A9G-ENABLED ACCIDENT DETECTION AND RESPONSE SYSTEM FOR ROAD SAFETY

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Abstract - *Road accidents pose a global public health concern, leading to significant loss of life, primarily due to delayed emergency response. In response to this critical issue, we have developed an innovative safety solution that leverages the Arduino Nano, MPU6050 sensor, and A9G GPS module. This system enhances road safety by autonomously detecting accidents and promptly alerting emergency services. The MPU6050 continuously monitors the device's motion, identifying abrupt changes that may indicate accidents, while the A9G GPS module provides real-time location data. In the event of an accident, the system triggers an SMS notification to the nearest police station, including precise GPS coordinates, date, and time, enabling faster emergency response. Extensive real-world testing has validated the system's effectiveness. With the potential to save countless lives, our solution holds promise for improving road safety and reducing fatalities.*

***Key Words*: MPU6050, A9G, Emergency Services, Helmet, SMS,Detection, Location**

1.INTRODUCTION

Road traffic accidents represent a global epidemic, claiming thousands of lives daily and inflicting immeasurable suffering. It's a sobering reality that, on average, a person loses their life in a road accident every five minutes. The severity of this problem is amplified by the disheartening fact many of these accidents occur within proximity to hospitals and emergency services, yet victims are often left unaided, as every second counts in the race against time.

The human brain can endure a mere 3 to 6 minutes without oxygen, emphasizing the critical importance of swift emergency medical attention. Addressing this dire need for expedited accident response, we present an innovative solution: an A9G-Enabled Accident Detection and Response System. Building upon existing protective headgear, our device seamlessly integrates advanced technologies such as the Arduino Nano, MPU6050 sensor, and the A9G GPS module to detect accidents in real time and connect with emergency services within moments.

The core concept revolves around the swift detection of accidents and the immediate relay of critical information to nearby law enforcement agencies. Once an accident is identified, the system automatically transmits an SMS, encompassing the accident's precise location, date, and time, to the nearest police station. This swift communication empowers emergency services to respond promptly, potentially saving countless lives in the process.

In this paper, we delve into the architecture, functionality, and real-world testing of our device, showcasing its effectiveness in detecting accidents and expediting emergency response. Our aim is to reduce fatalities resulting from road accidents and enhance overall road safety. With the potential to revolutionize accident response protocols, we believe that our system holds the promise of making our roads safer and preserving lives on a global scale.

2. FALL DETECTION SYSTEMS: A REVIEW OF EXISTINGAPPROACHES

A. *Vision-based approach*

One approach to fall detection is to use cameras to monitor the activity of the person. If a fall is detected, the camera can be used to capture images of the event. These images can then be used to assess the severity of the fall and to determine if medical assistance is required [16]. However, vision-based approaches can be expensive and difficult to use in low-light conditions.

B. *Machine learning-based approach*

Another approach to fall detection is to use machine learning algorithms to classify falls from other daily activities [17]. This approach requires a large dataset oflabeled data, which can be difficult to obtain. However,machine learning-based approaches can be very accurateand can be used in a variety of settings.

C. *Vibrations and sound-based approach*

A third approach to fall detection is to use vibrations and sound to detect falls. This approach is based on the principle that a fall will generate a characteristic pattern of vibrations and sound. These vibrations and sounds can be captured by sensors and then analyzed to determine if a fall has occurred [18]. However, this approach can be sensitive to noise and can be difficult to use in noisy environments.

D. Kinematic-based approach

The kinematic-based approach is a relatively new approach to fall detection. This approach uses sensors to measure the kinematics of the person, such as their acceleration and angular velocity. These measurements can then be used to identify falls [19][20]. The kinematic-based approach is relatively inexpensive and easy to use. However, it can be less accurate than other approaches, such as the machine learning-based approach.

E. Arduino microcontroller

The Arduino microcontroller is an open-source microcontroller board that can be used to implement fall detection systems. The Arduino is relatively inexpensiveand easy to use. It can be programmed using the Arduino programming language, which is a simple and easy-to-learn language.

3. EXISTING SYSTEM

Existing systems in the realm of accident detection and response primarily center around vehicle-centric technologies and services. Modern vehicles are equippedwith airbag systems that can detect collisions, deploying safety mechanisms for the protection of vehicle occupants. Telematics services, such as OnStar, have emerged to automatically detect accidents and promptly alert emergency services by using built-in communication hardware and subscription-based services. Some regions have adopted automatic emergency call systems, like Call, which are required in vehicles to initiate emergency calls to predefined numbers upon accidents. Smartphone apps also play a role, leveraging the sensors within smartphones to detect accidents and send alerts to specified contacts or emergency services. Roadside emergency call boxes are installed along highways in certain areas, allowing drivers to make emergency calls. Furthermore, traffic surveillance cameras monitor roadways and record accidents for traffic management purposes. Lastly, there are third-party accident detection devices that can be added to vehicles, using sensors to identify impacts and alert emergency services. These existing solutions primarily focus on accidents involving motor vehicles and may not cater to a broader range of scenarios or provide the mobility and direct connection with local authorities that your proposed wearable system offers, potentially revolutionizing accident detection and response in a more comprehensive manner.

4. PROPOSED SYSTEM

This system consists of a MEMS accelerometer, GPS device, and GSM module to detect road accidents and notify emergency services. The accelerometer is used to detect sudden changes in acceleration, which can be indicative of an accident. The GPS device is used to determine the location of the accident, and the GSM module is used to send a notification to emergency services.

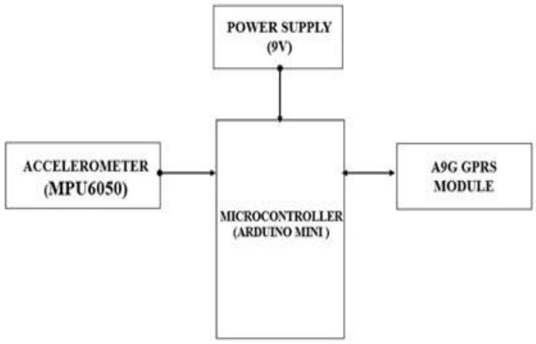

Fig -1: Proposed system design

A. Accelerometer (MPU-6050)

The MPU-6050 is a 6-axis MEMS motion tracking device that integrates a 3-axis gyroscope, a 3-axis accelerometer, and a Digital Motion Processor (DMP) on a single chip. The

DMP can handle sophisticated 9-axis motion fusion algorithms, which allow the MPU-6050 to track the orientation and motion of a device in three-dimensional space. To detect falls, thresholds are set on the net acceleration. If the value obtained from the accelerometer exceeds the threshold, a fall is detected [21][22]. This method is effective in detecting falls because it can distinguish between falls and other activities, such as walking or running.

B. A9G (GSM & GPS MODULE)

In the event of a fall, it is important to be able to track the location of the person who has fallen. This information can be used to send help to the person and to assess the severity of the fall. One way to track the location of a person whohas fallen is to use a GPS device [23]. The GPS device can be integrated with the fall detection system to track thelocation of the person in real-time. Once the location of the person is known, it can be sent through an SMS to the SOS number. The SMS will include a link with the coordinates ofthe person who has experienced the fall.

C. Arduino mini microcontroller

Arduino Mini is a small, inexpensive, and easy-to-use microcontroller board based on the ATmega328P chip [24].It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16MHz crystal oscillator, a USB connection, a power jack, and a resetbutton. It is compatible with the Arduino IDE, which is a free and open-source software development environment forArduino boards.it has an Operating voltage: 5 V, Input voltage: 7-12 V, Flash memory: 32 KB (of which 0.5 KB is used by the bootloader), SRAM: 2 KB EEPROM: 1 KB and Clock speed: 16 MHz.

The original setup of the system is shown below Fig 2

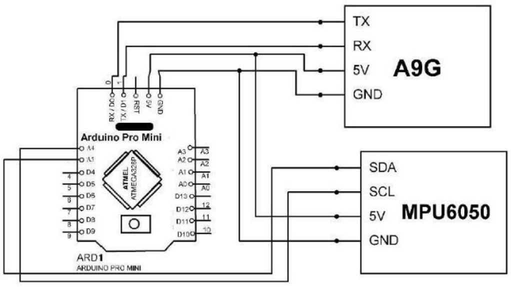

Fig -2: Component and Its Pin Configuration Setup

4. METHODOLOGY

This system consists of 1) Accelerometer (MPU-6050),2) A9G (GSM & GPS MODULE and 3) Arduino mini microcontroller, all integrated to work as one system. This device is to be fixed on the rider's helmet as how we will wear a normal crash helmet. The MPU-6050 accelerometer is the component that is used to detect falls. The MPU6050'saccelerometer values (x, y, z) are obtained by checking the values obtained from MPU6050 and sets it as initial value for values (x, y, z) The system described utilizes the

MPU6050 accelerometer to measure acceleration along its three axes (x, y, and z) and generates corresponding voltage outputs. These voltage outputs from the accelerometer are read by the microcontroller through an analog-to-digital converter (ADC). The measured ADC values are subsequently transformed into their equivalent 'g' values, where 1g corresponds to 9.80665 m/s^2.

When an accident or any untoward incident occurs while driving the vehicle, the MPU6050 measures the vehicle's acceleration, displacement, temperature, and angular velocity. The MPU6050 communicates with the Arduinomini via the I2C protocol. To power up, the VCC pin MPU6050 should be connected to the 3.3V pin of Arduino mini. Both the grounds are connected commonly. The MPU6050 SCL pin should be connected to the ArduinoSCL pin. The SDA pin of MPU6050 should be connected to the SDA pin of the Arduino. The data was obtained from an MPU 6050 sensor that has 3 axis accelerometer and 3 axis gyroscopes.

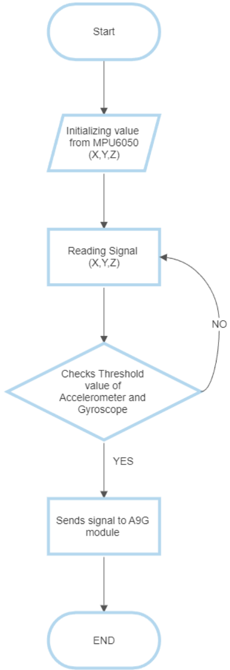

Fig.3 Working of Sensor MPU6050

MPU 6050 sensor uses a scale of 2g, 4g, 8g and 16g for Accelerometer and scale of 250, 500, 1000, and 2000.The value obtained in (X, Y,Z) are normalized similarly to [2].In this study, the accelerometer used a sensor of 2g scale. And 250 for gyroscope sensors (Table 1). The mpu6050sensor is connected to Arduino Nano and is set at a frequency. of 20 Hz. When the sensor-measured value surpasses the threshold data, it causes an accident. Otherwise, it would be a false indication. When the accidentoccurs, the controller and A9G GPRS/GSM get initiated. Itis a compact SMD (surface mount device) that combines GSM and GPRS modules. The location would be fetched in the NMEA (National Marine Electronics Association)format by the GPS of A9G through satellite.

Table 1: Operating range of MPU6050[2]

Range of Accelerometer	Scale	Range of Gyroscope	Scale
2g4g8g	16,384	250 °/s	131
16g	8,192	500 °/s	65,5
	4,096	1000 °/s	32,8
	2,048	2000 °/s	16,4

The microcontroller processes this data and transmits the data to the GSM of the A9G module. Then the reliable data would be sent to the ambulance and police for emergencies via GSM of the A9G module.

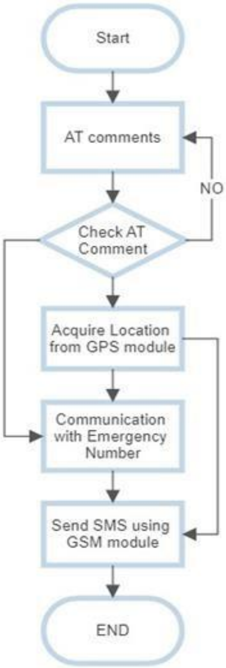

Fig.4 Working of A9G module.

5. HARDWARE IMPLEMENTATION

The hardware components are implemented as per pin configuration and attached inside the crash helmet. When the device is set to on condition the system updates its initial values (x, y, z) as an initial value and hence the current position will be considered as an initial value, this process takes some time to establish connection and set its initial values. When Accident occurs, there will be a sudden change in Acceleration along with sudden changes in Gyroscope angle. Those values are acquired from Mpu6050 sensor and transmitted to microprocessor (Arduino mini), Which contains logical conditions and threshold values, When the acquired values from Mpu6050 exceeds the threshold, it is considered as accident.

Fig.5 Helmet Rested in Neutral Position

Fig.6 Helmet During Crash Condition

Table 2: Value of Accelerometer for Different Movements [3]

Activity	Accelerometer values in(G)
Walking (normal)	1.41
Walking (fast)	2.24
Sitting(slow)	1.54
Sitting(fast)	2.0
Jogging	3.16
Freefall	Less than 0.8
On impact after Freefall	Greater than 2.45

6. Result and Discussion

The Mpu6050 sensors are connected and the values from theSensors are displayed [Fig:7]

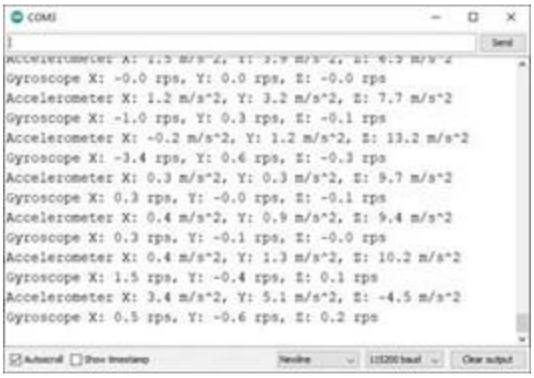

Fig.7 *Screenshot of Acceleration and Gyroscopic values*

Fig.8 Condition statement for Accident detection

Readings obtained from an MPU6050 sensor andtransmitted to a microprocessor (Arduino Mini), which incorporates logical conditions and predefined thresholds [Fig:8]. If the received sensor values surpass thesepredefined thresholds, they are classified as indicative of an accident.

Fig.9 Execution of A9G after accident detection

The system has demonstrated its ability to accurately detect falls during testing. Additionally, it effectively determines the current location and successfully sends an SMS containing location coordinates [Fig:9].

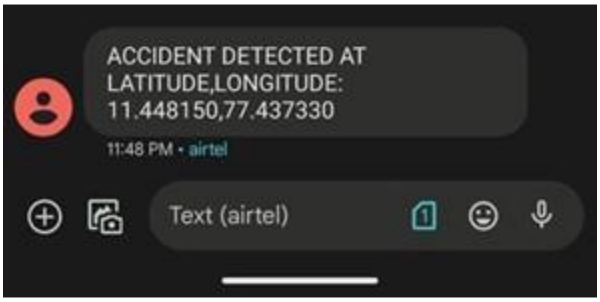

Fig.10 *SMS Alert Message with Coordinates*

These coordinates can be entered into Google Maps[Fig:10], with the received location serving as the destination and the mobile's current location as the starting point. Google Maps will then assist in finding the optimal and quickest route to reach the destination, providing step- by-step directions along the way.

Screenshot of Google Maps with the location of Coordinates

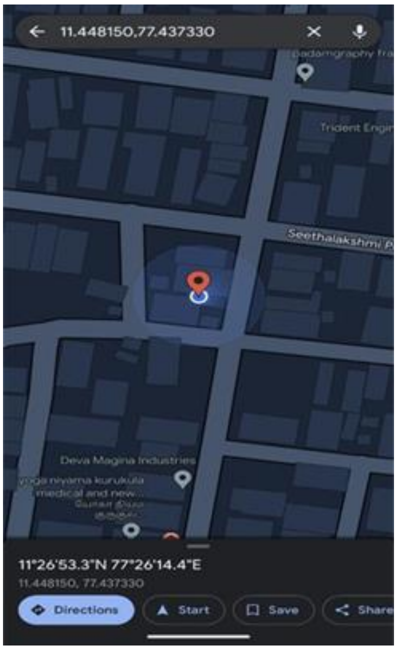

Fig.11 *Screenshot of Coordinates indicating Fall location on Google map.*

Discussion

The system takes more time to start and calibrate during initialization of values to gyroscope may easily cause calibration error. This system is highly sensitive hence causes many false detections.

A9G module doesn't support some high spectrum band operating Subscriber Identification Module and it's difficult to send or communicate at some area where the spectrum range is low.

7. Conclusion

In conclusion, our innovative system, incorporating the Arduino Nano, MPU6050 sensor, and A9G GPS module, represents a significant step forward in addressing the pressing global issue of road accidents. The delayed response to accidents has long been a major factor contributing to the loss of lives. Our solution aims to bridge this crucial gap in emergency services. Through continuous monitoring of motion with the MPU6050 sensor, our system can swiftly detect abrupt changes, a key indicator of accidents. The A9G GPS module supplements this by providing real-time location data, allowing for precise accident pinpointing. When an accident is detected, our system activates an SMS notification to the nearest police station, delivering vital information, including GPS coordinates, dates, and times. The result is a reduction in emergency response time and, potentially, countless lives saved. Rigorous real-world testing has confirmed the effectiveness of our solution, and we are committed to ensuring that it meets safety and regulatory standards for real-world deployment. With the potential to significantly improve road safety and reduce fatalities, our solution not only represents a technological achievement but also a step toward a safer and more secure road environment for everyone.

8. FUTURE SCOPE

Looking ahead, our project's future scope is filled with exciting opportunities for further innovation and impact. One promising avenue involves integrating our accident detection system with the evolving landscape of smart and connected vehicles. This integration could enable real-time communication between vehicles and emergency services, leading to even faster response times and immediate medicalassistance. Additionally, the implementation of data analytics and machine learning algorithms presents an opportunity to enhance accident detection accuracy, differentiating between true accidents and false alarms, thereby increasing the overall reliability of the system.

Extending the reach of our technology to wearable devices, such as smart helmets, offers the potential for enhanced safety for motorcyclists and bicyclists. These wearables could not only detect accidents but also monitor vital signs and facilitate voice-activated emergency calls. Collaboration with emergency service providers to establish standardized protocols for receiving alerts and responding to accidents can streamline the emergency response process.

Furthermore, we see the potential for global deployment, addressing road safety challenges on a worldwide scale. Tailoring the system to accommodate regional road safety concerns can have a profound impact in diverse environments. Public awareness campaigns will complement technical development, educating individuals about the benefits of safety systems and promoting responsible road behavior.

Advocating for regulatory support and industry adoption will be crucial in ensuring widespread deployment of such systems in vehicles and helmets, making road safety a collective priority. The future of this project not only involves technological advancement but also fosters a culture of safety on the road. Through ongoing innovation and the pursuit of these opportunities, we can work towardsa future with significantly reduced road accidents and improved emergency response, ultimately saving lives and enhancing road safety for all.

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