REPUBLIQUE ALGERIENNE DEMOCRATIQUE ET POPULAIRE

MINISTERE DE L'ENSEIGNEMENT SUPERIEUR ET DE LA RECHERCHE SCIENTIFIQUE

Université de Mohamed El-Bachir El-Ibrahimi - Bordj Bou Arreridj

Faculté des Sciences et de la technologie

Département d'Electronique

Mémoire

Présenté pour obtenir

LE DIPLOME DE MASTER

FILIERE : **Electronique**

Spécialité : Electronique Industrielle

Par

- **Maouchi Akram**
- **Bouadi Abdelmounim**

Intitulé :

Design and implementation of Smart Multi-Function System (SMFS)

Par la commission d'évaluation composée de* :

Nom & Prénom	*Grade*	*Qualité*	*Etablissement*
M. ABED Tarek	*MAA*	*Président*	*Univ-BBA*
Mme. Adoui Ibtissem	*MCB*	*Encadreur*	*Univ-BBA*
M. Azoug Seif Eddine	*MCB*	*Examinateur*	*Univ-BBA*

Année Universitaire 2022/2023

Acknowledgement

Completing any task brings immense satisfaction and euphoria. However, acknowledging the instrumental role played by the individuals who offered constant guidance and encouragement is crucial for a comprehensive recognition. We would like to express our heartfelt gratitude to our supervisor, Dr. Ibtissem ADOUI, who willingly undertook the responsibility of overseeing this project. Her invaluable assistance, cooperation, and insightful suggestions have been pivotal throughout the year. Working with her has been an absolute pleasure, as her expertise and knowledge have propelled our work to new heights.

Furthermore, we extend our appreciation to all the teachers at our institute for their unwavering support during the entirety of our academic journey. Their contributions have been instrumental in shaping our learning experience and helping us navigate challenges.

Lastly, we wish to express our deepest thanks to all those who played a part in bringing this project to fruition, particularly our friends and families and especially Mr.Ramzi Benkhira. Their unwavering support and encouragement have been our driving force, and we are immensely grateful for their presence throughout this endeavor.

List of Figures

CHAPTER II

CHAPTER III

Abbreviations

PCB Printed Circuit Board

SMFS Smart Multi-Function System

NMEA National Marine Electronics Association

AI Artificial intelligence

GPS Global Positioning System

GSM Global System for Mobile communication

Table of Contents

Chapter 03: Simulation and Practical Realization

General Introduction

General Introduction:

In today's rapidly evolving technological landscape, the integration of advanced functionalities in automobiles has become increasingly prevalent. Vehicles are no longer mere modes of transportation; they are transforming into intelligent machines that have the potential to revolutionize our driving experiences. This thesis explores the development and implementation of a smart system for cars, aimed at enhancing car operations and providing a seamless driving experience.

As we delve into the theoretical foundations and practical implementation of this smart system, we uncover its potential impact on the automotive industry. By understanding the intricate details of its development, we gain insights into the possibilities it presents for enhancing car operations and ensuring user convenience. The chapters that follow delve into the various aspects of this system's functionalities and showcase its transformative potential.

We explore the evolution of intelligent machines in the automotive industry and emphasize the need for a smart system to enhance the driving experience. It provides a foundation for understanding the significance of the research and its implementation. The focus then shifts to the primary objective of the smart tracking system: real-time monitoring of a vehicle's location and improved security measures. The hardware and software requirements for building an efficient smart tracking system, including components like Arduino Nano, NEO-8M GPS module, SIM800A GSM module, and relay control, are explored. The thesis concludes with a practical examination of the system's capabilities, including remote car control and safety features like accident detection and anti-theft alerts.

This thesis will allow you to embark on a journey that reveals the transformative potential of smart systems for automobiles. From understanding the evolution of intelligent machines to exploring the theoretical foundations and practical implementation of a smart tracking system, you will witness the possibilities that advanced technologies hold. Join us as we unravel the intricacies of this smart system, providing you with a deep understanding of its capabilities and potential future developments.

Chapter 1

General Idea of Smart Systems

1.1Introduction :

In today's rapidly evolving technological landscape, the integration of advanced functionalities in automobiles has become increasingly prevalent. From autonomous driving to connected features, vehicles are transforming into intelligent machines. In this chapter we focus on the revolution of a smart system for cars, which aims to development car operations and enhance the overall driving experience.

1.2 What is a smart system?

Smart systems incorporate functions of sensing, actuation, and control in order to describe and analyze a situation, and make decisions based on the available data in a predictive or adaptive manner, thereby performing smart actions. In most cases the “smartness” of the system can be attributed to autonomous operation based on closed loop control, energy efficiency, and networking capabilities.

1.3 Characteristics:

Smart systems typically consist of diverse components:

- Sensors for signal acquisition
- Elements transmitting the information to the command-and-control unit
- Command-and-control units that take decisions and give instructions based on the available information
- Components transmitting decisions and instructions
- Actuators that perform or trigger the required action

1.4 Benefits of Smart Systems:

Some of the key benefits of using smart technology are as follows:

1.4.1 Convenience:

Today, we find ourselves in an era where accomplishing multiple tasks simultaneously has never been easier. Thanks to the advent of smart technology, the power to control our environment with a simple voice command is now within reach. Whether it's adjusting the ambiance of a room, ensuring the security of our homes, or even satisfying our cravings through online orders, smart technology stands ready to serve our every need. It elevates convenience to an entirely new level.

What makes the latest smart technologies truly remarkable is their ability to adapt and cater to our individual preferences. Through sophisticated analysis, they gain a deep understanding of our likes and dislikes, enabling them to provide us with automated and personalized services that align with our unique tastes.

Moreover, these intelligent systems go beyond personalization. They possess the capability to consider external factors that impact our lives, such as traffic conditions, the state of our vehicles, or the surrounding environment. Armed with this knowledge, they proactively keep us informed and guide us safely towards our destinations.

1.4.2 Ensures Sustainability:

In the pursuit of environmental sustainability and cost savings, both industrial and domestic sectors are increasingly turning to smart technology solutions. The urgent need to embrace eco-friendly practices and reduce energy consumption has made the deployment of smart technology a crucial priority.

One of the significant challenges we face is the inefficient use of energy in our daily lives. Often, we forget to turn off domestic appliances or leave them running when not needed, resulting in unnecessary energy wastage. This is where smart technology can make a significant impact.

By leveraging intelligent automation and regulation, smart technology can effectively manage energy usage. It has the capability to automatically switch off or adjust lights, heating, cooling appliances, and other energy-consuming devices when they are not in use or when specific conditions have been met. This not only helps to conserve energy but also leads to cost savings, creating a win-win situation for both individuals and the planet.

1.4.3 Security

Smart technology offers more reliable security than traditional, manually operated security systems. Smart security gadgets such as door sensors, alarm systems, security cameras, and video doorbells help warn building owners about the various threats to their property. Apart from alerting the owners, law enforcement agencies are also informed, and protective measures such as, blocking certain pathways or locking rooms, are taken.

In addition to this, smart digital smoke, gas, water and sewerage leakage can not only be detected, but also the technology enables real-time preventive action, potentially saving one from discomfort and even bodily harm [1].

1.4.4 Efficiency

Smart technology makes use of data to understand how improvements can be made. It tracks and analyses what's going on to deliver better results in the future. This entails that processes and systems become more efficient, and you as a person become more productive.

Imagine waking up exactly on time after having slept comfortably to find that everything is ready for your needs to start your day well, eliminate distractions and leave for work on time.

1.4.5 Saves time and money

Energy bills can be reduced by using smart technological devices such as a smart thermostat, smart lighting, remote power management, water heaters, washing machines, and fridges as they can optimize the use of energy and in turn, use less of it to do more.

Smart technology automates repetitive chores and eliminates lost or wasted time.

1.5 What is Smart car system?

Smart car systems refer to the integration of advanced technologies and features in vehicles, leveraging connectivity, sensors, artificial intelligence, and automation to enhance safety, comfort, convenience, and overall driving experience. These systems encompass a wide range of components that transform cars into intelligent and connected devices. By utilizing internet connectivity, smart car systems enable real-time traffic updates, over-the-air software updates, and seamless integration with smartphones and other devices. Advanced Driver Assistance Systems (ADAS) utilize sensors, cameras, and radar to assist drivers with tasks like adaptive cruise control, lane keeping, collision avoidance, and parking assistance. Infotainment systems bring entertainment, navigation, communication, and connectivity features together, providing access to music, internet radio, hands-free calling, and voice-controlled commands. Autonomous driving capabilities, made possible by smart systems, allow vehicles to operate without human intervention, relying on sensors, cameras, artificial intelligence, and advanced algorithms. Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication systems enhance safety and traffic flow by enabling vehicles to exchange information with each other and with infrastructure elements like traffic lights and road sensors. Smart systems also contribute to energy efficiency and sustainability by optimizing engine performance, reducing fuel consumption, and supporting hybrid or electric vehicle capabilities. Cybersecurity measures are integrated into smart car systems to protect against potential cyber threats, ensuring the safety and privacy of occupants and data. In summary, smart car systems revolutionize the driving experience by incorporating advanced technologies to make vehicles safer, more efficient, connected, and environmentally friendly.

1.6 Examples of Smart cars in the market:

The market for smart cars, also known as connected cars or intelligent vehicles, has witnessed steady growth in recent years. Smart cars are equipped with advanced technologies, connectivity features, and autonomous driving capabilities, all aimed at enhancing safety, efficiency, and convenience for drivers and passengers.

Several major automakers and technology companies have made significant investments in smart car development and have introduced new models with advanced features. Tesla, under the leadership of CEO Elon Musk, has emerged as a pioneer in the smart car market, gaining attention for its electric vehicles (EVs) with advanced autonomous driving capabilities.

General Motors (GM) has also been actively investing in smart car technologies, introducing the Chevrolet Bolt EV. This model features connectivity and advanced driver-assistance systems (ADAS), contributing to the overall intelligence of the vehicle.

BMW has focused on incorporating connected features and autonomous driving technology into their vehicles. Models such as the BMW i3 and i8 have been introduced with advanced connectivity options, enabling seamless integration with various smart car systems.

Ford has been dedicated to smart car technologies, introducing features like Ford SYNC, which provides connectivity and voice control capabilities. Additionally, Ford is actively engaged in the development of autonomous vehicles, further expanding the realm of smart car systems.

Audi, known for its commitment to innovation, has integrated advanced technologies into their vehicles. The Audi Virtual Cockpit, for example, offers a digital instrument cluster and connectivity options, enhancing the overall intelligence and user experience of their cars.

Mercedes-Benz has also embraced smart technologies, incorporating features like the MBUX infotainment system and advanced driver-assistance systems into their vehicles. These advancements contribute to the intelligence and connectivity of Mercedes-Benz cars.

In the realm of autonomous driving, Google's subsidiary, Waymo, has emerged as a prominent player. Waymo has been actively developing self-driving technology and conducting extensive testing on public roads, pushing the boundaries of smart car capabilities.

Apple, known for its innovation in consumer electronics, has been working on autonomous vehicle technology under the name "Project Titan." Although specific plans have not been disclosed, Apple has been hiring experts and conducting research in this field, indicating their interest and involvement in smart car systems.

The combined efforts of these market players and their respective contributions to smart car technology have propelled the industry forward, shaping the landscape of connected cars and intelligent vehicles.

1.7 The smart multi-function system (SMFS) for cars:

The revolution of smart systems for cars has ushered in a new era of automotive technology, where vehicles have become intelligent and interconnected entities. These systems integrate advanced technologies such as connectivity, artificial intelligence, and sensor systems to enhance the overall driving experience. Imagine a car that seamlessly connects to your smartphone, allowing you to remotely control various functions such as locking or unlocking doors, starting or stopping the engine, and adjusting climate settings. With the power of artificial intelligence, your car becomes a personal assistant, understanding your voice commands, providing real-time information, and even learning your preferences to offer a tailored driving experience. Sensors embedded in the car's architecture ensure enhanced safety by continuously monitoring the environment, detecting potential hazards, and assisting with collision avoidance. These smart systems have truly revolutionized the way we interact with our cars, making them more than just modes of transportation but intelligent companions that prioritize convenience, safety, and efficiency [2].

1.8 The benefits of the SMFS in Cars:

The smart system for cars brings numerous benefits that revolutionize the driving experience. It offers convenience through remote control capabilities, enabling functions such as engine start, door unlocking, and climate adjustment from a distance. Enhanced safety features, including accident detection and emergency notifications, contribute to a safer road environment. The system facilitates efficient vehicle management through real-time location tracking and fleet monitoring. Personalization and user experience are enhanced through artificial intelligence algorithms that learn and adapt to individual preferences. Connectivity and integration capabilities create a cohesive ecosystem, allowing seamless interaction with smartphones, smart homes, and IoT-enabled devices. The system also promotes eco-friendly driving practices and holds great potential for future advancements [2]. Overall, the smart system for cars provides convenience, safety, efficiency, personalization, and connectivity, transforming the driving experience and shaping the future of the automotive industry.

1.9 Conclusion:

In summary, the revolution of a smart system for cars has transformed the automotive industry by integrating advanced technologies and features into vehicles. These systems leverage connectivity, artificial intelligence, and sensor systems to enhance safety, convenience, efficiency, and connectivity. Smart car systems offer remote control capabilities, advanced safety features, efficient vehicle management, personalized user experiences, seamless connectivity, and eco-friendly driving practices. Major automakers and technology companies have made significant investments in this field, introducing models with advanced features such as autonomous driving capabilities, connectivity options, and advanced driver-assistance systems. The market for smart cars is expanding, and the future holds immense potential for further advancements in intelligent vehicle technologies. Ultimately, the revolution of smart systems for cars is shaping the future of mobility, providing a more intelligent, connected, and sustainable transportation ecosystem.

Chapter 2

Study and Conception of the Car Tracker

2.1 Introduction:

The primary objective of this smart tracking system is to provide real-time monitoring of the vehicle's location and ensure enhanced security measures. In case of theft, the system is capable of sending immediate alerts to the user, enabling quick responses and recovery actions. Similarly, in the event of an accident, the system can detect the impact using sensors, trigger emergency alerts, and notify relevant authorities or emergency contacts.

In this chapter, we explore the theoretical foundations of building a smart system using Arduino Nano, NEO-8M GPS module, SIM800A GSM module, and relay control. Such as the hardware and software components required for building it.

2.2 Motivation for Project:

Algeria has a relatively high rate of accidents, according to Arab News. In 2021 the country's authorities recorded more than 7,000 traffic accidents which killed at least 2,643 people and left in excess of 11,000 injured as well as more than 5000 recorded private car theft cases in recent years.

This motivated us to build a smart system device to track car location, send alerts in case of theft and accidents, and remotely turn off the car. Pursuing this project will allow us to enhance security by enabling real-time monitoring of the vehicle's location, increasing the chances of recovery and minimizing losses in case of theft. Prompt theft detection is facilitated through motion sensors, ensuring immediate notifications and enabling rapid response to prevent further damage or loss.

The project also focuses on improved safety by integrating accident detection sensors, which provide instant alerts in case of collisions or changes in vehicle orientation. This allows for swift action, notifying emergency services or concerned individuals for prompt assistance. The continuous monitoring and real-time alerts provide peace of mind, allowing you to stay informed about your vehicle's status regardless of your location.

Additionally, the ability to remotely turn off the car adds an extra layer of security. This feature is particularly useful when the car is parked or being serviced, preventing unauthorized use and ensuring that you maintain control over your vehicle.

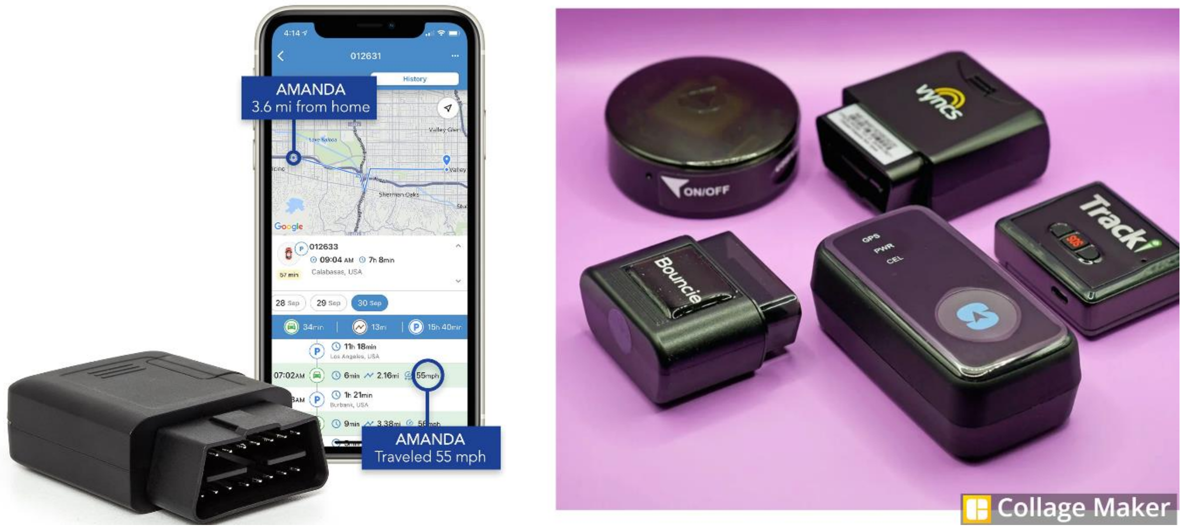

Figure2.1 Examples of various Smart Car tracking devices in the market

2.3 Methodology for Our Smart System:

The methodology for implementing a smart system using components like GSM, GPS, and MPU6050 involves initialization of critical components, checking GSM availability, reading sensor values, handling SMS responses, detecting accidents, and continuous testing. The system is initialized with proper communication and functionality. The availability of the GSM module is verified for SMS communication. Sensor values from MPU6050 are retrieved for analysis. Incoming SMS messages are analyzed to determine the appropriate response, such as controlling devices or sending location information. An accident detection algorithm continuously monitors sensor data for sudden changes and triggers alert notifications. The system undergoes continuous testing and waits for incoming commands and sensor data. This methodology enables effective car location tracking, theft and accident alerts, and remote control capabilities.

2.4 Specifications:

2.4.1 Electronic components used:

Various electronic components are used for creating electronic circuits. Consequently, our proposed circuit diagrams also contain those components that are specified in **Table.**

Components	Specifications
Arduino Nano	30 pins, Operating voltage: 5v,Memory 32KB
NEO-8M GPS module	4 pins, Operating voltage : 2.7v~3.6v
SIM800A GSM module	10 pins, Operating voltage : 3.4v~4.4v
Relay	5 pins, Operating voltage : 12v
BC547 transistor	Max current 800mA,C-E 65v,C-B 80v
LM2596 switcher	4 pins, Operating voltage 4.5v~40v
MPU6050	8 pins, Operating voltage 2.375V~3.46V

2.4.1.1 Arduino Nano

Arduino Nano is a compact and versatile microcontroller board based on the ATmega328P microcontroller, which is a low-power, high-performance chip from Atmel. It is similar to the Arduino Uno in functionality but with a smaller form factor, making it ideal for projects with limited space or for projects that require a low-cost and low-power board.

The Arduino Nano board is small in size, measuring only 18.5mm x 43.2mm, but still provides all the necessary features required for a typical Arduino project. It includes 14 digital input/output pins, 8 analog input pins, and 6 pulse-width modulation (PWM) pins. It also has a built-in USB interface, which allows it to be easily programmed and powered through a computer. Additionally, it has a 16 MHz crystal oscillator, a reset button, and an ICSP header for in-circuit programming.

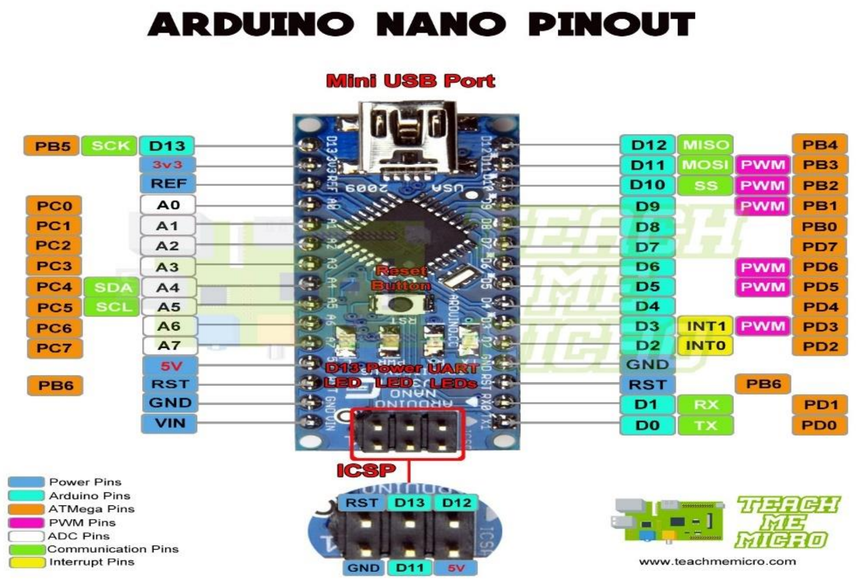

Figure2.2 Arduino Nano Pinout

2.4.1.2 NEO-M8M GPS module:

The Neo-M8M GPS module is built around the u-blox M8 positioning engine, renowned for its high performance and accuracy. It supports multiple satellite navigation systems, including GPS, GLONASS, Galileo, and BeiDou. This multi-constellation support ensures improved global coverage and enhanced positioning accuracy, even in challenging environments with limited line-of-sight to GPS satellites.

The module features an onboard antenna, eliminating the need for an external antenna setup. It operates on low power consumption, making it suitable for battery-powered applications. The Neo-8M also offers a variety of communication interfaces, including UART, I2C, and SPI, enabling seamless integration with a wide range of devices and platforms.

One of the standout features of the Neo-8M GPS module is its ability to provide highly accurate positioning information. By leveraging signals from multiple satellite systems, the module achieves improved positioning accuracy, enabling precise latitude, longitude, and altitude calculations. This accuracy is invaluable in applications such as vehicle tracking, asset management, precision agriculture, and surveying, where precise positioning information is essential.

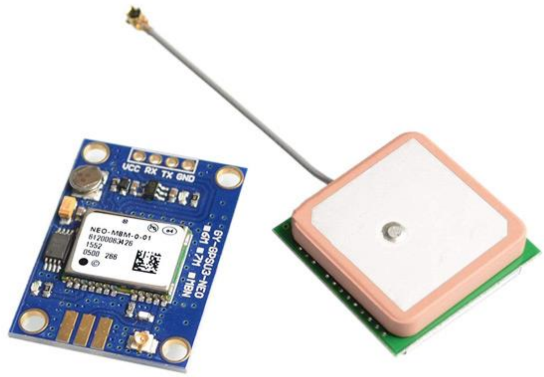

Figure2.3 Arduino Neo M8M Gps Module

2.4.1.3 SIM800A GSM module:

The GSM module SIM800A is a powerful and versatile cellular communication module widely used in various applications, including Internet of Things (IoT) projects, home automation systems, security systems, and more. With its compact size, low power consumption, and extensive feature set, the SIM800A module offers reliable and efficient connectivity through the Global System for Mobile Communications (GSM) network.

The SIM800A module is a feature-rich solution for wireless communication, making it an ideal choice for various applications. It offers GSM connectivity, supporting quad-band GSM/GPRS functionality for global network compatibility. This enables voice calls, SMS messaging, and GPRS data transmission. Despite its powerful capabilities, the SIM800A module has a compact size, making it easy to integrate into electronic projects with limited space. It consumes low power, making it suitable for battery-powered applications and offers power-saving modes and sleep modes to conserve energy. The module communicates with microcontrollers or host systems using a simple serial interface (UART) and supports standard AT commands. It enables data communication through GPRS, allowing devices to transmit and receive data over the internet using TCP/IP and HTTP protocols. The SIM800A module features an integrated SIM card slot, eliminating the need for external SIM card holders. It also offers enhanced functionality, including audio recording and playback, digital audio interfaces, Real-Time Clock (RTC) support, and General Purpose Input/Output (GPIO) pins for connecting multiple sensors and peripherals.

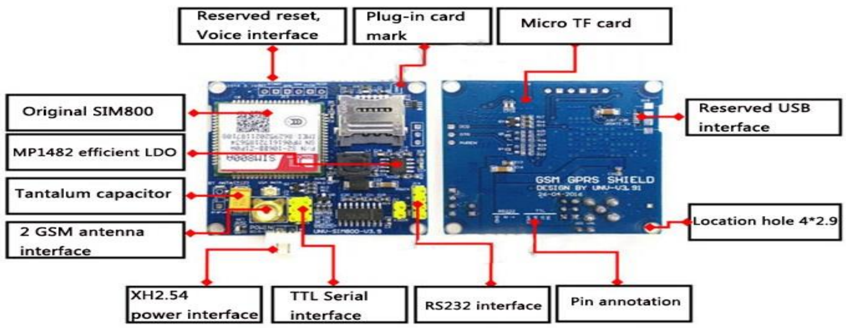

Figure2.4 SIM800A PCB components

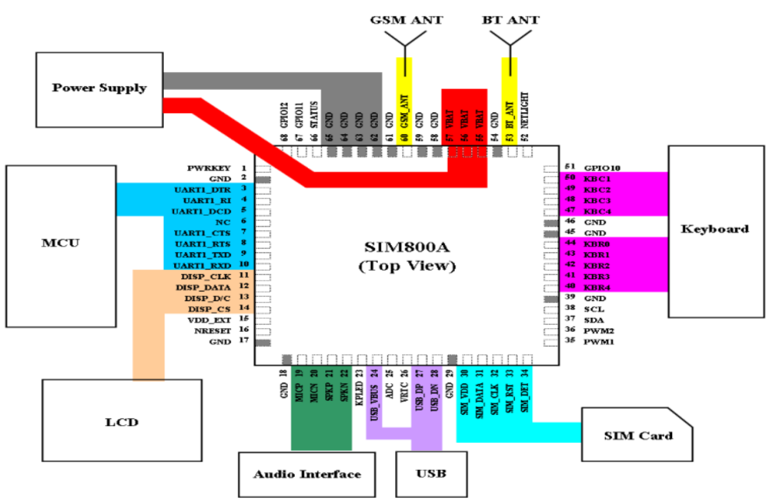

Figure2.5 SIM800A chip pinout

2.4.1.4 12V relay:

A 12V relay is an electrical switch that is activated by an electrical signal of 12 volts. It is used in a wide range of electronic applications, particularly in control circuits where low-power signals need to control high-power loads. The relay allows a low-power signal to control a high-power load by switching the load on and off with the help of an electromechanical switch.

A 12V relay consists of two main parts: a coil and a set of contacts. When a voltage of 12 volts is applied to the coil, it generates a magnetic field that causes the contacts to move and make or break an electrical connection. The contacts can be normally open (NO) or normally closed (NC), and when the relay is energized, the contacts change position, depending on the type of relay.

In a typical automotive application, a 12V relay can be used to control high-power devices such as lights, motors, and fans. For example, a 12V relay can be used to control the headlights of a car. When the headlight switch is turned on, the 12V signal is sent to the relay, which in turn activates the contacts, allowing the current to flow to the headlights. When the switch is turned off, the signal to the relay is interrupted, and the contacts return to their original position, cutting off the current to the headlights.

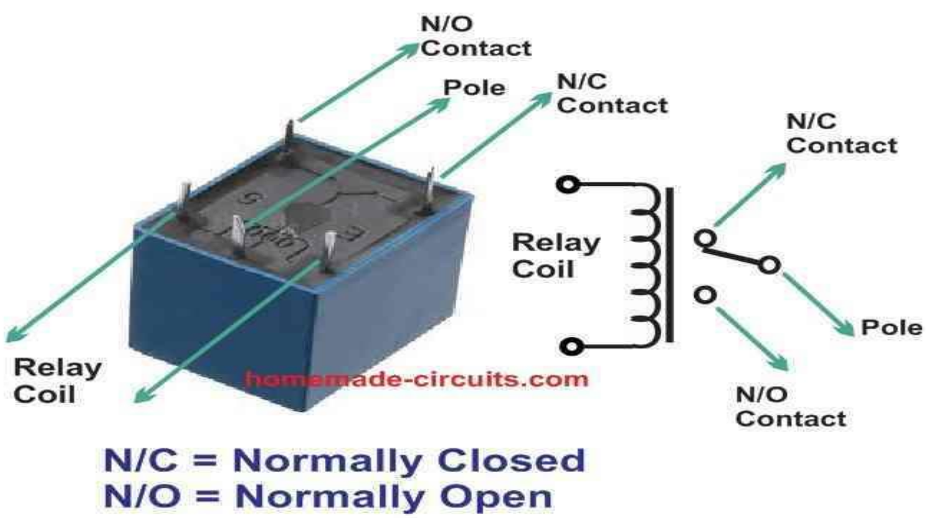

Figure2.6 Relay Pinout

2.4.1.5 BC547 Transistor:

The BC547 is a small signal NPN bipolar junction transistor (BJT) commonly used in electronic circuits for amplification and switching applications. It is one of the most popular general-purpose transistors due to its low cost, high gain, and low noise characteristics.

The BC547 transistor has three terminals: the emitter, the base, and the collector. When a small current is applied to the base terminal, the transistor allows a much larger current to flow between the collector and emitter terminals, allowing it to act as a switch or an amplifier.

The BC547 transistor has a maximum collector current of 100mA and a maximum collector-emitter voltage of 45V, with a typical gain (hfe) of 110-800. It is commonly used in low-power amplifiers, switching circuits, and signal processing applications.

Overall, the BC547 is a versatile and widely used transistor in electronic circuits due to its low cost and wide availability.

Figure2.7 BC547 transistor pinout

2.4.1.6 LM2596 Switcher:

The LM2596 switcher is a popular and highly versatile DC-DC step-down converter integrated circuit (IC) widely used in electronic projects and applications. It provides an efficient and reliable solution for converting higher input voltages to lower output voltages, making it a valuable component in power supply designs, battery-powered systems, and various electronics projects.

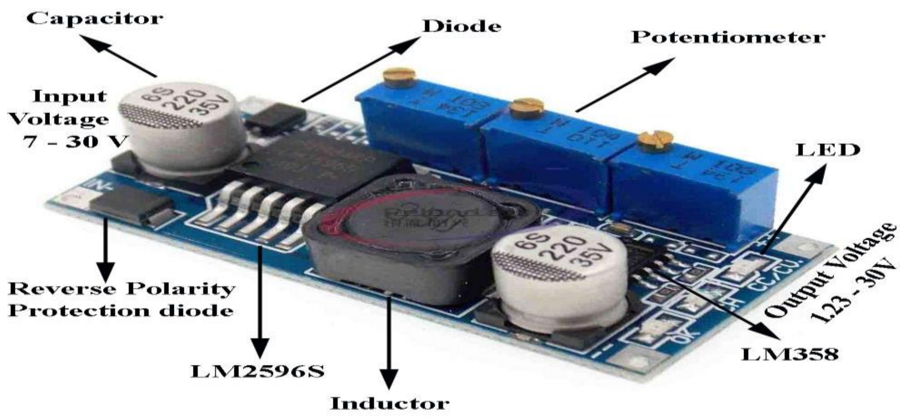

Figure2.8 LM2596 Step down converter IC components

The LM2596 switcher is a versatile voltage conversion solution known for its excellent features and performance. It accepts a wide range of input voltages, making it compatible with various power sources like batteries, wall adapters, and automotive systems. The primary function of the LM2596 is to step down the input voltage to a regulated output voltage, offering efficient conversion with minimal power loss. Its high-efficiency switch-mode architecture enhances overall efficiency and reduces power dissipation, resulting in improved energy efficiency and reduced heat generation. The LM2596 provides adjustable output voltage, allowing users to set the desired output level within a specified range, making it adaptable to a wide range of applications. The IC incorporates current limit protection to safeguard both itself and the connected circuitry from excessive current draw. Additionally, the LM2596 features thermal shutdown functionality, which temporarily shuts down the device if the operating temperature exceeds a safe threshold. It also offers short circuit protection to prevent potential damage in the event of a short circuit. These features make the LM2596 an excellent choice for voltage conversion applications where efficiency, reliability, and protection are paramount.

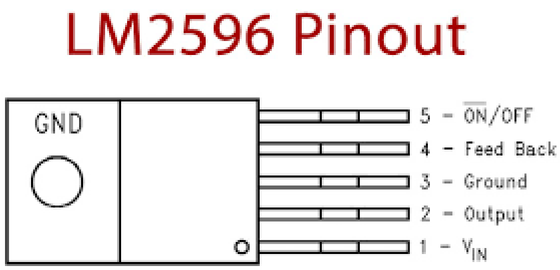

Figure2.9 LM2596 chip pinout

2.4.1.7 MPU6050

The MPU6050 module is a compact and powerful motion sensing device that combines a 3-axis accelerometer and a 3-axis gyroscope. With its ability to measure motion, acceleration, and rotation, the MPU6050 module has become a popular choice in various applications, including robotics, gaming, motion tracking, and gesture recognition. This page explores the features, working principle, and applications of the MPU6050 module.

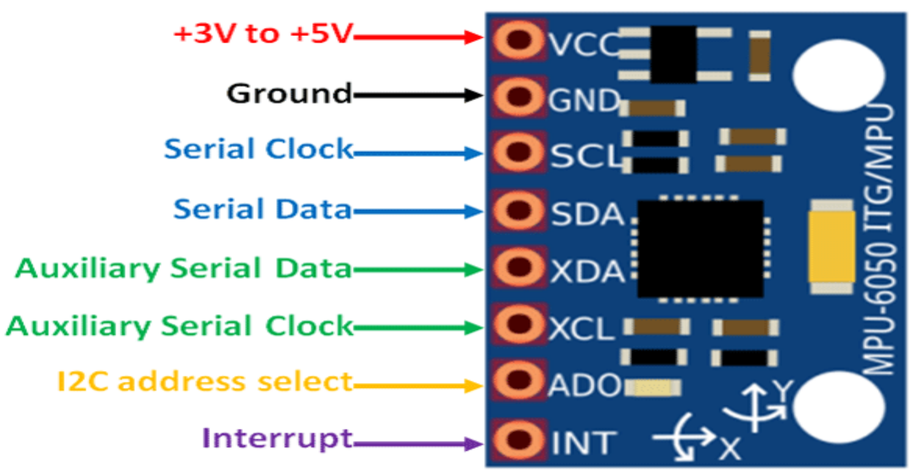

Figure2.10 MPU6050 pinout

The MPU6050 module is a highly capable motion sensing solution that offers a range of features for motion tracking applications. It combines a 3-axis accelerometer and a 3-axis gyroscope, providing a total of 6 degrees of freedom to accurately measure motion, acceleration, and rotational movement. One of its notable features is the onboard digital motion processor (DMP), which handles complex motion processing tasks, relieving the main microcontroller of computational burden. This results in efficient and streamlined motion tracking operations. The MPU6050 module ensures high sensitivity and accuracy in measuring motion and orientation changes, enabling precise tracking and detection of movements. Moreover, it is designed to operate with low power consumption, making it suitable for battery-powered applications where energy efficiency is critical. The module communicates with a microcontroller or host system using the widely adopted Inter-Integrated Circuit (I2C) protocol, facilitating seamless integration and control. With its comprehensive motion sensing capabilities and user-friendly interface, the MPU6050 module is an excellent choice for applications that require precise motion tracking and analysis.

Working Principle: The MPU6050 module combines the measurements from its accelerometer and gyroscope to determine the motion and orientation of an object. The accelerometer measures linear acceleration along the X, Y, and Z axes, while the gyroscope measures angular velocity or rotational changes around these axes.

Using sensor fusion algorithms, such as Kalman filtering or complementary filtering, the MPU6050 combines the data from the accelerometer and gyroscope to calculate the pitch, roll, and yaw angles of the module or the object it is attached to. This fusion of sensor data enhances the accuracy and stability of the motion measurements.

2.4.2 Useful Software Tools:

2.4.2.1 Arduino IDE:

Arduino IDE (Integrated Development Environment) is a software platform specifically designed for programming Arduino boards. It provides a user-friendly interface and a set of tools that simplify the process of writing, compiling, and uploading code to Arduino microcontrollers. With the Arduino IDE, even beginners can quickly get started with coding and building electronic projects. The IDE features a simple code editor with syntax highlighting, auto-completion, and error checking to help users write clean and error-free code. It also includes a built-in library manager, which allows users to easily access and include pre-existing libraries for various functionalities. Once the code is written, the Arduino IDE compiles it into a machine-readable format and uploads it to the connected Arduino board. The Arduino IDE is compatible with multiple platforms, making it accessible to a wide range of users. It has become the go-to programming environment for Arduino enthusiasts and professionals alike, empowering them to bring their electronic projects to life.

Figure2.11 Arduino IDE Logo

2.4.2.2 Proteus:

Proteus is a widely used software tool in the field of electronics design and simulation. It offers a comprehensive set of features that enable engineers and designers to design, test, and validate electronic circuits and systems. With its intuitive interface, Proteus allows users to create circuit diagrams using a vast library of components, including microcontrollers, sensors, and integrated circuits. The software offers both schematic capture and PCB layout modules, allowing users to seamlessly transition from designing the circuit diagram to designing the physical PCB layout. Additionally, Proteus provides a powerful simulation engine that enables users to test and validate their designs in a virtual environment, saving time and resources. The software also supports microcontroller simulation, allowing users to write and debug embedded software. Proteus is a versatile tool that caters to the needs of professionals, educators, and hobbyists, making it an essential resource in the electronics design and simulation process.

Figure2.12 Proteus Logo

2.4.2.3 Fritzing:

Fritzing is a popular open-source software tool used for designing, prototyping, and documenting electronic circuits. It provides a user-friendly interface that allows both beginners and experienced electronics enthusiasts to create circuit diagrams, design PCB layouts, and even simulate circuits. With its intuitive drag-and-drop functionality, Fritzing enables users to easily select and place components from a vast library of electronic parts. The software also offers features for creating custom parts and connecting them using virtual wires. Additionally, Fritzing allows users to create interactive views of their circuits, making it a valuable tool for educational purposes and sharing circuit designs with others. Whether you are a hobbyist, student, or professional, Fritzing simplifies the process of visualizing and prototyping electronic circuits, making it an essential tool in the world of electronics design.

Figure2.13 Fritzing logo

2.4.2.4 ConceptDraw Diagram:

ConceptDraw Diagram is a comprehensive diagramming and visualization software that offers a wide range of tools and features for creating professional-looking diagrams. It provides a user-friendly interface and a vast library of pre-designed shapes, symbols, and templates, making it easy for users to create flowcharts, organizational charts, mind maps, network diagrams, and many other types of visual representations. With ConceptDraw Diagram, users can quickly drag and drop elements onto the canvas, connect them with lines and arrows, and customize their appearance to convey information effectively. The software also supports collaboration, allowing multiple users to work on the same diagram simultaneously, making it a valuable tool for team projects and presentations. With its versatility and intuitive interface, ConceptDraw Diagram is a powerful tool for visualizing ideas, processes, and data, making it a popular choice for professionals across various industries.

Figure2.14 Concept DrawDiagram Logo

2.4.2.5 Blender

Blender is a powerful and versatile open-source 3D design software widely used by artists, designers, and animators. With its comprehensive set of tools and features, Blender enables users to create stunning visualizations, animations, and interactive 3D models. It offers a user-friendly interface that allows for efficient modeling, sculpting, texturing, rigging, and animation. Blender supports various rendering engines, including Cycles and Eevee, which produce high-quality and realistic visual outputs. The software also provides advanced simulation capabilities for fluid dynamics, particles, cloth, and more. Additionally, Blender has a vibrant and active community, contributing to the development of numerous add-ons and tutorials, further expanding its functionality. Whether you are a beginner or an experienced professional, Blender offers a robust platform for 3D design and animation, making it a popular choice in the industry.

Figure2.15 Blender Logo

2.5 Conclusion

In this chapter, we went through the methodology for the car tracker as well as the principle of operation for sending SMS texts using the GSM module. We also explained the various electronic components that make up this project and how they interact with each other. This will allow us to approach the practical part of our project in the next chapter.

Chapter 3

Simulation and Practical Realization

3.1 Introduction

The development of the SMFS has revolutionized the way we interact with and control our environment. One such example is the smart device used to remotely turn on and off a car by sending a simple text message. Not only does this system offer remote control capabilities, but it also provides safety features like accident detection and anti-theft alerts.

In this chapter, we will delve into the details of the program flowchart and the circuit design of this system, as well as explore the challenges we faced during its creation. Additionally, we will discuss the results of the system’s functionality and provide insights into possible future developments to improve it even further.

3.2 Working Principle in General:

The practical realization of a GPS and GSM car tracker involves designing and assembling the physical components of the device, including the GPS and GSM modules, microcontroller, sensors, and other electronic components. The design must also include a robust enclosure to protect the device from environmental factors such as moisture, dust, and vibrations.

Once the hardware has been assembled, the next step is to program the microcontroller to collect data from the sensors, process the GPS data, and communicate that data to a remote server or mobile device using the GSM module. This involves writing software in programming languages such as C or Python.

To validate and test the functionality of the GPS and GSM car tracker, simulation software can be used. Simulation software allows the device to be tested in a virtual environment, which can help identify and address any issues before deploying the device in the real world [3].

Overall, the practical realization and simulation of a GPS and GSM car tracker involves designing and assembling the hardware, programming the microcontroller, and testing the device using simulation software to ensure reliable and accurate tracking and monitoring of the vehicle.

3.2.1 Circuit Diagram for Car Tracker:

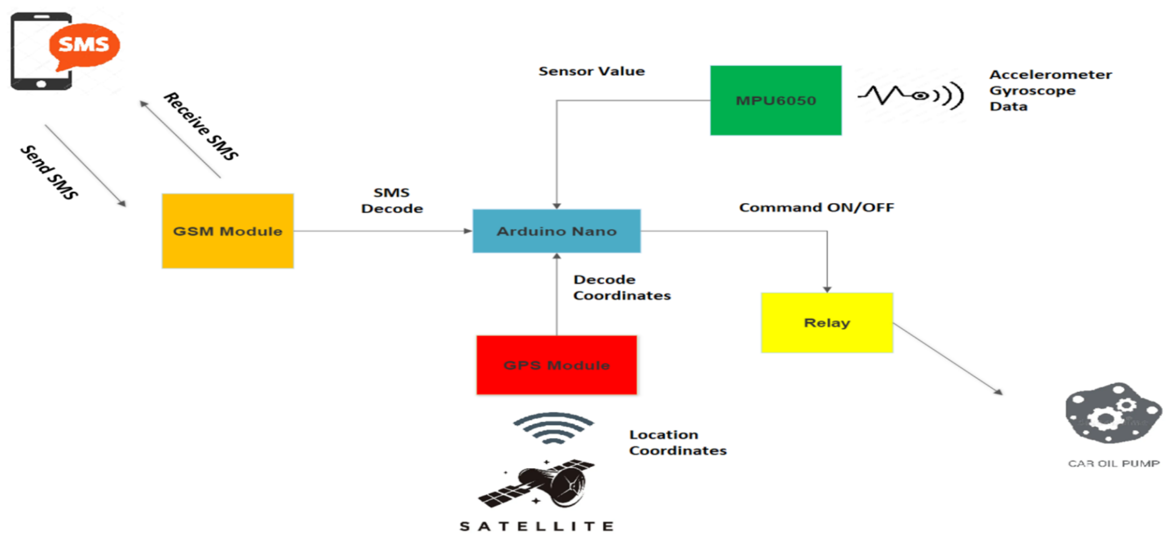

Figure3.1 Circuit diagram for SMFS

Here's the explanation of the circuit diagram we used involving Arduino Nano, GPS module, GSM module, MPU-6050 accelerometer and gyroscope module, and LM2596 switcher:

1. Arduino Nano: The Arduino Nano serves as the main microcontroller in the circuit. It provides the processing power and controls the various modules.

2. GPS Module: The GPS module communicates with the Arduino Nano via serial communication (UART) to receive location data from GPS satellites. It typically consists of a GPS receiver, antenna, and necessary circuitry.

3. GSM Module: The GSM module allows the Arduino Nano to communicate over the cellular network. It enables sending and receiving SMS messages, as well as transmitting data. The GSM module usually includes a SIM card slot and the necessary communication circuitry.

4. MPU-6050: The MPU-6050 module integrates a 3-axis accelerometer and a 3-axis gyroscope. It measures acceleration and angular velocity, providing information about the

vehicle's movement and orientation. It communicates with the Arduino Nano via I2C (Inter-Integrated Circuit) protocol.

5. LM2596 Switcher: The LM2596 is a step-down DC-DC switching regulator. It regulates the voltage input from the power source to a lower and stable voltage required by the circuit components. It ensures a consistent power supply for the Arduino Nano, GPS module, GSM module, and MPU-6050.

3.2.2 Circuit Design and Connections:

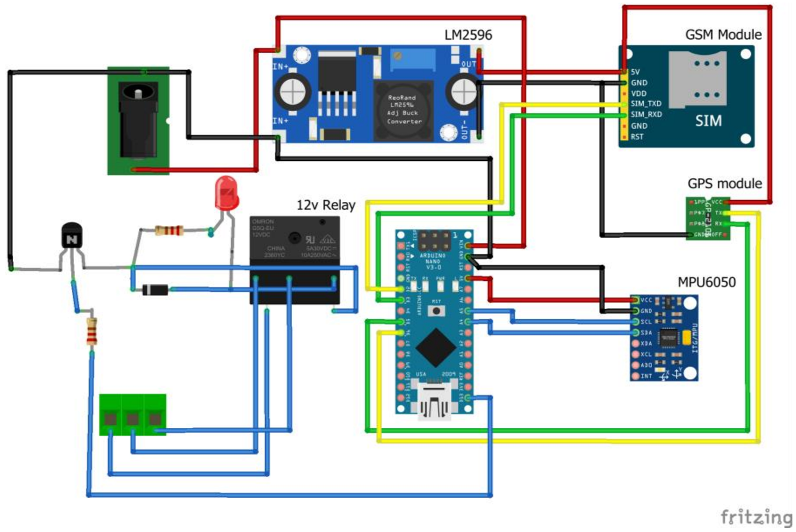

Figure3.2 Circuit design for SMFS

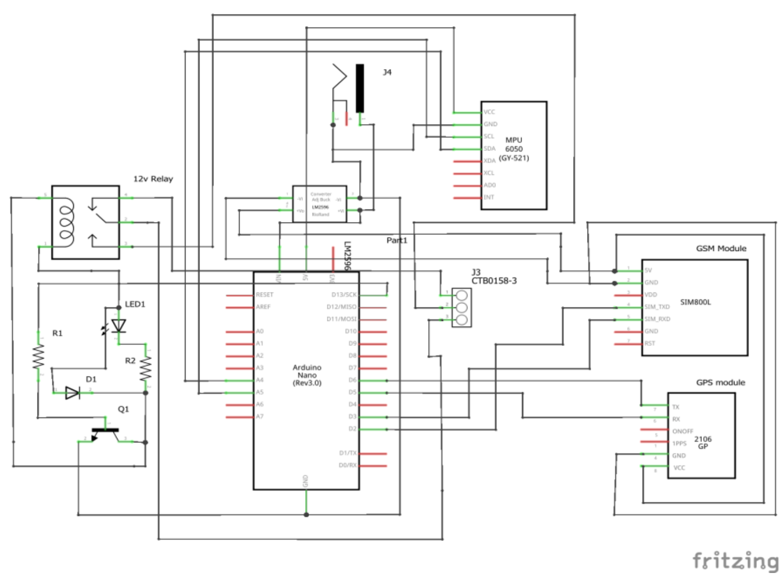

Figure3.3 Internal Circuit Connections and wiring

The circuit connections can be summarized as follows:

- The GPS module connects to the Arduino Nano's serial pins (RX and TX) for data communication.
- The GSM module connects to the Arduino Nano's serial pins for communication, and additional pins may be used for control signals (e.g., power on/off).
- The MPU-6050 connects to the Arduino Nano via the I2C interface, typically using the SDA (data line) and SCL (clock line) pins.
- The LM2596 switcher connects to the power source and provides regulated power to the Arduino Nano, GPS module, GSM module, and MPU-6050.

3.2.3 Pin Configuration:

GSM	LM2596
Vcc GND	Out$^+$ Out$^-$
	ARDUINO
Rx Tx	D3 (Tx) D2 (Rx)

GPS	LM2596
Vcc GND	Out$^+$ Out$^-$
	ARDUINO
Rx Tx	D6 (Tx) D5 (Rx)

MPU6050	ARDUINO
Vcc GND SCL SDA	SV GND A5 A6

ARDUINO	Circuit
VIN GND PIN 13	12V (Power Supply) GND (Power Supply) Coil input (Relay)

3.3 Challenges:

The development of the device is a complex task that requires careful planning and attention to detail. While the device can provide multiple benefits, there are several issues that can arise during development, including connectivity problems with GPS and GSM connectivity, device heat, and more. These issues can impact the overall performance of the device, reduce its usability, and negatively affect consumer satisfaction. It is essential to identify and address these issues during development to ensure a smooth and efficient user experience.

3.3.1 Relay heat:

When designing electronic circuits, it is crucial to ensure that each component operates reliably to avoid overheating and potential failures. One critical aspect is choosing the appropriate resistance value (R) to optimize circuit performance, the suitable resistance value (R) is approximately 12k ohms. By carefully selecting this resistance value, we can ensure reliable relay operation while minimizing heat generation and optimizing the overall circuit performance.

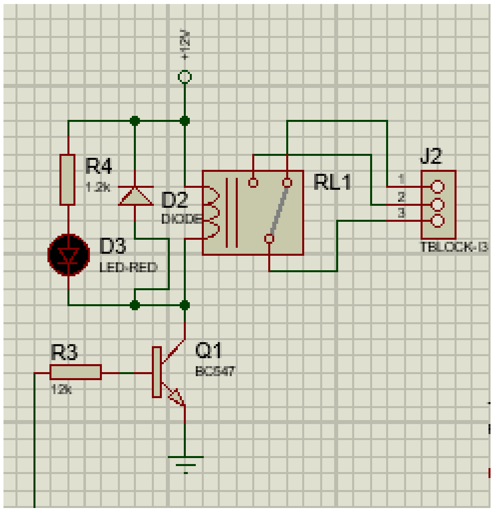

Figure3.4 Circuit part for Relay command

In the given setup, the Resistance (R3) is connected to the D13 pin of the Arduino nano. The purpose of this connection is to control the engagement of the relay. To achieve this, a transistor NPN Q1 is utilized for switching the relay. The base current of the transistor is limited by a 12k base resistor (R3).

To protect the transistor and the Arduino from coil discharges, a diode D2 is connected in parallel with the relay coil. This diode acts as a flyback diode, preventing voltage spikes and protecting the sensitive components.

The LED is used as an indication of the process end. It is connected with a 1.2k resistor (R4) for protection against excessive current. When the process is complete, the LED lights up and provides a visual indication.

3.3.2 Using GSM:

The GSM SIM800A module is a reliable GSM/GPRS module used in embedded systems for voice, SMS, and data functionality. However, users may face two common issues: power supply and network compatibility. Power supply problems arise when the module doesn't receive a stable and sufficient power source, leading to malfunctions or initialization failures. To solve this, using a voltage regulator like the LM2596 can ensure a stable power supply that meets the module's requirements. Network compatibility issues occur when the module's supported frequencies don't align with those of the network provider in a particular region. This can result in poor signal quality or failure to connect. Verifying the frequency bands supported by the module and comparing them with the network provider's specifications is vital to ensure compatibility. Additionally, selecting the appropriate antenna is crucial for optimal signal reception. In summary, to address power supply issues with the SIM800A module, use a voltage regulator like the LM2596. For network compatibility, verify the supported frequency bands and select a suitable antenna [4]. By considering these solutions, users can overcome these common challenges and ensure the reliable performance of the SIM800A module in their embedded systems.

Figure3.5 Network error and Power supply issues

3.3.3 Using GPS:

At times, we may encounter the common issue of being unable to acquire a GPS signal with our GPS module. This problem can arise due to factors such as limited satellite visibility, interference, or incorrect module configuration. However, there are steps we can take to address this problem. Firstly, we should ensure that our GPS module is positioned in an open area with an unobstructed view of the sky, avoiding any physical barriers that may block satellite signals.

It is also important to review and verify the module's configuration settings, ensuring they are correctly adjusted for GPS functionality. Another helpful solution involves updating the module's firmware, as well as checking the connection of our GPS antenna to ensure it is securely attached. In situations where the built-in antenna proves insufficient, we can consider using an external GPS antenna with higher gain to enhance signal reception [4]. By following these steps, we can increase the likelihood of successfully acquiring a GPS signal with our module.

Figure 3.6 GPS Signal Error

3.4 Design Methodology:

3.4.1 Circuit Implementation:

At first we used the Proteus program to design and print the circuit as we see in this figure:

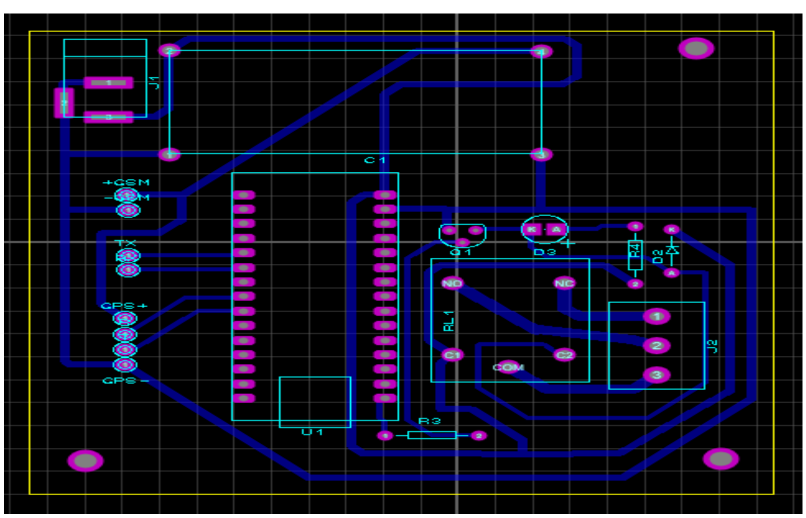

Figure3.7 Circuit simulation for PCB

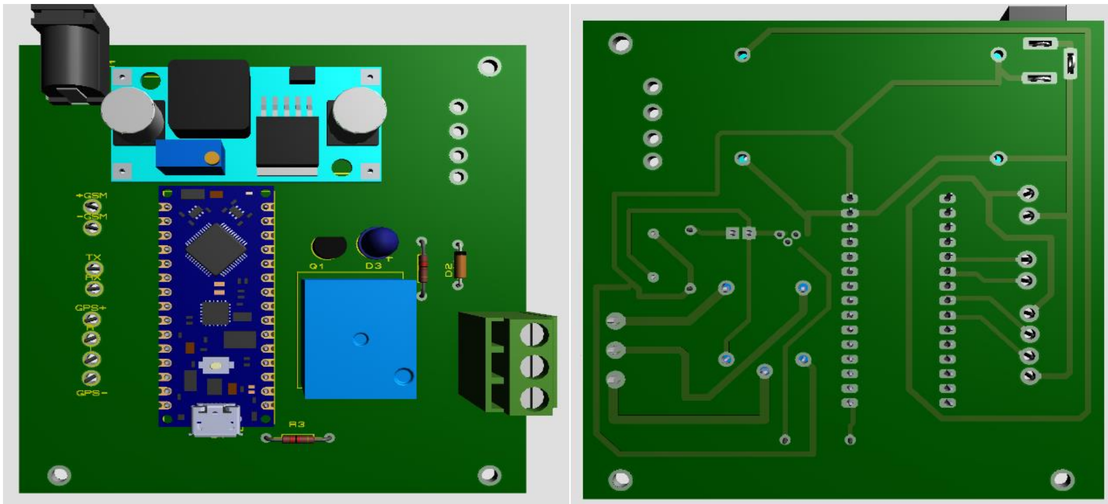

Figure3.8 3D visual for the PCB

Unfortunately since we decided to add the feature of car accident detection based on MPU6050, so we had to add 4 holes to the circuit which we wired manually to integrate the accelerometer

3.4.2 PCB Design Method:

Creating PCBs involves several steps, from designing the circuit schematic to manufacturing the actual board. Here's a step-by-step guide to help you create your own PCB:

3.4.2.1 What is PCB?

A printed circuit board (PCB) mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non-conductive substrate.

A printed circuit board has pre-designed copper tracks on a conducting sheet. The pre-defined tracks reduce the wiring thereby reducing the faults arising due to lose connections. One needs to simply place the components on the PCB and solder them.

3.4.2.2 Different methods to make PCB

There are in all three basic methods to make PCB

1. Iron on Glossy paper method

2. Circuit by hand on PCB

3. Laser cutting edge etching.

Since laser method is industrial method to make PCB we will get in detail of first two method to make PCB at home.

3.4.2.3 Creating PCB Layout of the Circuit

This is usually done by converting the circuit's schematic diagram into a PCB layout using PCB layout software. There are many open source software packages for PCB layout creation and design.

We designed my circuit schematic in Proteus.

Note: In Proteus: File> Export>Image Be sure to set DPIG to 1200 for better quality

3.4.2.4 Materials required:

Required materials
Magazines or advertising brochures (More on this later).
Laser printer Alternately, a photocopier should work
Household clothes iron
Copper clad laminate
Etching solution
Kitchen scrubs
Thinner (e.g. acetone)
Plastic coated wire

Figure3.9 Materials required for DIY circuit board printing

You need also: Permanent black marker, blade cutter, sandpaper, kitchen paper, cotton wool, some old clothes.

To start making PCB, consider a simple project TOUCH SWITCH using IC555

3.4.2.5 Take Printout of PCB Layout

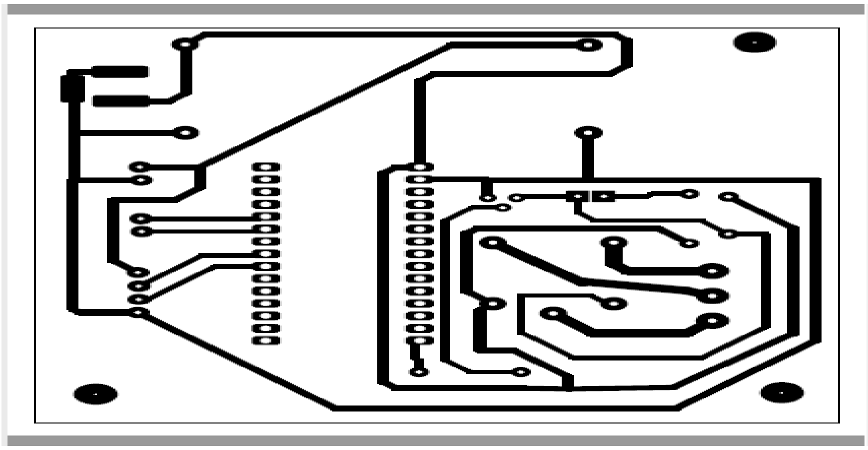

Figure3.10 Printout of PCB layout

Take a print out of your PCB layout using the laser printer and the A4 photo paper/glossy paper. Keep in mind the following points:

- You should take the mirror print out
- Select the output in black both from the PCB design software and printer driver settings
- Make sure that the printout is made on the glossy side of the paper

3.4.2.6 Cutting the Copper Plate and Make It Smooth

Cut the copper board according to the size of layout.

Rub the copper side of PCB using steel wool or abrasive spongy scrubs. This removes the top oxide layer of copper as well as the photo resists layer.

Sanded surface allow image to stick better

3.4.2.7 Iron on glossy paper Method

Transfer the printed image from the photo paper to the board. Make sure to flip top layer horizontally. Put the copper surface of the board on the printed layout. Ensure that the board is aligned correctly along the borders of the printed layout. Put tape along the two sides of the board non-copper side. This will help to hold the board and the printed layout in position.

- After printing on glossy paper we iron it image side down to copper side. Heat up the Electric iron to the maximum temperature.
- Put the board and photo paper arrangement on a clean wooden table and clothes with the back of the photo paper facing you.
- Hold one end of it by the Towel and put the hot iron on the other end for about 10 seconds. Now, iron the photo paper all along using the tip and applying little pressure for about 5 to 15 mins.
- Pay attention towards the edges of the board – you need to apply pressure, do the ironing slowly.
- Long hard press seems to work better than moving iron around.
- Here iron heat melts ink printed on glossy paper and get transfer to copper plate.

3.4.2.8 Peeling

After ironing, place printed plate in Luke warm water for around 10 minutes. Paper will dissolve and remove paper gently. Remove the Paper off at low angle & traces.

In some cases while removing paper some of track get fainted .

See figure in white box black line track is light in colour hence we can use black marker to dark lighted track as shown in image

3.4.2.9 Etching

Figure3.11 Etching step for removing unwanted copper from PCB

You need to be EXTREMELY careful & cautious while performing this step

• First put rubber or plastic gloves.

• Place some newspaper so that etching solution do not spoil floor.

1) Take a plastic box and fill it up with some water.

2) Dissolve 2-3 tea spoon of ferric chloride power in the water.

3) Dip the PCB into the Etching solution (Ferric chloride solution, Fecl3) for approximately 30 mins.

4) The Fecl3 reacts with the unmasked copper and removes the unwanted copper from the PCB.

5) This process is called as Etching. Use pliers to take out the PCB and check if the entire unmasked area has been etched or not. In case it is not etched leave it for some more time in the solution.

Gently move plastic box to and fro so that etching solution react with exposed copper and form iron and copper chloride.

After every 2-3 minutes check whether all copper is etched or not.

3.4.2.10 Final Touch

Figure show PCB of both circuit made using print out and using marker.

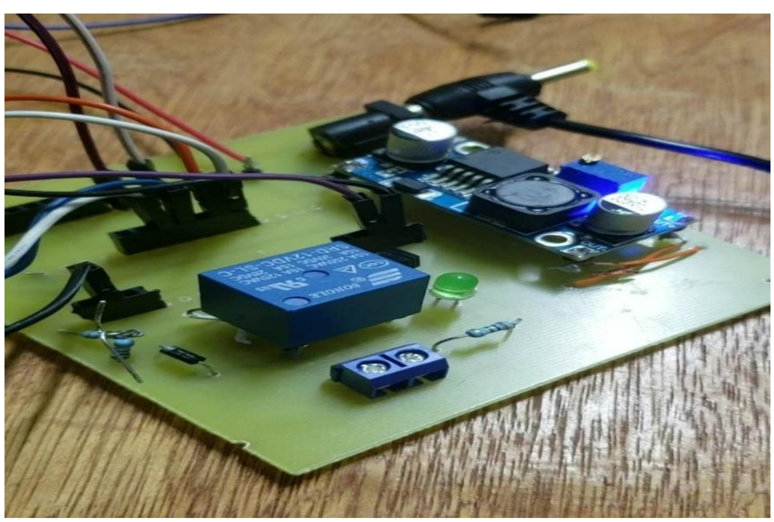

Figure3.12 final result after drilling and soldering all the components

A few drops of thinner (nail polish remover works well) on a pinch of cotton wool will remove completely the toner, bringing back the copper surface.Rinse carefully and dry with a clean cloth or kitchen paper.Trim to final size and refine edges with sandpaper.Acetone help glossy paper stick to rough paper.

Drill hole and solder all the component & PCB is ready.

Unfortunately, these circuits need a professional machine to print them, and this is because with the experience of printing the circuit, we faced a problem in soldering components and short circuits.

So we've enlisted the help of a professional circuit printing company by the name of Almitech, We sent them our gerber file as shown in this figure below

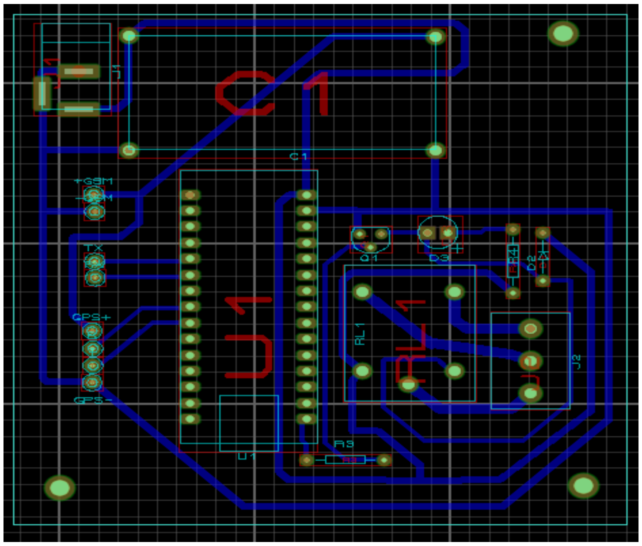

Figure3.13 Gerber file for Printing circuit

Then they printed the circuit and sent it to us via shipping and the result is as follows

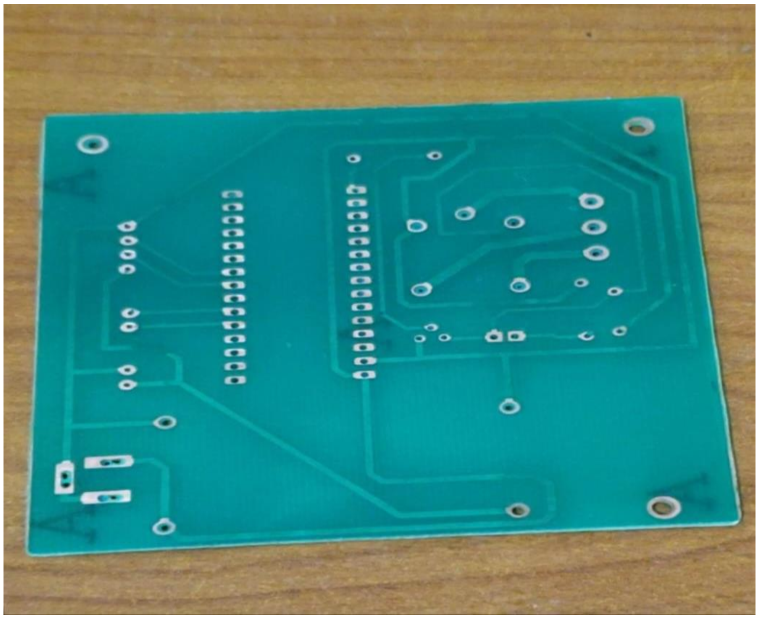

Figure3.14 Final result of almitech PCB

After we soldered the components and modules we got this result

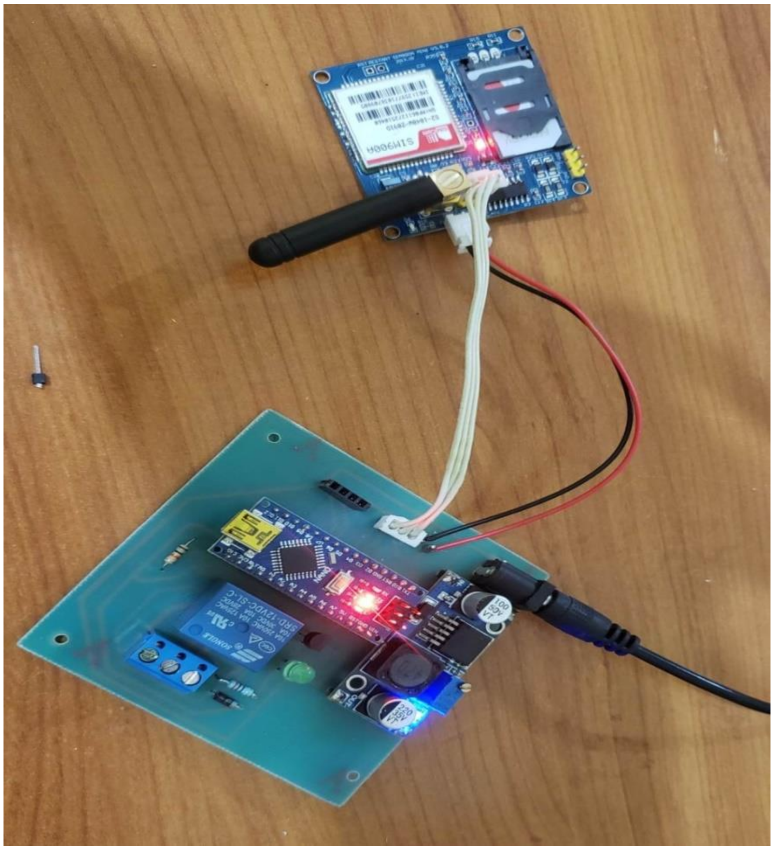

Figure3.15 Final result after soldering all the components

3.5 Program introduction:

In this section, we discuss how the programs of the system work. The following diagrams describe the flowcharts that illustrate the algorithms used. We also discuss some of the challenges faced during the programming of the system, with one of them being the problem of reading data from GPS and the algorithm of MPU-6050 to detect accidents and thefts.

3.5.1 Flowchart Program:

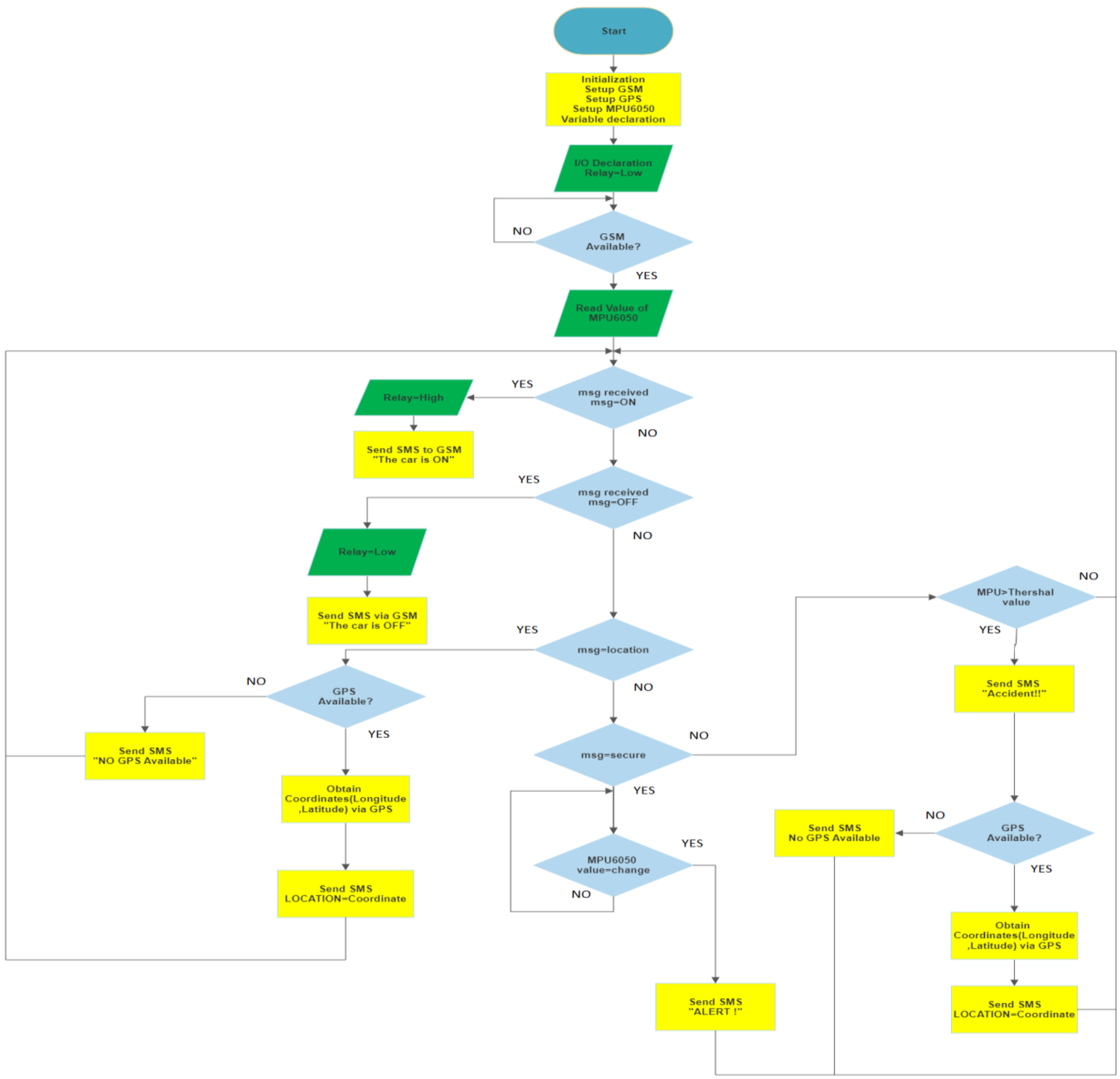

Figure3.16 Flowchart explaining the program

3.5.2 Program explanation:

The following flowchart describes the function of the entire system. Essentially, the program begins by initializing the critical components, such as the GSM, GPS, and MPU6050. After that, the program checks to see if the GSM module is available, indicating that it is ready to send and receive SMS messages.

Next, the system reads values from the MPU6050 to prepare for further action. Moving on to the crux of the program, when an SMS is received, the appropriate response is taken:

1. "SMS = ON/OFF" – The Arduino sets the 13th pin of the relay to high or low accordingly.
2. "SMS = location" – The Arduino attempts to obtain the location coordinates and then sends the information to the phone.
3. "SMS = secure" – The system utilises the MPU6050 data to send an alert SMS to the user if motion is detected.

The last function is to read the MPU6050 value by applying the accident detection algorithm. The system then sends an SMS to the user indicating an accident has been detected, along with the relevant location. Throughout, the program continuously tests and waits.

3.5.3 GPS Setup:

One of the remarkable features of the NEO-8M GPS receiver is its ability to provide data almost instantly upon power-up. After we upload the program to the Arduino board and open the Serial Monitor in the Arduino IDE, the GPS receiver starts sending data in the form of NMEA (National Marine Electronics Association) sentences.

NMEA is a standardized message format used by GPS receivers, consisting of rows of data known as sentences. Each sentence contains comma-separated data fields, making it easy for us as developers to parse and extract the information. The NEO-8M GPS module typically updates the data once per second (1Hz frequency) by default, but we can configure it to update at higher frequencies, such as up to 10 times per second (10Hz frequency), based on our requirements.

There are many sentences in the NMEA standard. The most common are: $GPRMC provides time, date, latitude, longitude, altitude, and estimated velocity

$PGGA, 123519, 4807.038, N, 01131.000, E, 1, 08, 0.9, 545.4, M, 46.9, M, , *47.

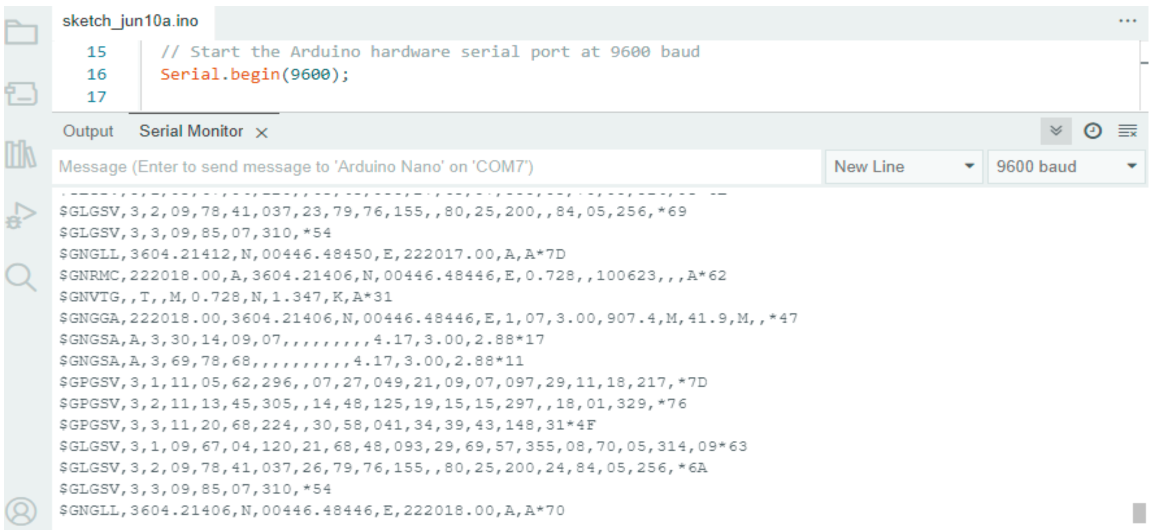

Figure3.17 Data sent by GPS using NMEA sentences

When working with NMEA sentences, it is common for us to read and parse them to obtain user-friendly information. Our goal is to extract relevant data from the NMEA sentence, such as latitude and longitude.

To simplify the parsing process, we can utilize various libraries like TinyGPS++ that help us extract specific information, including latitude and longitude, directly from the NMEA sentences received from the NEO-8M GPS module.

For example, by correctly encoding the new NMEA sentence, we can retrieve the latitude and longitude values. We can then process and utilize these values for various purposes in our program. As shown in the figure below

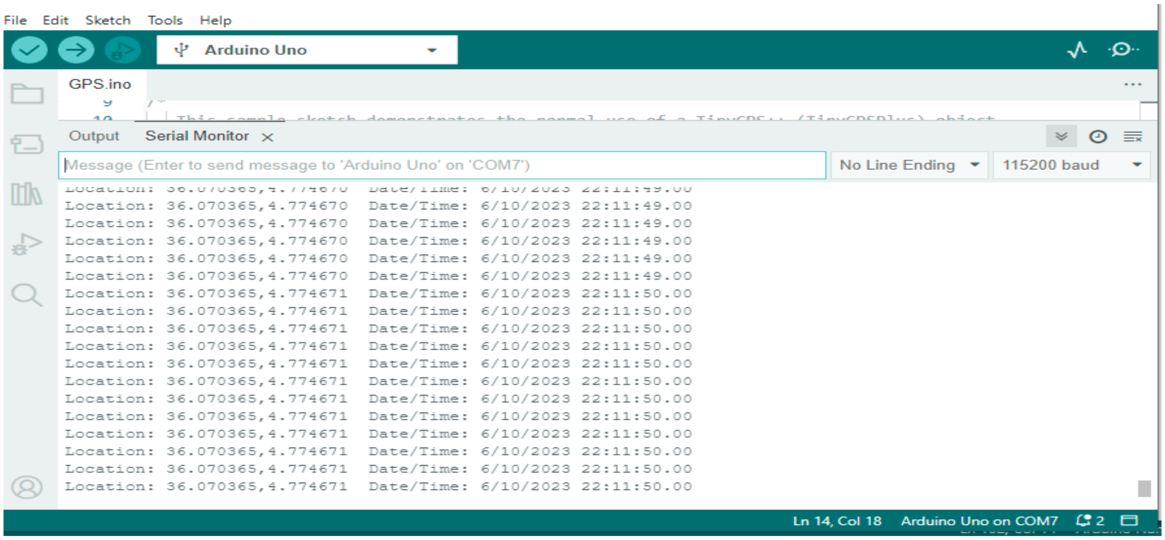

Figure3.18 Converting NMEA sentences to traditional (lat,long) format

3.5.4 Working principle of car accident detection with MPU6050:

In the pursuit of safer roads and reduced accident consequences, car accident detection systems have emerged as a vital technology. These systems employ sensors and intelligent algorithms to promptly identify and classify accidents, enabling swift responses and potentially saving lives [5] A key aspect of these systems is the determination of appropriate threshold values for accurate accident detection. This article explores the car accident detection system, its components, and the significance of threshold values in ensuring precise accident identification.

Car Accident Detection System: The car accident detection system integrates various components, including accelerometer sensors, to monitor vehicle dynamics and detect potential accidents. Accelerometers measure changes in g-forces, providing valuable data on acceleration and deceleration. Complementary sensors such as gyroscopes, GPS modules, and impact sensors enhance the system's accuracy and reliability [6].

Threshold Values for Accident Detection: Threshold values play a vital role in accurately detecting accidents. They establish the limits beyond which measured g-forces indicate the occurrence of an accident. Threshold values are carefully chosen considering the system's sensitivity, vehicle characteristics, and desired severity levels. Common threshold ranges include no accident (0-4g), mild accident (4-20g), medium accident (20-40g), and severe accident (>40g) [7].

Significance and System Functionality: The defined threshold values enable the car accident detection system to differentiate between normal driving events and potential accidents of varying severities. When g-forces exceed the thresholds, the system triggers appropriate actions such as emergency calling systems, safety mechanism activation, or alert notifications. This rapid response can significantly reduce emergency response times, provide timely assistance, and save lives.

3.5.5 How to power on the car using the relay:

To control the operation of an oil pump, you can connect it to a switch, providing a convenient means to turn the pump on and off as needed. One common approach is to use a relay as the intermediary between the pump and the switch. The relay acts as an electrically controlled switch that can handle higher currents and voltages, making it suitable for controlling the oil pump.

By connecting the oil pump to a relay, we can effectively isolate the pump's power circuit from the control circuit. The switch which is a command by the GSM to control the relay, allows us to activate or deactivate the pump with ease.

The relay setup typically involves wiring the pump to the relay's contacts, with one terminal of the pump connected to the relay's common (COM) terminal and the other terminal connected to the normally closed (NC) terminal of the relay. The switch, in turn, is connected to the relay's coil, which controls the switching action.

When the switch is activated, it energizes the relay's coil, causing the relay to switch its contacts and connect the pump to the power source, effectively turning it on. Conversely, when the switch is deactivated, the relay de-energizes, disconnecting the pump from the power source and turning it off.

Using a relay in this manner provides several benefits. It allows for the use of a smaller, more easily manageable switch in the control circuit, while still providing the necessary power handling capabilities for the oil pump. Additionally, the relay offers electrical isolation, protecting the control circuit from potentially high currents and voltages associated with the pump [8].

3.6 3D Design:

3D printing technology has revolutionized the way we design and manufacture objects. When it comes to electronic projects like a car tracker, 3D printing offers an excellent solution for creating custom enclosures that perfectly fit the components and provide protection and organization. In this article, we will explore the process of 3D printing a box for a car tracker to house its various components securely and efficiently.

3.6.1 Designing the Enclosure:

The first step in 3D printing a box for the car tracker is to design the enclosure. This involves creating a 3D model using computer-aided design (CAD) software. Consider the dimensions and shapes of the components, taking into account their positioning and connections. Ensure that the design allows for proper ventilation and accessibility to buttons, ports, and indicators.

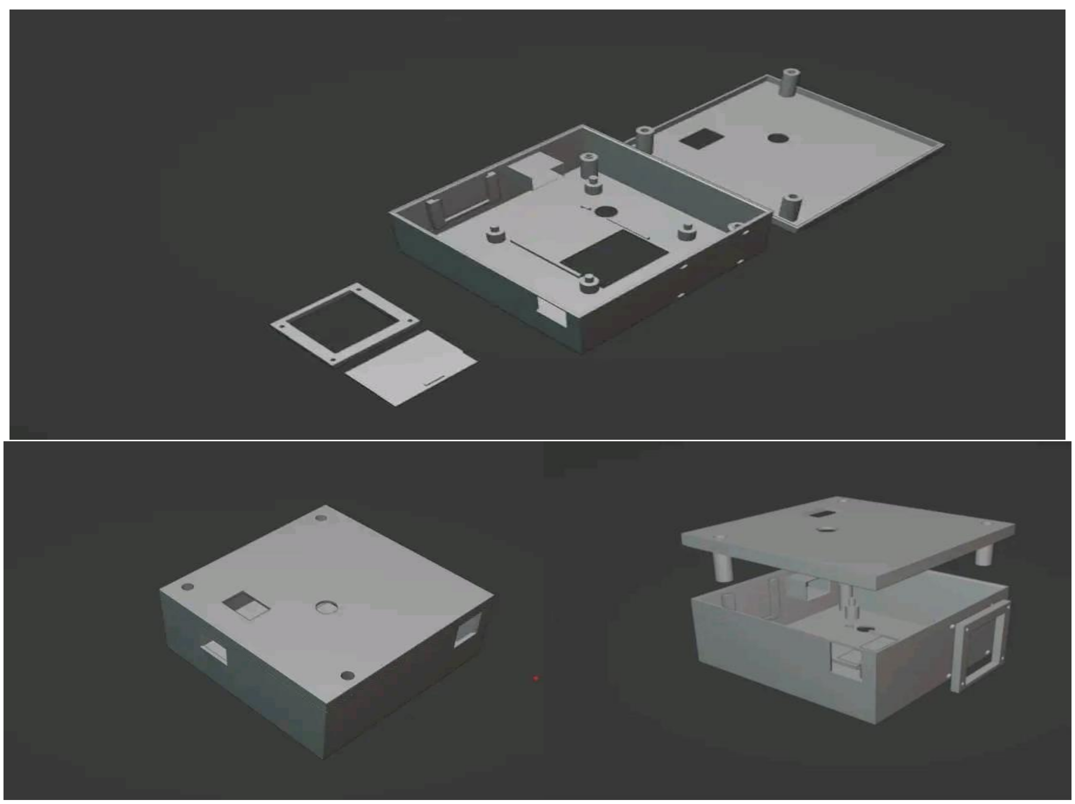

Figure3.19 3D design of the Enclosure using Blender

3.6.2 Prototyping and Iteration:

Before finalizing the design, it's advisable to create a prototype to verify its functionality and suitability. 3D printers allow for quick and cost-effective prototyping, enabling adjustments and modifications as needed. Test fit the components inside the prototype enclosure and make any necessary design tweaks to improve the overall fit and ease of assembly.

3.6.3 Material Selection:

Choose a suitable material for 3D printing the enclosure. Depending on your requirements, you can opt for materials like ABS, PLA, or PETG, which offer durability and ease of printing. Consider the temperature resistance, impact resistance, and any specific environmental factors that may affect the choice of material.

3.6.4 Printing the Enclosure:

Once the design is finalized and the material is selected, proceed with the actual 3D printing process. Prepare the 3D printer by ensuring it is properly calibrated and the print bed is level. Slice the 3D model using slicing software, adjusting settings such as layer height, infill density, and print speed as necessary. Start the printing process and monitor it closely to ensure the print quality.

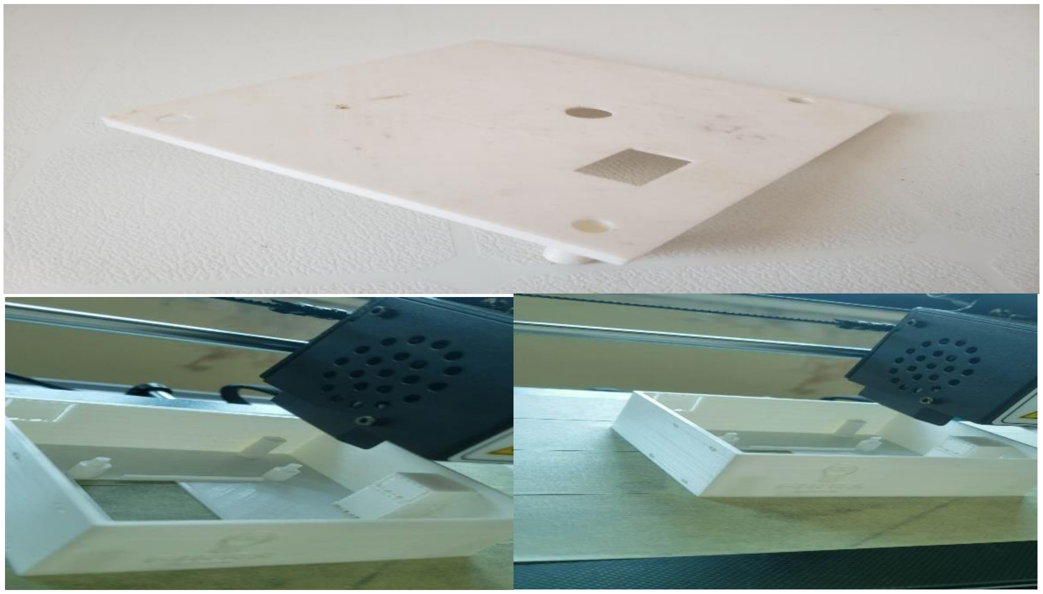

Figure3.20 3D printing the enclosure

3.6.5 Post-Processing:

After the 3D printing is complete, post-processing may be required. This can include removing any support structures, sanding rough edges, and applying a surface finish or coating for a polished look. Additionally, consider incorporating features like fastening mechanisms, snap-fit connections, or screw holes to facilitate easy assembly and maintenance of the car tracker enclosure.

3.6.6 Assembly and Integration:

Once the enclosure is printed and post-processed, it's time to assemble the car tracker components inside the box. Carefully position the GPS module, GSM module, Arduino Nano, MPU-6050, and other necessary components within the enclosure, ensuring proper alignment and securing them in place. Make appropriate openings or cutouts in the enclosure for cables, connectors, and ventilation.

3.6.7 Final Result:

After implementing the whole project including its hardware and software parts, by testing the performance of our robot .We got an acceptable result with some issues, also we are planning for more adjustment that's going to make our project much better. The advantage of our project includes seamless remote car control, real-time accident detection, and anti-theft alerts.

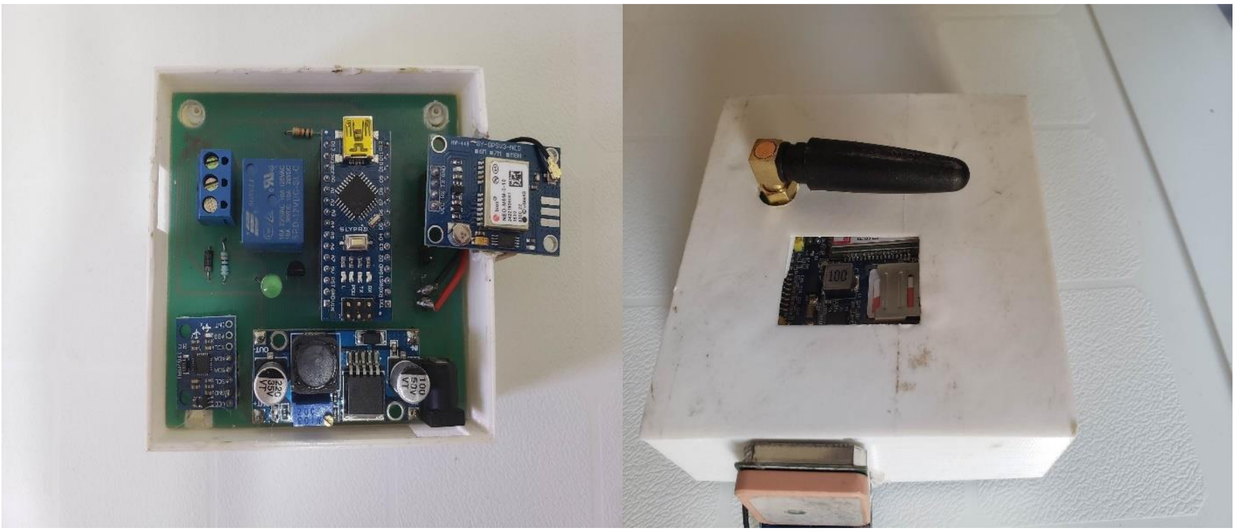

Figure3.21 Final result after assembling the device

3.7 Functionality result:

We will talk about our device results related to GSM and GPS testing and commands as well as discussing the results for problems that we faced

3.7.1 SMS and reply with pictures

In this figure we see when we send an SMS "1 on" the relay turns ON(the car starts running) and we receive an SMS that it turned on, also the green Led turns on when the Relay is on

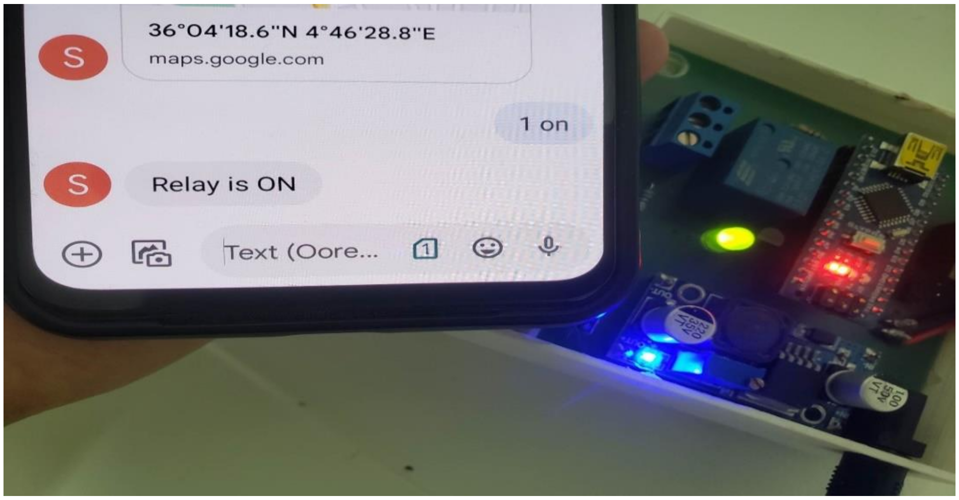

Figure3.22 showing Relay turning ON after sending SMS command

in this figure we see when we send an SMS "1 off" the relay turns OFF(the car stops running) and we receive an SMS that it turned OFF, also the green Led turns OFF when the Relay is OFF

Figure3.23 showing Relay turning OFF after sending SMS command

When we send the SMS"location" we receive a link to the current location of the system

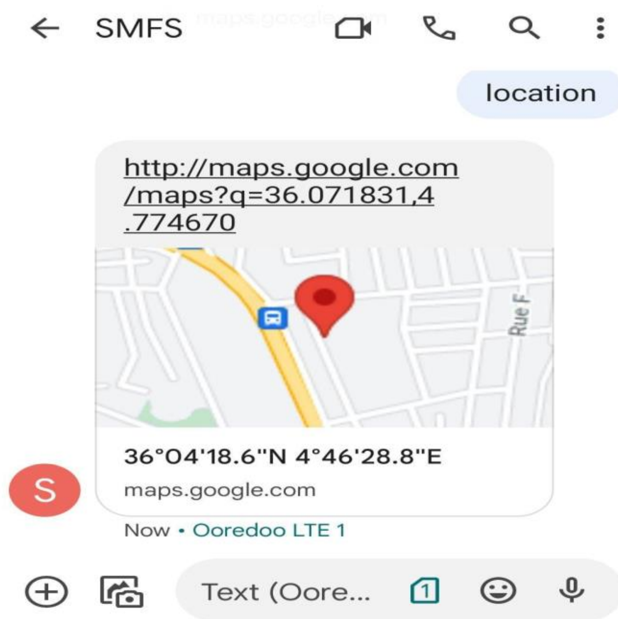

Figure3.24 showing device sending its current location after typing location command

When MPU6050 value changes the system sends an SMS to phone for "alert?"

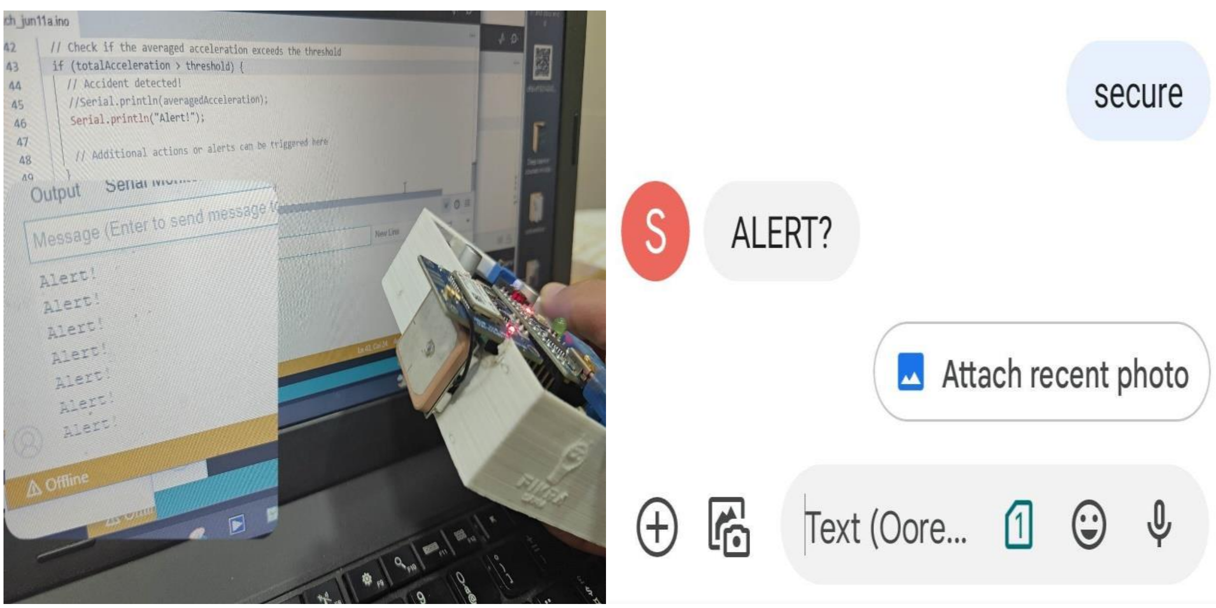

Figure3.25 showing Device sending Alert after typing the secure Command and moving the Device

When MPU6050 total acceleration value passes the threshold value the system sends SMS to phone for "Accident detected"

We've reduced the threshold value to test if the system will send the accident detected SMS or not

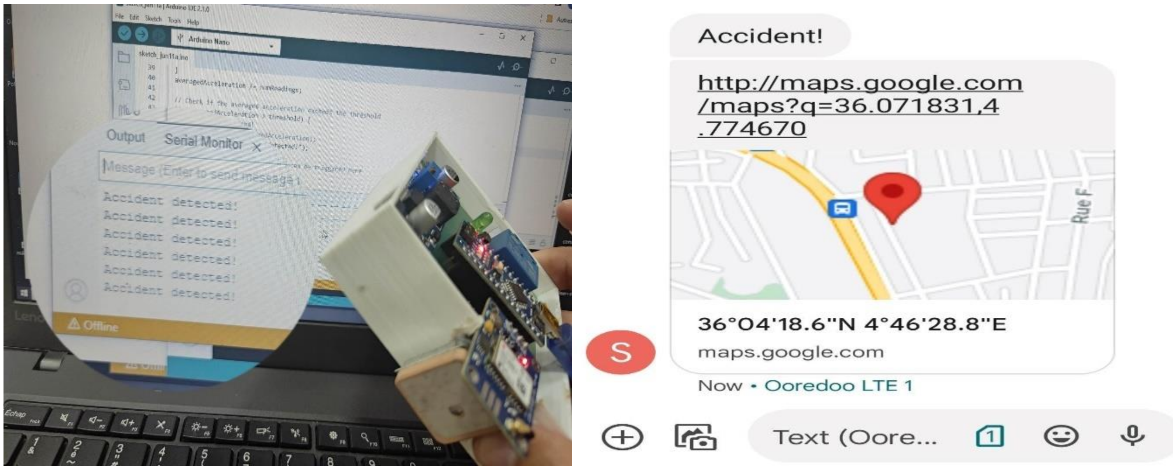

Figure3.26 Showing device sending Accident alert when device is subject to Shock over the threshold

3.7.2 Result discussion:

Despite our dedication and thorough testing, the minimum viable product (MVP) we created has exhibited acceptable Result in the other hand some issues that hinder its functionality.

For one, The GPS connectivity is sometimes unreliable due to poor satellite signal reception, particularly in limited areas. This can lead to inaccurate data tracking. Secondly, With GSM network connectivity, delays of approximately 4-10 seconds between SMS messages are experienced. These delays can cause inconveniences in communication.

Lastly, we encountered issues with the 3D printer components' precision, which was inconsistent and resulted in incorrect dimensions. Therefore, Modifications were made to the design of the box to fix the precision problems and ensure proper printing results.

3.8 Future development:

3.8.1 AI-Based Accident Detection Using Sound Analysis and MPU6050 Sensor Fusion

Accident detection systems play a vital role in ensuring road safety by promptly identifying and responding to potential collisions. In this article, we explore an innovative approach that combines sound analysis and sensor fusion using the MPU6050 module to accurately detect accidents. By leveraging the power of Artificial Intelligence (AI) algorithms, we can process sound data and motion sensor measurements to improve the accuracy and reliability of accident detection systems.

3.8.2 Sound Analysis for Accident Detection:

Sound analysis can provide valuable information about potential accidents. The AI algorithms can be trained to recognize specific sound patterns associated with collisions, such as the sound of screeching tires, impact noise, or sudden braking. By capturing and analyzing sound data in real-time using onboard microphones or external sensors, the system can identify these patterns and trigger an alert when a potential accident is detected [9].

3.8.3 Sensor Fusion with MPU6050:

The MPU6050 module combines a 3-axis accelerometer and a 3-axis gyroscope, allowing for precise measurement of motion and orientation changes. By fusing the data from the MPU6050 with the sound analysis, the accident detection system gains enhanced accuracy and reliability. The AI algorithms can leverage the accelerometer and gyroscope measurements to validate the occurrence of an accident detected through sound analysis. For example, if a significant impact sound is detected, the system can cross-reference it with abrupt changes in motion data captured by the MPU6050. This sensor fusion approach helps filter out false positives and ensures more accurate accident detection.

3.8.4 Training the AI Model

Training the AI model involves collecting a diverse dataset of sound samples associated with various types of accidents, including different vehicles and scenarios. The sound samples should cover a wide range of frequencies and intensities. Simultaneously, the MPU6050 sensor data should be synchronized with the sound recordings to create labeled training examples. Using supervised learning techniques, such as deep neural networks, the AI model can be trained to recognize patterns in sound data and correlate them with corresponding motion patterns captured by the MPU6050 .

3.8.5 Real-Time Accident Detection

Once the AI model is trained, it can be deployed on an embedded system, such as a Raspberry Pi, for real-time accident detection. The system continuously captures and analyzes sound data from microphones or sensors while simultaneously monitoring the motion data from the MPU6050. The AI model processes this data in real-time, identifying accident patterns and validating them using the motion sensor measurements. If a potential accident is detected, the system can trigger an immediate response, such as activating airbags, alerting emergency services, or notifying the driver or passengers [10].

3.8.6 Benefits and Considerations:

Using AI for accident detection with sound analysis and MPU6050 sensor fusion offers several benefits, including:

1. Improved Accuracy: The combination of sound analysis and motion sensor fusion enhances the accuracy of accident detection by reducing false positives and increasing confidence in identifying actual collisions.

2. Real-Time Response: The system can provide immediate alerts or trigger proactive safety measures to mitigate the impact of accidents, improving overall road safety.

3. Flexibility and Scalability: The AI model can be trained to recognize a wide range of accident types, making the system adaptable to different vehicle types and road conditions.

4. Integration and Compatibility: The system can be integrated into existing vehicle safety systems or aftermarket devices, leveraging the MPU6050 module and microphones or external sound sensors.

However, some considerations include:

1. Data Synchronization: Ensuring accurate synchronization between sound recordings and MPU6050 sensor data is essential during training and real-time accident detection to maintain reliable results.

2. Training Dataset Diversity: A diverse and representative dataset is crucial for training the AI model to handle various accident scenarios effectively.

3. False Positives: The system should be designed to minimize false positives, as unexpected or sudden loud

3.9 Conclusion:

The smart device system we have designed and created provides an innovative solution for remotely controlling a car, while also offering safety features such as accident detection and anti-theft alerts. The development process was not without its challenges, but through careful planning and adaptation, we were able to successfully overcome them. The end result delivers high-quality functionality that exceeds expectations. Moving forward, future developments can further refine the system, making it even more feature-rich and intuitive, ultimately improving its appeal and usefulness to drivers.

General Conclusion

General Conclusion:

In conclusion, we explore the development of a smart system for cars that incorporates tracking, alerting, and remote control functionalities. The research highlights the transformative potential of smart systems in optimizing processes and shaping a smarter and more sustainable future.

By utilizing components such as Arduino Nano, GPS module, GSM module, and MPU6050, the smart system enables precise location tracking, real-time alerting in case of accidents and thefts, and remote control capabilities. The implementation of the system addresses challenges and presents innovative features that enhance car security and user experience.

The findings emphasize the significance of smart systems in revolutionizing the automotive industry. Through technology and innovation, cars can become intelligent, connected, and responsive, paving the way for a safer and more efficient transportation ecosystem.

As research and advancements continue in this field, further refinements and improvements to the smart system can be expected, enhancing its functionality, usability, and overall appeal to drivers. The future holds immense possibilities for smart systems, bringing us closer to a smarter, more connected, and sustainable transportation landscape.

References:

[1]. Sathiyanarayanan, M., Mahendra, S., & Vasu, R. B. (2018, August). Smart security system for vehicles using Internet of Things (IoT). In *2018 Second International Conference on Green Computing and Internet of Things (ICGCIoT)* (pp. 430-435). IEEE.

[2]. Ye, X. (2017, May). Research on the Development Trend of Intelligent Vehicle. In *2017 International Conference on Applied Mathematics, Modelling and Statistics Application (AMMSA 2017)* (pp. 392-395). Atlantis Press.

[3]. Verma, P., & Bhatia, J. S. (2013). Design and development of GPS-GSM based tracking system with Google map based monitoring. *International Journal of Computer Science, Engineering and Applications (IJCSEA)*, *3*(3), 33-40.

[4]. Zohari, M. H. B., & Nazri, M. F. B. M. (2021). GPS based vehicle tracking system. *International Journal of Scientific &Technology Research*, *10*(04), 278-282.

[5]. Punetha, D., Kumar, D., & Mehta, V. (2012). Design and realization of the accelerometer based transportation system (ATS). *International Journal of Computer Applications*, *49*(15).

[6]. Mounika, J., Charanjit, N., Saitharun, B., & Vashista, B. (2021). Accident alert and vehicle tracking system using GPS and GSM. *Asian Journal of Applied Science and Technology (AJAST) Volume*, *5*, 81-89.

[7]. Senthilkumar, S., Brindha, K., & Bhandari, S. (2020). Vehicle accident management and control system using MQTT. *International Journal of Advances in Applied Sciences (IJAAS)*, *9*(1), 1-11

[8]. Wakhare, M. M. M. (2017). Remote vehicle shut off system for controlling Vehicle Ramming Attacks.

[9]. Kim, Y., Park, J., & Oh, C. (2021). A Crash Prediction Method Based on Artificial Intelligence Techniques and Driving Behavior Event Data. *Sustainability*, *13*(11), 6102.

[10]. Choi, J. G., Kong, C. W., Kim, G., & Lim, S. (2021). Car crash detection using ensemble deep learning and multimodal data from dashboard cameras. *Expert Systems with Applications*, *183*, 115400.

Abstract:

In a world of increasing concerns about car security and safety, we present an innovative solution—a smart system for cars that combines cutting-edge technology with Arduino Nano, GPS module, GSM module, and MPU6050 sensor. This system revolutionizes car tracking, accident detection, and theft prevention. The research is divided into three captivating chapters that take the reader on a journey—from the exploration of smart systems to the practical realization of this device. The findings highlight the immense potential of this smart system to enhance car security and safety, offering real-time location tracking, instant accident alerts, and theft prevention measures. This thesis paves the way for future developments in the exciting field of smart systems for cars.

Résumé:

Dans un monde où les préoccupations concernant la sécurité des voitures ne cessent d'augmenter, nous présentons une solution innovante : un système intelligent pour les voitures qui combine une technologie de pointe avec Arduino Nano, un module GPS, un module GSM et un capteur MPU6050. Ce système révolutionne le suivi des voitures, la détection des accidents et la prévention des vols. La recherche est divisée en trois chapitres captivants qui emmènent le lecteur dans un voyage, de l'exploration des systèmes intelligents à la réalisation pratique de ce dispositif. Les résultats mettent en évidence le potentiel immense de ce système intelligent pour améliorer la sécurité des voitures, offrant un suivi en temps réel de la localisation, des alertes d'accident instantanées et des mesures de prévention des vols. Cette thèse ouvre la voie à de futures avancées dans le domaine passionnant des systèmes intelligents pour les voitures.

ملخص:

في عالم يتزايد فيه القلق بشأن أمان وسلامة السيارات، نقدم حلاً مبتكراً - نظام ذكي للسيارات يجمع بين أحدث التقنيات مع Arduino Nanoووحدة GPS ووحدة GSM ومستشعر MPU6050. يقوم هذا النظام بثورة في تتبع السيارات وكشف الحوادث ومنع السرقة. تم تقسيم البحث إلى ثلاثة فصول جذابة تأخذ القارئ في رحلة - من استكشاف الأنظمة الذكية إلى التحقيق العملي في هذا الجهاز. تسلط النتائج الضوء على إمكانات هائلة لهذا النظام الذكي لتعزيز أمان السيارات وسلامتها، حيث يوفر تتبعًا فوريًا لموقع السيارة وإنذارات فورية بالحوادث وإجراءات لمنع السرقة. تمهد هذه الرسالة الطريق للتطورات المستقبلية في مجال الأنظمة الذكية المثيرة للسيارات.