ADVANCED VEHICLE FIRE SAFETY AND MONITORING WITH RAPID EMERGENCY DISPATCH SOLUTIONS

2024-058

Project Proposal Report

Peramunage A.N

B.Sc. (Hons) Degree in Information Technology specializing in

Information Technology

Department of Information Technology

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DECLARATION

We declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Name	Student ID	Signature
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The supervisor/s should certify the proposal report with the following declaration.

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the Supervisor:	2024.02.29	
Signature of the Co-Supervisor:	2024.02.29	

ABSTRACT

The Enhanced Vehicle Safety gadget provided in this record represents a novel technique to preventing vehicle fires by using integrating Internet of Things (IoT) and Machine Learning (ML) technologies. The machine is designed to decorate automobile protection by using putting in sensors in vehicles to detect smoke, temperature, flame, and automobile vibrations. These sensors provide real-time statistics this is analyzed using ML algorithms to are expecting capability fire incidents earlier than they amplify. One of the important thing capabilities of the gadget is its recognition on proactive fire prevention. By continuously monitoring sensor overall performance and integrating special types of sensors, inclusive of smoke, temperature, and vibration sensors, the device can offer a greater holistic and accurate detection system. This permits the machine to not only locate fires however also are expecting capacity incidents, providing a step beforehand of traditional detection systems. Another important thing of the gadget is its ability to technique and analyze records in real-time. This permits instant response to hearth threats, enhancing standard vehicle safety. Additionally, the gadget is designed to continuously research and adapt, enhancing its predictive accuracy over the years with greater data. To ensure the machine is effective and consumer-friendly, a custom designed alert mechanism is advanced to tell drivers of capability fire dangers. This mechanism is adapted to the motive force's situation, enhancing safety and response time. In conclusion, the Enhanced Vehicle Safety system represents a large development in vehicle hearth prevention. By integrating IoT and ML technologies, the machine provides a proactive technique to fireplace detection and prevention, enhancing general automobile safety and minimizing the damage because of vehicle fires.

Keywords: IoT, Machine Learning, Vehicle Safety, Fire Prevention, Sensor Technology, Real-time Data Processing , Emergency Alert.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATION

IoT - Internet of Things

ML - Machine Learning

GFR - Glomerular Filtration Rate

CNN - Convolutional Neural Network

ROI - Region of Interest

PCA - Principal Component Analysis

NMF - Non-negative Matrix Factorization

IHS - Intensity-Hue-Saturation

AWS - Amazon Web Services

API - Application Programming Interface

GUI - Graphical User Interface

WBS - Work Breakdown Structure

QA - Quality Assurance

IEC - International Electrotechnical Commission

IEEE - Institute of Electrical and Electronics Engineers

ESP32 - Espressif System's microcontroller

UI - User Interface

UX - User Experience

AMT - Agile Methodology Team

PID - Proportional-Integral-Derivative

FPGA - Field-Programmable Gate Array

BLE - Bluetooth Low Energy

CAN - Controller Area Network

OBD - On-Board Diagnostics

1 INTRODUCTION

1.1 Background and Literature Survey

Vehicle fires are a sizable protection subject global, posing risks to each occupants and surrounding infrastructure. According to the National Fire Protection Association (NFPA), there had been an predicted 212,500 dual carriageway vehicle fires said inside the United States in 2019, ensuing in 560 civilian deaths and $1.3 billion in assets harm. These incidents spotlight the pressing need for effective hearth prevention and detection structures in automobiles.Current hearth detection systems, whilst effective in lots of environments, are often inadequate for the unique demanding situations posed through motors. Traditional smoke detectors, as an instance, may not be sensitive enough to stumble on early symptoms of a hearth in a vehicle's engine compartment or indoors. Additionally, car-specific elements including engine vibrations and ranging temperature conditions require specialized detection mechanisms.Research within the area of vehicle fire detection has centered on developing modern answers to address those limitations. One technique is the integration of Internet of Things (IoT) and Machine Learning (ML) technologies, providing a proactive and intelligent technique to fireplace prevention. IoT-based totally sensor networks can efficaciously screen various parameters together with smoke, temperature, and vibrations in cars. These sensors provide actual-time facts that may be analyzed the usage of ML algorithms to are expecting capability fire incidents before they arise. By constantly mastering and adapting, those systems can improve their predictive accuracy over time, improving ordinary hearth detection talents.Additionally, studies has explored the development of superior alert mechanisms to notify drivers and emergency offerings of capacity fire risks. These mechanisms can be customized to the motive force's scenario, presenting timely and applicable information to decorate protection and response time.

Vehicle fires can occur due to a number of motives, which include electrical faults, fuel leaks, and engine malfunctions. The impact of automobile fires extends past the on the spot loss of existence and property. Vehicle fires can result in visitors disruptions, environmental pollution, and significant monetary

expenses. Preventing and mitigating car fires is important no longer simplest for the protection of individuals but also for the overall properly-being of communities and the surroundings.

Current fire detection systems in vehicles usually depend upon smoke detectors and temperature sensors. While these systems are effective in lots of instances, they're often constrained in their potential to hit upon fires early or in hard conditions including high temperatures or low visibility.One of the principle obstacles of cutting-edge fireplace detection systems is their reactive nature. These structures are designed to detect fires after they have already commenced, that could lead to behind schedule response instances and accelerated harm. Additionally, present day systems won't be optimized for the automotive surroundings, main to suboptimal overall performance in detecting and preventing car fires.

Literature Survey

Research has shown that IoT-primarily based sensor networks can effectively monitor numerous parameters in cars, such as smoke, temperature, and vibrations. These sensors can provide actual-time statistics that may be analyzed the use of ML algorithms to expect capacity hearth incidents earlier than they occur. By continuously studying and adapting, those structures can enhance their predictive accuracy through the years, improving universal fireplace detection capabilities.ML algorithms had been used to analyze sensor information and expect capacity fireplace incidents in vehicles. These algorithms can process big amounts of facts speedy and appropriately, providing valuable insights into potential hearth risks.Research has additionally targeted on growing superior alert mechanisms to notify drivers and emergency services of capacity fireplace hazards. These mechanisms may be custom designed to the driving force's state of affairs, imparting timely and applicable records to beautify protection and reaction time.In conclusion, vehicle fires are a vast safety problem that calls for progressive solutions to save you and hit upon incidents. The integration of IoT and ML technology gives a promising approach to enhance vehicle fire detection and prevention systems. By constantly tracking car parameters and analyzing facts in real-time, these structures can are expecting

potential hearth incidents earlier than they arise, in the long run improving normal safety on the roads.

1.2 Research Gap

Addressing the research gaps in vehicle hearth detection structures is vital for boosting vehicle safety. Current systems are more often than not reactive, lacking the capacity to proactively locate potential hearth hazards earlier than they improve. Integrating Internet of Things (IoT) and Machine Learning (ML) technology suggests promise, but there is a want for complete research demonstrating real-global effectiveness. Optimization for the automotive environment, such as factors like excessive temperatures and engine vibrations, stays a project. Additionally, making sure statistics protection and privateness, scalability, and accessibility are critical considerations. Overcoming those gaps will cause extra effective and efficient vehicle fire detection systems, ultimately enhancing usual automobile protection.One of the primary research gaps in automobile hearth detection systems is the shortage of proactive detection capabilities. Current systems depend closely on reactive measures, which includes smoke detectors and temperature sensors, which are best effective after a hearth has already began. Proactive detection structures, on the other hand, can discover ability fireplace hazards earlier than they escalate, making an allowance for timely intervention and prevention. Integrating IoT and ML technology offers a promising approach to this gap, as those technology can continuously screen automobile parameters and examine statistics in actual-time to expect capacity hearth incidents. However, there may be a need for more complete research that show the effectiveness of these structures in actual-global eventualities.Another research gap in vehicle fireplace detection systems is the shortage of optimization for the automotive surroundings. Vehicles are exposed to unique demanding situations, which include excessive temperatures, engine vibrations, and variable lighting situations, that could affect the overall performance of fire detection structures. Current structures won't be capable of correctly function in these conditions, leading to suboptimal overall performance. Addressing this gap requires the improvement of structures which are in particular designed to face up to the trials of the car environment.Data security and privateness also are important issues in automobile fire detection structures. As those systems turn out to be more related and reliant on

information collection, there's a want to make certain that touchy statistics is covered from unauthorized get right of entry to. Additionally, scalability and accessibility are essential elements to do not forget, as those structures need if you want to accommodate a big range of automobiles and sensors, as well as be available and less expensive for all automobile types.Addressing the research gaps in automobile fireplace detection structures is vital for reinforcing automobile protection. By growing systems which might be proactive, optimized for the automobile environment, and secure, scalable, and reachable, we will enhance the effectiveness and performance of automobile fire detection structures, ultimately decreasing the effect of car fires on both people and communities.

2 RESEARCH PROBLEM

In the world of car fireplace prevention, a fundamental task lies in the predominantly reactive nature of modern detection structures, which hampers their capability to discover capability hearth risks earlier than they increase. The present technology are not finely attuned to the specific needs of the car surroundings, ensuing in suboptimal overall performance in detecting and forestalling car fires. This inherent reactivity and absence of optimization make a contribution to not on time responses, thereby diminishing the efficacy of fireplace prevention measures. Furthermore, a great studies hole exists in the realm of leveraging voice recognition technology to not simplest detect the suitable area of a hearth but also predict hearth incidents earlier than they appear. This deficiency in proactive detection and prediction underscores the pressing want for progressive solutions that may markedly enhance automobile protection requirements.At the center of the issue is the reliance on conventional hearth detection systems that more often than not respond to fireplace occasions once they have already began. These systems frequently utilize smoke detectors, warmness sensors, and other comparable technology, which can be effective in lots of settings however fall quick within the dynamic and complicated environment of a car. In a automobile, various factors together with engine warmth, vibration, and different operational situations can create demanding situations for conventional fire detection techniques, leading to delays in detection and reaction.To address these demanding situations, researchers and engineers are exploring the integration of Internet of Things (IoT) and Machine Learning (ML) technologies into car fire prevention systems. IoT devices can accumulate information from various sensors hooked up inside the car, which

include smoke, temperature, and vibration sensors. This information is then analyzed using ML algorithms to pick out styles and anomalies that could indicate a capability hearth hazard. By constantly monitoring those parameters, the system can predict and prevent fire incidents before they arise, thereby improving car protection.One of the important thing benefits of IoT-based structures is their potential to offer real-time statistics analysis. This allows instant reaction to fire threats, allowing for timely intervention to prevent fires from escalating. Additionally, ML algorithms may be skilled to recognize styles associated with ability hearth risks, permitting the device to constantly research and adapt to new facts, enhancing its predictive accuracy over the years.In addition to IoT and ML technology, researchers also are exploring the use of voice recognition era in car fire prevention structures. Voice recognition may be used to locate the area of a fire based totally on sound patterns and frequencies related to exceptional varieties of fires. By combining this generation with IoT and ML, researchers wish to increase a complete fire prevention device which can hit upon, expect, and reply to fireplace incidents in automobiles extra efficiently than modern systems.Overall, addressing the demanding situations in vehicle fire prevention requires a multi-faceted approach that integrates superior technology and modern solutions. By leveraging IoT, ML, and voice popularity technologies, researchers intention to develop a brand new era of fire prevention systems that can considerably beautify automobile safety standards and decrease the risk of fire-related incidents on the street.

3 OBJECTIVES

3.1 Main Objectives

The primary goal of this assignment component is to layout and put into effect a novel fireplace detection answer for automobiles by using installing sensors to stumble on smoke, temperature, hearth, and vehicle vibrations. This gadget targets to proactively locate potential fire hazards in motors and offer early warnings to prevent fireplace incidents. By integrating sensors and advanced algorithms, the machine will examine real-time information to pick out unusual patterns indicating a ability fireplace. The closing intention is to decorate automobile safety and reduce the hazard of fireplace-related incidents on the road.

3.2 Specific Objectives

- Develop and optimize gadget studying (ML) algorithms tailor-made for automobile fireplace detection, specializing in analyzing sensor records to stumble on patterns indicative of ability fire risks.
- Implement a strong actual-time records processing device able to effectively handling and studying facts from various sensors mounted in cars to allow instantaneous response to hearth threats.
- Create an alert mechanism that integrates facts from more than one sensors and continuously monitors sensor performance to ensure correct and well timed detection of ability hearth risks.
- Utilize ML algorithms for predictive evaluation, allowing the system to research from historical facts and continuously improve its potential to detect and expect capability hearth incidents.
- Provide custom designed alerts to drivers based on actual-time sensor data, ensuring signals are tailor-made to the specific situation and introduced in a timely way to decorate motive force protection and reaction time.
- Implement protocols for continuous tracking and upkeep of the sensor gadget to make sure best overall performance and reliability in detecting capability hearth dangers.

- Integrate distinct types of sensors, consisting of smoke, temperature, and vibration sensors, to create a comprehensive and correct fire detection gadget for vehicles.
- Develop algorithms to analyze sensor information in conjunction with vehicle facts, which includes speed and engine fame, to enhance the accuracy of fireplace detection and prevention.

4 METHODOLOGY

4.1 System Architecture

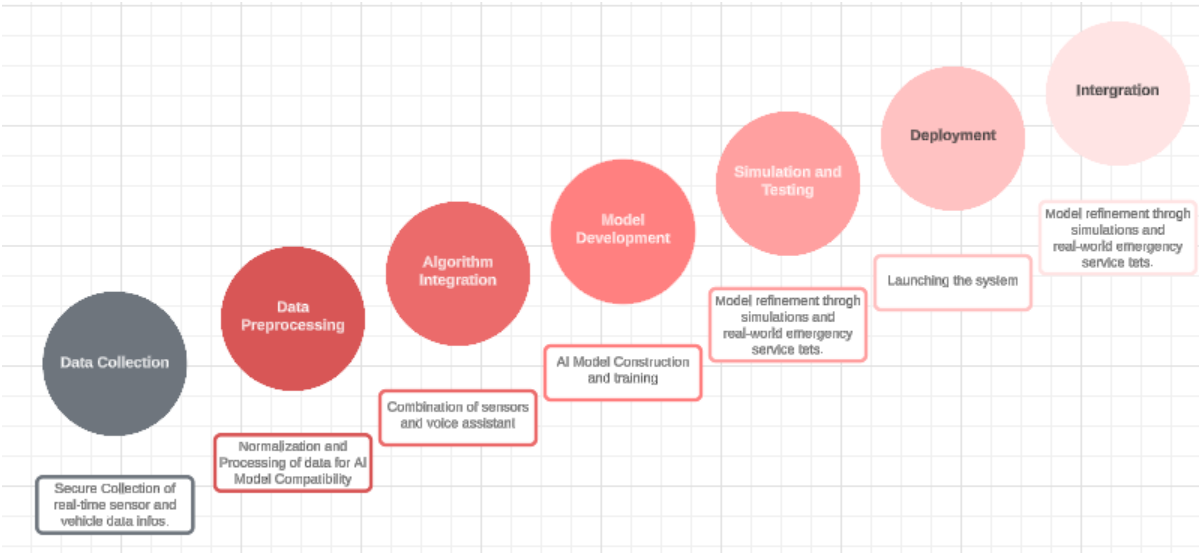

Figure 1:Component Architecture Diagram

The first step is to gather the necessary requirements for the system, including the types of sensors to be used and the functionality required for real-time data processing and alert generation. Next, the appropriate technologies need to be selected for implementing the system, such as IoT for sensor integration and ML for predictive analytics. The system will be developed using an agile methodology, with the project broken down into sprints for iterative development. Each sprint will focus on specific tasks, such as sensor installation, algorithm development, and system testing. Continuous integration and testing will be used throughout the development process to ensure the system meets the required standards. Once the system is developed, it will be deployed and maintained to ensure its continued functionality and effectiveness. Regular updates and maintenance will be performed to address any issues that may arise and to incorporate new features or improvements

4.2 Commercialization of the Product

1. Expand a advertising and marketing strategy: Create a plan to promote the gadget to car producers, fleet operators, and protection groups. this will encompass using online commercials, social media, and direct outreach.
2. Release the product: Introduce the enhanced car protection gadget to the market. make sure it's easy to use and integrates nicely with automobiles. recollect 14 providing trial intervals or demos to exhibit its blessings.

3. Offer competitive pricing: develop pricing alternatives that are appealing in comparison to other protection structures. Tailor applications based totally on fleet length and integration wishes.
4. Provide education and guide: provide education and help to help customers use the device efficaciously. this may encompass on-website schooling and person manuals.
5. Associate with industry gamers: Collaborate with car producers, insurance businesses, and regulators to sell the system's adoption. work collectively to set industry standards.
6. Collect and examine records: accumulate records from the system and customers to enhance its capabilities. Use this information to make the device higher and live in advance of competitors.
7. Enlarge into new markets: as soon as the gadget is hooked up inside the automotive area, don't forget entering other markets like public transportation or shipping. Adapt the machine to meet these markets' wishes and promote it accordingly

5 SOFTWARE / HARDWARE METHODOLOGY

5.1 Software methodology

Requirements Gathering and Analysis:

This initial phase involves thorough gathering of requirements for the mobile app and the overall system. This includes identifying the types of sensors required (smoke, temperature, fire, and vehicle vibrations), defining the diagnostic algorithms for sensor data analysis and fire prediction, and determining the necessary functionality of the system. The requirements are then analyzed to determine the scope and complexity of the project.

Technology Selection:

The technology selection for the Enhanced Vehicle Safety system involves the use of various technologies tailored to the specific requirements of the system. For sensor integration, industry-standard sensor modules compatible with the IoT platform will be utilized to detect smoke, temperature, fire, and vehicle vibrations. Data processing and storage will be managed using microcontrollers for real-time data processing and cloud storage solutions like AWS IoT Core and Amazon S3 for secure data storage. Machine learning algorithms will be developed using TensorFlow to analyze sensor data and predict potential fire incidents, continuously learning and adapting for improved accuracy over time. An alert mechanism will be implemented using SMS alerts, in-vehicle alarms, and dashboard notifications to inform drivers of potential fire hazards. Voice assistant integration, such as Amazon Alexa or Google Assistant, will enable drivers to receive fire-related alerts and information hands-free. Additionally, GPS and mapping technologies will be considered for integrating a fire area indicator to pinpoint the exact location of potential fire incidents, enhancing emergency response capabilities. These technologies are chosen for their compatibility, efficiency, and ability to meet the specific requirements.

Agile Sprint Planning:

Break down the project into sprints that last 1-2 weeks. During the planning phase of each sprint, prioritize the development tasks, assign them to team members, and estimate the time required for each task.

Agile Sprint Execution:

During each sprint, the development team will work on the tasks assigned to them. Team members will collaborate, share progress, and work towards the sprint goal. Continuous integration and testing will be used to ensure that the app is functioning correctly and meets the requirements.

Agile Sprint Review:

At the end of each sprint, review the work completed during the sprint and demonstrate any new features or functionality to stakeholders. Gather feedback and identify areas for improvement.

Agile Sprint Retrospective:

Reflect on the sprint and identify what went well, what didn't go well, and what can be improved for the next sprint. Implement changes to improve the development process.

Deployment and Maintenance:

Once the development phase is complete, the system will be deployed to vehicles through over-the-air updates or through installation at service centers. Ongoing maintenance will involve monitoring the system's performance, addressing any issues that arise, and updating the system as needed to ensure compatibility with new vehicle models and technologies. Regular maintenance checks will be conducted to verify the sensors' functionality and the system's overall effectiveness. Additionally, user feedback will be collected and analyzed to identify areas for improvement and to address any user concerns.

Quality Assurance:

Throughout the development process, rigorous testing will be conducted to verify the system's functionality, performance, and security. This will include testing the sensor integration, data processing algorithms, alert mechanism, and overall system integration. Testing will be performed in controlled environments as well as in real-world scenarios to ensure that the system performs as expected in all conditions. Additionally, the system will undergo thorough security testing to protect against unauthorized access and ensure data privacy. Regular audits and reviews will be conducted to assess the system's compliance with industry standards and regulations.

Tools and Technologies

Sensor Integration: Industry-wellknown sensor modules like minded with the IoT platform will be used for detecting smoke, temperature, hearth, and automobile vibrations.

Data Processing and Storage: Microcontrollers might be hired for real-time facts processing, even as cloud storage answers like AWS IoT Core and Amazon S3 could be applied for steady data storage.

Machine Learning Algorithms: TensorFlow could be applied for developing ML algorithms to research sensor records and are expecting potential fireplace incidents, continuously studying and adapting for stepped forward accuracy over the years.

Alert Mechanism: A mixture of SMS signals, in-automobile alarms, and dashboard notifications may be advanced to tell drivers of capability fire dangers.

Voice Assistant Integration: Integration with voice assistant systems, which include Amazon Alexa or Google Assistant, could be explored to permit drivers to get hold of hearth-associated indicators and records hands-unfastened.

Fire Area Indicator: GPS and mapping technology might be considered for integrating a fireplace area indicator to pinpoint the precise place of capacity fireplace incidents, enhancing emergency reaction competencies.

Deployment and Maintenance: The Device may be deployed to cars thru over-the-air updates or set up at provider facilities. Ongoing protection will involve tracking the device's overall performance, addressing any issues, and updating it as necessary for compatibility with new car models and technology.

Standardization methods that can be used:

Sensor Calibration Tools: Dedicated software and calibration equipment for adjusting sensor readings to a standard level.

Data Normalization Software: Algorithms and software tools for standardizing sensor data, accounting for environmental factors and sensor variations.

Signal Processing Libraries: Libraries such as SciPy or MATLAB for applying signal processing techniques to sensor data to remove noise and artifacts.

Data Fusion Platforms: Software platforms for integrating data from multiple sensors, such as Apache Kafka or Azure Stream Analytics.

Machine Learning Frameworks: TensorFlow or PyTorch for training machine learning models on standardized data for accurate fire prediction.

Monitoring Systems: Tools for continuous monitoring of sensor performance and data quality, such as Prometheus or Grafana.

Adaptive Learning Algorithms: Custom algorithms or libraries for implementing

adaptive learning mechanisms in the system.

User Feedback Interfaces: User interface components for collecting feedback from drivers on the system's performance and accuracy.

6 DESCRIPTIONS OF PERSONAL AND FACILITIES

Table 1-Description of personal facilities

Member	Component	Tasks
Peramunage A.N (IT21080562)	Enhanced Vehicle Safety: IoT-ML Integration for Fire Prevention system	1. Design the IoT device with sensors, ESP32, and necessary hardware tools, considering factors like sensor placement, power requirements, and communication protocols. 2. Implement the IoT device by assembling the hardware components, configuring the ESP32, and ensuring all sensors are correctly connected and functioning. 3. Configure the environment and create the program to set up the ESP32, including setting up the development environment, writing the code to read sensor data, and establishing communication with the cloud service. 4. Install security protocols to connect the IoT device securely to the cloud service, ensuring that data transmission is encrypted and protected from unauthorized access. 5. Create a dataset for training the machine learning model, selecting relevant features from sensor data and labeling data points based on fire incidents or normal operation. 6. Divide the dataset into training and testing data, ensuring that the model is trained on a diverse set of data and tested on unseen data to evaluate its performance. 7. Train the machine learning model to achieve the best accuracy, using algorithms suitable for the data and problem, such as decision trees, random forests, or neural networks. 8. Install the trained model into the ESP32, optimizing the model for deployment on the device by considering resource constraints and real-time processing requirements. 9. Write test cases to validate the IoT device's functionality, including testing sensor readings, model predictions, and alert mechanisms under various scenarios. 10. Test the IoT device with the written test cases, ensuring that it detects potential fire hazards accurately and provides timely alerts to drivers. 11. Validate the IoT device's performance in a real-world environment, conducting field tests to verify its reliability and effectiveness in preventing vehicle fires. 12. Install the IoT device in the vehicle properly, considering factors like mounting location, wiring, and integration with the vehicle's electrical system.

		13. Implement the corresponding mobile application, developing a user-friendly interface for users to monitor the IoT device's status, receive alerts, and access additional features. 14. Test the mobile application to ensure it syncs with the IoT device and provides a seamless user experience, including verifying data synchronization and alert notifications.

BUDGET AND BUDGET JUSTIFICATION

Resources	Estimated Price (LKR)
Travelling	10,000.00
Internet	5,000.00
Stationery	5,000.00
Hardware parts/Sensors	20,000.00
Total	**40,000.00**

Table 2-Expected Expenditure

The proposed budget total cost amount is LKR 40000. To cover this expenditure, our group plans to collect funds from group members. The budget table should detail all the project expenses, including any necessary equipment, materials, or services required to complete the project. These costs might change in the future due to unforeseen circumstances or unexpected expenses, but with a clear budget plan and contributions from group members, the project can be completed successfully.

7 GANTT CHART

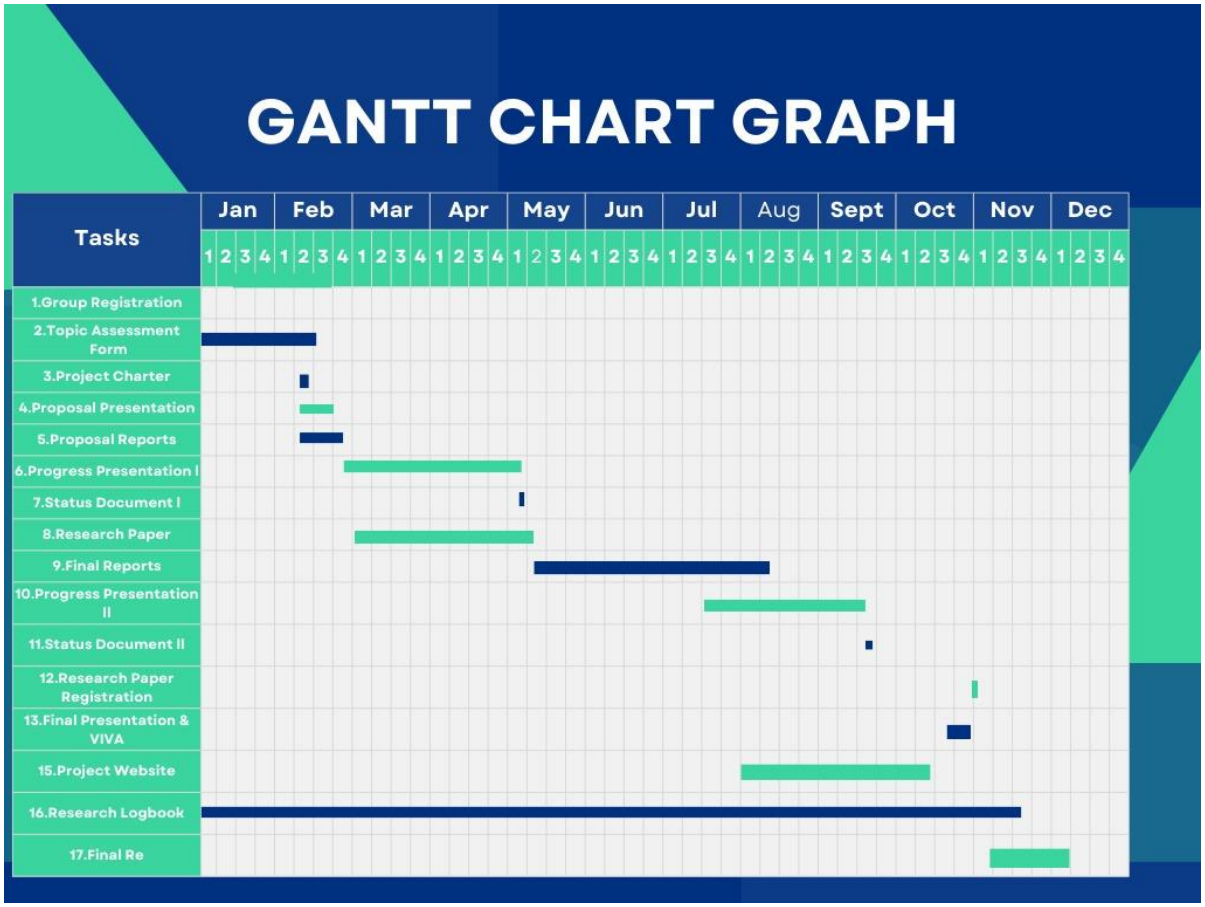

Figure 2:Proposed Gantt Chart

The Gantt chart above displays our recommended strategy for the research project, with a focus on my component. Since January, we have made progress up to this week. Without this Gantt chart, which enables us to effectively arrange our time and resources, our study strategy would not be the same. It shows the relationships between tasks, the project timeline, and the deadlines for each job

8 WORK BREAKDOWN CHART

Figure 3:Work-Breakdown Structure

The Work breakdown structure for the Enhanced Vehicle Safety: IoT-ML Integration for Fire Prevention Device encompasses several important ranges. Initially, the research trouble could be fastidiously recognized and analyzed to establish a comprehensive know-how of the assignment's targets and necessities. Following this, the preliminary degree will recognition at the meticulous design of both the hardware and software additives, consisting of the installation of sensors for detecting smoke, temperature, hearth, and vehicle vibrations, as well

as the development of information processing units. Moreover, the implementation phase will be dedicated to growing a strong IoT infrastructure and seamlessly integrating it with contemporary ML algorithms tailored for fireplace prediction. Additionally, the device will undergo thorough trying out to evaluate its overall performance, ensuring premiere capability. It will even involve the integration of voice assistant capabilities for stronger consumer interplay and a fireplace location indicator to pinpoint the precise area of potential hearth incidents. Subsequently, the documentation stage will embody preparing designated documentation, inclusive of technical specifications, consumer manuals, and the task record.

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10 APPENDICES