Fire Type Identification and Severity Assessment for Emergency Services

R24-058

Project Proposal Report

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

Department of Information Technology

Sri Lanka Institute of Information Technology

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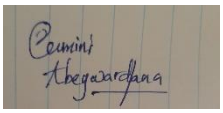
DECLARATION

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
Abeywardhana D.N	IT21133718	

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

Signature of the Supervisor:	2024.02.	
Signature of the Co-Supervisor:	2024.02.	

ABSTRACT

This proposal describes a thorough research project intended to improve vehicle fire detection and response capabilities by integrating cutting-edge technologies. The goal of the project is to create a unique fire detection system that can identify fire outbreaks and instantly determine their severity by using machine learning (ML), deep learning (DL), and Internet of Things (IoT) approaches. By installing specialized sensors in vehicles and training highly accurate ML models with real-time data, the system can predict fire type and severity levels with precision. Upon detection, the system promptly alerts the nearest fire department, facilitating swift response and appropriate action. Additionally, a mobile application displays real-time fire severity updates, ensuring occupants and responders stay informed. The commercialization strategy targets automobile companies in Sri Lanka, highlighting the product's potential to enhance vehicle safety and innovation in the local market. Overall, this research aims to significantly improve fire safety measures in vehicles, ultimately saving lives and reducing property damage.

Key Words: Machine Learning (ML), Deep Learning (DL), Internet of Things (IoT), Fire Detection, Emergency Alert, Fire type, Fire Severity

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LIST OF ABBREVIATION

IoT – Internet of Things
ML - Machine Learning
DL - Deep Learning

1 INTRODUCTION

1.1 Background and Literature Survey

With the majority of people depending on them for everyday mobility, vehicles have become an indispensable element of our lives. Unfortunately, as the number of cars on the road has grown, so too have the fatalities and injuries from accidents and vehicle fires. Accidents involving flames, especially in cars, are dangerous for emergency personnel as well as the passengers. In order to minimize damage, save lives, and guarantee the safety of first responders, it is imperative to be able to promptly and properly identify the type of fire and assess its severity.

This study focuses on the classification of fire types and the evaluation of fire severity in an effort to address the rising concern around car fires. Numerous things, such as electrical faults, gasoline leaks, engine problems, or exhaust system problems, might result in fires. Determining the most effective firefighting tactics and evaluating the possible threats to residents and emergency workers require an understanding of the cause and the materials involved. Additionally, for the safe deployment of resources and the protection of all parties involved, assessing the intensity of the fire, from minor occurrences causing minimal damage to significant ones with the potential for substantial harm, is crucial.

The study seeks to provide emergency services with the tools and knowledge to quickly recognize the type of fire they are dealing with and to accurately gauge its severity. This is not only vital for the immediate safety of individuals but also for the broader goal of reducing the impact of vehicle fires on society. By improving response strategies and risk assessment through our research, we aim to contribute to a safer environment for vehicle users and emergency responders alike.

The existing literature on Fire Type Identification and Severity Assessment for Emergency Services has been closely studied, and several similar studies were found. In the research paper "Design and Implementation of a Fire Detection and Control System for Automobiles Using Fuzzy Logic," [1] the authors tackle the important problem of vehicle fires, which cause damage to more than 2,000 cars every day and have cost the global auto and insurance industries billions of dollars in losses. The

study draws attention to the critical weakness in modern cars' complex fire safety systems. In order to address this, the authors created a novel fuzzy logic control fire detection and control system that is coupled with an Arduino microcontroller. In order to put out flames, this system includes modified mobile carbon dioxide air conditioners, temperature sensors, smoke sensors, and flame sensors. The device was tested on a medium-sized automobile, and it worked incredibly well, putting out flames in less than 20 seconds without setting off false alarms. This work offers a viable hardware solution for enhanced fire detection and suppression systems to be installed in cars, presenting a novel method to improve vehicle safety.

In another study named "Hardware Implementation of Fire Detection, Control and Automatic Door Unlocking System for Automobiles" [2] the focus is on a critical safety concern during automobile fires: the inability to save lives due to failure in opening vehicle doors. Recognizing the limitations of existing fire detection and control systems in automobiles, which primarily detect fire, alert the driver, and activate fire extinguishers, this research introduces a comprehensive safety solution. The developed system not only detects fires using temperature and smoke sensors but also automatically unlocks vehicle doors, thus enhancing occupant evacuation possibilities. Additionally, it alerts the driver with an alarm and deploys fire extinguishers to manage the fire. A notable feature of this system is its operational independence from the vehicle's battery or electrical system, ensuring functionality even if these systems fail or the doors are manually locked. With separate systems installed for each door, the design offers redundancy; if one system fails, others can still facilitate escape, significantly improving the chances of passenger survival during a fire incident. This study presents an innovative approach to vehicle safety, combining fire detection and suppression with critical emergency escape functionalities.

The study "A multimodal fire detection and alarm system for automobiles using Internet of things and machine learning" [3] addresses the important problem of car fires as well as the drawbacks of conventional fire detection systems, especially their tendency to generate false alarms. This study suggests a sophisticated model that may identify fires while they are still smoldering, allowing for early action. The use of a variety of Internet of Things (IoT)-based sensors, including temperature, flame,

smoke/gas, and visualization cameras, is the foundation of the system's effectiveness. By continually scanning the inside of the car for indications of fire, the camera plays a critical role in improving detection reliability. Through the application of machine learning algorithms to the data obtained from these sensors and the camera, the suggested method lowers false alarm rates and increases fire detection accuracy. The system's high degree of dependability is ensured by the use of many performance criteria, demonstrating the possibility of merging IoT and machine learning technologies to improve vehicle safety and reduce the number of fatal fire incidents.

The study "Advanced Vehicle Security System" [4] introduces a forward-thinking approach to vehicle safety, emphasizing the integration of fire detection within a broader accident detection framework. Central to this proposal is the development of a sophisticated vehicle safety application capable of not only detecting when an accident occurs but also identifying fire incidents within the vehicle. This system leverages a temperature sensor specifically for detecting signs of engine overheating—a common precursor to vehicle fires. Upon detection, the system alerts the occupants with a buzzer sound and sends notifications over a GSM module to authorize individuals, ensuring immediate awareness of the danger.

Another study titled "Research on Vehicle Exterior Fire Suppression Techniques" investigates methods for automatically detecting and suppressing fires occurring outside vehicles [5]. The study addresses several challenges encountered in this endeavor, including the complexity and variability of the external environment, the limited sensitivity of fire detectors, the rapid dispersion of extinguishing agents in open spaces, and potential nozzle blockage by dust and sand. To overcome these obstacles, the paper focuses on developing a specialized ultra-fine dry powder fire extinguishing agent tailored for automotive use. Additionally, it designs protective nozzles and explores automatic detection controllers equipped with condition monitoring and fault diagnosis capabilities, aiming to enhance the reliability of fire suppression. Through a combination of virtual and real vehicle tests, the effectiveness of the designed system in extinguishing fires outside vehicles is confirmed to meet the specified design criteria. This research contributes to advancing fire suppression techniques for vehicle

exteriors, with implications for improving overall vehicle safety and mitigating the risk of external fire incidents.

These studies collectively highlight innovative approaches and the potential for integrating modern technologies such as IoT, machine learning, and novel fire suppression materials to address this pervasive issue. This project aims to build upon these foundational works, leveraging cutting-edge technology to fill identified gaps and offer a comprehensive solution to vehicle fire safety.

1.2 Research Gap

After the analysis of the existing literature, it is apparent that although earlier research has made progress in creating automotive fire detection and suppression systems, there are still large gaps in the field. Research on Vehicle Exterior Fire Suppression Techniques, "Design and Implementation of a Fire Detection and Control System for Automobiles Using Fuzzy Logic," "Advanced Vehicle Security System," and "Hardware Implementation of Fire Detection, Control and Automatic Door Unlocking System for Automobiles" are just a few of the studies that have attempted to improve vehicle safety by identifying and putting out fires and protecting occupants and bystanders. The potential advantages of machine learning (ML) and deep learning (DL) techniques, which might improve the accuracy and efficacy of fire detection and suppression methods, have not, however, been examined in these investigations.

Additionally, "A multimodal fire detection and alarm system for automobiles using Internet of things and machine learning" highlights another gap by incorporating machine learning and IoT for fire detection but lacking mechanisms for fire suppression. This presents an opportunity to leverage ML/DL and IoT techniques to enhance the performance of fire detection systems. Moreover, integrating ML/DL and IoT technologies can facilitate notifying the nearest firefighter center about fire breakouts, enabling firefighters to better prepare for the situation upon arrival.

Furthermore, identifying the severity of the fire breakout will aid in their preparation. By addressing these gaps and leveraging advanced technologies, the effectiveness of fire detection and suppression systems in vehicles can be improved, ultimately enhancing overall safety for occupants and bystanders.

2 RESEARCH PROBLEM

The focus of the study is optimizing fire department practices to assist firefighters in better anticipating and managing fires more effectively upon arrival. When arriving at the site, fire department emergency systems are currently unable to allocate resources based on up-to-date fire-type information. Inefficient use of resources and lack of readiness result from this. Moreover, the ability of existing techniques to precisely evaluate the intensity of vehicle fires impedes the management of available resources and imperils the safety of responders and members of the public.

This study aims to address these issues by improving the accuracy of car fire detection and warning systems via the application of machine learning (ML), deep learning (DL), and Internet of Things (IoT) technologies. We want to boost these systems' performance by merging ML/DL and IoT. This would help fire departments better plan their resources and equipment ahead of time, reduce possible hazards, and ultimately increase the efficacy and efficiency of their firefighting operations.

Research Study	**Use of IOT**	**Use of ML/DL Techniques**	**Fire Detection & Alerting**	**Fire Suppress/Mitigation Action**	**Fire Severity Identification**	**Notifying Firefighters Through Mobile App**
Control and Automatic Door Unlocking System for Automobiles	×	×	✓	✓	×	×
Design and Implementation of a Fire Detection and Control System for Automobiles Using Fuzzy Logic	×	×	✓	✓	×	×

Hardware Implementation of Fire Detection	✗	✗	✓	✓	✗	✗
Advanced Vehicle Security System	✗	✗	✓	✓	✗	✗
Research on Vehicle Exterior Fire Suppression Techniques	✗	✗	✓	✓	✗	✗
A multimodal fire detection and alarm system for automobiles using internet of things and machine learning	✓	✓	✓	✗	✗	✗
This Study	✓	✓	✓	✓	✓	✓

Table 1: Comparison of Existing Research & Proposed Research

3 OBJECTIVES

3.1 Main Objectives

The primary goal of this study is to promptly detect fire breakouts in vehicles and assess their severity to instantly alert the nearest fire department.

3.2 Specific Objectives

Install Sensors: Equip vehicles with specialized sensors designed to detect various indicators of fire, ensuring comprehensive coverage and early detection capability.

Train ML Models: Develop and train highly accurate machine learning (ML) models using a diverse dataset of real-time sensor data collected under different conditions. This training process will enhance the models' ability to recognize patterns indicative of fire incidents with high precision.

Predict Fire Parameters: Utilize the trained ML models to analyze incoming sensor data, enabling the system to predict the type and severity level of the detected fire. This predictive capability facilitates timely decision-making and intervention.

Alert Nearest Fire Department: Upon analyzing the data and determining the fire parameters, the system will automatically generate alerts and dispatch detailed information to the nearest fire department, ensuring swift response and appropriate action.

Display Real-Time Information: Provide real-time updates on the severity level of the detected fire through a dedicated mobile application. This feature enables vehicle occupants and emergency responders to stay informed and take necessary precautions or actions promptly.

4 METHODOLOGY

Hardware Setup: Components like Arduino UNO microcontrollers, NodeMCU boards, temperature sensors, carbon monoxide detectors, gas sensors, flame sensors, and smoke detectors will be part of the hardware configuration for the fire detection system. Together, these parts will form an extensive sensor network that can identify different fire signs in automobiles.

Software Development: Python will be used for data analysis and machine learning model training, React Native for mobile application development, MongoDB for database management, Node.js for server-side scripting, and TensorFlow for creating and refining machine learning models throughout the software development process. AWS and Azure cloud computing services will also be used for data processing and storage.

System Integration: To establish a coherent fire detection and alerting system, the hardware and software components will be combined. Hardware parts and the cloud-based backend system will communicate using the MQTT (Message Queuing Telemetry Transport) protocol. The backend server, which will manage data processing, analysis, and communication with the mobile application, will be developed using Node.js.

Data Collection and Training: MongoDB databases will be used to store real-time sensor data that is gathered from the hardware parts. TensorFlow will be utilized to train machine learning models for fire detection and severity assessment, and Python scripts will be written to preprocess and analyze the data. To guarantee accuracy and dependability, a wide dataset of sensor readings collected under varied circumstances will be used to train the models.

Mobile Application Development: React Native will be used to create a smartphone application that will give emergency personnel and car occupants real-time information on fire severity levels. Through a simple and user-friendly interface, the application will communicate with the backend server to receive and show fire detection alerts and severity information.

Testing and Evaluation: To determine how well the proposed fire detection system performs in accurately detecting fires and promptly notifying the closest fire station, it will go through extensive testing and assessment. Testing will take place in real-world automobile settings in addition to simulated fire scenarios. Performance measures including false alarm rate, reaction time, and detection accuracy will be assessed to make sure the system satisfies the necessary requirements for efficacy and dependability.

Deployment and Commercialization: The commercial deployment of the fire detection system will occur when it has undergone satisfactory testing and certification. The system's potential to improve vehicle safety and innovation in the local market will be highlighted in product marketing and adoption efforts aimed at automobile firms in Sri Lanka. Support and maintenance services will be offered continuously to guarantee the system's sustained dependability and efficiency in practical applications.

4.1 System Architecture

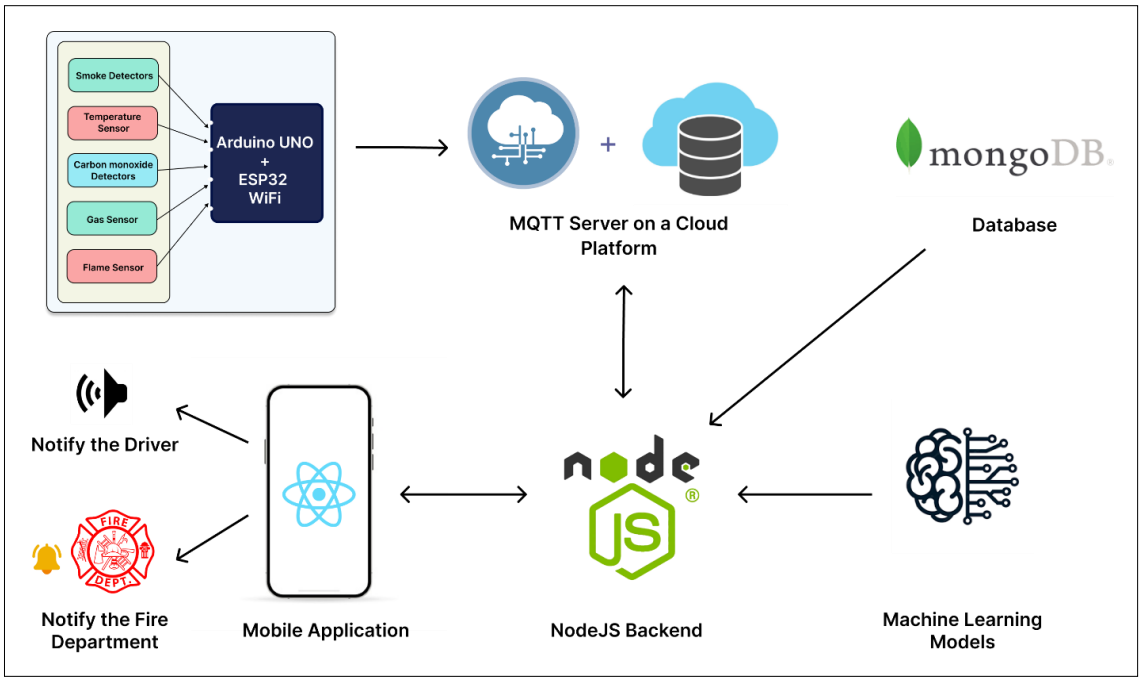

Figure 1: System Architecture

4.2 Commercialization of the Product

For car manufacturers, especially those in Sri Lanka, our fire detection system offers a significant marketing opportunity. Our objective is to directly approach car makers and distributors in Sri Lanka with our product, presenting an inventive way to improve vehicle safety. Our solution excellently satisfies the industry's demand for cutting-edge safety technology, given the growing emphasis on safety features in contemporary automobiles. We will highlight the advantages of our device, such as its capacity to promptly notify neighboring fire departments, precisely determine the severity of a fire, and identify fires early on. We will demonstrate how our fire detection technology can enhance the offerings of automakers and establish them as leaders in vehicle safety and innovation in the Sri Lankan automotive sector through focused marketing campaigns and direct sales pitches.

5 SOFTWARE / HARDWARE METHODOLOGY

5.1 Hardware Methodology

The hardware component of our fire detection system revolves around a robust network of sensors and microcontrollers, designed to operate seamlessly within the vehicular environment.

Integration of Sensors: Smoke, temperature, carbon monoxide, gas, and flame detectors will all be connected using the Arduino UNO and NodeMCU as central microcontrollers. These sensors were selected because of their capacity to reliably and sensitively identify a range of fire and hazardous state indicators.

Communication Protocol: To facilitate effective and dependable communication between the sensors and the processing unit (Arduino UNO/NodeMCU), the system makes use of the MQTT Broker. For prompt fire detection and response, this protocol guarantees real-time data transfer with low latency.

Power Management: Considering the automotive environment, the system is designed for low power consumption with high operational reliability. Strategies for power optimization and uninterrupted operation will be implemented, ensuring the system remains active and vigilant at all times.

5.2 Software Methodology

The software methodology is focused on data handling, analysis, and user interaction, ensuring accurate fire detection and efficient communication with emergency services.

Data Analysis and Machine Learning: Python, with TensorFlow, will be utilized for processing sensor data, training machine learning models for fire detection, and severity assessment. The models will learn from a diverse dataset to distinguish between different types of fire situations and false alarms.

Mobile Application and User Interface: Developed using React JS, the mobile application will serve as the primary interface for users, displaying alerts, fire severity levels, and safety instructions. The app will ensure users are promptly informed about potential dangers, facilitating quick and informed responses.

Backend Infrastructure: Node.js will serve as the backbone for server-side operations, managing data flow, analysis, and communication between the sensors, cloud storage, and the mobile application. MongoDB will be employed for database management, storing historical data for analysis, and improving the machine learning model's accuracy over time.

Cloud Computing and Storage: Utilizing AWS/Azure for cloud computing and storage solutions will offer scalability, reliability, and global access to data and resources. This infrastructure supports the system's data processing needs and enables continuous improvement through machine learning.

6 GRANT CHART & WORK BREAKDOWN

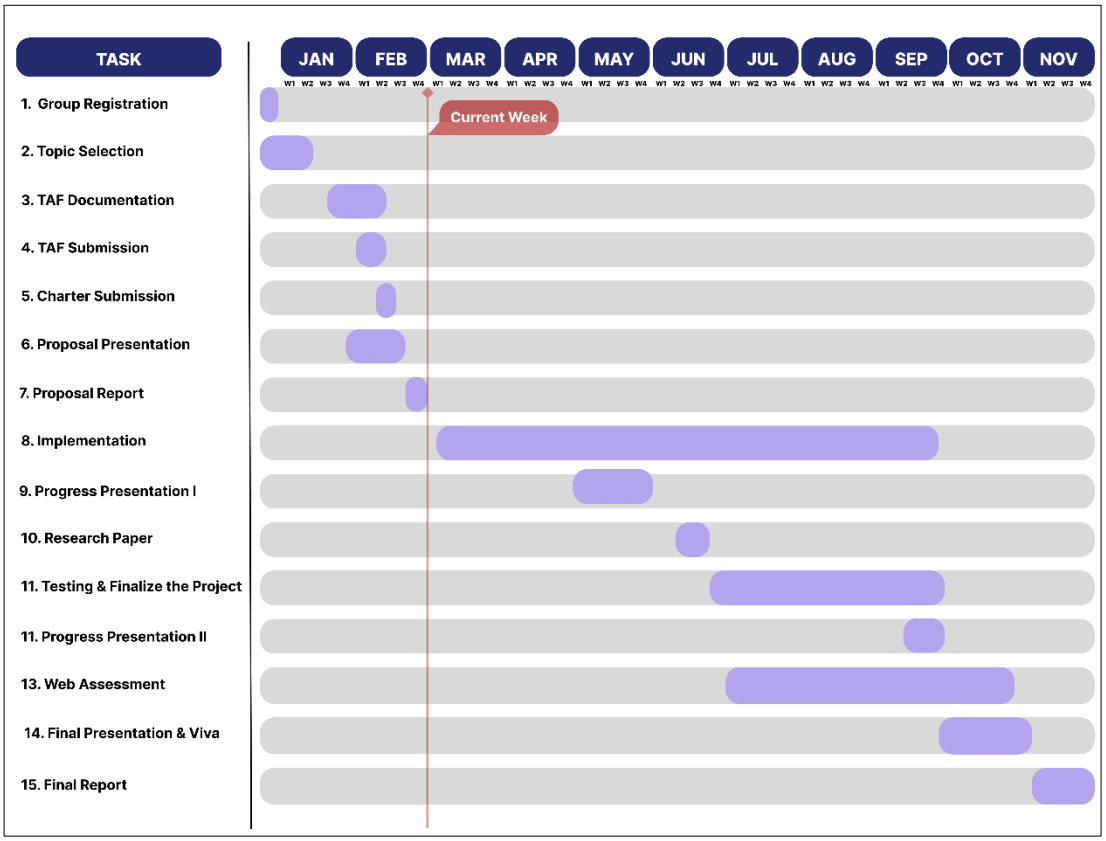

Figure 2: Gantt Chart

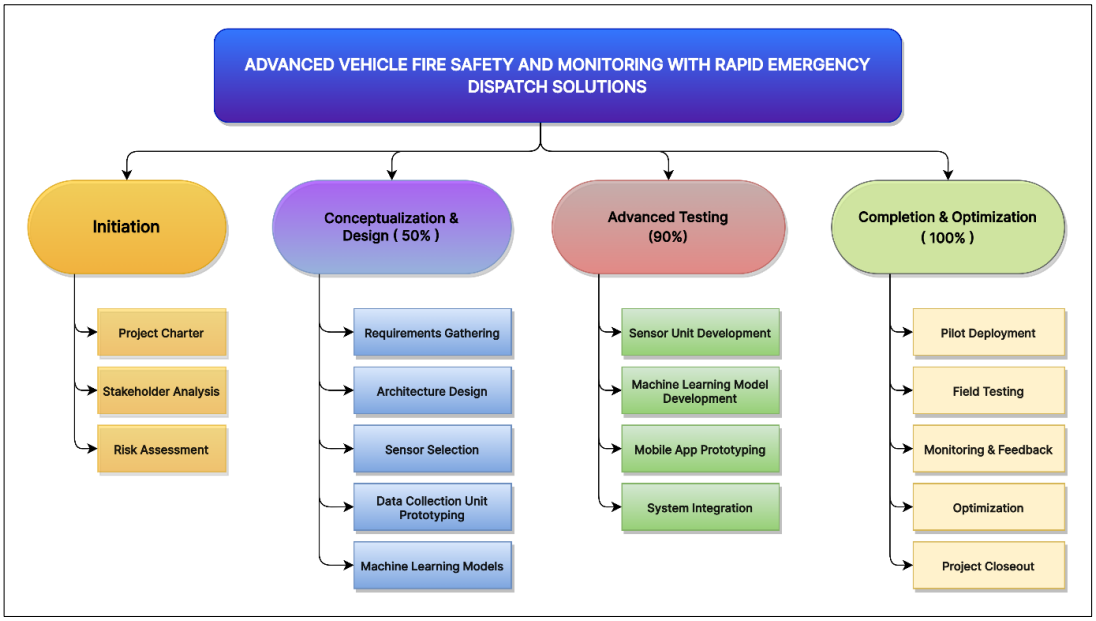

Figure 3: Work Breakdown

7 BUDGET & BUDGET JUSTIFICATION

Resource	Estimated Price (LKR)
IoT Device	25,000
Traveling	10,000
Internet	5,000
Stationery	2,000
total	42,000

Table 2: Budget

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