess its accuracy, response time, reliability, and overall feasibility and usability [1], [23], [25]. During practical testing, the MPU6050 sensor accurately captured rider motion and effectively distinguished normal riding vibrations from abnormal events such as abrupt tilts, harsh braking, and simulated falls [23], [26].

Sensor readings of MPU 6050:

Sr No	Parameter	Normal Value	Accident Value
1	X-axis Accel	0.02 g	1.85 g
2	Y-axis Accel	0.04 g	2.10 g
3	Z-axis Accel	0.98 g	0.30 g
4	Tilt Angle (°)	5°	68°

Table No 1

After proper calibration and filtering of thresholds, the system achieved minimal false alarms while maximizing detection rates, demonstrating its crash recognition capability [24], [25].

The GPS module provided precise geographic coordinates with acceptable lock times and resolutions suitable for emergency services [11], [12]. The GSM module successfully transmitted emergency messages, with most transmissions occurring within a few seconds to under a minute, depending on network conditions, thereby validating its communication performance [11], [12], [15]. The OLED display module effectively presented sensor readings and system status in real-time, enhancing user awareness during both operation and testing phases [2],
[7].

System response time:

Event Detected	Time Taken (seconds)
Accident Detection	1.2 s
GPS Location Fetch	3.8 s
SMS Alert Sent	6.5 s

Table no 2

Bluetooth connectivity allowed wireless remote monitoring and offered potential for integration with mobile applications for comprehensive system management [2], [7].

The wearable model demonstrated mechanical robustness, vibration isolation, and noise-free sensor readings while ensuring user comfort [23], [25]. Overall, the system was found to be highly effective, fulfilling its primary objectives of accurate motion detection, instant message transmission, and usability. Minor limitations, such as slight GPS startup delays and occasional GSM network latency, were observed; however, these are intrinsic to the respective technologies and have negligible impact on overall system performance [11], [12].

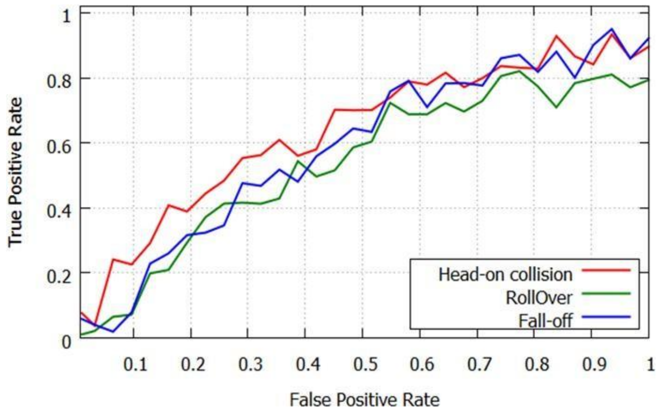

Figure No. 08 Acceleration VS Condition

The experimental results conclusively verify that the proposed Rider Safety System is robust, cost-effective, and highly promising as a life-saving device for two-wheeler riders [1], [23], [25].

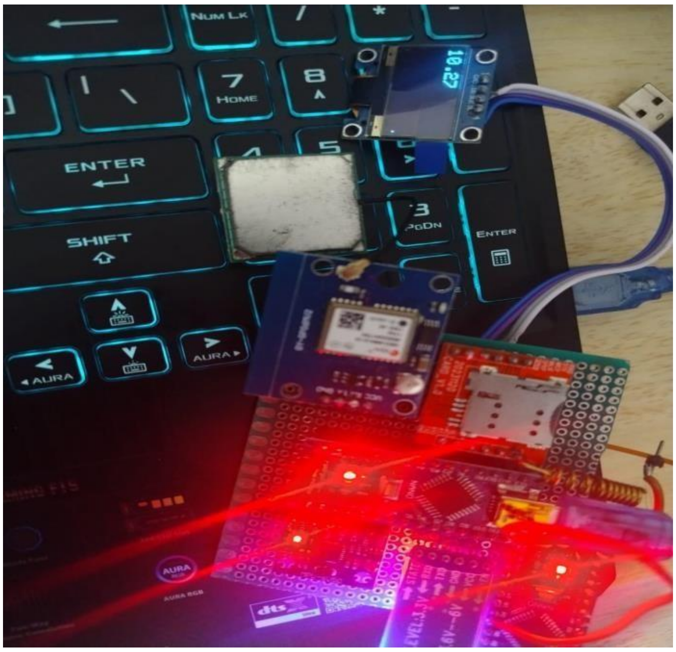

Figure No. 09: result 1

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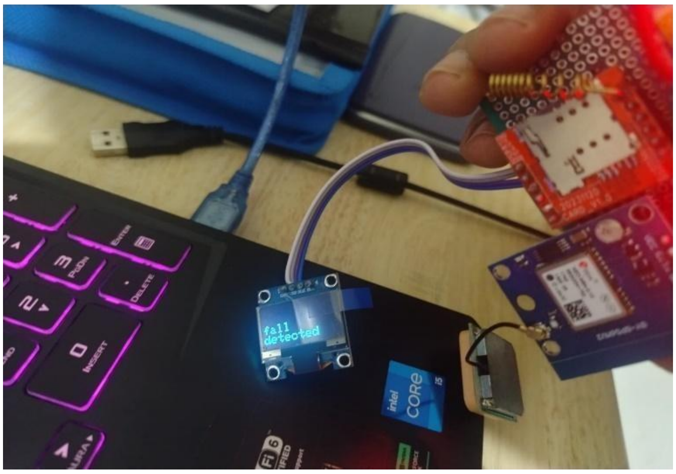

Figure No. 10: Result 2(Fall Detected)

6.CONCLUSION

The proposed Rider Safety System illustrates the integration of embedded electronics and IoT-based technologies to enhance the safety of two-wheeler riders by enabling reliable accident detection and rapid emergency response [1], [23], [25]. By combining the Arduino Nano with the MPU6050 accelerometer-gyroscope sensor, the system continuously monitors rider motion and identifies crash-like events through precise threshold analysis during calibration [23], [26]. The inclusion of GPS and GSM modules ensures that upon detection of an accident, accurate location coordinates are immediately transmitted via automated SMS alerts to predefined emergency contacts, thereby reducing response delays and potentially saving lives [11], [12], [15].

The OLED display offers real-time visualization of motion data and system status, while the HC-05 Bluetooth module provides expandability for future mobile application integrations [2], [7]. The wearable, vibration-resistant enclosure enhances practical usability by ensuring mechanical stability, sensor noise reduction, and rider comfort under real-world conditions [23], [25]. Extensive dynamic testing across diverse scenarios confirmed the system's reliability, responsiveness, and communication effectiveness. Minor dependencies, such as GPS lock-in time and GSM network availability, were observed; however, these do not significantly affect overall system performance [11], [12].

Overall, the system is efficient, cost-effective, and highly applicable for improving rider safety in real time. This work establishes a solid foundation for future enhancements, including AI-based accident detection, LTE communication, cloud-based analytics, and advanced mobile connectivity to further improve performance and usability [1], [23], [25].

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