ADVANCED VEHICLE FIRE SAFETY AND MONITORING WITH RAPID EMERGENCY DISPATCH SOLUTIONS

R24-058

Project Proposal Report

Dharmagunawardana W.M.P.I.

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

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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:	28.02.2024	
Signature of the Co-Supervisor:	28.02.2024	

ABSTRACT

Vehicle fires happen quickly and leave little time for reaction, taking both drivers and passengers by surprise. When the automobile burns down, not only are lives in danger but there is also significant financial loss. These circumstances frequently result in a panic attack when people are unable to respond appropriately, which increases the problem. This emphasizes how urgently we need to find a solution that can handle the present situation. Now for the creative system that has been suggested. It is intended to use innovative computing techniques to determine whether the factor of catching fire exists. In order to detect potential fire breakout hazards in real-time and promptly notify the closest fire department, this system makes use of modern technologies such as cloud computing, machine learning, and the Internet of Things. When notifying the public facilities of the accident, it carefully assesses the severity of the situation and determines if emergency medical attention is required. Furthermore, the system determines the quickest path to the endangered car in order to optimize reaction time and perhaps save lives. The design prioritizes affordability and reliability with the goal of making it widely available. From this perspective, this novel approach to vehicle fire emergency procedures promises increased protection for road users, therefore lowering the financial and mental impacts of such catastrophes in a world where such preventative measures are rare.

Keywords: Automobile, fires, driver, passenger, Panic attacks, emergency, severity, fire department, medical attention, cloud computing, machine learning, Internet of Things

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LIST OF ABBREVIATION

IoT – Internet of Things

ML – Machine Learning

GPS – Global Positioning System

IDE - Integrated Development Environment

CO – Carbon Monoxide

OS – Operating System

AWS - Amazon Web Services

UI - User Interface

ESP32 - Espressif Systems 32-bit Microcontroller

CNN - Convolutional Neural Network

1 INTRODUCTION

1.1 Background and Literature Survey

When it comes to vehicle safety, the risk of an automotive fireplace stands out as a serious emergency situation that is frequently unexpected and underestimated by both drivers and passengers [1]. This lack of preparation combined with the rapid growth of the fire can cause panic, which increases the situation and causes extensive damage to the automobile and its occupants. It is also likely to be the primary cause of serious accidents, fatalities, and enormous financial losses. By introducing a cutting-edge solution that can identify potential fire hazards before they become serious emergencies, the proposed device seeks to close this gap in vehicle protection. This will revolutionize the way vehicle fires are managed and significantly improve passenger safety. [1]

The development of the Internet of Things (IoT) and improvements in machine learning and cloud computing provide a potential foundation for developing a system that might detect indications of vehicular fire before they become apparent. Through the constant monitoring of several characteristics such as temperature, smoke, and the presence of dangerous gasses, this device is able to detect potential fireplace hazards in real-time. The technology is intended to notify the closest fire department of any potential hazards and provide them with important information such as the extent of the fire, the precise position of the vehicle, and whether any medical assistance is required at the site. This guarantees an effective emergency response that will probably save lives and reduce property damage. [2]

Additionally, the device uses machine learning algorithms to analyze data collected from the vehicle's sensors, allowing it to predict the probability of a fire outbreak with accuracy. Predictive functionality plays a crucial role in early detection, enabling treatments that might prevent the fire from starting in the first place. Utilizing cloud technologies makes the system even more effective by enabling real-time data processing and storing, ensuring that emergency responders can easily access the information. Furthermore, by allowing the system to learn from past events, the cloud platform constantly improves the prediction accuracy and dependability of the system.

The suggested approach also takes into account the best path for emergency personnel to take in order to reach the automobile that is in danger, taking into account capacity constraints and current traffic conditions. This increases the likelihood of reducing the effects of the automobile fire by ensuring that help comes as soon as possible. The system uses cutting-edge IoT devices, GPS locators, and communication modules to achieve this level of sophistication [3]. These components work together to deliver precise and fast information to emergency services as well as automobile occupants.

Even if some of these devices are undoubtedly beneficial, innovation and implementation of modern technology address many difficult challenges. These include making the device affordable for widespread use, guaranteeing the dependability and accuracy of the sensors and algorithms used for fire detection, and resolving privacy and security concerns related to information gathering and communication. Apart from that, there's the project of integrating this gadget with the current infrastructures for emergency response and cars, which calls for cooperation between emergency services, software developers, and automakers [4].

This research bridges a significant gap in the vehicle protection time frame because of the novelty of the suggested device and the lack of existing solutions created expressly to solve the issue of vehicle fires in such a comprehensive manner. It now highlights the need of utilizing modern technology to enhance public safety in addition to providing a technically sound solution. A successful deployment of this device might serve as a prototype for future advancements in the field of intelligent transportation systems, opening the door to more safe and robust vehicle transportation [4].

Finally, this work presents a novel use of IoT, machine learning, and cloud computing technologies to prevent and manage vehicle fires. This introduction lays the foundation for a thorough investigation of the sustainability, challenging circumstances, and benefits of the suggested solution by providing a thorough explanation of the device's design, capabilities, and impact on vehicle security. The ultimate objective is to make driving environments safer by lowering the risk of vehicle fires and the expenses associated with them, both financially and humanly.

This will help to enhance intelligent transportation systems and improve public safety worldwide.

1.2 Research Gap

The ambitious project uses a combination of hardware sensors, Internet of Things (IoT) generation, and advanced computer algorithms to create a complex system that enhances vehicle protection by detecting fire hazards. Despite its potential, this project exposed a significant research gap in the field of vehicle protection systems, particularly with regard to the integrated and immediate use of those technologies. One of the main challenges is integrating several sensors, IoT devices, and cloud-based solutions seamlessly to create a single device [5].

Furthermore, the project aims to use data analytics and machine learning for predictive safety measures, although real-time data processing and instantaneous decision-making capabilities are still not fully utilized. It is important to build algorithms that can quickly understand complicated sensor outputs in order to enable timely actions. Furthermore, because human behavior is unpredictable, the system's dependence on observing how people react to toxic gases and discomfort, possibly using face recognition technology introduces complexity.

The establishment of consistent, safe, and dependable communication protocols that work well with the emergency response infrastructures that are in place across various regions is yet another big gap. This difficulty emphasizes how important it is to guarantee data security and privacy while sending sensitive information. Finally, it is critical to strike a balance between the system's price, efficacy, dependability, and user-friendliness. The necessity for research aimed at creating affordable, approachable safety solutions is highlighted by the cost of development connected with cutting-edge technology, which frequently leads to solutions that are unavailable to the larger market. The necessity for a comprehensive strategy that tackles the integration of technologies, real-time processing capabilities, human behavior analysis, communication protocols, and the system's general accessibility and usability is highlighted by this broad research gap.

2 RESEARCH PROBLEM

Developing a system to predict car fires and notify drivers in advance of them, as well as identifying toxic gas leaks by analyzing driver facial expressions and sensor data, is the main research problem this study attempts to solve. Precisely identifying fire indications and harmful gas emissions in the intricate environment of a moving vehicle. In such situations, it requires the employment of extremely sophisticated sensors and algorithms that can spot little abnormalities.

Moreover, the system needs to be able to read facial responses in real-time, which means it needs to be built with strong machine-learning models that can adapt to various personal differences in face features and expressions and perform well in a range of ambient conditions [6]. To make sure that non-emergency-related elements are not confused with the existence of a fire or hazardous gas, this adds a characteristic of high accuracy to these emotion detection algorithms.

3 OBJECTIVES

3.1 Main Objective

Developing an innovative method that can identify harmful gas leaks within cars is the goal of this research. In order to provide warning signs in advance, it intends to use cutting-edge sensor technology and face expression analysis. The use of sophisticated algorithms that can read the driver's expressions for real-time monitoring of the vehicle's atmosphere is intended to significantly improve vehicle safety.

3.2 Specific Objectives

- **Development of Sensor Embedding and Integration**: Construct an advanced sensor array that can be integrated into the car and identify toxic gases and warning indicators such as unusual chemical compositions.
- **Face Expression Analysis**: Real-time facial expression recognition using algorithms based on machine learning is proposed. These methods recognize the driver's obvious and unconscious expressions, potentially indicating that they have been exposed to smoke or toxic gas.
- **Data analysis and algorithm optimization**: developing an intelligent algorithm to evaluate facial recognition and atmospheric sensor data at the same time.
- **Design of the Alert System**: An easy-to-use alert system that notifies the driver instantly of any possible hazards and provides clear directions for any necessary actions at that moment to further ensure the environment.
- **Cloud Communication System**: Provide a safe and effective mechanism for transferring the data that has been sent to the cloud. From there, it can be immediately shared with the closest emergency medical services and fire department, guaranteeing a timely reaction to the reported emergency.
- Establish a mechanism for the system to communicate with emergency services, including information about the incident's nature, its severity, and any immediate medical assistance needed.
- System Reliability and Privacy Considerations take into account privacy issues about face recognition and data transfer.

4 METHODOLOGY

4.1 System Architecture

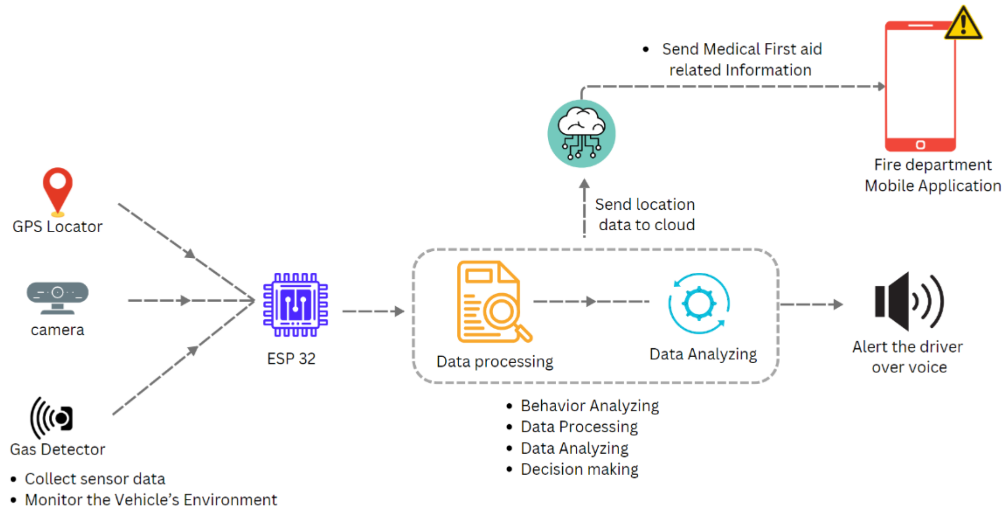

Figure 1:Component Architecture Diagram

The process of creating a system that can recognize hazardous gas leaks, detect car fires, and ensure the driver and emergency services are informed in a timely manner. To get started with, gathering requirements is essential to understanding the extent and details of what the system must do. Developing thorough use-case scenarios and personas during this phase will help in precisely determining the needs of the system. The next crucial stage after requirement identification is the selection of tools and technologies. To efficiently monitor the environmental factors within the car, the system will include a number of sensors. A GPS location allows for exact vehicle placement, a smoke detector detects the presence of fire and toxic gases, a carbon monoxide detector detects the presence of harmful gases. A dash camera records and analyzes the driver's condition in real-time [3]. As the central processing unit, the ESP 32 module will coordinate sensor inputs and carry out required operations in accordance with the data it receives. In the case of an emergency, the data collected by these sensors will be analyzed and sent to cloud services. This makes sure that the nearest fire department is informed about the incident as soon as possible, which allows for a timely response. Furthermore, an innovative alarm system uses voiceover notifications to guide drivers to safety when hazardous gases are detected. Data gathering on human reactions to these gases will be carried out in order to improve the system's response to exposure to harmful gases. This information will help to improve the machine-learning model to identify symptoms and respond appropriately. Regarding software requirements, the Anaconda with Jupyter notebook will be used as an Integrated Development Environment (IDE), and the selected programming language will be MicroPython. This choice satisfies the demand for an accurate and adaptable coding environment appropriate for the creation of Internet of Things (IoT) devices. Data security and integrity will be ensured by well-defined protocols controlling communication between IoT devices and cloud platforms. Additionally, a mobile application specifically designed for the fire department will be created, facilitating effective coordination and communication in times of emergency. It is important to guarantee the system's cost, dependability, and security. These factors are essential to creating a user-friendly device that can be widely utilized and significantly improve vehicle safety. The project is to produce a strong and dependable system that answers the important requirement for early detection of vehicle fires and dangerous gas leaks, eventually saving lives and limiting damage through the careful development and implementation of this technique.

4.2 Commercialization of the Product

1. **Patent Protection:** Make sure the product has sufficient protection against theft before releasing it onto the market. Getting patents for this novel idea may provide a competitive advantage and is essential to attract partners and investors.
2. **Pilot Programs**: For the deployment of pilot programs into action, work with fleet managers or manufacturers. This enables to get valuable feedback, show the efficiency and dependability of the system in real-world settings, and make any adjustments to the product prior to a launch.
3. **Strategic Partnerships:** Establish partnerships with automakers, suppliers of emergency response equipment, or insurers. Collaboration with such partners may bring beneficial outcomes including access to established customers, and chances for co-branding, advertising, and distribution.

4. **Direct Sales to Customers:** To sell directly to customers, make use of online platforms and e-commerce platforms. This approach may work especially well if the system is made for aftermarket installation. Sales may be increased by educating potential consumers**.**
5. **Government and Regulatory Approvals:** Seek certifications and approvals from pertinent regulatory and government agencies. In addition to giving this product more legitimacy, this might lead to customers for required installations in specific areas, which would greatly increase the number of potential consumers we could reach.
6. **Trade exhibitions and Expos**: To introduce this product to a larger audience, take part in safety conferences, technology expos, and car trade exhibits.

5 SOFTWARE / HARDWARE METHODOLOGY

5.1 Software methodology

Requirement Gathering: Clearly define the goals of the safety system, including fire detection, toxic gas leak identification, and emergency alerting capabilities. And clearly identify the requirement of the mobile application and the proposed IoT system. Engage with potential users, emergency response teams, and automotive experts to gather insights and expectations.

Market Research: Analyze existing solutions and identify gap between the products can focus on unique value of the proposed system.

Use Case Scenarios: Develop use case scenarios and personas to guide the design process and ensure the system meets varied user needs and fine tune the requirements better.

System Architecture: Design the overall system architecture, specifying how sensors, data processing units, and communication systems interact. And design the component wise System Architectures to identify the components properly and clearly. Then it will be easy to identify which component connect which.

Technology Selection: Choose appropriate technologies, including sensors (smoke, gas, GPS, dash camera), processing units (ESP 32 module), and software tools (Anaconda, Jupyter Notebook, MicroPython). These technologies may vary as the project goes on [5].

Sprint planning: create task list and break it down in to sprints. One sprint means 2 weeks. Allocate the tasks according to the weight of the task in to sprints. And always monitor the sprint plan and the actual work done during the sprint. And plan the remaining work to complete in the upcoming sprint and adjust the sprint plan accordingly.

Code reviews: Do code reviews with the team members during every week end or at the end of the sprint. And make sure user-friendly codebase will maintain throughout the project.

Prototype Development: Hardware Assembly begin with assembling the hardware components like sensors, cameras, and the ESP 32 module.

Software Development: Write the initial code for data gathering, processing, and emergency alerting, using MicroPython within the Anaconda and Jupyter Notebook IDE. Target is to program the Hardware components to work properly.

Integration: Integrate hardware and software components to create a functional prototype for initial testing.

Data Gathering and Model Training: To train the machine learning models, gather data on driving behaviors, vehicle settings, and emergency situations. Create and train models to recognize harmful chemicals, identify fire, and understand drivers from facial expressions.

System Testing: Test individual components (sensors, software modules) for functionality and reliability. Test the integrated system to ensure seamless operation and data flow between components. Conduct testing with potential users to gather feedback on system usability, effectiveness, and any adjustments needed. Repeat testing cycles to ensure all refinements are effectively implemented and new issues are addressed.

Deployment and Commercialization: Implement the system in a limited, controlled environment to validate its functionality in real-world scenarios. Prepare for larger-scale production, ensuring the quality and reliability of hardware components and officially launch the product to the market.

This tour ensures a thorough approach from concept to deployment and beyond by embracing the automotive safety system development lifecycle.

5.2 Tools and Technologies

Carbon Monoxide (CO) Sensors: Essential for detecting CO gas, which is colorless, odorless, and can be a lethal byproduct of combustion. Early detection of CO can prevent poisoning and indicate the onset of fire.

Camera Device: Utilized for monitoring driver distress through facial recognition, and detecting signs of smoke or fire. This real-time visual data is crucial for assessing emergency situations. CNN is going to be utilized for processing.

ESP 32 Device: A flexible microcontroller that can function as the central processing unit and has Bluetooth and Wi-Fi capabilities. It will gather information from sensors, process it, and coordinate interactions with emergency services and the cloud.

Speaker: Acts as the alert mechanism within the vehicle, providing auditory warnings to the driver based on the system's detections. This can include alerts about detected CO levels, the presence of smoke, or instructions for evacuation.

MicroPython: A lightweight and efficient Python 3 implementation intended for use on microcontrollers such as the ESP 32. It enables rapid development of IoT apps and simple scripting.

Jupyter Notebook: An open-source web tool that allows you to create and distribute documents with narrative text, equations, live code, and visuals. beneficial for the creation of machine learning models, data analysis, and visualization.

Anaconda: A distribution that makes package management and deployment easier for scientific computing applications using the Python and R programming languages. It's especially helpful for handling multiple environments and making TensorFlow and other data science libraries easier to install.

TensorFlow: A comprehensive open-source machine learning platform. It will be crucial for creating models that understand sensor and camera data, particularly for assessing facial emotions and predicting possible dangers.

AWS (Amazon Web Services): Provides a wide range of cloud services, such as processing capacity, storage alternatives, and IoT-specific services like Amazon IoT Core. It will make cloud data processing, analysis, and storage easier. It will also make emergency services communication easier.

React Native: With React Native, developers can create a mobile application that works with both Android and iOS.

6 DESCRIPTIONS OF PERSONAL AND FACILITIES

Member	Component	Tasks
Dharmagunawardana W.M.P.I	Identify the toxic gas leaks using driver behavior and sensor fusion technology.	Design the IOT device with sensors, ESP 32 and the necessary hardware tools. Implement the IoT device. Configure the environment and start to create the program to setup the ESP 32. Install the security protocols to connect with the cloud service. Create the dataset to train the model. Divide the data set in to training data and testing data. Train the Model to get the best accuracy level. After training the model, Install it in to the ESP 32. Write test cases to test the newly created IoT device. Start testing the IoT device along with the test cases created. Make sure it validated properly. After the validation install it in the vehicle properly and start testing it. Implement the Mobile application along with it. Check whether the mobile application sync with the system properly and test the mobile application corresponds with the system.

Table 1-Description of personal facilities

7 BUDGET AND BUDGET JUSTIFICATION

Resources	**Estimated Price (LKR)**
Travelling	10,000.00
Internet	5,000.00
Stationery	2,000.00
Hardware components/ Sensors	25,000.00
Total	**42,000.00**

Table 2-Expected Expenditure

A total of LKR 42000/= is the suggested budget cost. Our team has planned to raise funds from group members to pay for this expense. The budget table should list every expenditure related to the project, including any tools, supplies, or services needed to finish it. The project may be successfully finished with a clear financial plan and contributions from group members, even though these costs may alter in the future because of unknown circumstances or unexpected charges.

8 GANTT CHART

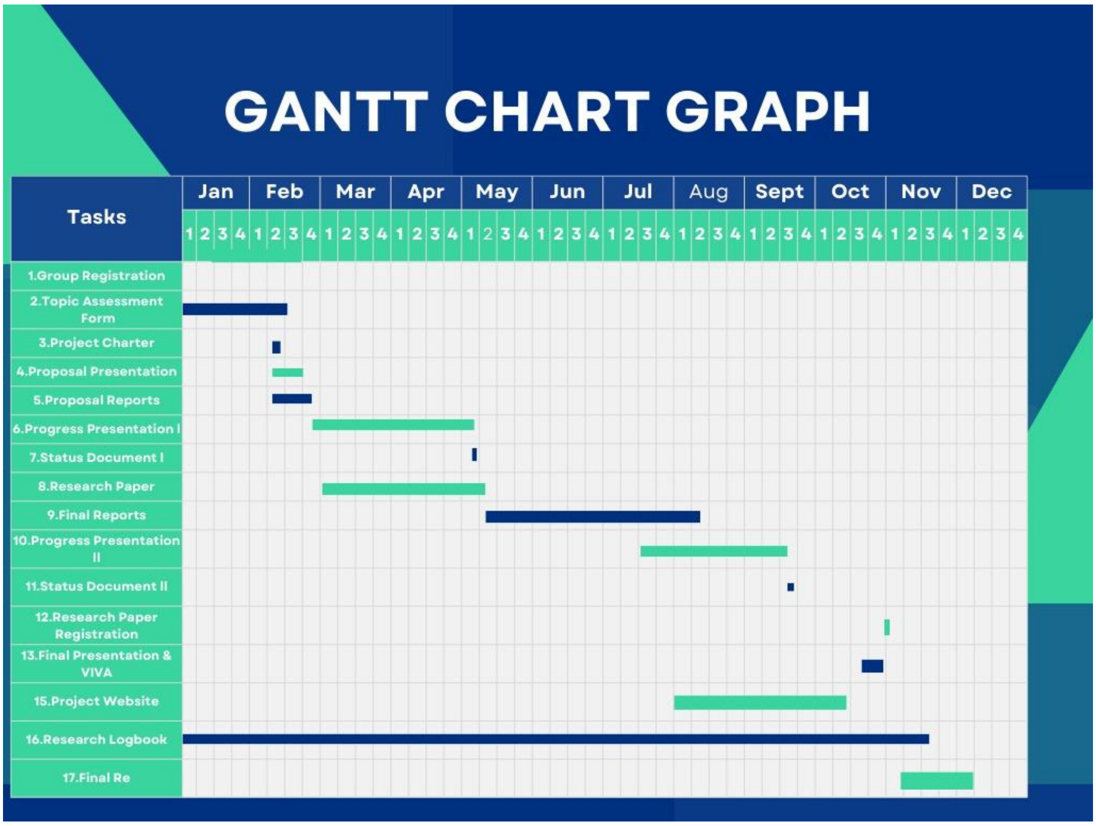

Figure 2: Proposed Gantt Chart

The Gantt chart above illustrates our proposed research project strategy, which focuses on my component. We've come a long way from January to today, the last week of February. The remaining duties will begin during the first week of March. Without this Gantt chart, our study strategy would not be the same since it makes it possible for us to spend our time and resources effectively. It shows the timeline for the project along with the due dates and dependencies for every task.

9 WORK BREAKDOWN CHART

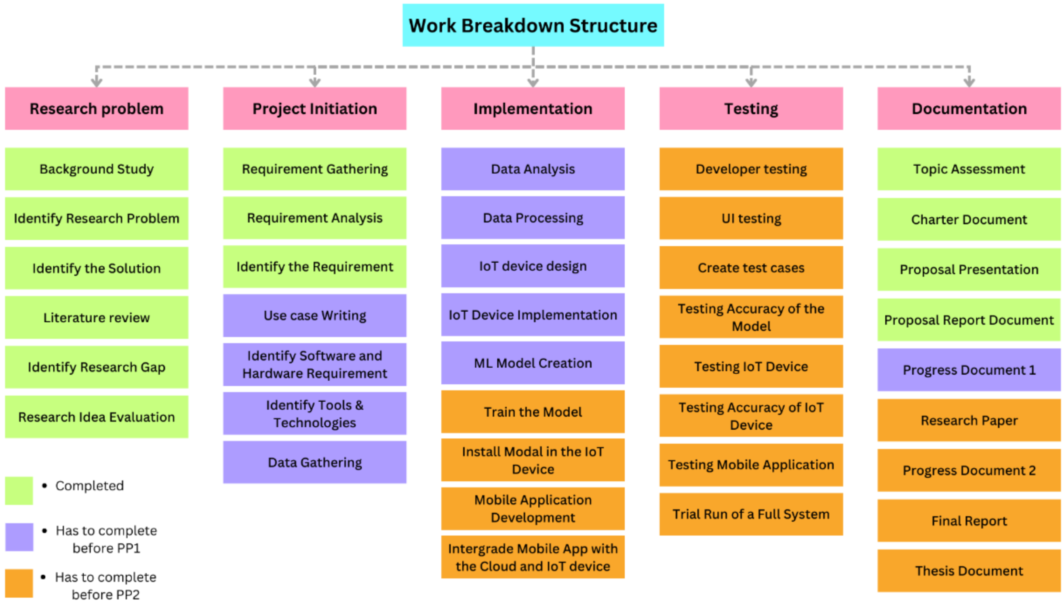

Figure 3: Work-Breakdown Structure

This work breakdown structure consists of the following 5 stages: identification of the research challenge, project commencement, implementation, testing, and documentation. The research problem and the research gap will be determined in the first step by doing a literature study and gathering all relevant research background information. Ultimately, each member of the panel assessed the proposed research concept. Data collection, requirement collecting, analysis, use case development, and the identification of software and hardware needs will all take place during the project beginning phase. Data processing, IoT device design and implementation, model construction and training, and mobile application creation and interaction with cloud services are all covered in the implementation stage. This is the phase of testing. All testing-related tasks will be coordinated at this stage. The research effort will be documented at every stage.

10 References

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11 APPENDIX