DEVELOPMENT OF GSM-BASED CAR ACCIDENT IDENTIFICATION SYSTEM USING ESP32 FOR ENHANCE VEHICLE SAFETY

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

Faculty of Electronics and Computer Technology and Engineering
Universiti Teknikal Malaysia Melaka

2025

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI TEKNOLOGI DAN KEJURUTERAAN ELEKTRONIK DAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Development of GSM-Based Car Accident Identification System Using ESP32 for Enhance Vehicle Safety
Sesi Pengajian : 2024/2025

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DEDICATION

To my beloved mother, Rosmaizaan Binti Abdul Rahman, and father, Husin Bin Mansor,

To my kind lecturers

And not forgetting to my beloved partner, siblings

And all friends for their

Love, guidance, encouragement, and moral support

Along with all hardworking and respected Supervisor

Ts. Dr. Nor Azlan Bin Mohd Aris

ABSTRACT

Fatal road accidents often occur in Malaysia. Most cases loss of life are caused by delays in treating victims with severe injuries. Therefore, we introduce the car accident system that helps to notify vehicle owners and emergency services as fast as possible. The design of this system consists of main components like acceleration sensor and vibration sensor that placed inside the vehicle to communicate with ESP32. When a road accident occurs, the acceleration sensor and vibration sensor detects collisions of the vehicle, then send this information to the ESP32 microcontroller then ESP32 will analyze the information, track location using GPS and send the notification via GSM. It uses GSM technology to convey information rapidly and effectively without having an internet connection. System performance was tested under various condition and the threshold for vibration is set 170 with angle of accelerometer ± 70° that provide 95% accuracy. The system effectively distinguished minor disturbances from genuine accidents across various road conditions, demonstrating its capability to promptly alert emergency responders and potentially save lives.

ABSTRAK

Kemalangan jalan raya yang meragut nyawa sering berlaku di Malaysia. Kebanyakan kes kehilangan nyawa disebabkan oleh kelewatan merawat mangsa yang cedera parah. Oleh itu, kami memperkenalkan 'sistem pemberitahuan kemalangan' untuk menyampaikan maklumat dengan cepat kepada pihak yang terlibat seperti pemilik kenderaan, unit kecemasan atau waris terdekat. Reka bentuk sistem ini terdiri daripada komponen utama yang mengesan kemalangan iaitu sensor pecutan dan sensor getaran yang diletakkan didalam kenderaan untuk berkomunikasi dengan ESP32. Apabila berlaku kemalangan jalan raya, pecutan sensor dan sensor getaran mengesan perlanggaran lalu menghantar kepada ESP32 kemudian ESP32 akan menganalisis dan menghantar maklumat, mengesan lokasi semasa menggunakan GPS dan menghantar notifikasi melalui GSM. Sistem pemberitahuan kemalangan berjaya dilaksanakan dengan menggunakan GSM yang boleh menghantar maklumat dengan cepat dan berkesan kerana tidak memerlukan rangkaian internet. Keberkesanan sistem telah diuji dibawah beberapa keadaan dan nilai anggaran yang ditetapkan ialah 170 dan sudut accelerometer ± 70° yang memberikan ketepatan sebanyak 95%.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Dr. Nor Azlan Bin Mohd Aris for your precious guidance, words of wisdom and patient throughout this project.

I am also indebted to Universiti Teknikal Malaysia Melaka (UTeM) for the financial support through claiming the component which enables me to accomplish the project. Not forgetting my fellow colleague for the willingness of sharing his thoughts and ideas regarding the project.

My highest appreciation goes to my parents and family members for their love and prayer during the period of my study. An honourable mention also goes to my best friend for all the motivation and support. And to my seniors, thanks for always guide me.

Finally, I would like to thank all the staffs at the Universiti Teknikal Malaysia Melaka, fellow colleagues and classmates, the faculty members, as well as other individuals who are not listed here for being co-operative and helpful.

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LIST OF ABBREVIATIONS

WHO	-	World Health Organisation
GPS	-	Global Positioning System
GSM	-	Global System for Mobile Cmmunication
IoT	-	Internet of Thing
mph	-	Miles per hour
km/h	-	Kilometres per hours
PPE	-	Personal Protective Equipment
ISO	-	International Organisation for Standardization
ADAS	-	Advanced Driver Assistance System
AI	-	Artificial Intelligence
IDE	-	Integrated Development Environment
LCD	-	Liquid Crystal Display
GUI	-	Graphic User Interface
RS	-	Register Select
VCC	-	Voltage Common Collector
GND	-	Ground
SCL	-	Serial Clock Line
SDA	-	Serial Data Line
SMS	-	Short Message Service

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, transportation is the one of essential needs for society. It provides convenience for developed the country and it also important for some individuals to stabilize their economic through the services like Grab, Maxim and Foodpanda. However, transportation developments has a negative impact which is road accidents. World Health Organization (WHO) stated that approximately 1.35 million people die anually due to road crashes. According to Minister of Transport Malaysia, road accident have increased annually since 2010. Traditional methods of accident reporting are often caused by communication issues that found difficulty of identifying the accurate location of the incident. So, it will leading to delays in emergency response times and inaccurate assessments of the incidents. Thus, accident identifying is needed to give the fastest information and accurate location.

In 2020, WHO recorded Malaysia's accident ranked is third highest among Asian countries with a rate of 22.76, compared to Vietnam rates 29.81 at the ranked 2rd and Thailand takes the top ranked with 30.48 accident. Malaysia also ranked 60th in the world record of car accident [1]. The main causes of accidents in Malaysia are due to several factors such as human error, driver inexperience, road infrastructure, and etc. Some Malaysian drivers love to speeding the car without considering the safety of no one, while others get distracted by using mobile phones also the road infrastucture is so poor. Other than that, fatal accident in Malaysia increased for two times which is from 6,080 to 12,417 in one year (2022 to 2023). The Malaysian Public Works Department always improve and check the safety of the road, where all blackspots have been identified. However, the accident rates always keep increasing. This issue must be given priority in order to address the problem effectively.

When accident occured, there is still a chance to individual suffer from the serious injury or fatal instantaneously but no one gave them fast treatment that they needed. To avoid the fatal accident, integrating ESP32 with sensors, Global Positioning System (GPS) and Global System for Mobile Communications (GSM) technology can provide a solution for real-time accident identifying system. These technologies always work together to improve and identify the accident, give the rapid emergency response to enchance road safety.

Car Accident Identification is applied when there is the high velocity detect the high momentum and it transmit information to the emergency unit. The most important is using the sensors to detect the impact. The impact happend will send to the phone. The technology GSM plays role to send the message info to the emergency unit so that they can reach the accident location and help the needful. Using this system, no more communication issues because the system consist of GPS that can give an accurate location and GSM will send the location quickly. Therefore, this system can save lives quickly after the accidents occurs, most fatalities cases is about organ failure post-impact.

1.2 Addressing Road Safety Impact on Social and Economy

Fatal accident cases are often reported on television with increasing numbers each year. In 2023, the number of deaths resulting from accidents has doubled compared to the previous year [2]. This trend involving loss of life, it is not easy for families to accept this situation and it can cause trauma to individuals due to the sudden loss of a family member. Therefore, addressing this issue is crucial for the wide world to become a developed nation and well-off communities. There are several factors that gives the big positive impact by using the GSM car accident identification system on global road safety and emergency response.

1.2.1 Social Impact

Global road safety has social implications that affect the communities and individual in all aspects. This issue causes the emotional trauma and social interruption. It is because family members and communities faced a sudden loss of their family in serious injuries, and it caused financial burdens. Road safety often impact the vulnerable population including the children and elderly individuals.

Therefore, this system enables faster and effective emergency response so that the precious lives can be saved. This fast response capability especially in urban environment where the traffic jam and the complex road can pose challenges to emergency responders. In addition, traffic control actions, such rerouting, temporary road closures, or modifying signal timings, may be implemented immediately by authorities due to real-time data on accident locations and severity.

1.2.2 Economic Impact

Car accident identification plays a significant role in enhancing the global economy because the system will reduce the economic losses associated with road traffic accident. Enhancing traffic control through an effective accident notification system can enhance transportation effectiveness. In addition, traffic jammed is not only wasting time, but it will increase the fuel consumption and higher transportation cost. When emergency response is fast, this system helps to reduce the fuel usage and optimize the movement for goods and services.

Besides, investment for car accident identification technology drives innovation and creation the stimulates job for the technology section. By developing the accident identification system, it requires a job such as information technology, transportation engineering and telecommunications. So, it helps fresh graduated students who did not find a job. It is not only leads to creation the new technology but it also to bear many skilled workforces for technological innovation in related business. This project reaches a positive impact on economic growth and society.

1.3 Problem Statement

In this globalization era, the topic that is always discussed is about the rapid and sophisticated technological changes especially when new devices are released in the market. The most question discussed are how good the product is, how much the price is and etc. However, during the research there is a problem faced by individuals and also large organizations about the risk of human life which is an accident. The problem to be addressed is inefficiencies and delay of emergency services. Therefore, this project aims to develope a real-time accident identification system using GSM, ESP32, GPS technologies to meet this demand. It also has a cost-effective measures to guarantee the system's sustainability and affordability. The project aiming to give the fastest possible response to save lives caused by accidents. The project is very efficient as it helps to send the notification for real-time and the exact current location accident occured. The development of a real-time accident identification system poses several challenges. These include the necessity of accurate and efficient accident identification system, as well as the need for dependable data gathering and communication between system components. Additionally, effective communication channels must be in place to guarantee that warnings are heard and taken seriously right away.

In brief, the problem statements are summarized as follows:

- Urgent need for precise and early identification systems due to the high risk of fatal accident.
- Lack of a real-time accident identification system utilizing GSM, ESP32, and GPS technologies.

1.4 Project Objective

The growing incidence of road accidents, we need the advanced systems that capable to detecting and responding to collisions in real-time. Implementing a reliable accident detection system can greatly enhance safety by ensuring emergency services are promptly notified following an accident. This study focuses on the design and development of a system that employs accelerometers and vibration sensors to achieve precise and efficient car accident detection.

The objectives of this study are as follows:

- To design a car accident identification system that uses accelerometers and vibration sensor to detect collision impact. This include selecting suitable sensors and design tjr hardware configuration.
- To develop a car accident identification system that can deliver accurate and real time accident identification. This system aims to deliver rapid alerts response and reduce accident-related.

1.5 Scope of Project

The project scope defines the development and implementation of a car accident notification system, as described in the following details:

- Crash detection will be decided based on accelerometer and vibration sensors by setting the threshold.
- Data processing and collection will utilize ESP32 by determine the sensor readings.
- Alert notification for accident detection will be sent through SMS using the GSM.
- A real-time collision will be determined by using the accelerometer sensor to detect the angle and vibration sensor to detect the crash.
- An accurate current location will be analyzed by GPS.

- The project will be carried out on a prototype and not on a real vehicle.
- The effectiveness of SMS alerts is dependent on GSM network coverage.
- The system may send the incorrect data because of sensitivity of the sensors.
- The location can also be inaccurate due to tunnels or weather.

1.6 Report Organisation

The project is about the car accident identification system by using the GSM system. This report consists of five main chapters. Chapter 1 is the short introduction about the project. This chapter covers the introductions such as background, societal issue, problem statement, project objective, and scope of the project. Next, chapter 2 focuses on a literature review and analyze previous research studies relevant and similar to the project title. By comparing these studies, the chapter lay the groundwork for further analysis and discussion. Chapter 3 describe the methodology employed for the project's development. This chapter will describe the specific methods and procedures used to design, implement, and test the car accident notification system. Next, Chapter 4 shows the results and analysis of the proposed system. Finally, the last chapter explores recommendations for future advancements of this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In order to develop a comprehensive understanding of existing methods, several journals and articles were reviewed and compared. By comparing the theory and existing methods, we aim to identify the most effective approach for achieving the excellent result. Some journals develop this project using the Internet of Thing (IoT), and there are some components like sensors are different. In this literature review, GSM technologies, ESP32 microcontroller, and GPS module devices must be used to create real-time accident identification system. First of all, we will review the design project and its workflow, which includes the function of sensors used to monitor the car's speed and other critical parameters. Next, the data accuracy, network connectivity, the system's challenges, and relationship between the speed and severity of injuries that cause the effect during accident also discussed.

2.2 Ambulance Response Delay

Over 1.1 million severely ill patients experienced for waiting for an ambulance longer than the target of eight minutes. This group comprised individuals suffering from cardiac arrests, strokes, and injuries from road traffic accidents. Some had to wait for nearly two hours [4]. The communities always complaints about the ambulance service being slow. In this situations, people often express anger and frustration towards the government hospital ambulance service. For your information, some of ambulance response delay has their own reasons:

i) The caller provided incorrect information and location.

ii) The caller was unfamiliar with the area.

iii) The caller outside the reach which no internet.

2.3 Accident Cause of Death

Over the previous ten years, this country has recorded 4.94 million accident instances. Of those, 414,421 cases occurred in 2010 and 567,516 cases occurred in 2019 [3]. It is a shocking fact that road accidents claim more lives annually in many other developing countries than wars and diseases. The biggest factor is high speed of car.

2.3.1 Car Speeding

Many road accidents are caused by driving at high speeds, although there are other contributing factors as well. A car moving at 50 km/h usually needs 13 meters to come to a complete stop, whereas a car traveling at 40 km/h can stop in less than 8.5 meters. The driver and passengers in a crash at an impact speed of 80 km/h, the risk of death is 20 times higher compared to a crash at 30 km/h [4]. Car drivers are significantly more likely to be injured in high-speed collisions. On average, in frontal impacts, drivers will face a 17% risk of fatal injury at 40 mph and a 60% risk at 50 mph. Notably, half of the drivers who were fatally injured were involved in impacts at 34 mph and above.

To calculate the miles per hour (mph) of the car, used the formula [20]:

$$Speed\ (mph) = \text{Speed in } km/h\ x\ 0.621371 \quad (2.1)$$

Example 1:

Car speeding at 80km/h. What is the speed in mph?

$Speed\ (mph) = 80\ km/h\ x\ 0.621371$

$Speed\ (mph) = 49.71$ mph

(The probability for fatally injured is around 60%)

2.3.2 Car Impact based on Different Speed

Increased speeds lead to the collapse of the passenger compartment and pose a serious risk of life-threatening injuries. Even the most crashworthy vehicles currently available cannot adequately protect the driver and passenger in frontal impacts at speeds exceeding 70 km/h. [5] Figure 2.0 shows the cat impact at the different speed.

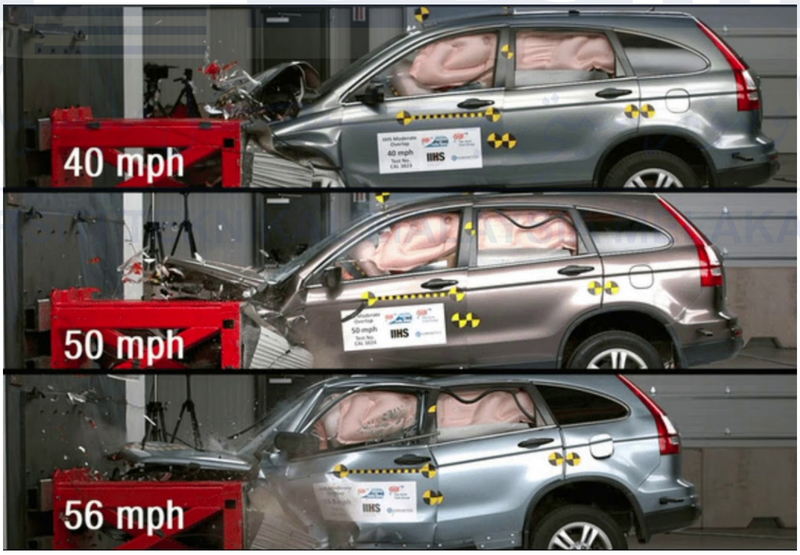

Figure 2.0: Car Impact for different speed.

2.4 Current State of Car Accident Identification System Using GSM Technology

GSM-Based Car Accident Identification System have made a good significant progress in improving the vehicle safety. This system includes several sensor, GPS and GSM modules to identify the crash quickly notify emergency services. Efficient delivery information of accident facts and real-time communication are made possible by the use of GSM technology.

Recent advancements include systems that uses GPS to locate the accident occurred, acceleration sensors and vibration sensor to identify when a car crashes, and GSM to transmit notifications to emergency services or registered contacts [6]. In order to identify incidents and notify the appropriate authorities via GSM modules, several systems further make use of vibration, gyroscopes, and other sensors [7].

Currently, the focus of automobile accident identification systems that use GSM technology is on rapid contact with emergency services, and rapid and effective accident detection in order to provide accident victims immediate assistance.

2.5 Key Features and Functional of Existing GSM-Based Car Accident Identification System

The current generation of GSM-based vehicle accident detection systems comes with a host of important features and capabilities designed to improve traffic safety and give immediate help in case of an accident. The following are some of important features and functions:

- Accident Detection: To identify accidents, these systems have sensors including gyroscopes, accelerometers, and vibration sensors. [7]
- Location Tracking: These systems utilize the GPS technology for the exact pinpoint location of the accident. [7][18][19]
- Emergency Alerts: To send the quick notification for the emergency service and close contact to ensuring victims get the immediate assistance. [18][19]
- Two-Way Communication: GSM modules used in two-way communication because it is possible to send the accident information and get the emergency service's reaction.

- Real-Time Notifications: These systems provide rapid reaction and help by informing police, hospital, and rescue teams about incidents in real-time. [18][19]
- Automatic Messaging: When the crash occurred, the systems automatically send messages to rescue team about location coordinates, ensuring efficient communication during emergencies.
- Vehicle Tracking: Certain systems offer features for tracking stolen vehicles, fleet management, and monitoring vehicle activities to make sure there is effective communication in emergency. [7]
- Reduce the time responses, and providing prompt aid to accident victims is main essential characteristics and functions.

2.6 Benefits and Challenges Associated with GSM Technology for Car Accident Identification

There are some benefits of the GSM technology for car accident identification such as accurate location tracking, real-time notifications, two-way communication, enhanced road safety, and vehicle tracking. This system can **tracking exact current location** of the accident. When combining the GSM technology with GPS technology, it will analyze the accurate location of the vehicles. Besides, this system is the **real-time identification** system because GSM modules gives the real time notification to the emergency contact or emergency unit to reduce the time for assist the victim [8]. The benefits of this system is **two-way communication**. It is to enabling the transmission GSM technology allows for two-way communication, enabling the transmission of accident details and receiving responses from emergency services [8]. Lastly, this system provide the safety and monitoring the vehicle activities for **enhanced road safety**.

The benefits always come with challenges. This system faced a several challenges to make sure it functional well. The first challenge for this system is to **reliability on GSM network**. When connection is poor, it will be affected the signal to transmit and sending the information about the accident especially in a rural area. [8]. Cost and complexity also the one of challenges because implementing of GSM technology need extra cost and the system a bit complex for potential limiting their adaption. **Data security and privacy** need the information via GSM technology. It raises concerns about data security and privacy, which need to be addressed through appropriate security measures. [8] It is also to maintaining user confidence and adhering to data protection laws by protecting sensitive data transferred [9].

2.6.1 GSM Technology Facilitate Real-Time Transmission of Accident Data to Emergency Service

GSM (Global System for Mobile Communications) technology plays a crucial role in facilitating the real-time transmission of accident data to emergency services. The process for this technology as followed:

i. When the accident occurred, the accelerometer sensor and vibration sensor detect the collision of the car that occurred then send the signal to the ESP32 microcontroller.
ii. The microcontroller will communicate with GPS technology to give the accurate location of the accident.
iii. The microcontroller is automatic connect to a GSM module to allow two-way communications.
iv. The microcontroller sends an alert message with the accident location coordinate through the GSM modem.
v. The owner of the car, police and emergency services will receive the alert message and location that send through the GSM using the cellular network.

By leveraging GSM technology, these systems can quickly transmit accident data and including location coordinates, to emergency services and relevant authorities to increasing the chances of saving lives.

2.6.2 Limitation of using GSM Technology for Car Accident Identification

Table 2.0: Limitations of using GSM technology [10], [11] and [12].

LIMITATION	EXPLAINATION
Network Coverage Issues	Due to cellular network coverage limitations in rural or remote areas, GSM technology may not be able to provide timely or accurate accident notifications.
Network Congestion	The transmission of accident data may be slowed down or stopped by heavy network congestion, which might cause delays in emergency response times.
Limited Functionally in Areas with No GSM Coverage	Car accident identification systems may not be as successful in places without GSM service as GSM technology may not work there.

2.7 Factor Influencing Vehicle Safety and Accident Prevention in Automotive Engineering

In automotive engineering, factors that impact vehicle safety and accident include a variety of crucial components. The design of the vehicle is the most important factor to take into mind. To ensure overall safety, structural integrity, crashworthiness, and the installation of safety equipment like airbags and electronic stability control are essential. Accidents are largely caused by the acts of drivers, including human error, distraction, fatigue, and impairment [13]. Encouraging safe driving behaviours, following traffic laws, and reducing distractions are crucial strategies for preventing accidents.

Another factor is road conditions. Sustainable safety depends on well-maintained road surfaces, appropriate signs, and intelligent design. The chance of accidents may be considerably decreased by maintaining and designing roads appropriately. Tyre problems also need to be resolved by routine maintenance, such as monitoring tyre pressure and tread, is essential for maintaining vehicle stability and preventing accidents. Other than that, the government also needs to identify the high-risk locations and provide the safety actions about the accident.

Safety and health rules at work are also very important in the automotive the workplace. Overall safety and the prevention of workplace accidents are enhanced by ensuring the safety of employees via appropriate training, manual handling skills, the use of personal protective equipment (PPE), and adherence to safety standards. The automobile industry can greatly improve vehicle safety and successfully avoid accidents by addressing these variables holistically, including through vehicle design, driver education, road maintenance, tyre care, safety features, and occupational health and safety measures.

2.7.1 Key Factors Contributing to Vehicle Accidents

There are several key factors contributing to vehicle accidents that can be addressed:

2.7.2 Driver Distraction

Driver distraction, particularly smartphones and in-vehicle infotainment systems is a major cause of accidents. Based on the Hand Phone Users Survey 2021 in Malaysia, 94.8% of adults in Malaysia used smartphones, indicating a high level of smartphone adoption across all age groups, with the highest usage among those under 35 years old [14]. Driver will lose their focus when using a phone while driving. Devices such as driver monitoring systems can identify signs of inattention or sleepiness in a driver and warn them to maintain concentration.

2.7.3 Impaired Driving

There are other risks in accidents such as risks that are committed under the influence of drugs or alcohol or if the driver is drowsy. According to the Florida Department of Highway Safety and Motor Vehicles, DUI caused 3,668 crashes involving injuries and 1,084 fatalities in the year 2022. This can be resolved using the alcohol ignition interlock devices as these gadgets deny a car any starting button and key if the driver has taken alcohol.

2.7.4 Lack of Safety Features

Fatigue, drugs, or drinking alcohol while driving is another major cause of accidents. On Florida roadways alone in 2022, there were an estimated 42,795 fatalities due to vehicle crashes. This may be addressed using alcohol ignition interlock devices, which prohibit a car from starting if the driver has consumed alcohol.

2.7.5 Mechanical Failures

Accidents can result from mechanical malfunctions such as defective steering or brakes. The vehicle functional safety standard, International Organization for Standardization ISO 26262, makes sure that electronic parts are made safely to avoid these kinds of malfunctions. This standard requires a thorough investigation of hazards during the vehicle development process.

2.7.6 Environmental Factors

Accidents can also be caused by external variables such as poor road conditions, bad weather, and animals. Drivers can overcome these threats more safely by use of advanced driver assistance systems (ADAS), such as cross-traffic alert, adaptive cruise control, and lane departure warning.

The car industry can keep lowering the frequency of accident and saving lives by addressing these important issues with a mix of modern automobile technology, safety features, and driver education.

2.8 Area for Further Research in the Development of GSM-Based Car Accident Identification Systems

When it comes to implementing GSM-based car accident identification systems, there are a few gaps that need to be researched . Additional investigation may concentrate on enhancing the accuracy of accident detection by advancements in sensor technology and algorithmic techniques to minimize false alarms and accurately identify accidents [26]. Furthermore, by using more complex patterns in the sensor data, new machine learning algorithmic techniques may be applied to improve the model's accuracy for accident identification, hence increasing the system's capacity. [16][17]. The application of common technologies like artificial intelligence and machine learning can increase the accuracy of GSM-based accident detection systems.

The tool can also improve the probability of identifying, tracking, and providing timely reports about the incidents leveraging artificial neural networks and other machine learning. Rapid emergency reaction and potentially saving of lives. In addition, it is necessary to reduce the impact caused by bad weather and other factors in order to increase the stability and dependability of GSM-based accident detection systems. Weather and environmental adaptability study will be beneficial in optimizing the system when the climate changes. In addition, modifying the road safety and the effectiveness of the accident identification and response system in the future [26].

Therefore, by discussing the identified research gaps and directions for future work, the domain of GSM based car accident identification systems can be advanced further and open the way to enhancing car security and emergency services.

2.9 Potential Benefits for vehicle Occupants and Emergency Responders.

Benefits for Vehicle Occupants:

Modern safety technologies greatly assist car occupants by providing rapid emergency response and exact accident location tracking. These systems identify accidents quickly and alert emergency contacts, and hospitals nearby. It provides responders precise accident locations via GPS technology and sends using GSM, which makes it possible for rescue team to get to the location immediately.

Benefits for Emergency Responders:

Modern safety systems that offer precise accident location, comprehensive accident information, and rapid response times are very beneficial to emergency team. GPS tracking provides precise accident scene coordinates, allowing rapid detection of location. In addition, the system provides essential information to responders so they may prepare the required resources, such as the kind of vehicle and accident severity. Because of the rapid accident detection and communication, reaction times are drastically shortened, enabling rescuers to reach victims sooner and provide critical care more successfully.

2.10 Previous Studies Of GSM-Based Car Accident Identification Systems

Table 2.1: Comparison from previous project

Title	Year	Software/Microcontroller	Hardware Component	Advantages	Disadvantages
Vehicle Accident Detection and Alert (Medhane et al., 2023)	2023	-IoT application -Thinkspeak serve for IoT webpages	-Arduino Nano -GPS (Neo6m) -Accelerometer (ADXL345) -Buzzer -LCD Display	-Immediate accident alert -Local help notification -Enhanced Security	-GPS accuracy issue -Internet dependency

Table 2.1: Comparison from previous project

Title	Year	Software/ Microcontroller	Hardware Component	Advantages	Disadvantages
Smart Accident Detection and Emergency Notification System with GPS and GSM integration (Amat et al., 2023)	2023	Arduino IDE/ Arduino UNO R3	-Arduino UNO R3 -Accelerometer sensor -GPS(SIM28ML) -GSM(SIM900A) -LCD module	-Real time accident detection -Immediate notification to emergency services -Potential to save lives by reducing response time	-Reliance on GSM network coverage -Possible false alarms due to sensor sensitivity

Table 2.1: Comparison from previous project

Title	Year	Software/ Microcontroller	Hardware Component	Advantages	Disadvantages
An Active System for Vehicle Accident Detection and Tracking (Prof. Dr. Sayyad Naimuddin et al., 2022)	2022	Blynk mobile application / ESP32	-Contact sensor -GSM module -GPS module -LCD -Buzzer -ESP32 camera -Ignition control	-Provide immediate response and alerts live location tracking -Theft tracking functionality	-Mobile network availability -Limited effectiveness in area without mobile signals.

Table 2.1: Comparison from previous project

Title	Year	Software/ Microcontroller	Hardware Component	Advantages	Disadvantages
A Mobile Communicative Prototype for Fatal Rate Reduction in Vehicle Accident: Development and Analysis (Lal & Malkani, 2022)	2022	-Arduino IDE/ Fritzing (for simulation) and Fusion 360 (CAD modelling) / ESP32	-ESP32 microcontroller -Sim900a GSM module -GPS Neo-6M module -MPU6050 accelerometer -Piezo Shock Sensor -12V DC Motor -Rechargeable battery	-Low-cost system (low power consumption, usability) -Rapid Accident Alert -Improving emergency response	-Slower response times in weak area signal -Requires regular battery maintenance

Table 2.1: Comparison from previous project

Title	Year	Software/ Microcontroller	Hardware Component	Advantages	Disadvantages
Real-time Vehicle Accident Alert System Based on Arduino with SMS Notification (Aldegheishem et al., 2018)	2018	Arduino IDR version 1.8.5/ Arduino Mega 2560 board	-Ultrasonic sensor -Vibration sensor -GSM module -GPS (Neo-6M) -Antenna -12 volts with 2 ampere battery -Remote-controlled car (for prototype testing)	-Real time Notification -Automation -Usability -Efficiency	-Dependency on Network Coverage -Prototype Limitations -Potential sensor Manufacturing

Table 2.1: Comparison from previous project

Title	Year	Software/ Microcontroller	Hardware Component	Advantages	Disadvantages
Automatic Vehicle Accident Detection and Healthcare Unit Notification using IoT Technology with ESP32 (K.P. et al., 2022)	2022	Arduino IDE, Blynk application (for monitoring and control)/ ESP32	-ESP32 microcontroller, -GPS, -GSM, -IR Sensor, -Ultrasonic Sensor, -ADXL335 accelerometer -MQ-3 gas sensor	-Reliable multisensory system that detect accident -User-friendly Blynk app integration	-Depend on GPS and GSM signal accuracy. -Limited functionality without network coverage -Potential for false positives due to sensitive sensor settings.

Table 2.1: Comparison from previous project

Title	Year	Software/ Microcontroller	Hardware Component	Advantages	Disadvantages
Vehicle Accident Detection System using Accelerometer(Azlan & Salimin, 2023)	2023	Arduino IDE/ ESDP32 NodeMCU	-GPS module -GSM SIM900A Module -MPU6050 (3-axis accelerometer and gyroscope) -16x2 LCD -Piezo buzzer -LED(green and red) -6V PV Solar Panel -Li-on 18650 3.7V battery (2000mAh)	-Rapid detects accidents and sends notifications to emergency contact. -Real-time location tracking -Energy efficient because use solar panel -Compact design	-Power limitation because the on the solar and battery -Accuracy of detection -limited scope, only design specifically designed for motorcycle

From the table 2.1, there are several significant insight that can be highlighted. First of all, this project enhanced component integration. This project integrate multiple sensors and components such as accelerometer sensor and vibration sensor, GPS, GSM. This combination improves the accuracy and ensures better accident notification capabalities.

Next, this project offers the energy efficiency. Unlike these previous project, it used the traditional power sources, while this project incorporates 3000mAh Li-ion battery that offering a longer operational lifespan and ensuring reliability during emergencies.

Furthermore, this project highlighted the compact and cost-effective design because it used the ESP32 microcontroller . It will achieves the compact and cost-effective while maintaining the high process capabilities. This is good microcontroller compare the project that used Arduino UNO or Arduino Mega 2560.

In summary of these previous project, all the comparison presents that this project builds on strengths of design by integratig the components, enegery efficiency, compact and cost-effective.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will describe how the project will be carried out to achieve the objectives of car accident identification. Chapter 3 includes the hardware and software specification that will be designed to fulfil and complete the project's objectives. It consists of workflow that includes the flowchart and block diagram. Other than that, this chapter has a circuit diagram to show the connection between components. Next, this chapter also has a Gantt Chart at the end.

3.2 Study Design

This project aims to design a system using ESP32 that can identify the accidents. The main device that will be used is an ESP32 that act as microcontroller. The software used in this project is Arduino IDE as both editor and compiler platform. In case an accident is detected, this system will be integrated to record the location information (longitude and latitude) of the vehicle.
GSM Module: A GSM module will be utilized to transmit the emergency messages and send the car's GPS location to emergency service or emergency contact if the driver unresponsive after the collision such as represented in Figure 3.0.

Vibration sensor: The SW-420 sensor will detect the collision or crash and combining the information with acceleration sensor to collect data and send to microcontroller.

Accelerometer sensor: The ADXL345 sensor will continuously collect data on the car's acceleration. An algorithm will be created to analyse the sensor data and identify sudden acceleration spikes that could signify a potential collision.

The GPS module will get the car's position coordinates when it detects a collision. The GSM module will be triggered to transmit an emergency message containing the GPS coordinates to designated emergency responders. This study design focuses on a basic proof-of-concept prototype. Further research and development are required to refine the system's accuracy, reliability, and user-friendly. Figure below shows the link between component of this system.

Figure 3.0: Design of study

3.3 Hardware and Software

Through research and review of previous projects, the following components have been identified as suitable for this project.:

Table 3.0: List of Component

NO	COMPONENTS	QUALITY
1	Arduino IDE (software)	**-**
2	ESP32 Microcontroller	1
3	Accelerator sensor	1
4	Vibration Sensor	1
5	GPS modules	1
6	GSM modules Sim800l	1
7	LCD I2C	1
8	Li-on 3.7V 3000mAh Battery	1
9	Lithium battery USB-C Charger	1
10	Button	1
11	Buzzer	1

3.4 Enable Sustainable Development: Hardware Component Selection for Enhance Vehicle Safety

Implementing an ESP32, GPS, GSM module, accelerometer sensor, and vibration sensor, a sustainable car accident alerting system must be developed with a comprehensive strategy to reduce environmental impact and improve endurance. ESP32 microcontroller with fast processing speeds and power-saving modes can lower energy usage without losing system performance. Energy efficiency is critical and may be reached by using power-saving mode.

Besides, choosing durable and recyclable parts increases the life of the system and cuts the amount of electronic waste. It is ensured that the system can adjust to future technology improvements and user demands without requiring total overhauls by designing for scalability and upgradeability. By promoting the longevity and lowering the frequency of hardware changes, this strategy will minimize the usage of resources.

In summary, it is acceptable to improve vehicle safety while encouraging responsibility for the environment and improving sustainable development goals by giving consideration to energy usage, material sustainability, and scalability when selecting hardware components.

3.5 Hardware Implementation

3.5.1 ESP32

Figure 3.1: ESP32

ESP32 is a microcontroller for this project. It has 38 pins that includes the general GPIO pins, analog pins, DAC pins, communication protocol and power pins. These all pins support the various function like I2C, UART and it also useful for connecting analog sensors. It is suitable for support the serial communication and I2C for communicate with other microcontrollers, sensors and device. ESP32 suitable to operates up to 240 MHz so it can handle the task quickly. ESP32 can be using with the Arduino IDE or the Espressif ESP-IDF framework, which provides libraries for working with Wi-Fi, Bluetooth, GPIO, and other components. Its just around 25.5mm ~1inch, its lenght approximately 50.0mm ~ 2 inches and usally about 5-10 grams. This component is good for the energy efficiency because it offer the low power mode that can be reduce the power consumptions. Its also allow the devices to connect to the internet or communcation wirelessly via Bluetooth and enabling the real time data exchange.

3.5.2 I2C LCD (Liquid Crystal Display that equipped with inter-intergrated circuit)

Figure 3.2 : I2C LCD

I2C LCD is Liquid Crystal Display that equipped with the Inter-Integrated Circuit is used to display the output such as the number, alphabet and special characters. This component only need four connections such as VCC, GND, SDA and SCL. VCC always connected to the 3.3V or 5V and the ground will always connect to the ground while SDA will connect to the GPIO 21 and SCL to GPIO 22. When coding for the LCD, it's essential to specify the correct address (either 0x27 or 0x3F) to ensure the microcontroller can send data to that particular LCD module. Using an incorrect address will prevent the display from responding, as the microcontroller would attempt communication with a device that doesn’t exist at that address.

3.5.3 Global System for Mobile Communication (GSM)

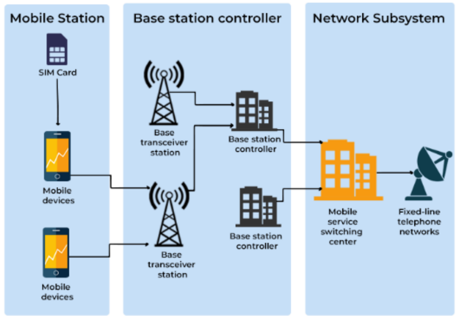

Figure 3.3 : Workflow for GSM modules

Figure 3.4 : GSM(SIM800L)

A popular GSM solution for international mobile communication is the SIM800L module, which is small and effective. It has functions including voice calls, SMS sending, and data transmission compatibility. Because of its power-efficient design, it can operate on a voltage range of 3.4V to 4.4V, making it appropriate for battery-powered applications. Its modest dimensions (15.8 x 17.8 mm) make it compatible with small designs. This module provides dependable connectivity for a variety of applications, such as emergency alert systems like accident detection, and operates on quad-band GSM frequencies (850/900/1800/1900 MHz). With its speaker and microphone interfaces, the SIM800L can make audio calls. It also supports UART for serial connection. Important characteristics include TXD and RXD pins for data transmission and reception, VCC pins for connecting the power source, and speaker and microphone ports for audio communications.

3.5.4 The Global Positioning System (GPS)

Figure 3.5 : GPS Module

The NEO-6MV2 GPS module is used to capture the location of a vehicle on Earth. These coordinates are then transmitted to the ESP32 board, enabling the ESP32 to process and use the location data as needed for various applications within the project. It allows data transmitted to a designated contact using the GSM module. GPS has a power supply pins which is VCC and ground (GND). It also has two communication pins such as TX and RX. TX functions to transmit the serial data from GPS while RX will receive it. The tracking sensitivity is about -161dBm.

3.5.5 Accelerator Sensor (ADXL345)

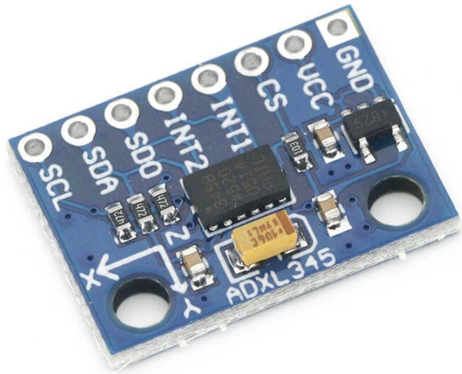

Figure 3.6 : ADXL345 sensor

An accelerometer is a sensor used in accident detection systems to measure acceleration and detect changes in motion, crucial for identifying vehicle collisions or impacts. When an accident occurs, the sudden impact causes a significant change in acceleration, which can be detected by the accelerometer. This data can then be used to trigger an alert or activate safety systems.

The ADXL335 accelerometer module features have power connection such as VCC and GND to ESP32. It also has SCL (serial clock line) and SDA(serial data line) . The ADXL345 accelerometer sensor measures acceleration along three perpendicular axes which is X, Y, and Z. X-axis if for measure horizontal pointing sideways, Y-axis pointing forward or backward and Z-axis pointing upward and downward. This allows it to detect and quantify motion and tilt in three-dimensional space. Integrating this accelerometer module with a microcontroller is straightforward and user-friendly. The fundamental structure of an accelerometer includes fixed plates and moving plates.

3.5.6 Vibration Sensor (SW420)

Figure 3.7: Vibration Sensor

The vibration sensor (SW420) widely used in accident detection system because it has higher sensitivity which is it detect even a small vibration and its very suitable for system that need precision. This component have adjustable sensitivity. VCC ranges is about 3.3V to 5V. D0 (Digital Output) is connected to pin D5 of microcontroller. The dimension of this board typically around 32mm x 14mm x 10 mm.

3.5.7 Li-on 3.7V 3000mAh battery

Figure 3.8: Li-on 3.7V 3000mAh Battery

Li-ion batteries are commonly used in electronics due to their rechargeable nature, high energy density, and long lifespan. This battery capacity is measured in milliampere-hours (mAh), it typically have an energy density ranging from 150 to 250 Wh/kg and a low self-discharge rate jusst between 2–3% per month. This battery almost come in cylindrical design with diameter 18mm and length 65mm and there are some variations feature like a tickness and witdth. A thickness is 3–10 mm and a width is about 50 × 100 mm, depending on the specific type. This type of battery is common used because it is lightweight and compact, rechargeable and energy-efficient with low self-discharge However, they are sensitive to high temperatures and require a safety circuit to avoid risks like overcharging or overheating.

3.5.8 Type-C Lithium-ion Chargers

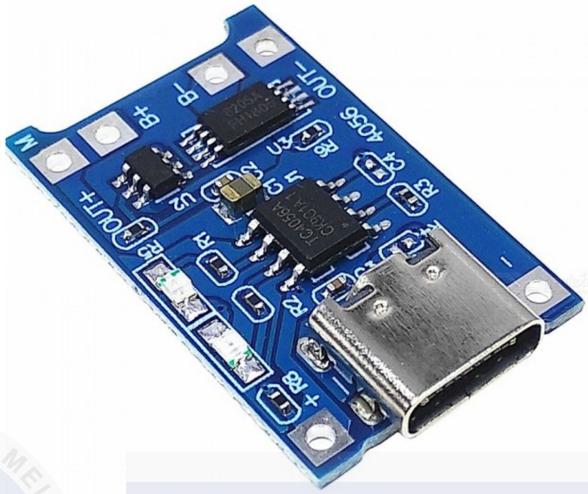

Figure 3.9: Li-on 3.7V 3000mAh Battery

This charger is powered by USB port and type C, it offering fast and efficient charging. The length of this charger is 50mm to 100mm, while the width is around 30mm to 70mm. The current flow is limited which is bertween 1A-3A for single cell to prevent the battery from overheating. It designed to charge multiple devices or batteries simultanously. This charger also regulates the current flow to ensure the circuit is protected and prevent any damage to the battery. There are many advantages of using this charger which is fast charging, compact design, wide compability and safety features because it built-in protection for safe charging.

3.5.9 Piezoelectric Buzzer

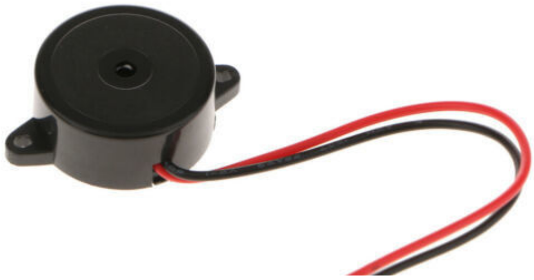

Figure 3.10: Piezoelectronic Buzzer

Piezoelectronic buzzer is used as an alarm or alerts of this system. This buzzer produce a loud tone, the range of the sound is around 70-100dB. The positive pin is connected to the power supply while negative pin is connected to the ground. The diameter is approximately 12~30mm with the height around 7~15mm.

3.5.10 Button

Figure 3.11: Button

A momentary push-button switch is used to turn the prototype system on and off. The red button serves as the interface for pressing and is encased in a black housing. The red wire represents the positive connection, while the black wire is connected to the ground. The button and its casing typically have a diameter of 10–20 mm, with a height of approximately 20–30 mm.

3.6 Software Implementation

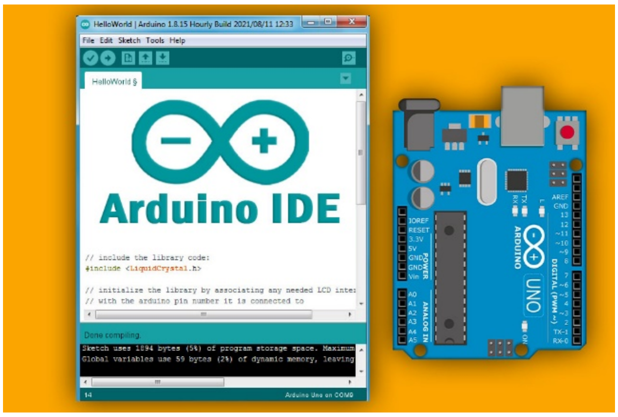

Figure 3.12: Arduino Software Programming

In this project, the system operates in two phases. Initially, the Arduino monitors the pin connected to the impact sensors and waits for the input signal to become active. In the second phase, the GPS receiver retrieves the GPS location. Once the precise location is calculated, the GSM module generates an SMS containing details of the accident and sends it to the appropriate authorities. The Arduino Integrated Development Environment (IDE) is a cross-platform application developed in Java. It is derived from the IDE used for the Processing programming language. Arduino programs are written in C or C++. It runs on Windows, Mac OS X, and Linux. This software can be used with any Arduino board.

The functions to make an executable cyclic executive program:

1) setup (): function runs once at the start of a program which may initialize settings.

2) loop (): function repeated until the board powers off.

There is the flow of the accident identification:

1. Start

2. Power on all the modules

3. Wait the sensors to detect accident.

4. Get this location from the GPS modem.

5. Calculate the precise location

6. Check whether the GSM modem is registered on the network.

7. Send the SMS notification.

3.7 Flowchart

Figure 3.9 illustrates the ordered sequence of actions taken by the car accident notification system. This employs standard flowchart symbols that representing entities, decisions, conditions, and the processes. The system begins when the car starts moving. GPS will connect with the GSM module. The system continuously monitors the car's speed. When a driver is driving at high speed and gets into an accident, there is a strong possibility that the individual got serious injuries especially if there is no one nearby help them. Then, the ADXL345 sensor will detect if the car angle more than threshold. The SW-420 sensor detect the vibrate or motion greater than threshold, the system retrieves the car's location data using GPS. So for the monitoring loop, the vibration sensor will detect the collision and if there is an accident, it will send the information while if the accident is not detected, the accelerometer will analyse the angle to identify the car is fall down to the gorge. If the angle and vibration is not triggered, so there are monitoring loop until the sensors triggers. An emergency notification message, including the GPS location, is then sent via GSM to owner number and emergency services. The system waits for a response from emergency services. If no response is received, the loop restarts, presumably to await a future collision.

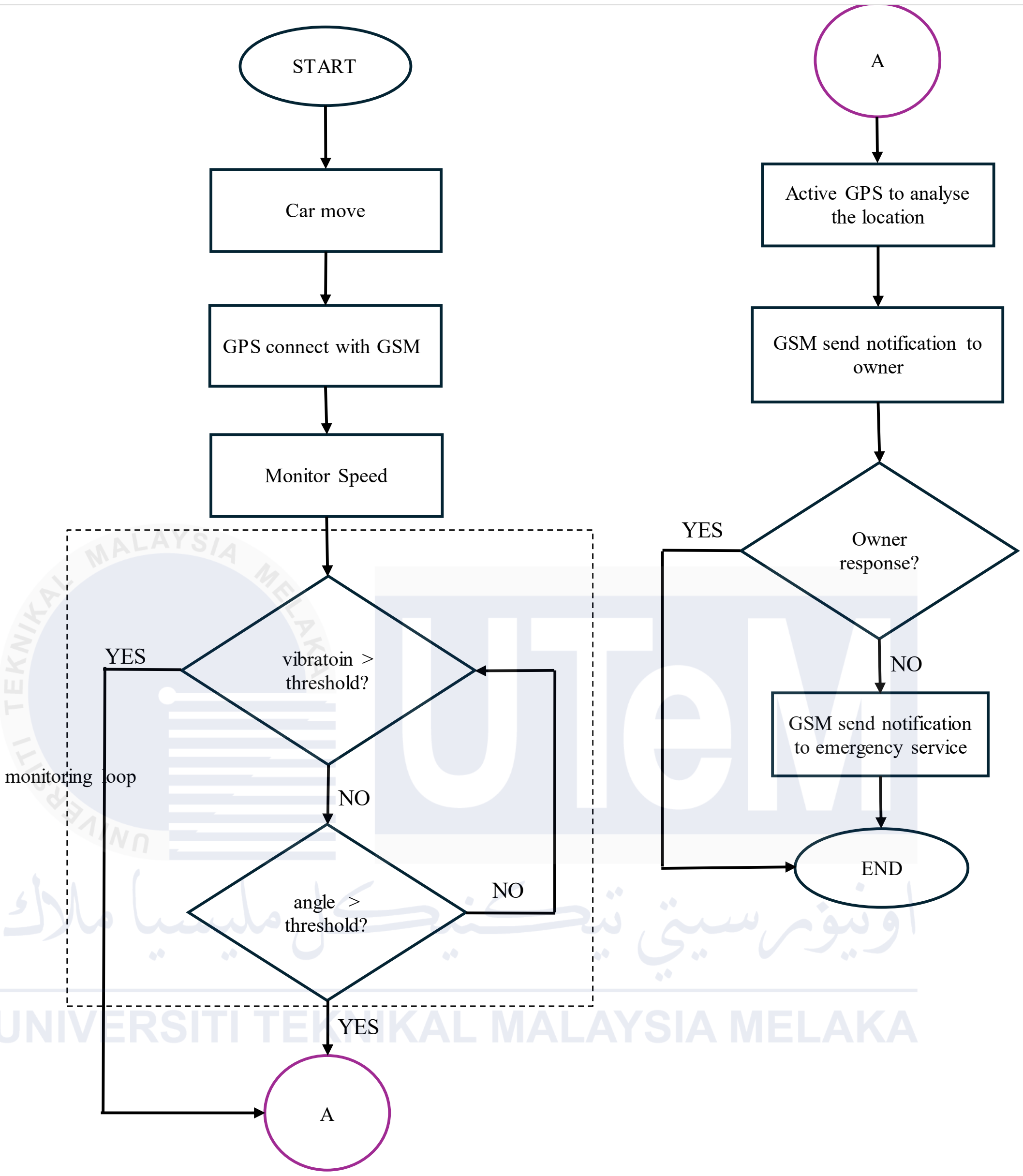

Figure 3.13: Flowchart of System

3.8 Block Diagram

Figure 3.10 showed the block diagram of car accident identification system. When the power is switched on, the acceleration sensor and vibration sensor will detect a collision and angle of the car, and the GPS will identify the location of the accident. The ESP32 compile all information and sends a GSM signal output to a receiver, typically a phone, to transmit information or data. Alert message will send and display the accident information. The system functions as an accident identification system that collects vehicle information when an accident occurs, precisely identifies the accident location, and transmits this information to emergency services or emerrgency contact.

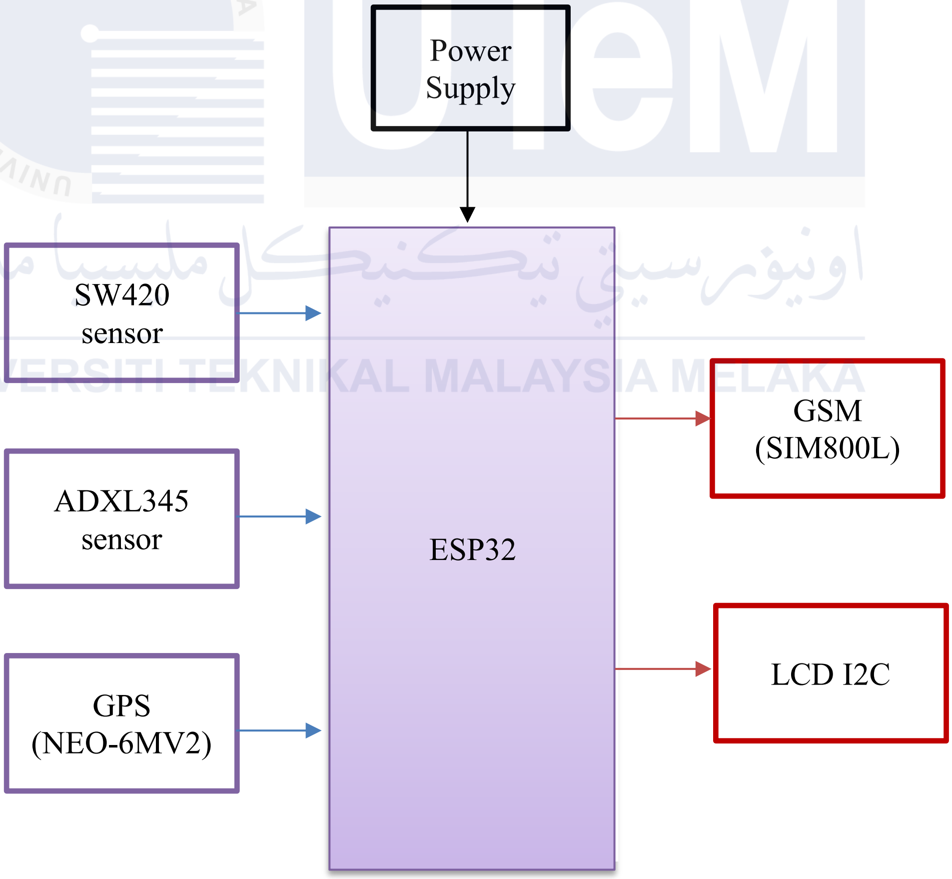

Figure 3.14: Block Diagram of System

3.9 Gantt Chart

Table 3.1: Gantt Chart PSM 1

Task / Progress	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Briefing about PSM 1 by Supervisor	■													
Briefing Chapter 1		■												
Comfirmation Research Project Title			■											
Background of study				■										
Problem Statement				■										
Briefing Chapter 2 (Literature Review)				■										
Research of previous related project					■									
Sorting important from previous Project					■	■								
Literature Review Writing						■	■							
Submission Logbook and project progress						■								
Briefing Chapter 3,4 and 5								■						
Focus on methodology								■	■					
Submission Draft for Chapter 2,3 and 4										■				
Correction of PSM report 1										■	■			
Submission logbook week 7 - week 12												■		
Correction and submission of PSM report 1													■	
Preparation and Presentation of PSM 1													■	■

Table 3.2: Gantt Chart PSM 2

Task / Progress	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Finding the information and research														
Built the programming for project														
Compile all the coding using Arduino IDE														
Troubleshoot the connection														
Preparation for Chapter 4														
Testing and troubleshooting														
Submission Logbook and project progress														
Soldering the complete circuit														
Collect data analysis														
Preparation for Chapter 5														
Report draft submission														
Submission logbook week 7 - week 10														
Preparation Poster														
Correction of PSM 2 report														
Preparation and presentation PSM 2														
Prepare for Competition (if participate)														

3.10 Summary

In conclusion, Car Accident Identification System for enhancing the vehicle safety may be sucessfully contructed. Software like Arduino and all the hardware component are correctly linked and satiesfy their criteria. Any difficulties identifed during the project will be addressed to ensure all the objectives are achieve. For further understanding about the process and data gathering will be explains for the next chapter.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter contains the schematic diagram and analysis of car accident identification system using ESP32. The goal of this project is to save lives as soon as possible after a crash occurs. The schematic diagram used components like GSM, GPS, accelerometer sensor (ADXL345), vibration sensor (SW-420) and ESP32. Chapter 4 consists of basic data gathering of ADXL345, SW-420 to get the suitable value for the prototype. This chapter also discussed how to troubleshoot the circuit and explained the connection of the circuit.

4.2 Limitation

As the findings, the factor of the vehicle's accident caused by speeding. It will be there a limiting rule or circumstance in every product or project.

The limitation of this project is:

a) Does not cover the presence of fire during events occur.

b) The system cannot send a message when outside the reach of the coverage area. (no networking/signal)

4.3 Circuit Diagram

This section shows the schematic diagram of this project that contains the ESP32 board as a microcontroller and followed by two sensors like acceleration sensors and vibration sensors also several components like GPS, GSM, button, battery, LCD. This section also lists the details connection of the project based on shcematic diagram in Figure 4.0.

4.3.1 Schematic Result

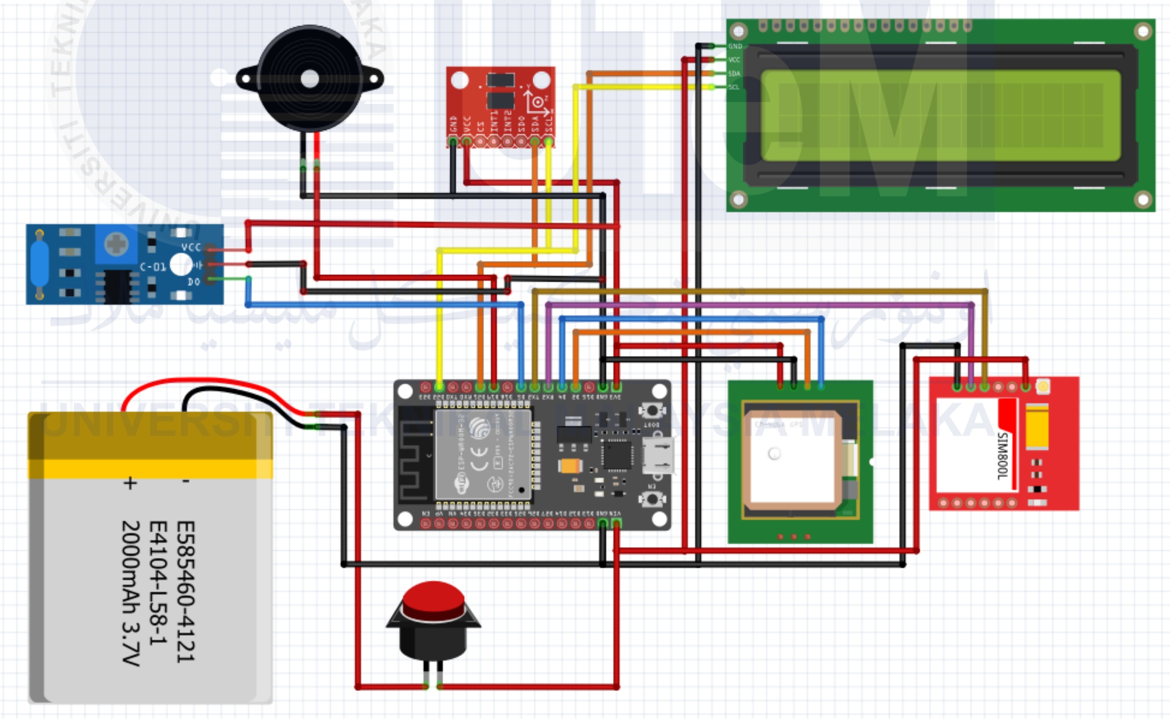

Figure 4.0: Schematic Diagram

4.3.2 Explanation of Schematic Diagram

Table 4.0: Explanation of Schematic Diagram

TERMS	COMPONENTS	CONNECTION WITH ESP32
INPUT	Accelerometer Sensor	-VCC colour connected to 3V3 -Ground connected to ground - SDA connected to pin D21 and SCL with D22.
	Vibration Sensor	- VCC connect to 3V3 -GND connected to ground -Digital Output connected to pin D5
	GPS Module	-VCC connected to 5V -GND connected to Ground -TX connected to D2 -RX connected to D4
	Li-on Rechargeable Baterry	-negative connected to GND -Positive connected to input charger and output charger to the D1
OUTPUT	GSM Module	- VCC connected to Vin -TX connected to RX2 -RX connected to TX2
	LCD	-GND connected to Ground -VCC connected to 3V3 -SDA connected to SDA accelerometer -SCL connected to SCL accelerometer

	Buzzer	-positve connected to D19 -negative to the GND

4.4 Output Result

The result of hardware development will run in Arduino IDE. The simulation is focus to turn on and run device sensor and component like vibration sensor, accelerometer sensor, GSM and GPS.

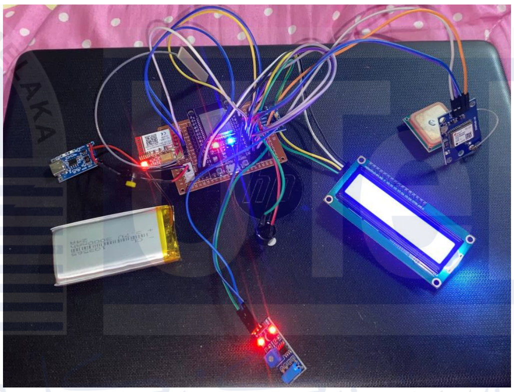

Figure 4.1 Complete Circuit

Figure 4.1 shows the components are function. GSM and GPS bliking to show there is stable signal. Vibration sensor and ESP32 also flashing means all the component is connected each other. The system operates on a rechargeable battery and consumes power depending on its activity level.

Figure 4.2: The system is on

Based on Figure 4.2, it shows the system on. It means the system ready to trigger the collision, LCD displays "Drive Safe, Condition Ok" while GPS works to get current location of the car.

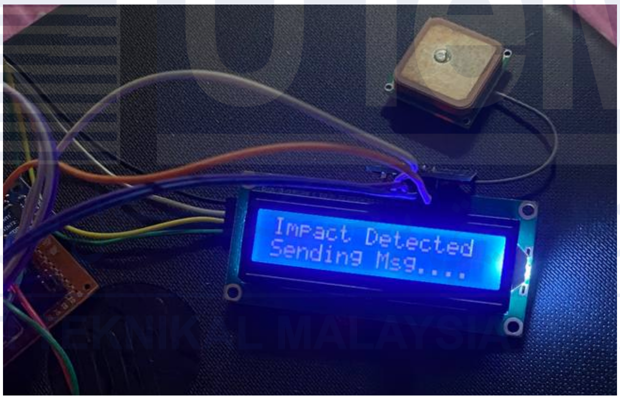

Figure 4.3: The system detects accident

Figure 4.3 shows the result after the accident detected. The LCD displays "Impact Detected, Sending Msg"that means the sensors trigger the collision and send data to ESP32 board. At the same time, GSM sends the notification to driver or owner of the car and the system waits the reply from driver.

Figure 4.4: System waits for response

When the message is sending to check either drivers in a good condition or not, the LCD displays “Reply Yes If You Are Ok” like Figure 4.4. For the prototype, the system will wait for response only in 20 second.

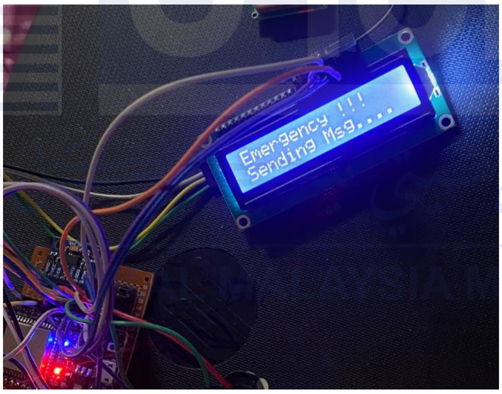

Figure 4.5: Message for emergency service

Figure 4.5 shows the LCD displays if the drivers is not responsive. “Emergency!!! Sending Msg...” means the system will notify the emergency service that there is an accident occurs. This message contains latitude and longitude of current location to inform the the emergency service so that there is no miscommunication about location. This system also provide the real-time notifacation using GSM.

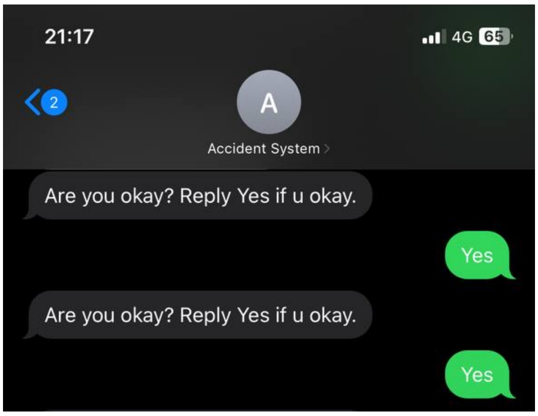

Figure 4.6: Message sent by system

Figure 4.6 presents the result when the message sent. The system sent the this message to check either the driver is safe or need emergency help. If the driver replied "YES" or "Yes" or "yes". The system will detect it as a driver safe and all the system go back to the "Condition Ok" means everything is safe.

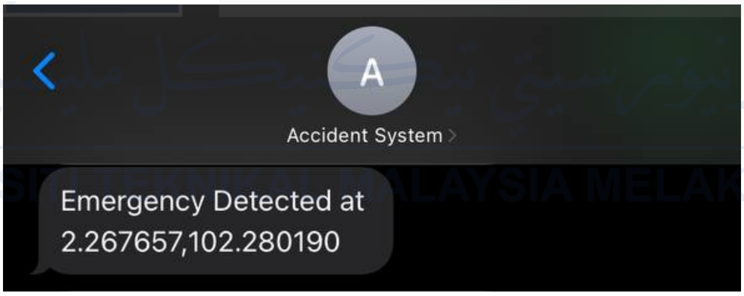

Figure 4.7: Message send to the emergency unit

Figure 4.7 shows the message sent by GSM to the emergency unit if the drivers is not response. This message contains the latitude and longitude that provide the current location. If the driver reply yes to the system, so this message is not generate and not send to the emergency service or emergency contact.

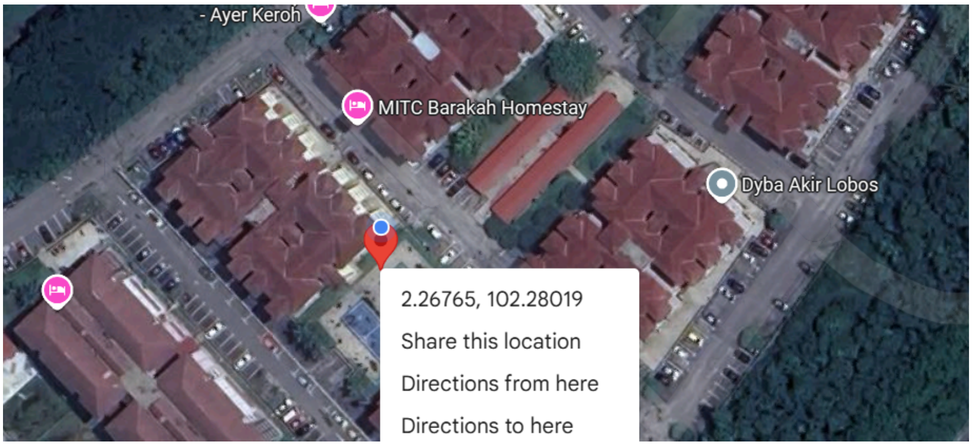

Figure 4.8: Result in GoogleMaps(Satellite)

Figure 4.8 shows the result of current location for the car accident when observed using the satellite. It shows the latitude and longitude of the location so that the emergency unit can track where the victim is.

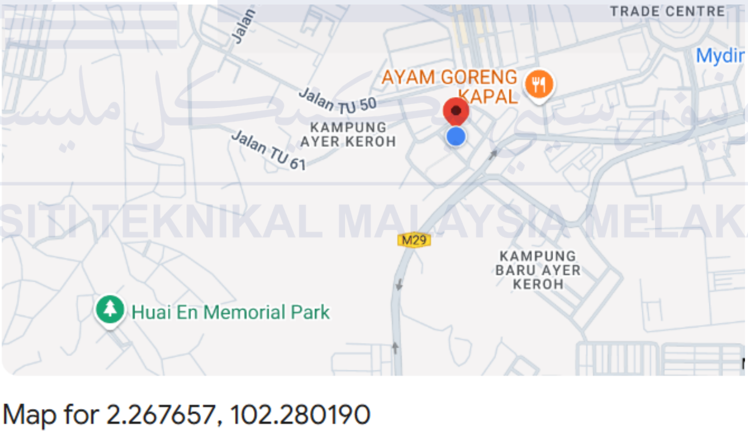

Figure 4.9: Result in GoogleMaps(Traffic)

Figure 4.9 represents the same location as Figure 4.8 in GoogleMaps but in traffic version, not the satellite. So this pinpoint location sent via GSM to make sure there is no delays in treating the victims.

4.5 Data Analysis

This section shows the analysis of sensor calibration and accuracy analysis, threshold analysis, response time analysis, system reliability testing, power consumption analysis, notification and delivery performance and the comparative analysis with existing system.

4.5.1 Threshold analysis

For the outcome event, it will be 4 types of events:

True positive (TP) - the system can correctly identify the accident

True negative (TN) - the system correctly detected the is no accident

False positive (FP) - the system detects the accident when there's no accident

False Negative (FN) – the system fails to detect when the accident happens

Based on table 4.1, the threshold value that suitable to use on vibration sensor is around 150-200 and for the prototype, the system only used 170 threshold value. This value gives the right balance between accuracy and sensitivity. For low threshold value which is value between (10-100), the system will detect the accidents even there is no accident occurred (FP). This means that the threshold is very sensitive, make the vibration sensor trigger to the small vibration and unreliable for real-world use. Best performance with minimal errors is between 150-200 while threshold value between 300 and above is not sensitive and misses the accident. Refer table below:

Table 4.1: Threshold of Vibration sensor

Threshold value	Actual Event	System Detection	Outcome of Event	Rate for Threshold value (%)
10	No Accident	Detected	FP	1
50	No accident	Detected	FP	10
100	No Accident	Detected	FP	30
150	No Accident	Not Detected	TN	90
200	Accident	Detected	TP	95
250	Accident	Detected	TP	85
300	Accident	Not Detected	FN	30
350	Accident	Not Detected	FN	10
400	Accident	No Detected	FN	1

From the analysis Table 4.2, the threshold for the accelerometer sensor set to the prototype is around $50^0 – 70^0$, it give the most effective in detecting the driving conditions like head tilts during drowsiness. Threshold angle for 30^0 is not suitable for steep uphill road because the angle will trigger the sensor, and it detect the unnecessary events. Threshold angle 110^0 is not detected because it already read the angle -20^0. Angle 70^0 suitable for prototype because the system reaches 95% of accuracy. The accuracy of accelerometer sensor gave the weak performance when the threshold value is above 110.

Table 4.2: Threshold of Accelerometer sensor

Threshold angle	Detected	Not Detected	Condition Test	Accuracy rate suitable angle (%)
±10	✓		Too sensitive	10
±30	✓		Sensitive	50
±50	✓		Good	85
±70	✓		Good	95
±90	✓		High	80
±110		✓	Too high	0

4.5.2 Response Time Analysis

Based on Table 4.3, we can see that the most important thing is strength of network. The system works efficiently when the network is strength. 4 Bar of network means that the network is strong while 1 Bar network means weak network. The delay is set for waiting time. For prototype testing, the system delays 20 second for waiting the driver reply, if the driver is not response within that time, the system automatically send the notification for emergency unit or emergency contact. For Test 1, Test 4, Test 6 and Test 9, the network is strong, and it provide the fast delivery time between (5.93 to 8.28 second) while the lowest bar is 1 bar which is the significantly slower, give the range of delivery time is (32.88 to 33.72).

For the moderate network, which is 3 Bar, the delivery time is slower compared to the 4 Bar network. It takes 6.97-13.89 second to send the notification for driver and it takes 8.72-16.15 to receive yes from the driver. Time taken for delivery the message to emergency unit is around 24.56 second. The limitation for this system is network coverage. It is because the system cannot work efficiently when there is weak network. Test 7 and Test 8 show there are some delays and not delivered the message because of 1 Bar network.

Table 4.3: Notification Delivery Performance

Test	Strength of Network (Bar)	Time taken to delivery message for driver (s)	Time taken to receive "yes" (s)	Time taken to delivery message for emergency unit (s)
Test 1	4 Bar	6.565	13.19	-
Test 2	3 Bar	8.21	16.15	-
Test 3	2 Bar	18.96	8.60	-
Test 4	4 Bar	7.66	6.72	-
Test 5	3 Bar	13.89	8.72	-
Test 6	4 Bar	8.28	No reply	20.10
Test 7	1 Bar	32.88	No reply	Not Delivered
Test 8	1 Bar	33.72	No reply	30.28
Test 9	4 Bar	5.93	No reply	20.03
Test 10	3 Bar	6.97	No reply	24.56

4.5.3 System Reliability Testing

This section evaluates the system's reliability by analysing whether the accident are accurately detected under various road conditions. This finding demonstrates the system's ability to distinguish between minor vibration and actual collision to ensure that only relevant incidents are flagged as accident. As we can see, there is small vibration detected for both bumpy road and smooth road, but the system not detected it as an accident. It means that the system is not sensitive to detect the minor disturbances because it is not considered as an accident. For gravel road and muddy road, there is high vibration, but it is still not detected as the accident because there is no sudden collision. This reinforces the system's reliability in avoiding the false-positive detections, ensuring the accuracy in real-world scenarios. Overall, the result is not too sensitive for the normal driving so it can maintain high reliability in detection online genuine collision events.

Table 4.4: Type of road

Road Condition	Event Simulated	Detection Result
Bumpy Road	Small vibration	Not detected
Smooth Road	Small vibration	Not detected
Gravel Road	High Vibration	Not detected
Muddy Road	High Vibration and angle	Not detected

4.6 Testing and Troubleshooting

The inspection following the installation of hardware and software for the project should be conducted to ensure everything is in perfect condition and functions properly. Here are a few things to consider during the checking process:

- Examine the connection of the circuit either correct or not.
- Ensure that all wired components are properly soldered onto their respective pins on the circuit board.
- Compile the code to scan for errors before uploading it to the ESP32 board.

GPS is a sensitive component that may require troubleshooting, as it can sometimes be the cause of signal loss (inability to detect satellites).

4.7 Summary

This chapter shows the analysis for the project, the connection between the component and microcontroller. It also discussed the limitations and how to troubleshoot the circuit when faced with the problem.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

In summary, the use of ESP32 in the construction of a GSM-Based Car Accident Identification System has shown to be a major step forward in improving vehicle safety. The project's goal is successfully achieve to identify car crashes and rapidly alerting the emergency services or emergency contact. By combining several components like sensors, GSM, and GPS, with the ESP32 microcontroller, the system ensures the transmission of accident data in real-time and provide exact position information.

5.2 Future Works

The development of innovations is created year by year. This system works to notice the emergency contact and save lives without emergency services delay. The message will be sent quickly using GSM technology by giving the precise locations of the accident. Here are suggestions for project future works:

- Machine learning to detect the type of accident. Machine learning can be used to identify the type of vehicle that involves a crash between any object and to identify the situation of accidents such as falling into ravine and various hazards.
- Voice and Video Alerts: It will introduce features like capturing voice and video and send to the emergency services. From voice and video clips, it provides the information such as number of people that are involved and condition of environment so that the emergency unit or relatives can prepare more effectively to help the victims.

- Waterproof and rugged design. It is needed to protect the sensitive component like ESP32, sensors and power supply from environmental damage so that the system operates reliably in challenging environment like heavy rains and snow. Benefits from rugged and waterproof design, it will increase the longevity that prevents environmental damage, the system also consistent the performance because it works under various weather conditions.

5.3 Potential to commercialization

This Car Accident Identification System is an effective device designed to detect accidents and provides real time accident identification. Using ESP32, GPS, GSM and sensors, the system can share the current locations and send details about accidents to ensure they save lives. This project is suitable for individuals who seek affordable safety, especially for drivers travelling alone in remote areas. It is also suitable for fleet operators such as logistics and transportation companies that ensure vehicle safety. This is a cost-effective system because this system is budget friendly. The price is about RM200 including the accident detection and SMS alerts.

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APPENDIX

Coding Project

```
#include <Wire.h>

#include <Adafruit_Sensor.h>

#include <Adafruit_ADXL345_U.h>

#include <TinyGPS++.h>

#include <LiquidCrystal_I2C.h>



#define ss Serial1 // (rx=2,tx=4)

#define mySerial Serial2



#define impactPin 5

#define buzzer 19



LiquidCrystal_I2C lcd(0x27, 16, 2);

TinyGPSPlus gps;

const unsigned long eventInterval = 1000;

unsigned long previousTime = 0;

double latitude = 2.747441;

double longitude = 102.944181;

String Data;

String mylocation;

String sendMsg;

String askMsg = "Are you okay? Reply Yes if u okay.";
```

```
int conImpact = 0;

int conMsg = 0;

bool count = false;

int c = 0;

float pitch;

float roll;

int replyTimer = 20; // in sec


// Define threshold values

float vibrationThreshold = 200.0;  // Vibration threshold (magnitude)

float angleThreshold = 50.0;       // Angle threshold (degrees)


Adafruit_ADXL345_Unified accel = Adafruit_ADXL345_Unified(12345);


void setup() {

  mySerial.begin(9600);

  ss.begin(9600);

  Serial.begin(115200);

  lcd.init();

  lcd.backlight();

  lcd.clear();

  pinMode(impactPin, INPUT_PULLUP);

  pinMode(buzzer, OUTPUT);

  digitalWrite(buzzer, LOW);
```

```
  if (!accel.begin()) {
    Serial.println("Ooops, no ADXL345 detected ... Check your wiring!");
    while (1);
  }
  accel.setRange(ADXL345_RANGE_4_G);
  Serial.println("ADXL345 Initialized");

  mylocation = "Emergency Detected at " + String(latitude, 6) + "," + String(longitude,
6);
  pinMode(impactPin, INPUT);
  mySerial.println("AT+CMGF=1"); // text mode
  delay(2000);
  mySerial.println("AT+CNMI=1,2,0,0,0"); // receive msg
  delay(2000);
}

void loop() {
  unsigned long currentTime = millis();
  if (currentTime - previousTime >= eventInterval) {
    rollEvent();
    int impact = digitalRead(impactPin);
    Serial.println(impact);

    // Check if pitch, roll, or vibration exceeds thresholds
```

```
  if (impact == 1 || pitch > angleThreshold || pitch < -angleThreshold || roll >
angleThreshold || roll < -angleThreshold || checkVibrationThreshold()) {
    if (conImpact == 0) {
      lcd.clear();
      lcd.setCursor(0, 0);
      lcd.print("Impact Detected");
      lcd.setCursor(0, 1);
      lcd.print("Sending Msg....");
      digitalWrite(buzzer, HIGH);
      Serial.println("trigger");
      conImpact = 1;
      sendMsg = askMsg;
      msgUser();
      mySerial.println("AT+CNMI=1,2,0,0,0");
      count = true;
    }
  } else {
    conImpact = 0;
  }


  if (count) {
    c++;
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Reply Yes If");
```

```
  lcd.setCursor(0, 1);

  lcd.print("You Are Ok");

} else {

  lcd.clear();

  lcd.setCursor(0, 0);

  lcd.print("Drive Safe");

  lcd.setCursor(0, 1);

  lcd.print("Condition Ok");

}


if (c > replyTimer) {

  lcd.clear();

  lcd.setCursor(0, 0);

  lcd.print("Emergency !!!");

  lcd.setCursor(0, 1);

  lcd.print("Sending Msg....");

  Serial.println("emergency detected");

  msgEmergency();

  mySerial.println("AT+CNMI=1,2,0,0,0");

  c = 0;

  count = false;

  digitalWrite(buzzer, LOW);

}


previousTime = currentTime;
```

```
}


gps1();

getSms();


// If user replies "Yes" to the message

if (Data.indexOf("+CMT:") >= 0) {

  Serial.println("SMS Received: " + Data);


  // Check if the message contains "Yes" (case-insensitive)

  if (Data.indexOf("Yes") >= 0 || Data.indexOf("YES") >= 0 || Data.indexOf("yes") >=
0) {

    Serial.println("Driver responded: OK");


    // Stop buzzer and reset emergency escalation

    c = 0;

    count = false;

    digitalWrite(buzzer, LOW);


    // Display safe status on LCD

    lcd.clear();

    lcd.setCursor(0, 0);

    lcd.print("Driver OK");

    lcd.setCursor(0, 1);

    lcd.print("Condition Safe");
```

```
    }

    // Clear Data to prepare for the next SMS
    Data = "";
    mySerial.println("AT+CNMI=1,2,0,0,0");
  }
  delay(50);
}

// Function to send SMS to user
void msgUser() {
  mySerial.println("AT+CMGF=1");
  delay(1000);
  mySerial.println("AT+CMGS=\"+60173486426\"\r"); // Replace with your number
  delay(1000);
  mySerial.println(askMsg);
  delay(100);
  mySerial.println((char)26); // ASCII code of CTRL+Z
  delay(1000);
}

// Function to send emergency message with location
void msgEmergency() {
  mySerial.println("AT+CMGF=1");
  delay(1000);
```

```
  mySerial.println("AT+CMGS=\"+60173486426\"\r"); // Replace with emergency
contact number
  delay(1000);
  mySerial.println(mylocation);
  delay(100);
  mySerial.println((char)26);
  delay(1000);
}

// Function to get SMS
void getSms() {
  while (mySerial.available() > 0) {
    Data = mySerial.readString();
    Serial.print(Data);
    delay(10);
  }
}

// Function to get GPS data
void gps1() {
  while (ss.available() > 0) {
    gps.encode(ss.read());
    if (gps.location.isUpdated()) {
      latitude = gps.location.lat();
      longitude = gps.location.lng();
```

```
      mylocation = "Emergency Detected at " + String(latitude, 6) + "," + String(longitude, 6);
      Serial.println(mylocation);
    }
  }
}

// Function to calculate pitch and roll
void rollEvent() {
  sensors_event_t event;
  accel.getEvent(&event);
  float ax = event.acceleration.x;
  float ay = event.acceleration.y;
  float az = event.acceleration.z;

  pitch = atan2(ay, sqrt(ax * ax + az * az)) * 180.0 / PI;
  roll = atan2(-ax, az) * 180.0 / PI;

  Serial.print("Pitch: ");
  Serial.print(pitch);
  Serial.print(" degrees, ");
  Serial.print("Roll: ");
  Serial.print(roll);
  Serial.println(" degrees");
}
```

```
// Function to check vibration threshold
bool checkVibrationThreshold() {
  sensors_event_t event;
  accel.getEvent(&event);
  float ax = event.acceleration.x;
  float ay = event.acceleration.y;
  float az = event.acceleration.z;

  float vibration = sqrt(ax * ax + ay * ay + az * az);
  if (vibration > vibrationThreshold) {
    Serial.println("Vibration Detected!");
    return true;
  }
  return false;
}
```