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Automatic Accident Detection and Rescue System

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Abstract: The Automatic Vehicle Accident Detection and Rescue System using Arduino, GPS, GSM, Buzzer, and Switch Button is designed to detect vehicle accidents in real-time and automatically alert emergency services with the vehicle's location. The system aims to reduce the time taken for rescue operations, which is critical in saving lives during road accidents.

The system utilizes sensors to detect a collision, upon which the Arduino microcontroller processes the data and triggers a buzzer to alert nearby individuals. Simultaneously, the GPS module retrieves the vehicle's location coordinates, and the GSM module sends an SMS containing these coordinates to predefined emergency contacts, such as hospitals or family members. A manual reset button is incorporated, allowing the driver to cancel the alert in case of a false alarm.

This project offers a cost-effective and reliable solution to address delays in accident reporting and rescue operations. It enhances road safety and ensures prompt assistance to accident victims, potentially reducing fatalities caused by delayed emergency response. The system can be easily integrated into any vehicle, making it highly scalable for widespread use.

Keywords: Accident Detection, Arduino, GPS, GSM, Emergency Alert System, Vehicle Safety, Real-time Tracking, Rescue System, Road Safety, IoT-based Alert System, Collision Detection, Automated Emergency Response, Smart Vehicle System, False Alarm Prevention, Embedded Systems

I. INTRODUCTION

A. Background

Road accidents are a global issue. causing significant loss of life. injuries, and economic impact. According to the World Health Organization (WHO), approximately 1.3 million people die each year due to road traffic crashes, and between 20 to 50 million suffer non-fatal injuries. Many of these fatalities and severe injuries could be prevented with timely medical assistance. but one of the primary challenges is the delay in accident detection and the subsequent emergency response.

In many developing and rural areas, where traffic monitoring systems are less sophisticated. accidents often go unreported for extended periods. leading to a lack of timely medical intervention. Even in urban areas. the exact location of an accident might not be immediately known. causing delays in emergency services reaching the site.

The concept of an "Automatic Vehicle Accident Detection and Rescue System" was born out of the need to bridge this critical gap in accident response times. Traditional methods of reporting accidents rely heavily on human intervention. such as bystanders calling emergency services. However. this method is not always reliable. as witnesses may not always be present. or the severity of the situation might not be accurately communicated.

With advancements in technology. particularly in the fields of microcontrollers. GPS. and GSM communication. it has become feasible to design a system that can automatically detect accidents and alert emergency services with precise location information. This is where the integration of Arduino GPS. GSM. and other components comes into play.

B. Objective

1) Accident Detection: To automatically detect vehicle accidents in real-time using sensors and algorithms.
2) Immediate Alert: To instantly notify emergency services and designated contacts about the accidentwith precise location details.
3) Rescue Assistance: To facilitate quicker response times by providing real-time data to rescue teams. Improving the chances of saving lives.
4) Data Collection: To gather and analyze accident data for future safety improvements and prevention strategies.
5) User Safety: To enhance overall road safety by minimizing the time between accident occurrence and rescue efforts.

C. Purpose:

The purpose of this project is to enhance road safety and improve the efficiency of emergency response systems by developing a technology-driven solution that automatically detects vehicle accidents and immediately notifies rescue services with precise location details.

This system aims to address the critical issue of delayed accident reporting which often leads to increased fatalities and injuries.

D. Scope

The scope of the project encompasses the design. development. implementation, and testing of a comprehensive system for automatically detecting vehicle accidents and facilitating prompt emergencyresponse. The project is structured to cover several key areas:

1) System Design and Integration:

• Develop a system architecture that integrates Arduino. GPS. GSM. a buzzer. and a switch button to create an automated accident detection and alert system.
- Ensure seamless communication between the different modules to achieve accurate detection and reliable alert transmission.

2) Hardware Development:

Select and configure the appropriate hardware components, including sensors for impact detection. GPS for location tracking. GSM for communication. a buzzer for audible alerts. and a switch button for manual triggering.

3) Software Development:

- Write and test the Arduino code to process sensor data. detect accidents. and manage the communication between the GPS. GSM. buzzer. and switch button.
• Develop the logic for accident detection based on sensor thresholds and real-time data processing

4) Accident Detection Mechanism:

Define and implement the criteria for accident detection. including the types of impacts or sudden movements that should trigger the system.Calibrate the system to distinguish between minor bumps and actual accidents. minimizing false positives.

5) Emergency Communication:

Program the GSM module to send SMS alerts with location details to predefined emergency contacts.Ensure that the messages are formatted clearly and contain essential information. such as the GPS coordinates of the accident.

6) Testing and Validation:

- Conduct extensive testing of the system in various scenarios to ensure its accuracy, reliability. and responsiveness.

7) User Training and Documentation:

Develop user manuals and training materials for vehicle owners. technicians. and emergency responders on how to use. maintain. and respond to the system.

E. Limitation:

- The system relies on GSM network availability for sending alerts. which may be limited in remote areas.
-Accuracy of accident detection may vary depending on sensor sensitivity and the nature of the impact.
- The system is designed primarily for vehicles and may require modification for use in other contexts. such as motorcycles or heavy machinery.

F. Applicability:

Accident Detection: The system uses sensors connected to an Arduino to detect significant impacts or sudden decelerations that indicate a possible accident.
Location Tracking: A GPS module captures the precise location of the vehicle at the time of the accident. ensuring accurate and timely information is available for rescue teams. Emergency Alerts: The GSM module sends an SMS alert containing the accident's location to predefined contacts, such as emergency services and family members. immediately after an accident is detected. Manual Trigger: A switch button allows occupants to manually activate the emergency alert system. providing an additional layer of safety. Audible Alarm: The buzzer sounds an alert at the accident scene. drawing attention to the incident and potentially prompting nearby individuals to assist.

G. *Stakeholders:*

1) *Primary Stakeholders:*

- Vehicle Owners/Drivers:

End-users who benefit directly from the system, as it enhances their safety by automatically detecting accidents and notifying emergency services.

- Emergency Services (Ambulance, Police, Fire Department):

Key beneficiaries who receive timely alerts with location details, enabling quicker responses to accidents.

- Hospitals and Medical Staff:

Healthcare providers that respond to emergencies and treat accident victims. The system ensures they receive timely alerts for preparation and dispatch of medical aid.

- Vehicle Manufacturers:

Automakers interested in incorporating this system to improve vehicle safety features, adding value to their products and enhancing brand reputation.

- Insurance Companies:

Can use the system to quickly receive accident reports, reducing fraud and speeding up claim processes by receiving accurate accident data.

2) *Secondary Stakeholders:*

- Government and Regulatory Authorities:

Responsible for promoting road safety. They may enforce or encourage the use of accident detection systems in vehicles to reduce road fatalities.

- Tech Developers/Engineers:

Engineers involved in designing, developing, and maintaining the system. They are responsible for improving system efficiency, reliability, and security.

- Telecommunication Providers:

Companies providing GSM network services, essential for sending alert messages. The system depends on reliable network connectivity to function properly.

- Road Safety Organizations:

Non-governmental organizations focused on reducing road accidents. They may advocate for such technologies to improve road safety and reduce fatalities.

3) *Tertiary Stakeholders:*

- Insurance Claim Investigators:

They may use accident data from the system to assess accident conditions and verify claims.

- Software and Hardware Suppliers:

Companies that provide Arduino components, GPS, GSM modules, sensors, and other hardware for the system's development and operation.

- Researchers and Academics:

Researchers studying road safety or developing future advancements in accident detection technologies will benefit from data and insights generated by the system.

- Roadside Assistance Providers:

Service providers responsible for towing or repairing vehicles involved in accidents may receive information through the system.

4) Potential Investors:

- Venture Capitalists/Business Investors:

Investors who may fund the commercialization and scaling of the system, seeing its potential in improving vehicle safety and reducing accident-related deaths.

H. Achievements:

• Successfully developed and tested a functional prototype that integrates all components to create a reliable and responsive system.

- Demonstrated the system's ability to significantly reduce the time between an accident and the arrival of emergency responders. potentially saving lives.

Provided a scalable design that can be further developed for commercial use and integration with broader smart vehicle or IoT systems.

I. Advantages:

1) Quick Emergency Response:

-The system significantly reduces the time between an accident and the arrival of emergency responders by automatically sending alerts with precise location details, which can save lives and minimize the severity of injuries.

2) Accurate Location Tracking:

The integration of GPS technology ensures that the exact location of the accident is sent to emergency services. enabling them to reach the site quickly and efficiently.

3) Automatic and Manual Alert Options:

The system combines both automatic detection of accidents and manual triggering options through a switch button. providing flexibility and ensuring that help can be summoned even if the automatic system fails.

4) Increased Road Safety:

By ensuring that accidents are reported immediately, the system contributes to overall road safety. helping to reduce fatalities and injuries on the road.

5) Audible Alerts:

The buzzer provides an immediate audible alert. which can attract attention from nearby individuals and prompt them to assist or call for help.

J. Disadvantages:

1) Dependency on GSM Network:

- The system relies on GSM networks to send alerts. In areas with poor or no cellular coverage. the system may fail to communicate with emergency services. reducing its effectiveness.

2) False Positives:

The system might generate false positives by detecting non-accident events (e.g.. sudden braking or minor bumps) as accidents. leading to unnecessary alerts and potential panic.

3) Power Consumption:

- The continuous operation of GPS. GSM. and Arduino modules may consume significant power. which could be an issue for vehicles with limited battery capacity or during extended periods without engine operation.

4) Installation and Maintenance:

- Installing and maintaining the system in vehicles might require technical expertise. which could be a barrier for some users. Additionally, improper installation could affect the system's reliability.

5) Privacy Concerns:

- The continuous tracking and communication of location data might raise privacy concerns among users. Particularly regarding who has access to the data and how it is used.

II. SURVEY OF TECHNOLOGIES

A. Existing System:

1) Basic GPS Tracking Systems:

- Tracks vehicle location using GPS.
- Sends GPS coordinates via SMS or to a tracking server.
- No accident detection capability; manual alerts only.

2) Manual Emergency Alert Systems:

- Equipped with a panic button for sending emergency alerts.

- Sends SMS with location data when manually triggered.
- Requires the driver to be conscious and able to press the button.

3) *Smartphone-Based Accident Detection Apps:*
- Uses smartphone sensors (accelerometer, GPS) to detect accidents.
- Automatically sends an alert with location data.
- Relies on the availability and functionality of a smartphone.

4) *Vehicle Telematics Systems:*
- Integrated with the vehicle's onboard diagnostics (OBD) and sensors.
- Detects accidents and automatically sends detailed alerts to emergency services.
- Typically, expensive and only available in newer, high-end vehicles.

5) *Arduino-Based Simple Accident Alert Systems:*
- Utilizes Arduino for accident detection and GSM for sending SMS alerts.
- Often includes a manual override or reset button.
- Basic functionality with limited sensor integration; requires customization.

6) *Advanced Integrated Safety Systems:*
- Integrated into the vehicle's electronic control unit (ECU).
- Detects accidents, deploys airbags, and sends alerts automatically.
- High reliability but expensive and not easily retrofitted to older vehicles.

B. List of Technologies:
1) *Arduino Uno:* Microcontroller board used as the central processing unit to control all other components.
2) *GPS Module (NEO-6M):* Provides real-time geographic location data (latitude and longitude) to determine the vehicle's position.
3) *GSM Module (SIM800L):* Sends SMS alerts to predefined contacts using a cellular network when an accident is detected.
4) *Accelerometer (ADXL335):* Detects sudden changes in motion or orientation (acceleration) which could indicate a vehicle accident.
5) *Buzzer:* Emits an audible alarm to alert nearby people of an accident.
6) *Switch Button:* Allows manual intervention to cancel the alert in case of a false alarm.
7) *Software Serial Library:* Enables serial communication between the Arduino and multiple modules (GPS, GSM) on different digital pins.
8) *TinyGPS Library:* A GPS data parsing library used to extract and process location data from the GPS module.
9) *AT Commands:* A set of instructions used to control the GSM module for sending SMS messages and other functions.
10) *Pull-up Resistor:* Ensures reliable input readings from the switch button by avoiding floating states.
11) *Power Supply:* Provides the necessary voltage and current to power the Arduino and all connected modules.

C. Comparatively Study:
1) *Functionality:*

Feature	Arduino-Based System	Smartphone-Based Systems	Integrated Vehicle Telematics	Manual Emergency Systems
Accident Detection	Detects accidents using an accelerometer (ADXL335).	Detects accidents using smartphone sensors (accelerometer, gyroscope).	Detects accidents using vehicle's internal sensors (airbags, accelerometers).	No automatic detection; relies on manual input.
Location Tracking	Provides GPS coordinates using the NEO-6M module.	Utilizes the smartphone's built-in GPS.	Uses advanced GPS systems integrated within the vehicle.	Limited or no tracking capability; location sent manually via SMS.
Alert System	Sends SMS alerts via GSM module (SIM800L)	Sends alerts via the smartphone's messaging	Sends detailed alerts to emergency services with	Sends alerts manually by pressing a button.

	to predefined contacts.	service.	vehicle data and location.	
Audible Warning	Emits a sound using a buzzer to alert nearby individuals.	No built-in audible warning.	May use the vehicle's horn or internal buzzer as an audible warning.	No audible warning unless manually activated.
User Intervention	Equipped with a switch button to cancel false alerts.	Alerts can be manually canceled via the smartphone interface.	Fully automated; user intervention is minimal or not required.	Requires full manual operation.

2) *Cost:*

Aspect	Arduino-Based System	Smartphone-Based Systems	Integrated Vehicle Telematics	Manual Emergency Systems
Initial Setup Cost	Low to moderate; affordable components such as Arduino, GPS, GSM, and sensors.	Low; depends on the smartphone being used.	High; requires professional installation and advanced hardware.	Low; simple panic buttons and basic GSM modules.
Maintenance Cost	Low; mainly involves replacing or updating components if necessary.	Low; mainly depends on smartphone maintenance.	High; requires specialized maintenance by trained technicians.	Low; basic checks and battery replacement.
Operational Cost	Low; includes the cost of SMS messages sent via GSM.	Low; depends on the data/SMS plan of the smartphone.	Moderate to high; may involve subscription fees for telematics services.	Low; minimal operational costs.

3) *Ease of Use:*

Aspect	Arduino-Based System	Smartphone-Based Systems	Integrated Vehicle Telematics	Manual Emergency Systems
Installation	Moderate; requires some technical skills for wiring and programming.	Easy; installs as an app on a smartphone.	Complex; requires professional installation and integration with vehicle systems.	Easy; simple to install and use.
User Interaction	Simple; mainly requires user action in case of false alerts.	Moderate; depends on the app's user interface and settings.	Minimal; fully automated and integrated into the vehicle's systems.	High; requires the user to manually trigger alerts.
Customization	High; can be customized according to specific needs (e.g., sensitivity of accident detection).	Moderate; customization is limited to app settings.	Low; typically pre-configured and difficult to customize.	Low; limited to basic settings like contacts for alerts.

4) *Reliability*:

Aspect	Arduino-Based System	Smartphone-Based Systems	Integrated Vehicle Telematics	Manual Emergency Systems
Detection Accuracy	Moderate; depends on sensor calibration and placement.	Moderate; depends on smartphone's sensor quality and position in the vehicle.	High; uses multiple vehicle sensors and systems for accurate detection.	Low; no automatic detection, prone to human error.
Alert Delivery	High; reliable GSM communication for SMS alerts.	High; reliable as long as the smartphone is functional and has network coverage.	Very high; uses robust vehicle communication systems and networks.	Moderate; depends on manual activation and GSM network.
Power Dependence	Low to moderate; runs on vehicle power or a dedicated battery pack.	High; depends on the smartphone's battery life.	Low; integrated into the vehicle's power system.	Low; usually operates on a simple battery or vehicle power.

5) Integration & Compatibility:

Aspect	Arduino-Based System	Smartphone-Based Systems	Integrated Vehicle Telematics	Manual Emergency Systems
Integration with Vehicle	Limited; mainly standalone but can be integrated with basic vehicle systems.	Minimal; operates independently of the vehicle's systems.	Full integration with vehicle systems (airbags, brakes, etc.).	None; operates independently.
Compatibility with Vehicles	High; can be used with any vehicle but requires customization.	High; compatible as long as the smartphone can be secured in the vehicle.	Low to moderate; typically limited to specific vehicle models and makes.	High; can be used in any vehicle.

D. Why we need this Technologies:

We are undertaking the development of the "Automatic Vehicle Accident Detection and Rescue System using Arduino. GPS. GSM. Buzzer. and Switch Button" to significantly enhance road safety by addressing the critical issue of delayed emergency response following vehicle accidents. Road accidents remain one of the leading causes of injury and death globally, and in many cases, the time it takes for emergency services to be notified and respond can make a crucial difference in the survival and recovery of the victims. Traditional methods of accident reporting rely heavily on the presence of witnesses or the ability of the vehicle's occupants to make a call. which may not always be possible due to the severity of the crash or the location of the accident.

This project leverages the capabilities of Arduino. a versatile and cost-effective microcontroller. to automate the detection and reporting process. By integrating a GPS module. the system can accurately pinpoint the accident's location. while the GSM module ensures that this information, along with an alert. is promptly sent to emergency services or designated contacts via SMS. The inclusion of a buzzer serves to immediately alert nearby individuals. potentially speeding up the rescue process if they are within earshot. The switch button adds an important manual control. allowing for the system to be triggered or reset by a user in scenarios where automatic detection might fail or in case of a false alarm.

In essence. this project is designed to create a robust. reliable, and automatic safety net that works independently of human intervention during critical moments. thereby reducing the time it takes for help to arrive. This can potentially save lives by ensuring that the victims receive medical attention as quickly as possible. even in remote areas where accident detection and reporting would otherwise be delayed.

III. REQUIREMENTS & ANALYSIS

A. Problem Definition:

1) Background:

Road accidents are a leading cause of death and injury worldwide. In many cases, the delay in detecting the accident and notifying emergency services significantly contributes to the severity of injuries and fatalities. In remote areas, where accidents may go unnoticed for extended periods, the situation is even more critical. Traditional methods of accident reporting rely on manual communication, which may not be possible if the victim is unconscious or incapacitated.

2) Current Problem:

- *Delayed Accident Detection:* Many accidents go undetected for a considerable time, especially in isolated locations or during nighttime. In such cases, emergency response teams are not informed in time to take immediate action.
- *Manual Reporting Dependence:* Current systems depend on the driver or nearby individuals to report an accident. However, this may not be possible if the driver is unconscious, injured, or there are no witnesses nearby.
- *Lack of Precise Location Information:* Even when an accident is reported, there is often a delay in identifying the exact location, particularly in areas with poor infrastructure or limited visibility, causing further delays in rescue operations.
- *High Costs of Existing Systems:* Advanced accident detection and reporting systems are typically expensive and only available in high-end vehicles, limiting accessibility to a broad section of vehicle owners.
- *Risk of False Alarms:* Systems with motion sensors alone may trigger false alarms due to minor incidents such as sudden braking or rough terrain, leading to unnecessary panic or false alerts being sent to emergency services.

3) Proposed System:

The "Automatic Vehicle Accident Detection and Rescue System" addresses these issues by automating accident detection and response using affordable technology. The system detects accidents in real-time and sends an immediate SMS alert to emergency contacts, including the precise location using GPS data. A buzzer provides an audible alert for nearby individuals, and a manual switch button is included to cancel false alarms.

4) Key Problem Solve:

- *Immediate Accident Detection:* Using an accelerometer sensor, the system detects sudden changes in the vehicle's movement and automatically triggers the accident alert mechanism.
- *Automated Notification:* The GSM module sends an SMS with GPS coordinates to predefined emergency contacts, reducing dependence on the driver to report the accident.
- *Accurate Location Tracking:* GPS integration ensures that the exact location of the accident is communicated, enabling quicker rescue response.
- *Low-Cost Implementation:* By utilizing affordable components like Arduino, GSM, and GPS modules, the system provides a budget-friendly solution, making accident detection accessible to all vehicle owners.
- *Manual Override for False Alarms:* The switch button allows for manual cancellation of false accident detections, reducing the likelihood of sending unnecessary alerts.

B. Requirements Specification:

1) Functional Requirements:

- *Accident Detection System:*
  - Component: Accelerometer (e.g., ADXL335)
  - Function: Detect sudden changes in acceleration or orientation that signify an accident.
  - Specification: The system should detect high impact or rapid deceleration, which could indicate a collision.
- *Location Tracking:*
  - Component: GPS Module (NEO-6M)
  - Function: Pinpoint the vehicle's geographical location post-accident.
  - Specification: Provide real-time latitude and longitude data to be included in the emergency alert message.
- *Alert Communication:*
  - Component: GSM Module (SIM800L)
  - Function: Send an automated SMS with the vehicle's GPS coordinates to emergency contacts.
  - Specification: The system should store up to 5 emergency contact numbers and send SMS alerts within 10 seconds after detecting an accident.
- *Audible Alarm:*
  - Component: Buzzer
  - Function: Produce a loud audible signal to alert nearby individuals or passersby when an accident is detected.
  - Specification: The buzzer should activate immediately after an accident is detected to assist in manual rescue efforts.
- *Manual Override:*
  - Component: Switch Button
  - Function: Allow the driver or passenger to cancel the automatic alert in case of a false alarm.
  - Specification: The switch should deactivate the GSM and GPS modules if pressed within 15 seconds of accident detection.

2) Non-Functional Requirements:

- *Reliability:*
  - The system must reliably detect real accidents without frequent false positives, even under harsh environmental conditions (temperature extremes, vibrations, etc.).
  - Specification: The system should have at least a 95% accuracy rate in detecting collisions.
- *Cost-Effectiveness:*
  - The system should use affordable and widely available components to ensure accessibility.

- Specification: The total cost of materials should not exceed \$50 per unit to make it affordable for mass adoption.
- *Power Efficiency:*
- The system should minimize power consumption to ensure it doesn't drain the vehicle's battery.
- Specification: The system should use low-power sleep modes when idle, and the active state should consume less than 1W of power.
- *Scalability:*
- The system should allow for easy integration of additional sensors (e.g., alcohol sensors, temperature sensors) or components as required by future needs.
- Specification: The Arduino platform should have at least 2 spare analog/digital input ports for future scalability.

3) Hardware Requirements:

- *Arduino Board (e.g., Arduino Uno):*

Purpose: Acts as the control unit that interfaces with sensors and components, processes inputs, and triggers appropriate outputs.

- *GPS Module (NEO-6M):*

Purpose: Tracks and provides the vehicle's location in real-time after an accident.

- *GSM Module (SIM800L):*

Purpose: Sends SMS alerts to emergency contacts when triggered by accident detection.

- *Accelerometer (ADXL335):*

Purpose: Detects vehicle acceleration and orientation changes to identify a collision event.

- *Buzzer:*

Purpose: Alerts nearby individuals by emitting a loud sound when an accident is detected.

- *Switch Button:*

Purpose: Provides manual control for canceling the alert in case of false accident detection.

4) Software Requirements:

- *Arduino IDE:*

Purpose: Used to write, compile, and upload the system's program to the Arduino microcontroller.

- *GPS Data Parsing Algorithm:*

Purpose: Extract GPS coordinates from the NEO-6M module's output and format them for the GSM message.

- *SMS Transmission Code:*

Purpose: Send SMS alerts using AT commands to the GSM module, triggered by accident detection.

- *Impact Detection Logic:*

Purpose: Code that processes accelerometer data to differentiate between normal driving conditions and accident scenarios.

5) Performance Requirements:

- *Response Time:*

Requirement: The system should detect the accident and send an alert within 10 seconds of impact detection.

- *GPS Accuracy:*

Requirement: The GPS coordinates must be accurate within a range of 10 meters.

- *GSM Communication Range:*

Requirement: The system should operate wherever GSM cellular networks are available and send SMS messages reliably.

6) Environmental Requirements:

- *Operating Temperature:*

Requirement: The system should operate reliably within a temperature range of -10°C to 50°C, ensuring functionality in various weather conditions.

- *Durability:*

Requirement: All components should be shock-resistant and able to withstand vehicle vibrations and impacts without malfunctioning.

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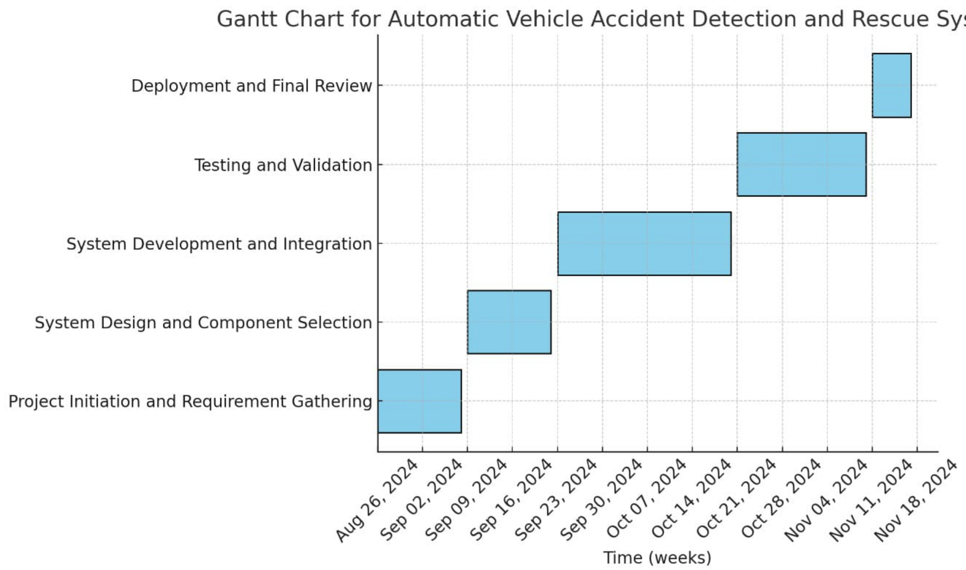
C. Gantt Chart:



D. Program Evaluation Using PERT:

The Program Evaluation and Review Technique (PERT) is a project management tool used to plan, schedule, and control tasks in a project. It accounts for uncertainties by estimating the time required for each task with optimistic, pessimistic, and most likely times.

1) Key Phases of the Project:

- Requirements Gathering
- Hardware Selection and Procurement
- Software Development
- Integration of Components
- Testing and Debugging
- Final Deployment

2) PERT Time Estimates:

PERT uses three-time estimates to calculate the expected duration for each activity:

- Optimistic time (O): The shortest time in which the task can be completed.
- Most likely time (M): The best estimate of the time required to complete the task.
- Pessimistic time (P): The longest time a task might take if things go wrong.

The expected time (TE) is calculated using the formula:

$$TE = \frac{O + 4M + P}{6}$$

3) PERT Table for Project Tasks:

Task	Optimistic Time (O)	Most Likely Time (M)	Pessimistic Time (P)	Expected Time (TE)	Dependencies
1.	1	2	3	2 weeks	None

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Requirements Gathering	week	weeks	weeks		
2. Hardware Selection	1 week	2 weeks	4 weeks	2.5 weeks	1
3. Software Development	3 weeks	5 weeks	8 weeks	5.33 weeks	1, 2
4. Component Integration	2 weeks	3 weeks	5 weeks	3 weeks	3
5. Testing and Debugging	1 week	2 weeks	4 weeks	2.16 weeks	4
6. Final Deployment	1 week	1.5 weeks	2 weeks	weeks	5

4) Critical Path Analysis:

The critical path is the sequence of tasks that determines the minimum project duration. To identify the critical path:

- Calculate the total time for each path.
- The path with the longest duration is the critical path, which determines the project's overall duration.
- ➢ Path 1: Requirements Gathering → Hardware Selection → Software Development → Component Integration → Testing → Final Deployment
- ➢ Total Duration: 2+2.5+5.33+3+2.16+1.5≈16.52 + 2.5 + 5.33 + 3 + 2.16 + 1.5 \approx 16.52+2.5+5.33+3+2.16+1.5≈16.5 weeks

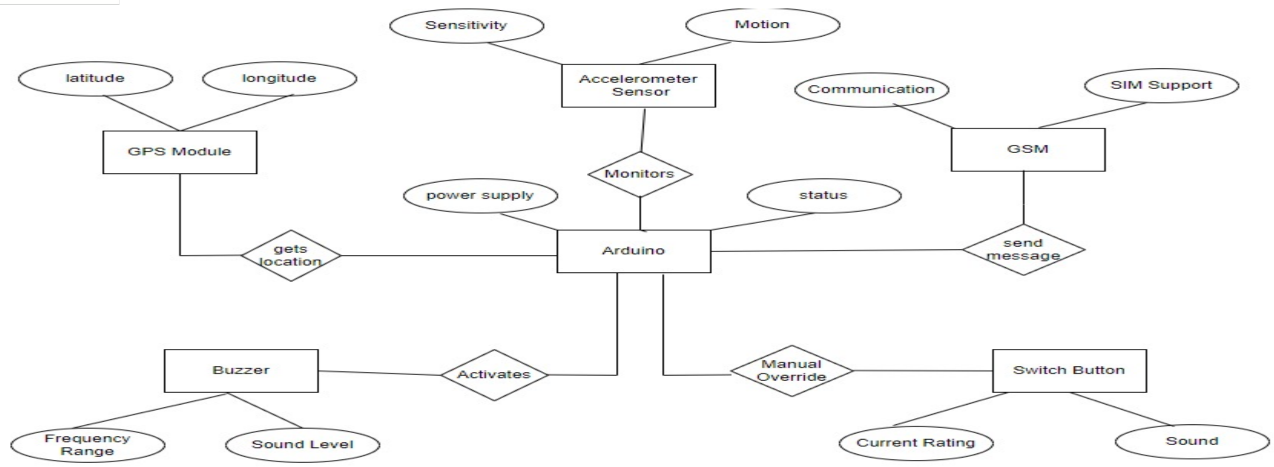
The expected project duration using the PERT method is approximately 16.5 weeks. The critical path highlights that any delays in the Software Development or Component Integration phases could extend the overall project duration.

E. Conceptual Model:

1) Entity-Relationship (ER) Diagram:

An Entity-Relationship (ER) Diagram is a conceptual representation of the data structure of a system. It illustrates the relationships between various entities (components or objects) in the system and how they interact with each other. In the context of the Automatic Vehicle Accident Detection and Rescue System, the ER Diagram outlines the entities involved, such as the vehicle, sensors, GPS, GSM module, and their interrelations.

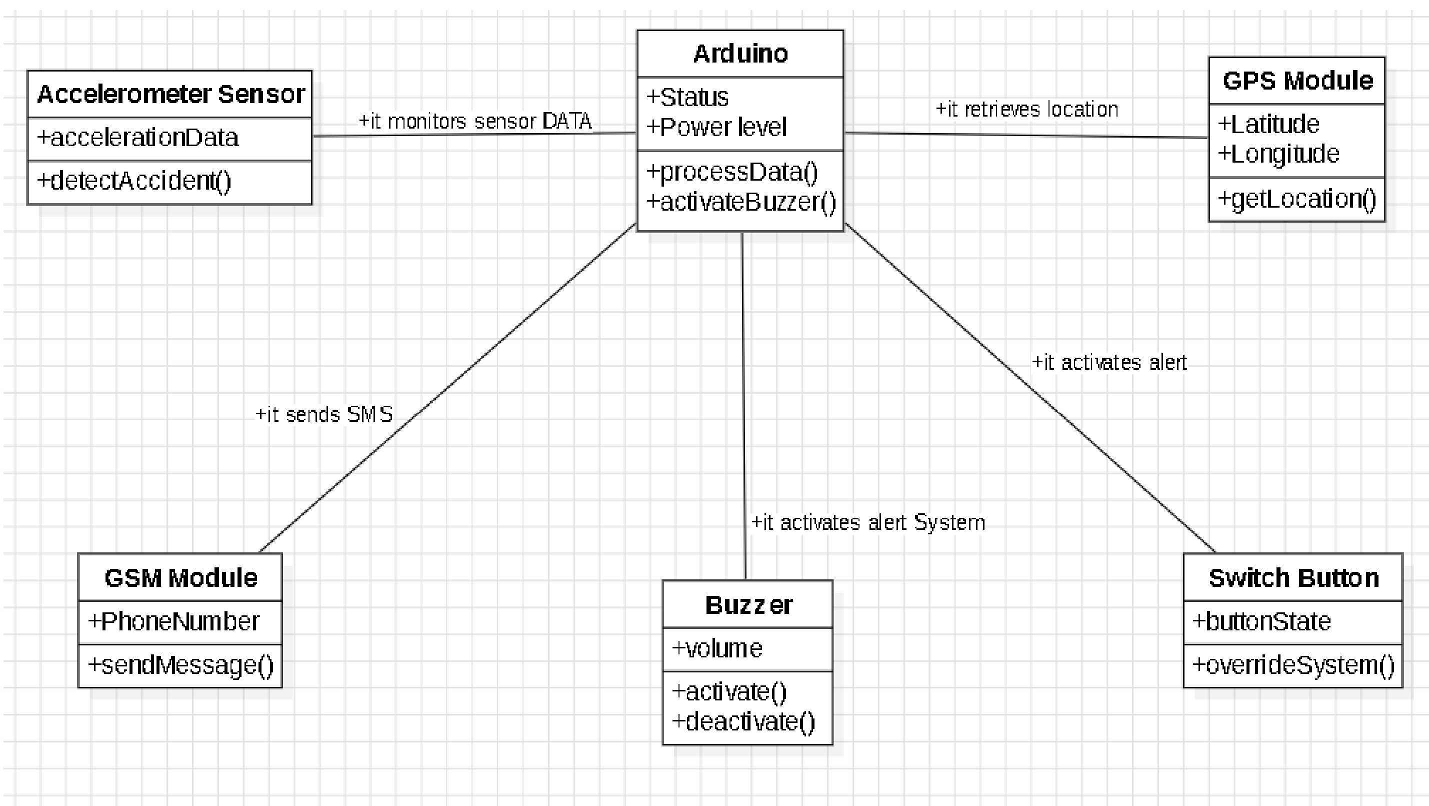
The ER Diagram helps visualize the relationships between various components of the Automatic Vehicle Accident Detection and Rescue System and their interactions. It provides a high-level view of how data flows within the system, how components are linked, and the data attributes involved in each entity. This diagram is particularly useful for database design, as it helps define how data will be stored, managed, and accessed in the system.



2) Class Diagram:

A Class Diagram is a type of structural diagram used in object-oriented design to represent the static structure of a system. It shows the system's classes, their attributes, methods, and the relationships between the classes. In the context of the Automatic Vehicle Accident Detection and Rescue System, the Class Diagram outlines how the various components (such as the Arduino, GPS, GSM, Buzzer, and Switch Button) are modeled as classes and how they interact.

The Class Diagram in this project shows the static design of the Automatic Vehicle Accident Detection and Rescue System by highlighting the various components of the system, their attributes, behaviors (methods), and how they interact with each other. This diagram is essential for understanding the overall system architecture and for implementing the system in an object-oriented manner. It provides the foundation for coding by specifying how each component should be designed in the software.



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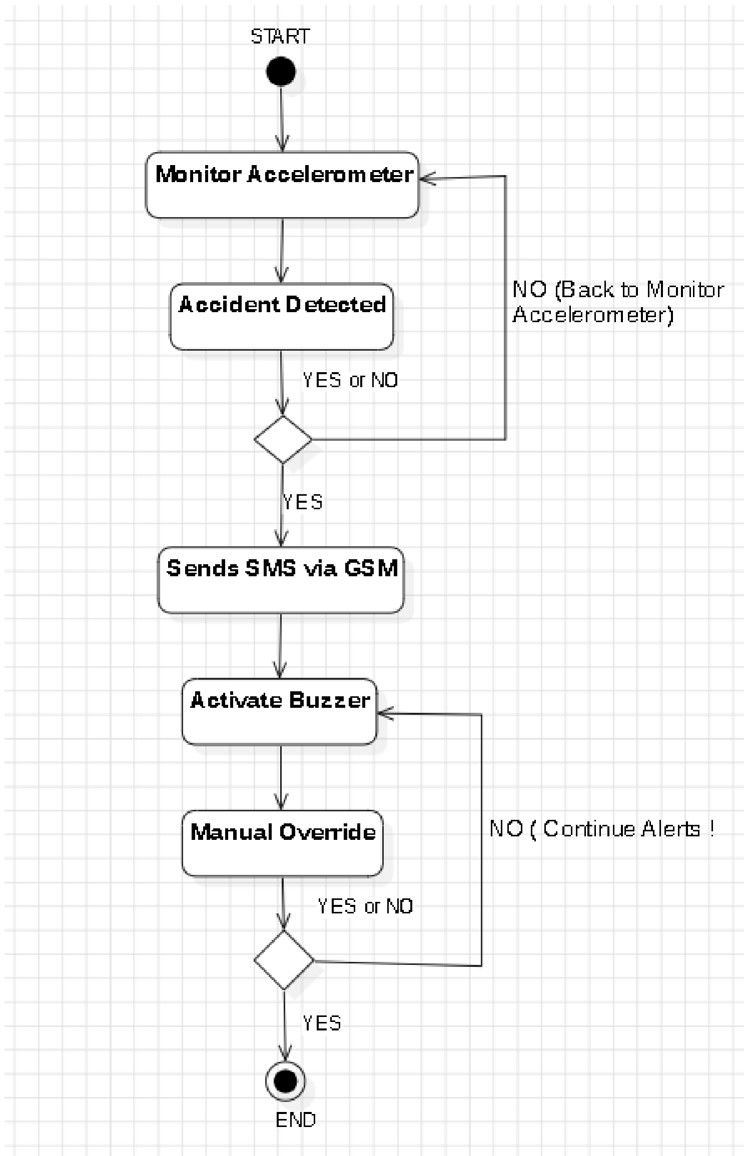
3) System Flow Diagram:

A System Flow Diagram (also known as a Data Flow Diagram, or DFD) represents the flow of data through a system and how different processes interact within it. It depicts the sequence of operations, the flow of control, and the interactions between different components or entities in a project. In the context of the Automatic Vehicle Accident Detection and Rescue System, the System Flow Diagram visually represents how the system processes input from various sensors and modules to detect accidents and trigger an appropriate response.

The System Flow Diagram for the Automatic Vehicle Accident Detection and Rescue System shows the flow of information and the interactions between the components in the system. It illustrates how data is collected (through sensors), processed (using the Arduino), and triggers actions (like sending an alert or activating a buzzer). This diagram is useful for understanding the operational flow of the system, showing how data and control signals move between different elements to achieve the desired functionality.

This diagram helps developers and stakeholders visualize how the system functions and identify potential bottlenecks or areas for improvement in the flow of data and processes.

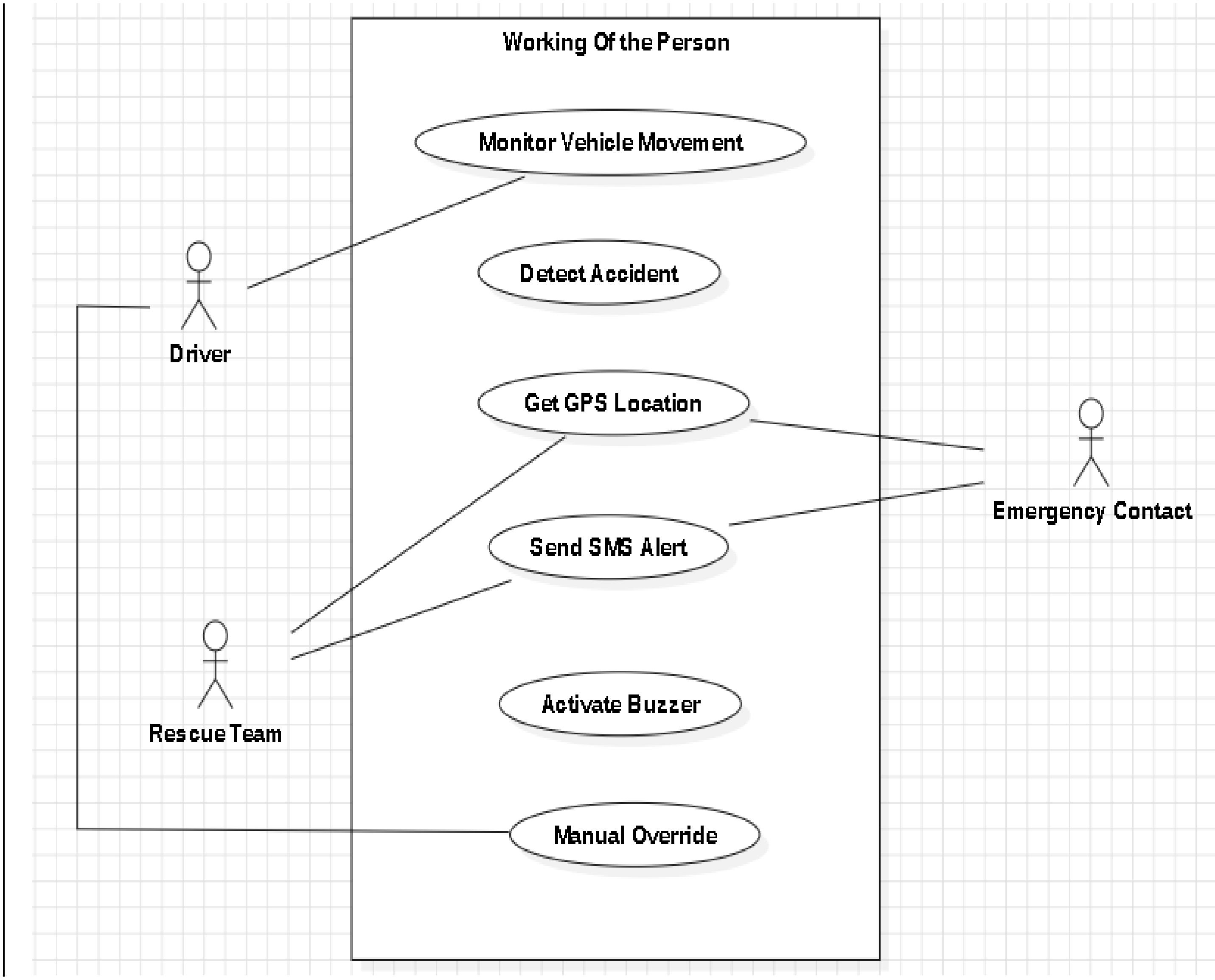


4) Use Case Diagram:

A Use Case Diagram is a behavioral diagram in UML (Unified Modeling Language) that illustrates the interactions between a system and its external actors. It shows how different users or external systems (actors) interact with the system to achieve specific goals or use cases.

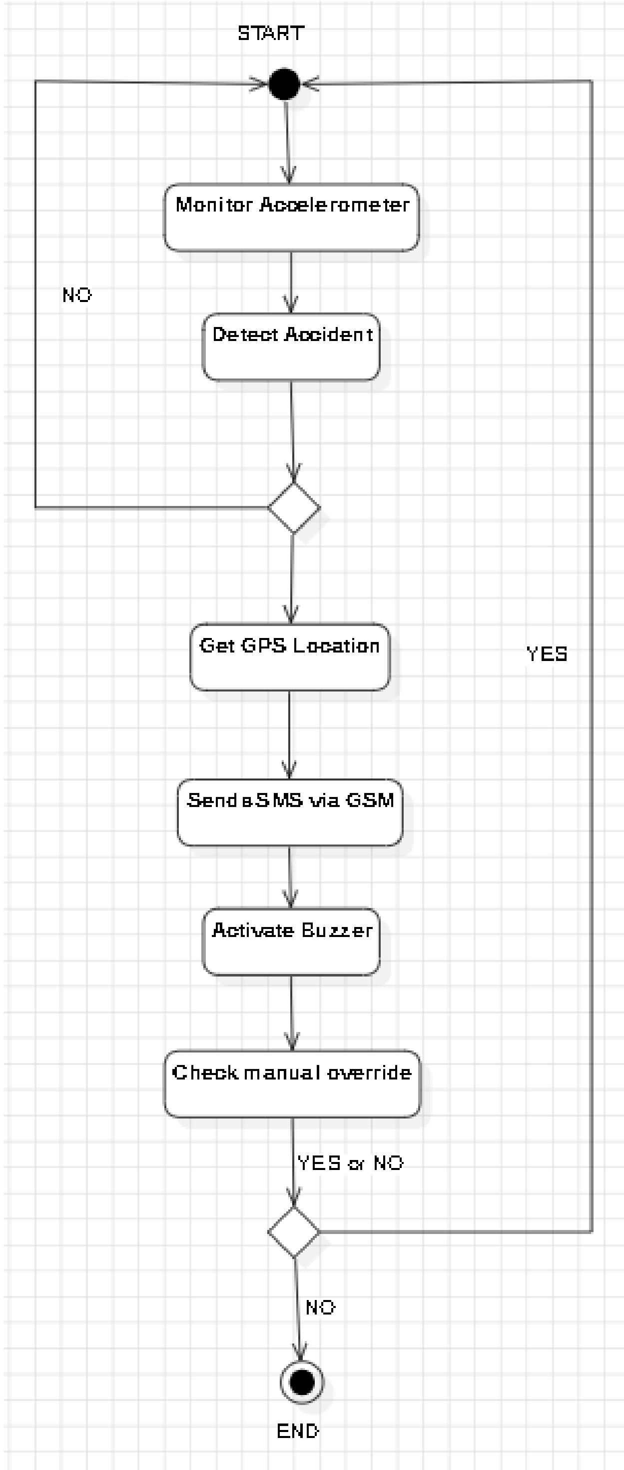
In the context of the Automatic Vehicle Accident Detection and Rescue System, the Use Case Diagram represents the various functionalities or scenarios in which the system is used, and how the system interacts with different actors such as the driver, emergency contacts, and emergency responders.

The Use Case Diagram for the Automatic Vehicle Accident Detection and Rescue System provides a high-level view of how the system interacts with external users and what functionalities it offers. It helps identify and define the main functionalities (use cases) that the system must support, as well as how different external actors (such as drivers, emergency contacts, and responders) interact with the system.



5) Activity Diagram:

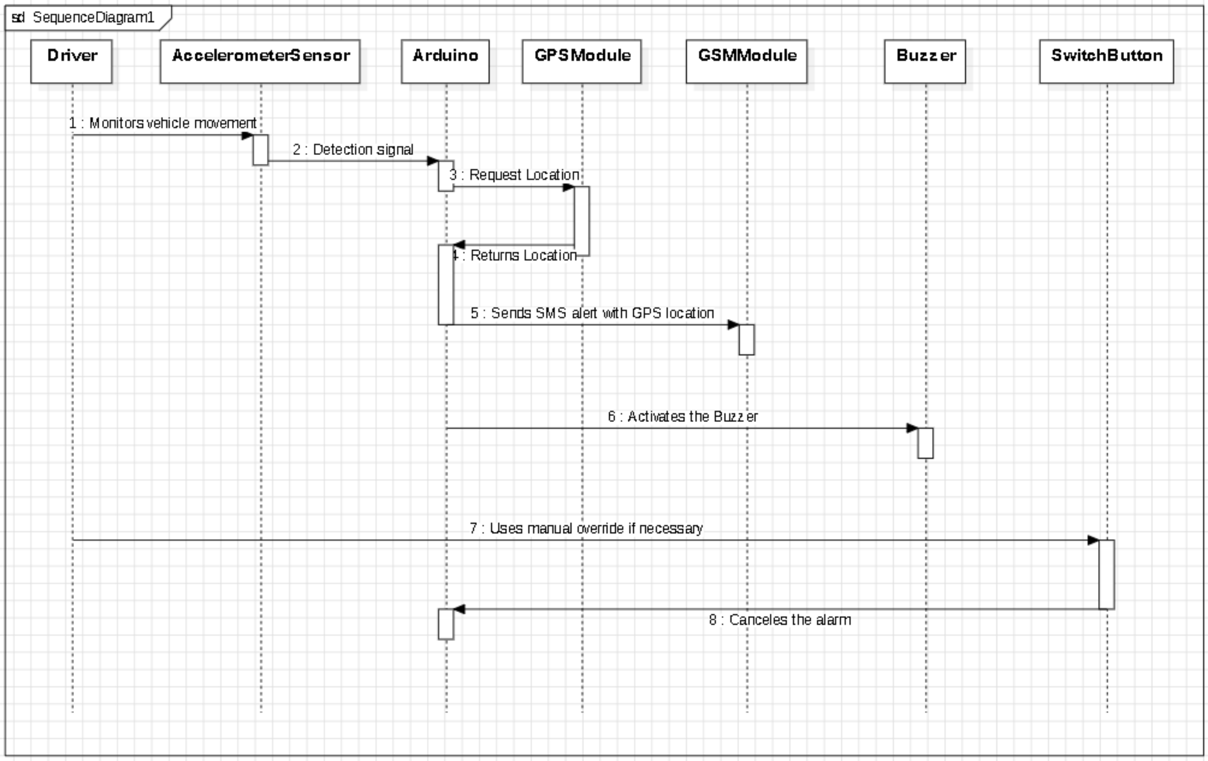
An Activity Diagram is a type of behavioral diagram that represents the dynamic aspects of the system by showing the flow of activities or actions in a process. For the Automatic Vehicle Accident Detection and Rescue System using Arduino, GPS, GSM, Buzzer, and Switch Button, the Activity Diagram captures the sequence of operations from detecting an accident to sending an alert and activating a buzzer.The diagram helps visualize how each component in the system works together to detect and respond to vehicle accidents, ensuringquick action and potentially saving lives.



6) Sequence Diagram:

A Sequence Diagram is a type of interaction diagram in UML (Unified Modelling Language) that shows how processes operate with one another and in what order. It visualizes the sequence of messages exchanged between objects or components of the system to carry out specific functionality. In the context of the Automatic Vehicle Accident Detection and Rescue System, the Sequence Diagram represents the flow of interactions between various system components like the Arduino, GPS, GSM, Buzzer, and Switch Button, along with external actors like the driver and emergency contacts

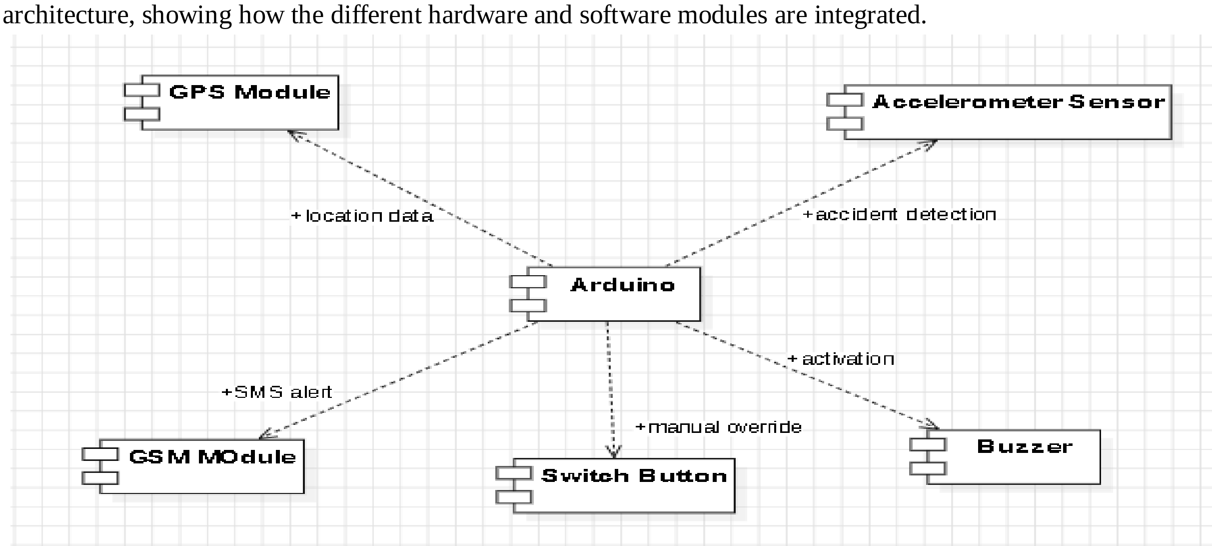
The Sequence Diagram for the Automatic Vehicle Accident Detection and Rescue System visually demonstrates the order and interaction between components to perform the core functionalities of accident detection and alert generation.



7) Component Diagram:

A Component Diagram is a structural diagram in UML (Unified Modelling Language) that visualizes the physical components of a system and how they interact. It represents the organization and dependencies between software components, hardware elements, and external interfaces. In the context of the Automatic Vehicle Accident Detection and Rescue System, the Component Diagram illustrates how the various hardware and software modules (such as Arduino, GPS, GSM, Buzzer, and Switch Button) are integrated to detect accidents and send alerts

The Component Diagram for the Automatic Vehicle Accident Detection and Rescue System provides a high-level view of the system's architecture, showing how the different hardware and software modules are integrated.



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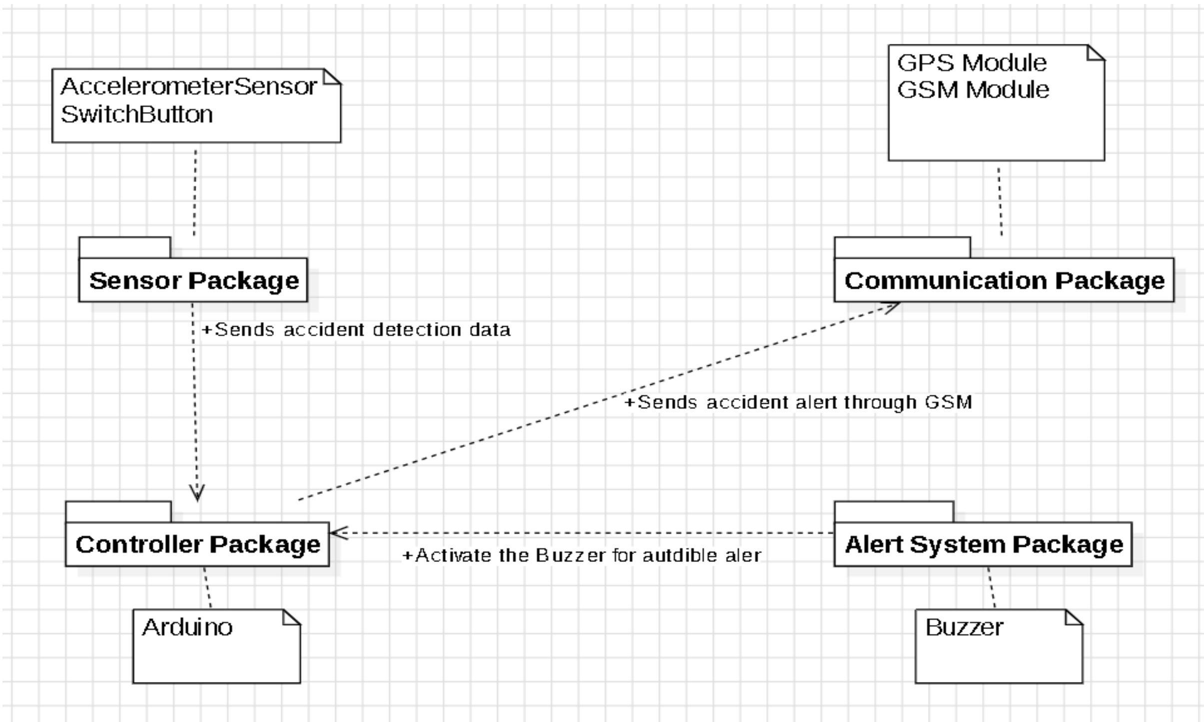
8) Package Diagram:

A Package Diagram in UML (Unified Modelling Language) is used to organize and group related elements of a system into higher-level units called packages. It provides a way to manage the complexity of large systems by logically grouping elements (such as classes, components, and subsystems) and showing their dependencies and relationships. In the context of the Automatic Vehicle Accident Detection and Rescue System, the Package Diagram illustrates how the various components, modules, and subsystems of the system are organized and interact with each other.

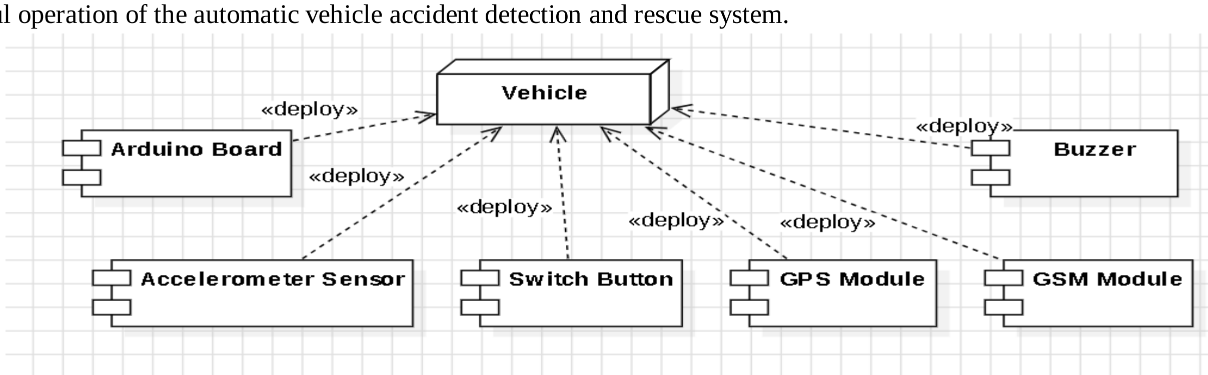
The Package Diagram helps in visualizing the structure of the Automatic Vehicle Accident Detection and Rescue System by logically organizing the various hardware and software components (e.g., sensors, Arduino, GPS, GSM, buzzer, switch) into packages. It demonstrates how these packages interact with each other and highlights the system's dependencies, improving modularity and maintainability.



9) Deployment Diagram:

A deployment diagram in the context of a project like "Automatic Vehicle Accident Detection and Rescue System" represents the physical arrangement of hardware components and their interactions. For this project, the deployment diagram would illustrate how the various hardware elements are connected and interact to implement the system.

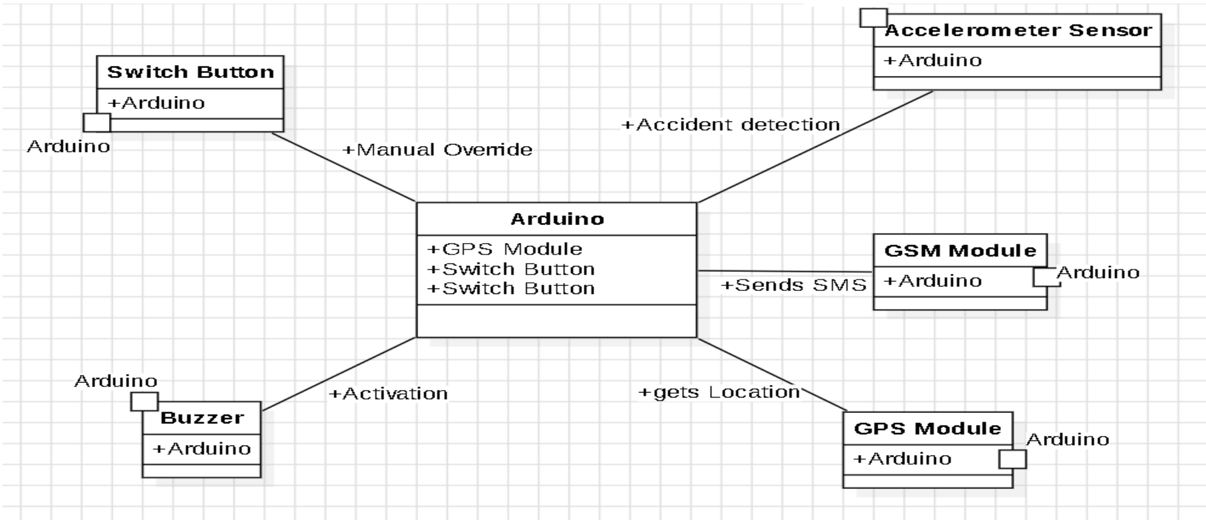
The deployment diagram helps visualize the physical deployment of the system's components and their interactions to ensure the successful operation of the automatic vehicle accident detection and rescue system.



10) Structure Diagram:

A structure diagram, in the context of a project like the "Automatic Vehicle Accident Detection and Rescue System," typically refers to a diagram that outlines the physical and logical structure of the system. It focuses on how different components and modules of the system are organized and interact with each other.

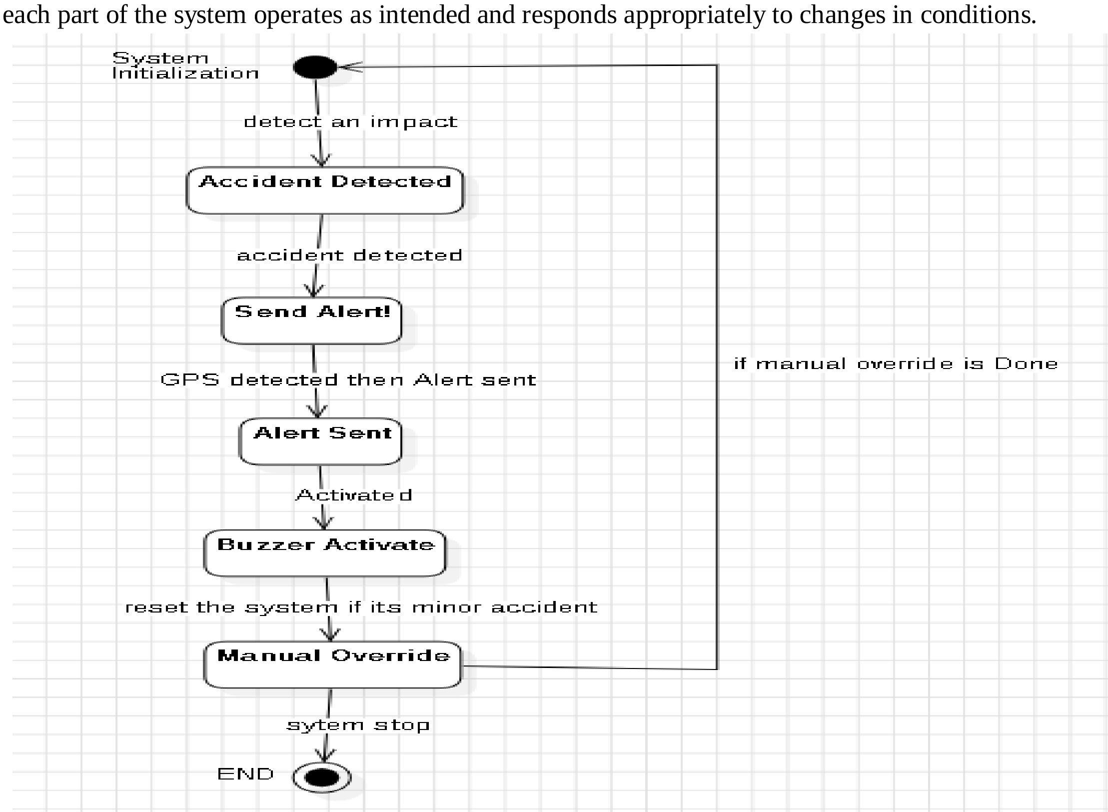
The structure diagram provides a comprehensive overview of how the various components are arranged, connected, and interact to function as a cohesive system.



11) State Machine Diagram:

A state machine diagram (or state diagram) for the "Automatic Vehicle Accident Detection and Rescue System" represents the different states the system can be in and the transitions between these states based on events or conditions.

The state machine diagram helps visualize how the system transitions through various states in response to different events, ensuring that each part of the system operates as intended and responds appropriately to changes in conditions.



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IV. SYSTEM DESIGN

A. *Modules: -*

1) *Sensor Module*
- Components: Accelerometer, impact sensors.
- Function: Detects any sudden change in the vehicle's orientation or a significant impact, indicating a potential accident.
- Operation: Sends real-time data to the Arduino for processing.

2) *Controller Module (Arduino)*
- Components: Arduino microcontroller.
- Function: Serves as the brain of the system, processing sensor data and making decisions based on pre-programmed algorithms.
- Operation: Analyzes the input from sensors to detect an accident and triggers the appropriate response, such as activating the buzzer and sending an alert.

3) *Communication Module (GPS and GSM)*
- Components: GPS module, GSM module.
- Function: Enables communication of the vehicle’s location and sending emergency messages.
- Operation:
  - The GPS module tracks the location of the vehicle.
  - The GSM module sends an SMS alert with the vehicle’s location to predefined emergency contacts or services.

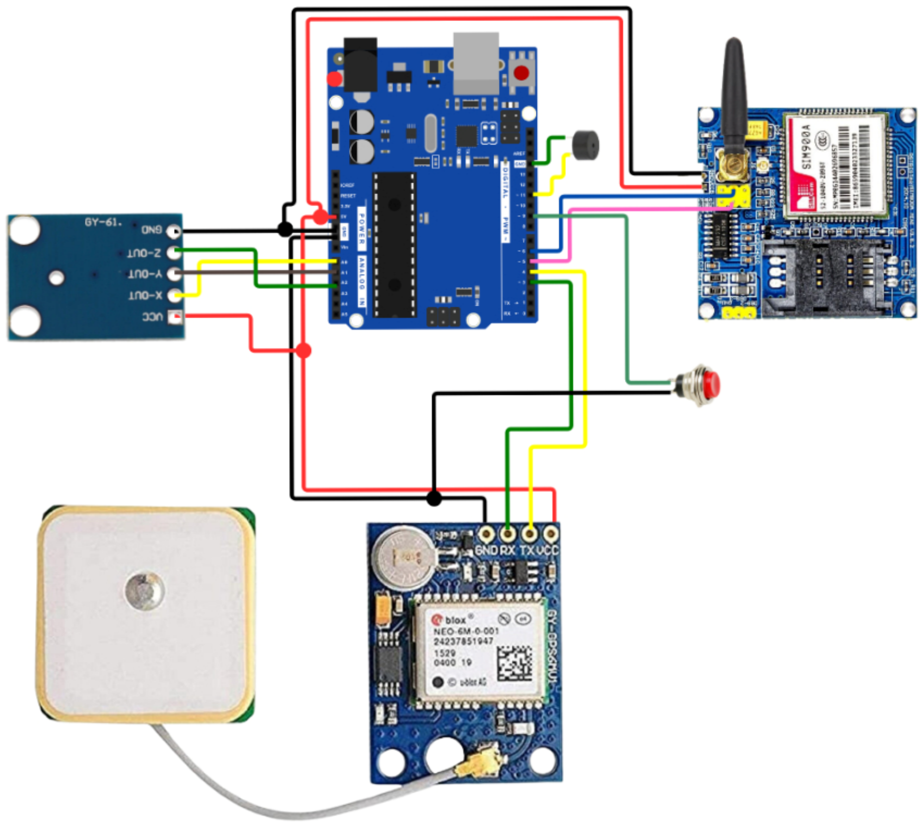
4) *Alert System Module*
- Components: Buzzer.
- Function: Provides an audible alarm in case of an accident.
- Operation: The buzzer is triggered to alert nearby people of the accident, potentially prompting immediate assistance.

5) *User Interface Module*
- Components: Switch button.
- Function: Allows manual control by the driver.
- Operation: The driver can press the switch button to reset or stop the alert system in the case of a false trigger or minor incidents.

6) *Power Supply Module*
- Components: Battery or vehicle power source.
- Function: Provides the necessary power to all the components.
- Operation: Supplies consistent power to the Arduino, sensors, and communication modules, ensuring the system is always active.

7) *Accident Detection Algorithm*
- Components: Software code within the Arduino.
- Function: Determines whether an accident has occurred based on sensor inputs.
- Operation: Utilizes predefined thresholds (e.g., from the accelerometer) to detect sudden impacts or deceleration, triggering the system to send an alert if an accident is confirmed.

B. Schematic Diagram: -



C. Algorithm:

Step 1: System Initialization

- Power on the system (Arduino, sensors, GPS, GSM, buzzer).
- Initialize all the components: accelerometer, impact sensors, GPS, GSM, and buzzer.
- Set default values for sensor thresholds (e.g., for detecting impact or tilt).

Step 2: Read Sensor Data

- Continuously monitor the accelerometer and impact sensors.
- Read the vehicle's speed, orientation, and impact data.

Step 3: Accident Detection Condition

- Check if the sensor data exceeds predefined thresholds (e.g., sudden deceleration, high impact force, or abnormal vehicle tilt).
- If the threshold is met, proceed to the next step.

Step 4: Accident Confirmation

- Wait for a small delay (e.g., 5 seconds) to confirm the accident (avoiding false triggers).
- If the condition persists after the delay, confirm the accident.

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Step 5: Trigger Alarm
- Activate the buzzer to alert nearby people about the accident.

Step 6: Get Location Data
- Use the GPS module to retrieve the vehicle’s current location (latitude and longitude).

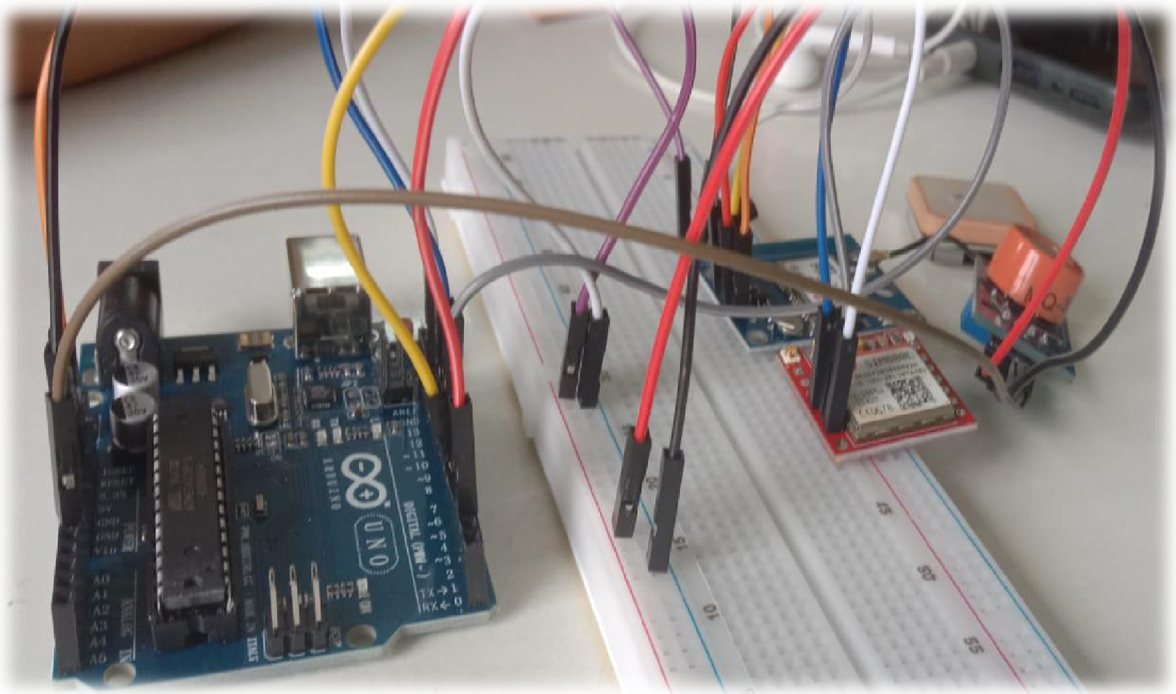
Step 7: Send Alert
- Use the GSM module to send an SMS with accident details and the vehicle’s GPS coordinates to predefined emergency contacts (e.g., family, hospital, or emergency services).

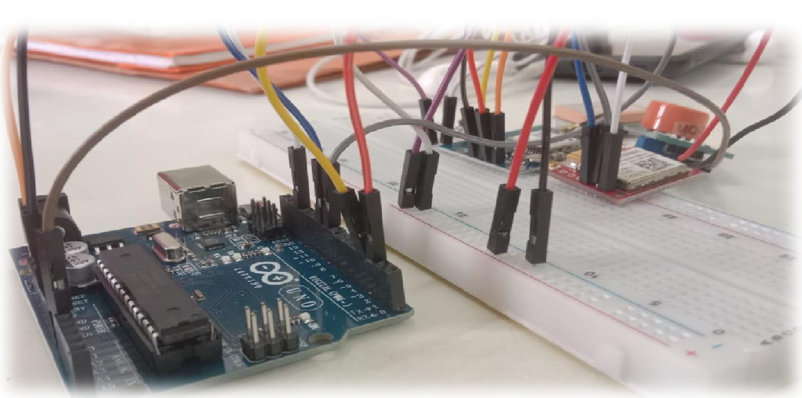
Step 8: Manual Override
- Continuously check if the driver presses the switch button.
- If the button is pressed, reset the system and stop the alarm and message-sending process.

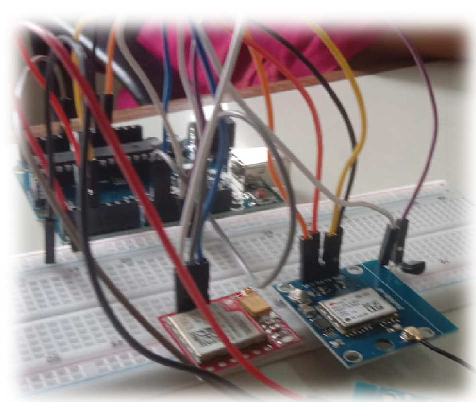
Step 9: System Reset
- After sending the alert or if the manual button is pressed, reset the system to normal mode and continue monitoring sensor data.

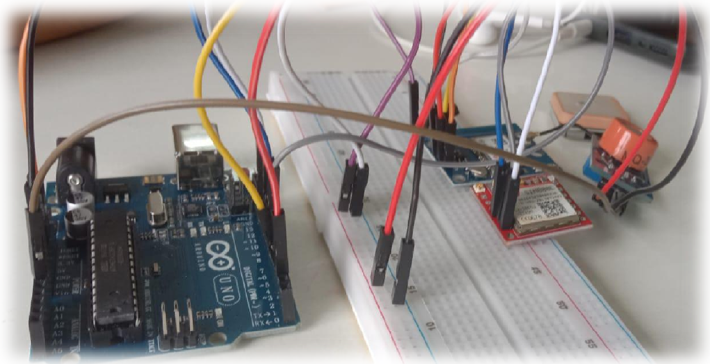
Step 10: End Process
- The system remains active and continues monitoring for future accidents.

D. User interface: -









E. Security Issues: -

1) *Data Privacy Concerns*
- Location Tracking (GPS): The system uses a GPS module to send location data. Unauthorized access to this data can lead to misuse, such as tracking the vehicle's movements.
- SMS Data (GSM): The system sends accident alerts via SMS, which contains sensitive information like location. If these messages are intercepted or hacked, it can lead to privacy breaches.

2) *Unauthorized Access*
- System Tampering: Physical tampering with the Arduino, sensors, or switch button could allow malicious actors to disable the system, preventing it from working during an actual emergency.
- Manual Reset Vulnerability: The reset button allows users to cancel alerts. In some scenarios, unauthorized individuals could abuse this feature to disable the system's alarm or notifications.

3) *False Alarms*

Sensor Sensitivity: If the sensors are too sensitive, the system might trigger false alarms, overwhelming emergency services with incorrect data, which could be exploited or lead to general distrust of the system.

4) *Data Transmission Vulnerabilities*
- Unencrypted Communication: GSM modules typically do not offer robust encryption mechanisms for transmitting SMS messages. This makes the system vulnerable to interception or eavesdropping during the transmission of emergency alerts.
- Network Security: If the GSM network used is not secure, hackers could manipulate or block emergency SMS messages, preventing the alert from reaching its destination.

5) *Reliability of Components*
- GSM Module Downtime: If the GSM network is down, or the module malfunctions, the system will fail to send critical alerts, which could be exploited by malicious individuals.
- Power Supply Vulnerabilities: The system depends on continuous power. A malicious actor could cut off the power to the Arduino, disabling the entire system.

6) *Firmware Vulnerabilities*
- Code Exploits: If the system's firmware (the Arduino code) contains bugs or vulnerabilities, it could be exploited by hackers to bypass or disable accident detection or alert features.
- Lack of Updates: Without regular updates to fix vulnerabilities or improve performance, the system can remain susceptible to known threats.

F. Mitigation Strategies:
- Encryption: Implement secure encryption protocols for SMS and data transmission.
- Physical Security: Use tamper-proof casings for the Arduino and sensors.
- Access Control: Restrict access to the manual reset button and system components.
- Sensor Calibration: Ensure sensors are properly calibrated to minimize false alarms.
- Periodic Maintenance: Regularly check for firmware updates and maintain the system components for optimal performance.

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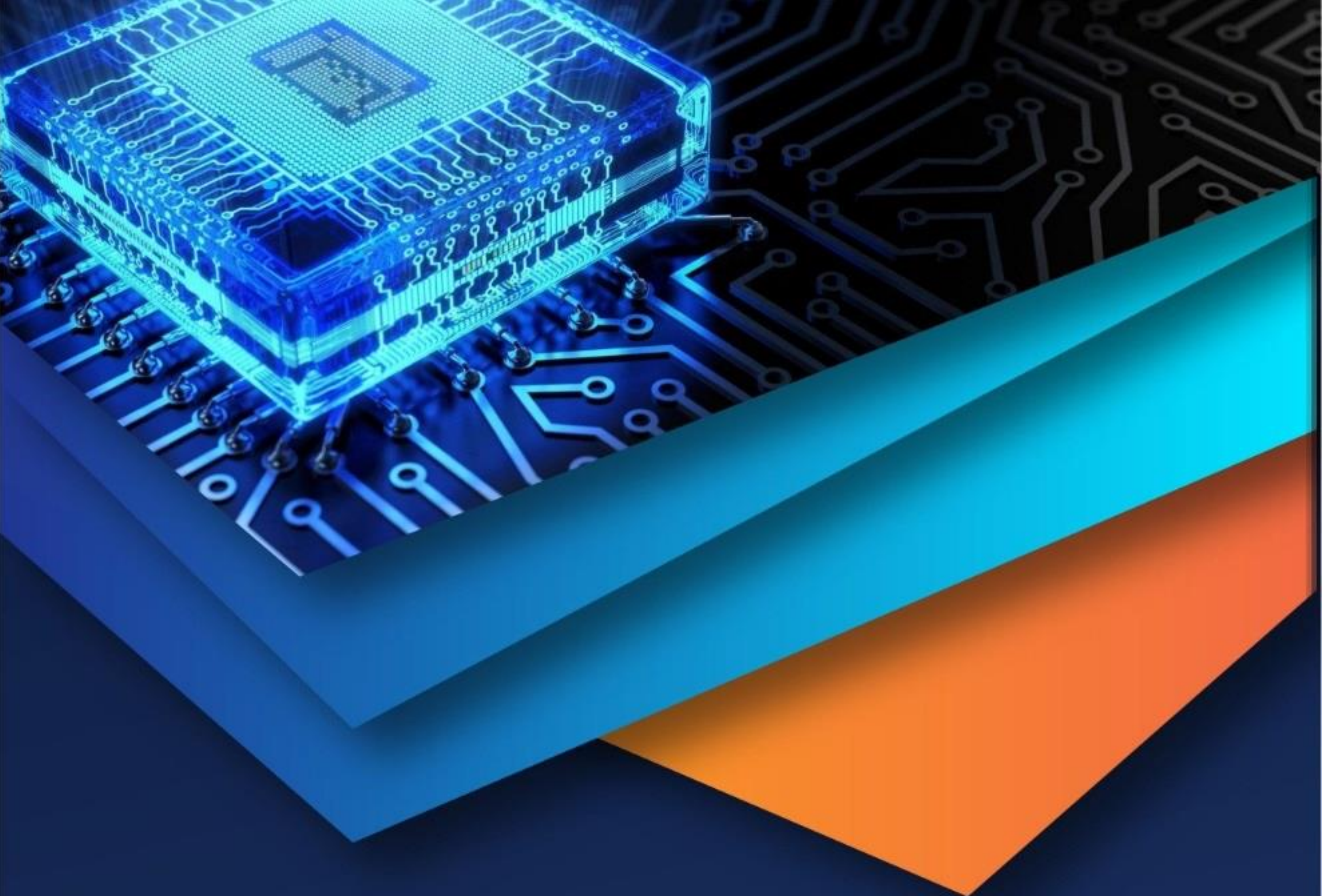

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