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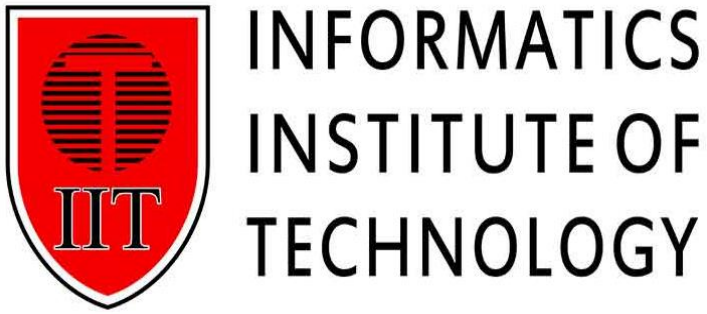

TRAFFII

Traffic Management System

A dissertation by

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LIST OF ABBREVIATIONS

CNN	Convolutional Neural Network
ML	Machine Learning
DL	Deep Learning
IOT	Internet of things
OCR	Optical Character Recognition
DNN	Deep Neural Network
VDL	Virtual Detection Lines
LIDAR	Light Detection and Ranging
GPS	Global Positioning System
IPTO	Improved Phase Timing Optimization
GSP	Generalized System of Preferences
ITS	Intelligent Transportation System

ABSTRACT

This proposed work aims to provide a comprehensive overview of traffic management and its impact on commuters, road management institutions, and authorities. Traffic congestion is a major threat to urban life, resulting in accidents, harm to economic growth, and increased gas emissions. This study investigates the importance of traffic management tools, such as image-based intelligence and camera vision, and IoT to alleviate traffic congestion, and increase public safety and economic output. The paper also discusses the limitations of current traffic management systems and suggests improvements, mainly focusing on camera/computer vision-based techniques.

In addition to discussing the benefits and limitations of existing traffic management systems, this proposal will also explore the potential ethical and privacy concerns associated with the use of image-based intelligence and IoT in traffic management. The study will analyze the different stakeholders involved in traffic management, including road users, public transportation agencies, and law enforcement agencies, and how they can work together to improve the efficiency of traffic management systems.

This work will provide a comprehensive review of the literature on traffic management, including studies on the effectiveness of different traffic management tools, and will also highlight case studies from cities around the world that have implemented successful traffic management strategies. The findings of this study will be valuable to policymakers and urban planners in developing effective traffic management plans and improving the quality of life for urban residents.

1. INTRODUCTION CHAPTER

1.1 CHAPTER OVERVIEW

In this chapter the author has written an explanation about the aim of writing of this proposal, the problem domain is also explained by adding the problem statement where it is elaborate about the addressing problem of the research. Along with that is provides an organized explanation of the exsiting working of the research problem to be addressed. Also the research gap where the research is about to address along with the aim, the objectives, the contributions towards the technological and problem domain and the challengers about the research. The author also provides the scope of the research as well and it is further elaborated using prototype feature diagram.

1.2 INTRODUCTION

By providing a structural overview of traffic management, this proposal aims to comprehensively understand how it impacts daily commuters as well as road management institutions and authorities. A review of existing work on the research topic will also be presented. Furthermore, the problem-solving approach suggested by the author is also discussed in the proposal.

1.3 PROBLEM DOMAIN

Effective Traffic Management

Congestion may boost the number of accidents, harm economic growth, and result in higher gas emissions. Currently, traffic congestion is seen as a severe threat to urban life. Suffering as a result of increased car traffic, insufficient infrastructure, and inefficient traffic management has exceeded the tolerance limit. (Naveed et al., 2022) With an ever-increasing population growth in cities around the world, continuous production of all kinds vehicles by manufacturers, and the number of vehicles on the roads will only continue to rise. This naturally leads to increased traffic congestion, especially in large metropolitan areas and even more so

during peak rush hour time. This phenomenon constantly puts pressure on researchers, city officials, and urban planners to continue to improve traffic management systems in ways that are safer and economically more efficient. In order to address this evolving problem, a number of studies have been conducted that have resulted in some notable improvements such as designated lanes for emergency vehicles in urban areas. (Avatefipour, 2018)

Issues faced by drivers and the Government due to traffic congestion

With ever-growing population growth in cities around the world, continuous production of all kinds of vehicles by manufacturers, and the number of vehicles on the roads will only continue to rise. This naturally leads to increased traffic congestion, especially in large metropolitan areas and even more so during peak rush hours. This phenomenon constantly puts pressure on researchers, city officials, and urban planners to continue to improve traffic management systems in safer and economically more efficient. (Avatefipour, 2018) Traffic management tools can be beneficial for both the public and private sectors because they can improve public safety, manage resources more efficiently, and increase economic output.

The importance of a traffic management system

The traffic inflow prediction adapts the traffic movement phase time accordingly and avoids long waiting queues and congestions at intersections. The smart navigation enables the optimal distribution of traffic to possible paths and subsequently improves road safety at intersections. (Deepajothi et al., 2021) Traffic management tools that use image-based intelligence and camera vision can help to alleviate traffic congestion by reducing the need for manual input, predicting traffic patterns, and providing real-time information to drivers. IoT can also help to improve public safety by providing information about potential hazards on the road. In addition, traffic management tools that use IoT can increase economic output by reducing the amount of time that vehicles are idling in traffic.

Traffic congestion can be solved using camera vision and image-based intelligence as part of a traffic management tool. A camera vision system can be applied to monitor traffic flow and identify congestion hotspots. It can also be used to provide real-time information to drivers about traffic conditions. Traffic congestion can be reduced with the help of this information, which may help drivers choose better routes.

1.4 PROBLEM DEFINITION

The traffic management system of a metropolitan city is a keystone for urban mobility. With the rise of the population, the demand for vehicles grows up and hence the requirement of transportation has also increased. Infrastructural development becomes an indispensable part of complementing the population growth to augment urban mobility. (M. K. M. Rabby et al., 2019) Traffic congestion problems consist of incremental delay, vehicle operating costs, such as fuel consumption, pollution emissions and stress resulting from vehicle interference in the traffic stream, particularly as traffic volumes approach a road's capacity.

Traffic congestion occurs when demand is greater than available road capacity. Many reasons cause congestion. Almost all of them reduce the road's ability at a certain point or over a certain distance. There are always concerns that traffic congestion may delay emergency vehicles during critical moments when they need to arrive at the scene as quickly as possible.

1.4.1 Problem Statement

Matching the traffic demand with the optimal usage of available roads along with the concomitant optimization of citizens' private resources for travel needs is very important. Informally without using road traffic can be seen as managing traffic optimally on a road network using available public resources is very much crucial. This allows travelers to complete their travelling needs optimally and efficiently.

1.5 RESEARCH MOTIVATION

Traffic is a common day-today matter in all around the world and there are many existing systems in many technologies. IOT based Intelligent Transportation Systems make the exchange of information possible through cooperative systems that broadcast traffic data to enhance road safety. (S. Kumari et al., 2020) This rapid expansion has motivated many researchers all over the world to incorporate camera vision into traffic management systems. This resulted in an increase the accuracy in finding the cause and the density of the traffic in modern systems. Moreover, most of these solutions lack one common element: an effective monitoring system in which is the accurate density of the traffic.

1.6 RELATED WORK

As the author's work is mainly focused on camera/computer vision-based techniques, a comparison was conducted along that path. Computer / Camera vision approaches using images

and video processing as the input for detection models have been frequently used and implemented in Traffic Management Systems by most researchers.

Citation	**Brief Description**	**Limitations**	**Improvement**
(Sowmya et al., 2021)	This paper proposed an adjustable traffic signal timer to be used to calculate the traffic density using YOLO object identification and live pictures of cameras. Through that the paper elaborate the decreasing of the road traffic congestion and other traffic.	Some extra time added because of the lag in each vehicle suffers during start-up and the non-linear which increase in lag suffered by the vehicles which are at the back.	The proposed traffic control system is developed using a self-adaptive road traffic algorithm based upon DL which can promotes intersection flow of vehicles and reduces congestion, CO2 emissions, etc.
(Deepajothi et al. , 2021)	In this paper the author elaborates on Edge Cloud-centric IoT based smart traffic management system for traffic inflow prediction and time optimized smart navigation of the vehicles. The smart navigation optimizes the distribution of traffic flow into possible paths and subsequently improves road safety as well.	This proposed model will most beneficial to the surrounding residents in the facilities while providing safe, direct, vehicular access to new facilities.	This CNN based traffic management system will not be affected by weather conditions. This is also coordinate between multiple intersections connected to ensure smooth traffic flow. It also has the prioritization of emergency vehicles.

(kumari et al., 2020)	In this paper an IOT based Intelligent Transportation Systems is introduced to make the exchange of information through cooperative systems to broadcast traffic data. Traffic light assistance systems can utilize real-time traffic light timing data by accessing through this from the traffic management center.	Fixed-time signal control system is not work properly due to the daily changers in traffic ratio. In the algorithm second part it is not accurate to get the capacity of traffic.	The proposed project has used Blob Detection Algorithm that has the capability of noise reduction which is used in video stream but at the local server.
(Bhuiyan et al. , 2019)	In this paper, the author proposed a vision based traffic monitoring system to help to maintain the traffic system smartly. In here the author emphasize on detecting and counting vehicles with a proposed method to provide an easy and cost effective solution with an operative traffic monitoring system along with the gathered information to an efficient traffic model.	DNN based detection and classification model is very expensive when consider the computational resources and time it is not suitable for real time. The two VDL is minimizes the chance of missing or counting twice. The accuracy of the method decreases in the rush hours.	Camera is cheaper than radar or LIDAR. The proposed method uses Haarlike feature based Adaboost classifier that is faster to compute and provide a very good accuracy in detection.
(Nayak et al. , 2019)	In this paper the author has used machine vision and the algorithm will be developed to maintain the traffic signal status to smoothen the traffic. This has also used image processing and also OCR to	The proposed model has used the MATLAB as processing tool mechanism but for remote usage Raspberry Pi can be used as RTOs based board on which various processing	The calculation of vehicle density on the roads are mainly calculated by Image Matching.

	read license plates of the vehicles to map the number with the connected database.	of video frames are executed after extraction along with OCR.	

Table 1.1 Related work

1.7 RESEARCH GAP

The huge number of vehicles on the roadways is making congestion a significant problem. The line longitudinal vehicle waiting to be processed at the crossroads increases quickly, and the traditionally used traffic signals are not able to program it properly. Manual traffic monitoring may be an onerous job since a number of cameras are deployed over the network in traffic management centers. (B. Sowmya, 2021) Researchers, however, solved this issue by creating sophisticated multi-layer filters combined with powerful image classifiers and different technologies.

Hence, the application of IoT in the smart traffic management system is not only limited to the reduction of the traffic congestion, air quality improvement, and traffic flow optimization but also extended to the continuous monitoring and ensuring the security and safety for the elderly people. (M.K.M. Rabby et al., 2019) Even so, when it came to detecting real time traffic and finding the cause and the density of it, is the most majority of the researchers faced as a huge challenge. These were occurring due to various reasons, including insufficient and imbalance datasets and inefficient classifying models.

The root cause of traffic mismanagement is the dynamic nature of the traffic on roads and the incapability of legacy systems to interpret such dynamics in real-time. (Sahil and S.K. Sood, 2021) It is crucial to capture these issues and re-classify them into their exact class type, so that captured data can be used for further model training.

1.8 RESEARCH CONTRIBUTION

The research contributes to technological and domain sectors through highlights in here.

1.8.1 Technological Contribution

A camera vision-based real-time Traffic detection and management system will be developed to properly monitor and verify traffic along with some traffic information. The detected traffic volume and density will be captured and uploaded to the cloud. This approach will be integrated into an IoT device to increase the system's efficiency and accuracy.

1.8.2 Domain Contribution

The existing traffic management systems will be reduced with the implementation of the system while ensuring the accuracy of traffic detection and managing it, the author intends to support the domain by creating a larger dataset with road traffic with time collected from the local roads.

As a developing country Sri Lanka's roads are the primary transport domain and traffic management is always an increasing matter. As a solution, the camera vision-based IoT traffic management system will be implemented by the relevant government institutions and drivers to cut down the time taken for the manual examination which will eventually improve and strengthen the road network and traffic congestion in the country.

1.9 RESEARCH CHALLENGES

These are the identified challenges while analyzing the existing works.

1. The accuracy of some methods or approaches decreases when there is so much rush on the roads.
2. Differences in the tested environments and the real environments.
3. Gathering and managing of the well-balanced local dataset.

From above, the most challenging task will be gathering and managing a well-balanced dataset for training and testing the solution. As there will be an opportunity of increase in the number of false information in daily traffic when detecting. The other challenge will be designing a system that can detect traffic congestion during nighttime. Proper usage of different filters for extracting the camera vision features from an image at very low light should be tested continuously before training the model. In that point of view sorting out the best fitting architecture and implementing the most accurate and suitable model would be the next challenge.

1.10 RESEARCH QUESTION

RQ1: What are the limitations of modern-day traffic management systems using IoT and camera vision?

RQ2: What are the different approaches that used in traffic management and what is the best and most suitable approach for real-time traffic management using IoT?

RQ3: What are the different camera vision based models used in traffic management?

RQ4: How to overcome the background limitations effect on traffic management and what are solutions to overcome them?

1.11 RESEARCH AIM

"The aim of this project is to design, develop and evaluate a system which could detect and manage traffic in roads and give necessary data regarding the traffic to the necessary users."

This project aims to implement a real-time traffic management system with camera vision, and it will give users relevant data to improve their routes. The information and most suitable methodology required to design and implement this project will be assembled by reviewing existing research. The model will be evaluated against accuracy and efficiency in detection to validate the derived hypothesis.

1.12 RESEARCH OBJECTIVES

Research Objectives	**Explanation**	**Learning Outcome**
Problem Identification	**RO1** - In this potion, the author primarily focuses on selecting a problem domain where the author could identify a problem for the research.	LO1
Literature Review	**RO2 -** In here, the research will be done to analyzing the related existing works on the selected research topic to gather information about limitations, improvements, and future works presented by the researchers. **RO3 -** Different vision-based approaches will be analyzed by the author to find the best fit for the research and analyzing them thoroughly to selected the approach for further research. **RO4** - Sorting out different tools, frameworks, APIs, and technologies that will be required in the development phase of the project.	LO2, LO4

Data Gathering and Analysis	This stage the author will be focused in gathering the relevant data for conducting the research. **RO5** - Analyzing the functional and non-functional requirements of the system will be evaluate in this section.	LO3, LO7, LO8
Research Design	The proposed solution's design steps is mentioned below. **RO6** – As the first step of designing a model for traffic management first the author will sort out the test plan for the testing phase and to designing the UI of the application.	LO5
Implementation	The proposed designs of this research will be implemented to create the prototype. **RO7 -** To develop implement and integrate the traffic management system with the IoT device along with an application.	LO5, LO6
Testing and Evaluation	For the prototype below mentioned requirements will be tested and evaluated. **RO8 -** To identify the relevant test cases and verify them. **RO9 -** To test the prototype with different testing methodologies and benchmarking the accuracy and efficiency with existing solutions.	LO8
Research Project Demonstration	**RO10 -** The developed Prototype and the conducted research thesis will be presented to the viva panel.	LO9

Table 1.2 Research objectives

For learning outcomes (LO) please refer the Appendix B

1.13 PROJECT SCOPE

The following research is conducted on developing an IoT device that could detect traffic management and then to provide necessary data. (cause of the traffic, density of the traffic, etc.) The main features of this research project (in-scope) and the other features that will not be covered (out-scope) are mentioned below.

1.13.1 In Scope

- Traffic management system will be implemented for real-time traffic management detection including the existing features. The proposed detection model will be able to detect and classify traffic and its conditions in different background limitations.
- The detection system will detect traffic and then collect to cloud in a certain time frame will be used to analyze and provide necessary data regarding the traffic conditions to the users.

1.13.2 Out Scope

•Alternative route suggestion to the selected route due to traffic.

1.13 PROTOTYPE FEATURE DIAGRAM

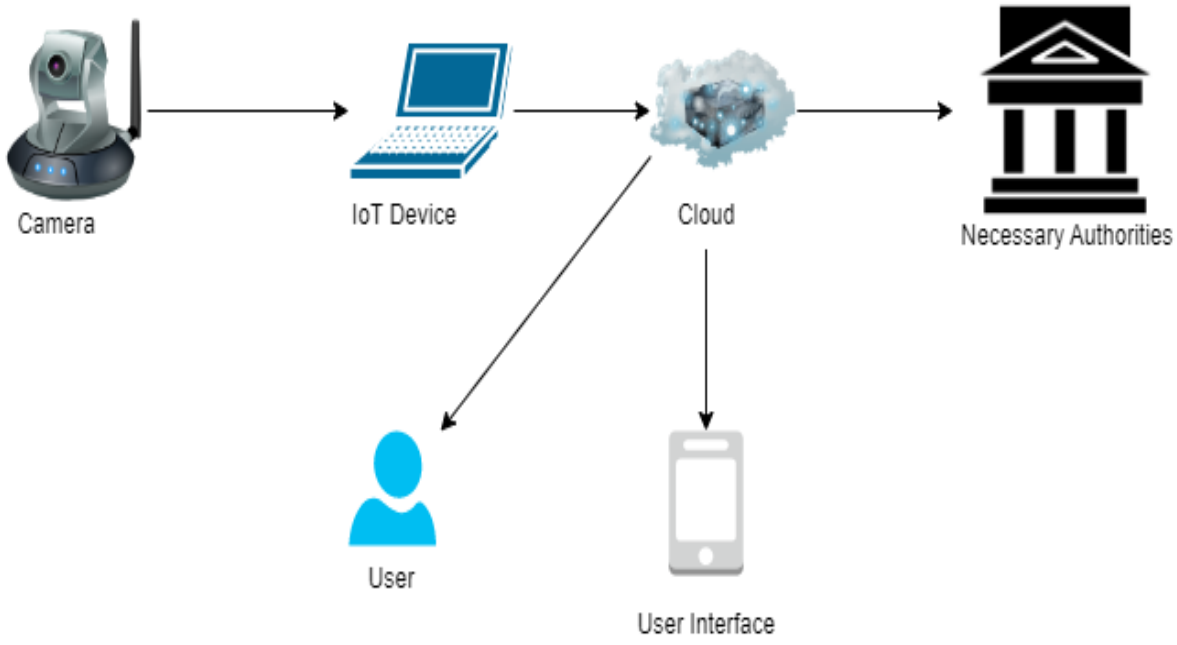

Figure 1.1 Prototype feature diagram

1.15 CHAPTER SUMMARY

This chapter covers the introduction towards the research by addressing the problem to be addressed along with the magnitude of the research alongside providing the comprehensive detail about the exsiting work comparison, aim, challengers and the contributions for the technological and problem domains.

2. SOFTWARE REQUIREMENT SPECIFICATION

2.1 CHAPTER OVERVIEW

The proposed Traffic Management system aims to use new technologies, such as IoT, camera vision, and machine learning, to address the limitations and gaps in existing traffic management systems. The development process involved a literature review to identify common issues and research gaps, stakeholder analysis to understand key stakeholders' roles and perspectives, and the use of prototyping to refine requirements and add new features. The insights gathered through these techniques informed the selection of suitable requirements elicitation methods, such as surveys, brainstorming, and observations. The literature review provided useful findings related to the use of magnetic sensors and wireless sensor networks, while the integration of computer vision and machine learning techniques was found to be a promising solution for optimizing traffic flow. Overall, the Traffic Management system seeks to meet the needs and expectations of various stakeholders, including end-users, system operational staff, investors, and government authorities.

2.2 RICH PICTURE

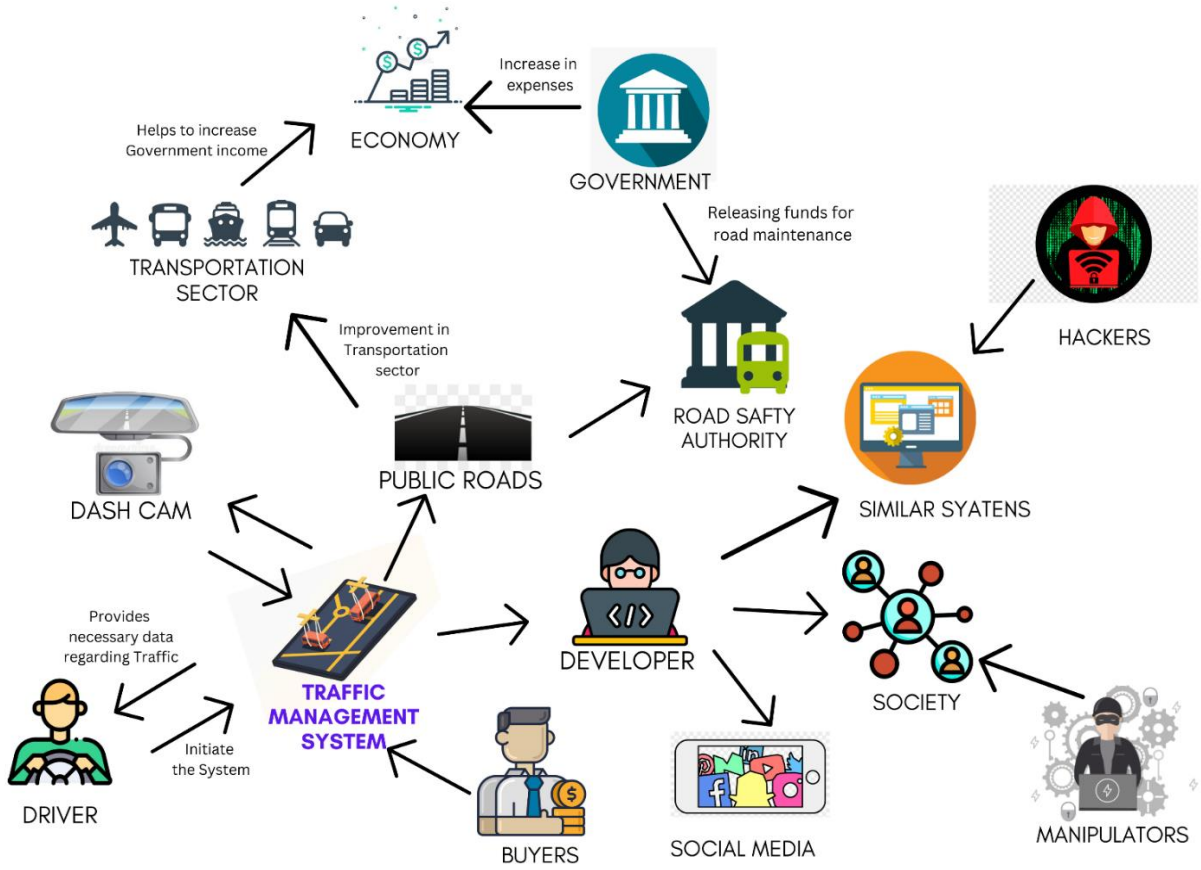

Figure 2.1 Rich picture diagram

2.3 STAKEHOLDER ANALYSIS

2.3.1 Onion Model

Figure 2.2 Onion model

2.3.2 Stakeholder Viewpoints

Stakeholder	Role	Benefits
Cloud Engineer, Data Scientist, IoT Engineer	System operational staff	System updates and maintenances.
Product Investor	Financial beneficiary	Invests in the product for improving the user experiences and beneficiary along with that also gain profit.
Potential Buyers	Fundamental beneficiary	Buy or gain interest or expand their knowledge and explore Traffic Management that they're interested in.
Driver (End user)	Functional beneficiary	Uses the developed product for detecting road traffic and manage traffic to save time in their daily travels.
The Government	Functional beneficiary	Uses the developed product same as the end users and for traffic management authorities necessary work.
Product Owner (Developer)	System owner and functional beneficiary (Operational and Administrative)	Owns and develops the product .
Social Media Users	Operational - Secondary and fundamental beneficiary	To get direct and indirect influences in search on the items of interest and possibly turn them into potential buyers.
Social Media Influencers		To influence other social media users while creating and driving trends on social media.
Social Media Manipulators	Negative stakeholders	This group destroys above mentioned trends and influences towards the proposed product and navigate them on similar or other type of products/systems.
Hackers		Disrupt, manipulates and interrupt the product and its data.

Same Product Developers (Competitors)		Creates the product with same features and creates a negative competitions to the proposed product.
Technical Advisers	Advisor	Provides technical assistance and advices in selecting technological pathways to this project.
Researchers	Fundamental beneficiary	Creates documentation and gather data for the same technological or research domains of the proposed system.
Testers	Functional beneficiary	To inspect on the quality of the product.
Product Supplier	Financial beneficiary	Supplies hardware equipment for the manufacturing of the proposed product.

Table 2.1 Stakeholder Viewpoints

2.4 SELECTION OF REQUIREMENT ELICITATION TECHNIQUES/ METHODS

Techniques 1: Literature Review
The author began the project by conducting a literature review to identify the common issues and gaps in the existing Traffic Management systems. This technique provided a deeper understanding of the field and helped to identify research gaps. The existing systems and related technologies were studied to understand the possibilities of applying new technologies to the project.
Techniques 2: Surveys
The author used a questionnaire survey as a tool to gather requirements and insights from potential users of the proposed Traffic Management system. This helped the author understand people's expectations and needs for the system, as well as the public's perception of the problem domain and whether the proposed solution would solve existing problems. The survey was also the best option for gathering a majority opinion on the proposed solution.

Techniques 4: Brainstorming and Observations
In the development of the Traffic Management system, the focus was on thoroughly understanding the requirements through the requirement elicitation process. A rich picture was created to visually depict the key elements of the system and a stakeholder analysis was conducted to identify key stakeholders and understand their roles, benefits, and perspectives. The latest trends and advancements in the field were gathered through the analysis of literature review and survey results, which included the use of magnetic sensors, computer vision and machine learning, genetic algorithms, and RFID technology. These insights will inform the development of the Traffic Management system using IoT and camera vision with Raspberry Pi technology, ensuring that all stakeholders' needs and requirements are considered and addressed.
Techniques 5: Prototyping
The Traffic Management system project followed an Agile software development life-cycle and utilized evolutionary prototyping as its methodology. This allowed for a recursive learning process, where the project team could refine requirements and add new features as they emerged. The process of prototyping resulted in the identification of several requirements and challenges, including a lack of suitable local dataset for implementation, the need to source data from an open API, and the challenge of filtering a large amount of data received from the literature review, survey results, and IoT technologies. To overcome these obstacles, the data was normalized and alternative mapping methods were used. The incorporation of social trend data provided valuable insights for informing the recommended features.

Table 2.2 Selection of requirement elicitation techniques/ methods

2.5 DISCUSSION RESULTS

2.5.1 Findings from LR

Finding	Citation
The technique for vehicle detection using magnetic sensors is a new development that aims to improve the accuracy of detecting vehicles. The detection process works by using magnetic sensors that generate a magnetic field. As a vehicle approaches the sensors, the magnetic field is distorted, which can be measured and analyzed.	(Avatefipour and Sadry, 2022)

The use of magnetic sensors has the advantage of being more accurate compared to other methods of vehicle detection. However, it is important to consider the limitations and potential drawbacks of the technique.	
The novelty focuses on the impact of new technologies on wireless sensor networks (WSNs), which have become increasingly popular in a variety of applications. The development of these new technologies has been seen as a positive aspect, as they make the WSNs more reliable and economical. However, this paper acknowledges the limitations faced by WSN nodes, such as limited battery power, memory, and computing capabilities. This is an important factor that must be considered in the design and deployment of these networks.	(Naveed et al., 2022)
This paper highlights the integration of computer vision and machine learning techniques in the optimization of traffic flow at road crossings. Specifically, the use of the You Look Once (YOLO) object detection system and adjustable traffic signal timers helps to determine the density of traffic, leading to reduced road congestion, faster transit times, and reduced fuel consumption. This is an innovative solution that leverages the potential of modern technology to address the challenges faced by traditional traffic management systems. Despite the exciting potential of these technologies, it is important to recognize their limitations and address them appropriately in order to maximize their benefits and ensure their optimal implementation.	(Sowmya et al., 2021)
The author is introducing a new technique for optimizing traffic signal timings in urban areas. This method is based on a genetic algorithm, which helps to reduce the total travel time and evens out the travel time per unit distance with PARAMICS software platform, which is a simulation management protocol. The author has emphasized the importance of being mindful of the limitations of the optimization method and software platform that was used to implement it like the complexity of the model. It is crucial to consider these limitations and their impact on the results of the	(Shanmugasundar et al., 2020)

optimization process to ensure accurate and effective traffic signal timing in urban areas.	
The novelty highlights the use of Radio-Frequency Identification (RFID) technology in the field of inventory management and asset tracking. The authors suggest that RFID technology can be integrated with other existing technologies to enhance their performance and provide better results for traffic management systems. However, the authors also acknowledge that RFID technology has some limitations that must be considered before implementing it. In other words, organizations must assess the advantages and disadvantages of RFID technology and decide whether it is suitable for their requirements.	(Shanmugasundar et al., 2020)

Table 2.3 Findings from LR

2.5.2 Findings from Survey

Question	Aim of the questions	Findings and Conclusion
Have you read the Introduction given above or in the WhatsApp message and understood the purpose of conducting this questionnaire?	Obtaining the consent from the participants.	People have understood the massage which was mentioned in the Google form and in the WhatsApp massage shared among them along with the purpose and the aim of carrying out the questionnaire and their rights of being part of it. This is also represented from the results of the questionnaire as well. Proof of these results can be found in the appendix.
Do you understand that you have the right to not to participate in this study and understand that you are free to withdraw from the study at any time, without having to give a reason?		
Do you agree to take part in this questionnaire?		
Do you have driver's license and do you drive?	Getting an overview of the other exsiting Traffic Management	This was asked to get the feedback of the both parties (With and without license / Drivers and non-

	Systems and there usage by the public.	drivers) with their experience and expertise regarding the proposed work. According to the survey results most of the personals who has license has participated on this survey.
In you daily travels for Traffic Management do you use any software tool like Google Maps?		The majority of the participants use Traffic Management Tool not only to manage traffic but also various purposes always. In percentage wise it is 75.2% and the percentage of the sometimes users are 20.8%
If yes please mention the name of the software tool that you use.		According to the results most of the participants use Google Maps or Apple Maps as the software tool when comes to traffic management and other related issues.
What is the frequency of using that software tool?		The frequency of using such a tool variates from the below given percentages. Always – 47.5% Often – 31.7% Sometimes – 10.9% Rarely - 9.9%
From the software tool that you use for Traffic management in your daily travelling what is most using feature in that software tool?	Figuring out the features that mostly used in those exsiting Traffic Management Systems and the results given by that is	According to the responses given by the participants there are 3 main reasons. The reasons and the percentage as follows; 1. Traffic density indicator – 61.4%

	always/most of the time satisfactory or not.	2. Delay of the given route and other time calculations – 55.4% 3. Alternative path suggestion – 72.3% Other than this people use these tools to manage their travels when they use public transport to find the correct trains and buses.
Is that given data accurate?		According to the statistics accuracy of the presented data from the exsiting systems as follows; Always – 42.6% Sometimes – 42.6% Often – 10.9% Rarely – 4% According to the results shown above the results deviates to the low accuracy in the exsiting systems.
How much do you satisfied with that given data?		As mentioned above same indicates when comes to the satisfactory levels of the final output data. According to the charts statistics its majorly moved towards to the dissatisfactory levels as total percentage of the neutral level to highly dissatisfactory level is 56.5%.
Are you aware about IoT(Internet of Things)?	Classifying the limitations in those exsiting Traffic Management Systems	Nearly 50% (Precisely 49.5%) do not aware of IoT, the technology stack that the author using to implement the proposed system.

If yes please tell what are the traffic management systems that you aware using IoT(internet of things)?	and the features that the users wish to be included along with the capacity of their software literacy.	62% from the participants are not aware about the traffic based implementations in IoT. Rest of the participants has mentioned Cone-connect, Waze, Google maps, Apple maps, Traffic signals etc. These answers are somewhat correct as partially IoT has used camera or sensor wise in these systems.
In your opinion, what are the background limitations of camera vision based IoT Traffic Management Systems? (If you are not aware please state it below as the answer as Not Aware)		The main 2 reasons that have mentioned in this section are; 1. Image quality / low resolution 2. Accuracy and efficiency of the data gathering, filtering and generation. Other than that most of the answers indicate that the survey participants are not aware in this area that much.
Are you comfortable in using software tool which is connected with a dash cam (Dashboard Camera)?		73.3% have stated that that they are well aware and know how to handle a dashboard camera and are comfortable in using if the proposed system contains it.
The yet to be implemented Traffic Management System mainly include the features while capturing the real time traffic using a dash cam. **1. Traffic density indication.** **2. Calculating other traffic details like time delay.**	Evaluating the feedback given by the public regarding the features in the new system that planned to be implemented.	66.3% states that they are satisfied and 29.7% are neutral. Which means 96% are agreeing and wanting to implement this proposed systems.

3. Traffic smoothen suggestions. **In your point of view are you satisfied with the given features?**		
Give reason/s for the selection you made in above question.		The highly indicated reason of this section is new technology like IoT with daily improvement will effectively solve the problems in the remaining system but in the other hand some mentioned these are already in the exsiting systems as well. Which means this proposed system has a competition in accuracy and efficiency.
Along with the remaining features in the exsiting systems what are the new features that you would like to be include in the yet to be implemented? What suggestions can you make regarding the system?		Almost the given features need to be sided with the future scope as it is related with route and maps because indications of emergency services in the secreted routs with the contact details is related with the alternative path suggestion which is added in the future scope.

Table 2.3 Findings from Survey

The proof and the percentages and charts can be found in the **Appendix C**.

2.5.2 Brainstorming and Observation

The new Traffic Management system, we focused on providing a comprehensive overview of the requirement elicitation process. We started by creating a rich picture to give a visual representation of the key elements of the system. Then, we conducted a stakeholder analysis to identify the key stakeholders and understand their roles, benefits, and perspectives. We also

discussed the selection of requirement elicitation techniques and analyzed the results of a literature review and survey to gather information on the latest trends and advancements in the field. The findings from these studies included the detection process using magnetic sensors, integration of computer vision and machine learning techniques, use of genetic algorithms, and the use of RFID technology. These insights will inform the development of the Traffic Management system, ensuring that the needs and requirements of all stakeholders are considered and addressed using IoT and camera vision with Raspberry Pi technology.

1.5.2 Prototyping

During the process of prototyping, several requirements and challenges arose. One of the major obstacles was the lack of a suitable dataset locally for the implementation of the main component. The data had to be sourced from an open API and then filtered. The main challenge encountered was the large amount of data received regarding Traffic Management systems and various technologies associated with IoT and survey results. This data had to be narrowed down to the most useful information that could be utilized for recommendations. Not all of the data had valuable information, so it was necessary to normalize various fields and find alternative ways to map items using other available data. The incorporation of social trend data provided a new and valuable perspective that could be used to inform the recommended features.

2.6 CONTEXT DIAGRAM

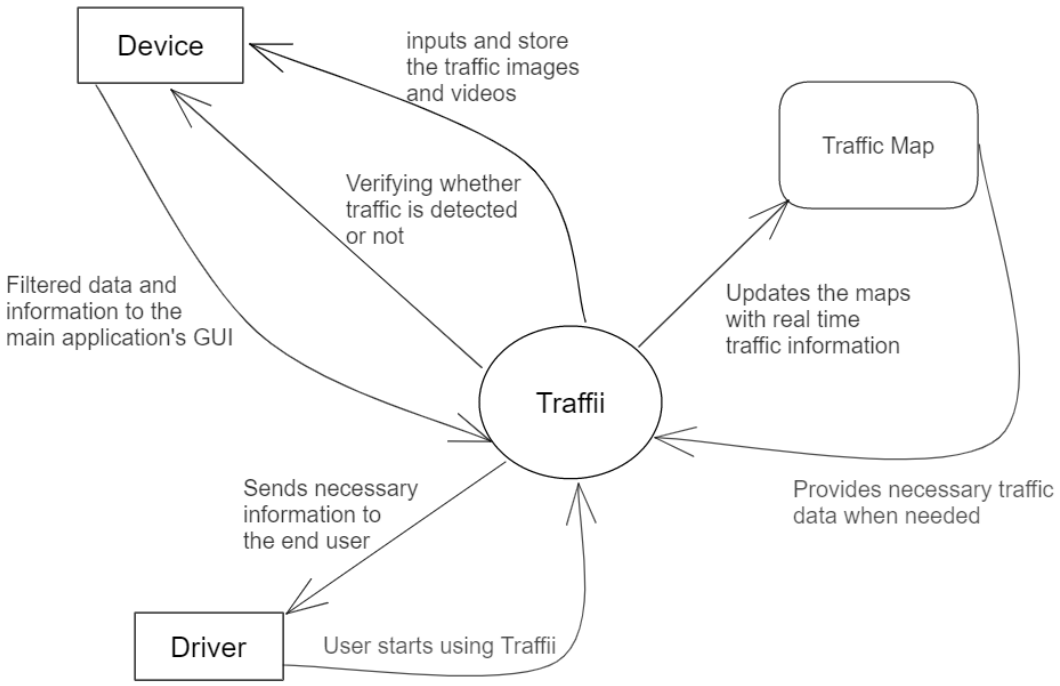

Figure 2.3 Context diagram

2.7 USE CASE DIAGRAM

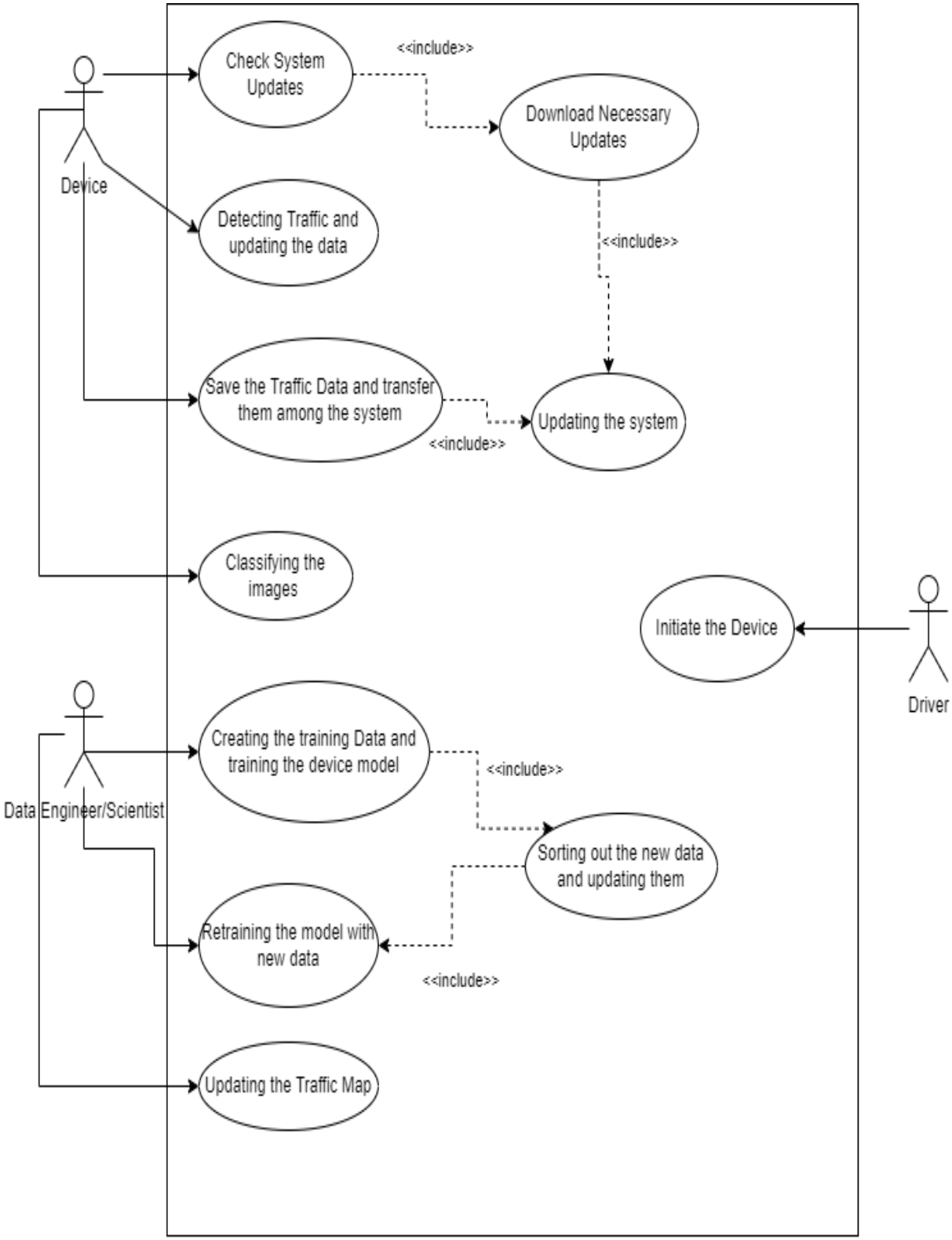

Figure 2.4 Use Case Diagram

2.8 USE CASE DISCRIPTIONS

Use Case Name	Detecting traffic and updating the data
Use Case ID	UC1
Description	The system should possess the capability to identify vehicular movement via the camera and subsequently record the footage to facilitate the detection and extraction of relevant data.
Participating Actors	Device
Pre-conditions	The system is required to receive a live video stream as an input from the camera.
Extended use cases	None
Included use cases	None
Main Flow	• The device requires activation. • The camera captures real-time images of traffic, which are subsequently transmitted to the detection model embedded within the device. • The images are segmented into individual frames. • The frames are then subjected to the detection model to identify and extract relevant traffic-related data.
Alternative Flow	None
Exceptional Flow	The detection of traffic will not be achieved.
Post Conditions	The frames comprising traffic and other relevant data will be saved within the storage medium of the device.

Use Case Name	Save the Traffic Data and transfer them among the system
Use Case ID	UC2
Description	The system should be able to inform the driver when traffic is detected along with other traffic related data generated by the system.
Participating Actors	Device
Pre-conditions	Traffic should be detected and the traffic related data should be generated.
Extended use cases	None.
Included use cases	UC1
Main Flow	After the traffic data extracted those data will be shown in the user interface to the user.
Alternative Flow	None
Exceptional Flow	No traffic will be detected.
Post Conditions	None

Use Case Name	Creating the training Data and training the device model
Use Case ID	UC3
Description	Using the detected images the data will be extracted and will be stored in for the classifications.
Participating Actors	Verification Model
Pre-conditions	None
Extended use cases	UC5
Included use cases	UC4
Main Flow	Model will be trained according the traffic data.
Alternative Flow	None
Exceptional Flow	None
Post Conditions	None

Use Case Name	Retraining the model with new data
Use Case ID	UC4
Description	Model will be retrained with new data.
Participating Actors	Verification Model
Pre-conditions	None
Extended use cases	UC5
Included use cases	UC3
Main Flow	Model will be retrained with new data.
Alternative Flow	None
Exceptional Flow	None
Post Conditions	None

Use Case Name	Updating the Traffic Map
Use Case ID	UC5
Description	The system must possess the capability to map out the positions of identified irregularities.
Participating Actors	Verification Model
Pre-conditions	The verification model must validate the anomalies detected by the system.
Extended use cases	None
Included use cases	None
Main Flow	None
Alternative Flow	These updations will not be happen accordingly.
Exceptional Flow	None
Post Conditions	The updating of the maps will happen regular and that will be shared with the users.

Table 2.4 Use Case Descriptions

2.9 REQUIREMENTS

2.9.1 Functional Requirements

FR Id	Requirement Description	Priority Level	Use Case
FR1	The device must have the capability to record the video feed.	Must have	UC1
FR2	The device should be able get the GPS location	Must have	UC1
FR3	The device must possess the ability to acquire the GPS coordinates.	Must have	UC1
FR4	The model should have the ability store traffic images with their locations	Must have	UC2
FR5	The device should have the ability to send the extract data to the user when traffic is detected.	Must have	UC2
FR6	The model should have the ability to re-classify the traffic and its data that detected through the device	Should have	UC3
FR7	The model should have the ability to store the verified traffic images and data	Could have	UC4
FR8	The model should have the ability to save and re-train with its new input data	Could have	UC4
FR9	The model should have the ability to update and save the new weights in storage	Could have	UC5
FR10	The newly re-trained weights need to be deployed into the device and give the user the required data.	Could have	UC5

Table 2.5 Functional Requirements

2.9.2 Non-Functional Requirements

NFR Id	Requirements	Requirement Description	Priority Level
NFR1	Performance	The system must possess the ability to identify traffic in real-time without experiencing any delays or malfunctions.	Important

NFR2	Accuracy	It is imperative for the system to deliver precise results to the user, particularly with regards to traffic-related information like traffic density that could lead to travel delays and vehicle wear and tear over time. Accurate data is essential to ensure optimal user experience.	Important
NFR3	Usability	The end-user must be able to utilize the developed system with ease. It is important that the configuration and setup procedures are straightforward, given that this application will primarily be utilized by individuals with limited technical expertise.	Desirable
NFR4	Scalability	Once the system is installed, the models are designed to learn from the traffic-related data collected on various traffic patterns that they were trained on. This enables the system to quickly identify traffic and provide drivers with more precise results.	Desirable

Table 2.6 Non-Functional Requirements

2.10 CHAPTER SUMMARY

This Chapter provides an overview of the requirement elicitation process for the Traffic Management system project. It presents a visual representation of the system through a rich picture and conducts a stakeholder analysis to identify key stakeholders and summarize their roles, benefits, and perspectives. The selection of requirement elicitation techniques and results from the literature review and survey are discussed, highlighting the detection process, integration of computer vision and machine learning, genetic algorithms for optimizing traffic signal timings, and the use of RFID technology in inventory management and asset tracking. This chapter provides a comprehensive understanding of the requirement elicitation process and its results to inform the development of the Traffic Management system, ensuring all stakeholders' needs and requirements are considered.

3. SYSTEM ARCHITECTURE & DESIGN

3.1 CHAPTER OVERVIEW

In this chapter the author aims to provide an in-depth understanding of the architecture and design of the system. It begins with a discussion on the design goals, including accuracy, ease of use, and scalability. The high-level design is presented through the architecture diagram, which discusses the different tiers involved and the components' functions. The low-level design includes the choice of design paradigm, such as object-oriented, component-based, or service-oriented architecture, and the design decisions made to achieve the architecture's objectives. The chapter ends with the design diagrams, primarily the component diagram, which illustrate the interactions between the components of the architecture, providing a detailed understanding of the system's internal workings.

3.2 DESIGN GOALS

Performance	Efficient performance is crucial in a real-time traffic detection model to ensure accurate and timely results. The proposed system must promptly alert drivers upon detecting road traffic without any delays. Therefore, the model's detection capabilities must be high-performing and efficient to meet the system's requirements.
Adaptability	The system's design should facilitate the seamless addition of new features without compromising the system's overall performance or causing any system malfunctions.
Scalability	From a scalability perspective, the ease of deployment of the device is critical to ensure the system's scalability. If the device requires complex technological steps to be followed during deployment, it could limit the system's scalability and make it difficult for non-technical individuals to use. Therefore, the designed edge device must be easy to deploy and use, even by non-technical individuals. This will ensure that the system can be scaled easily, and new users can be added without significant training or technical knowledge. By considering ease of deployment during system design, organizations can ensure that the system is scalable and can accommodate growing user bases and increasing data volumes.

Robustness	To ensure that the traffic detection system can operate effectively across diverse geographical regions, it is crucial to design it to handle varying traffic patterns without causing system failures or performance issues. Thorough testing of the system in multiple locations is necessary to ensure that it can provide consistent and reliable results across different traffic conditions. By conducting comprehensive tests, the system can identify any potential limitations and adjust accordingly to enhance its scalability. This will enable the system to handle different traffic patterns and volumes, making it adaptable to various regions and use cases. Ultimately, the system's ability to handle a range of traffic conditions without compromising its performance is critical to ensuring its scalability and facilitating future growth and expansion.

Table 3.1 Design Goals

3.3 HIGH LEVEL DESIGN

3.3.1 Architecture Diagram

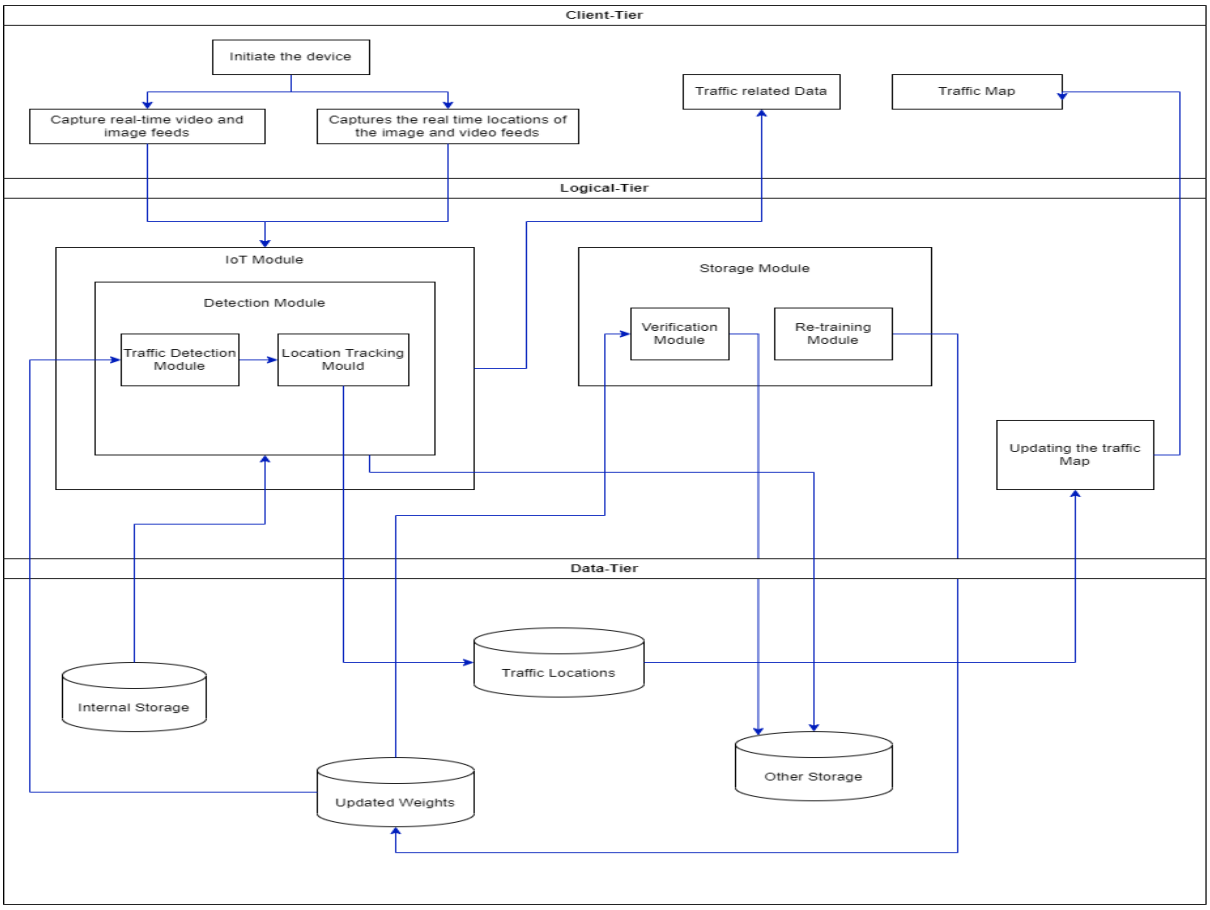

Figure 3.1 Architecture Diagram

3.3.2 Discussion of tiers

The proposed system is designed with a three-tier architecture, which includes the client tier, logical tier, and data tier, with each tier functioning independently of the others to enhance system security, scalability, and reliability. In the client tier, the system captures real-time traffic data through a camera and GPS tracker installed in the vehicle, and the detected traffic is displayed on a traffic map that is updated continuously. In the logical tier, the IoT module is composed of the traffic detection module for detecting traffic from captured data and the location tracking module for tracking the traffic's location. The storage module consists of the verification module for uploading detected traffic for further verification and the re-training module for retraining the detection and verification models using the saved traffic images. The data tier includes internal storage for storing detected traffic data and cloud storage for saving the verified traffic data, updated weights storage for newly trained weights, and traffic location storage for storing the detected traffic's longitudinal and latitudinal values.

3.4 LOW-LEVEL DESIGN

3.4.1 Choice of design paradigm

3.5 DESIGN DIAGRAMS

3.5.1 Component Diagram

3.6 CHAPTER SUMMARY

This chapter offers valuable insights into the system's architecture and design, covering topics such as design goals, high-level and low-level design, and design diagrams. The chapter is an essential read for individuals who are looking to develop systems with a focus on accuracy, ease of use, and scalability. Overall, the chapter provides a comprehensive understanding of the system's workings and makes a significant contribution to the development of efficient systems.

4. IMPLEMENTATIONS

4.1 CHAPTER OVERVIEW

This chapter focuses on the technical aspects of the system's development. It begins by discussing the technology selection process, including the technology stack, dataset selection, development frameworks, programming languages, libraries, and IDE. The chapter provides a summary of the technology selection, highlighting the key technologies used in the development of the system. The core functionality implementation is then discussed, providing a detailed understanding of the system's technical workings. Finally, the chapter covers the user interface and its design, highlighting the key features and functionalities. Overall, this chapter is an essential read for individuals interested in the technical aspects of system development, providing valuable insights into the technologies, frameworks, and tools used in the development of the system.

4.2 TECHNOLOGY SELECTION

4.2.1 Technology Stack

Client Tier	Logical Tier	Data Tier
Thonny Python IDE Java Script Google Maps Phlatform	Python NumPy Tensor Flow Keras Google Maps API	SQL

Table 4.1 Technology Stack

4.2.2 Data-set Selection

4.2.3 Development Frameworks

4.2.4 Programming Languages

To develop the Traffic detection system, the author considered Python and R programming languages. The selection was based on various factors such as wide usage in the research domain, availability of pre-trained models, and a strong set of external libraries for deep learning. Additionally, Python has a

larger community support compared to R. After conducting a thorough analysis of these factors, the author concluded that Python would be the best choice for developing the project.

4.2.5 Libraries

4.2.6 IDE

4.2.7 Summary of Technology Selection

4.3 IMPLEMENTATION OF THE CORE FUNCTIONALITY

4.4 USER INTERFACE

4.5 CHAPTER SUMMARY

In this chapter the author has focused on implementations highlights the technical aspects of the system's development, covering the technology selection process, core functionality implementation, and user interface design. The chapter provides a comprehensive overview of the key technologies used in the development of the system, including the technology stack, dataset selection, development frameworks, programming languages, libraries, and IDE. The core functionality implementation section provides detailed insights into the system's technical workings, while the user interface design covers the key features and functionalities of the system's interface. Overall, the chapter is an essential read for individuals interested in system development, providing valuable insights into the technical aspects of the system's development.

5. CONCLUSION

5.1 CHAPTER OVERVIEW

This chapter covers the scope and schedule related deviations, initial test results, required improvements, and a demo of the prototype of a new system. It highlights the challenges encountered and the adjustments made during the development process, including the need to improve the accuracy and efficiency of the test results. The demo on YouTube provides an overview of the system's purpose, the technologies used, and the reason for choosing them. Overall, this chapter provides an informative overview of the development process and offers insights into areas for improvement moving forward.

5.2 DEVIATIONS

5.2.1 Scope related deviations

Up to now the author has manage to import necessary libraries and IDE with hardware components to implement the system. The models are still training and yet not included in the system.

5.2.2 Schedule related deviations

According to the original Grantt chart showed in the Appendix D up to now the implementation should be at least done up to 40% - 50% but due to personal issues it has been still in the beginning level.

5.3 INITIAL TEST RESULTS

The environment set up is completed now by importing necessary libraries and IDEs in the software wise dives wise the necessary headwear components to implement the camera module is also done and left to do is adjust it according to the proposed system.

5.4 REQUIRED IMPROVEMENTS

The rest of the GUI and the other part such as traffic map the data model needed to be implemented and improve the accuracy and the efficiency of the test results.

5.5 DEMO OF THE PROTOTYPE

Demo of the prototype was uploaded in YouTube and the link for it is given below. In the video the author has included a small description about what is this system, the purpose of implementing such a system, what are the technologies used and why.

Video Link: https://youtu.be/t7MU8wrVoNM

5.6 CHAPTER SUMMARY

In here the author has stated the scope and schedule related deviations, initial test results, required improvements, and prototype demo for a new system. It highlights the challenges faced and the need to enhance test results accuracy and efficiency. The demo provides an overview of the system's purpose, technologies used, and its selection. Overall, the chapter offers insights into the development process and identifies areas for improvement.

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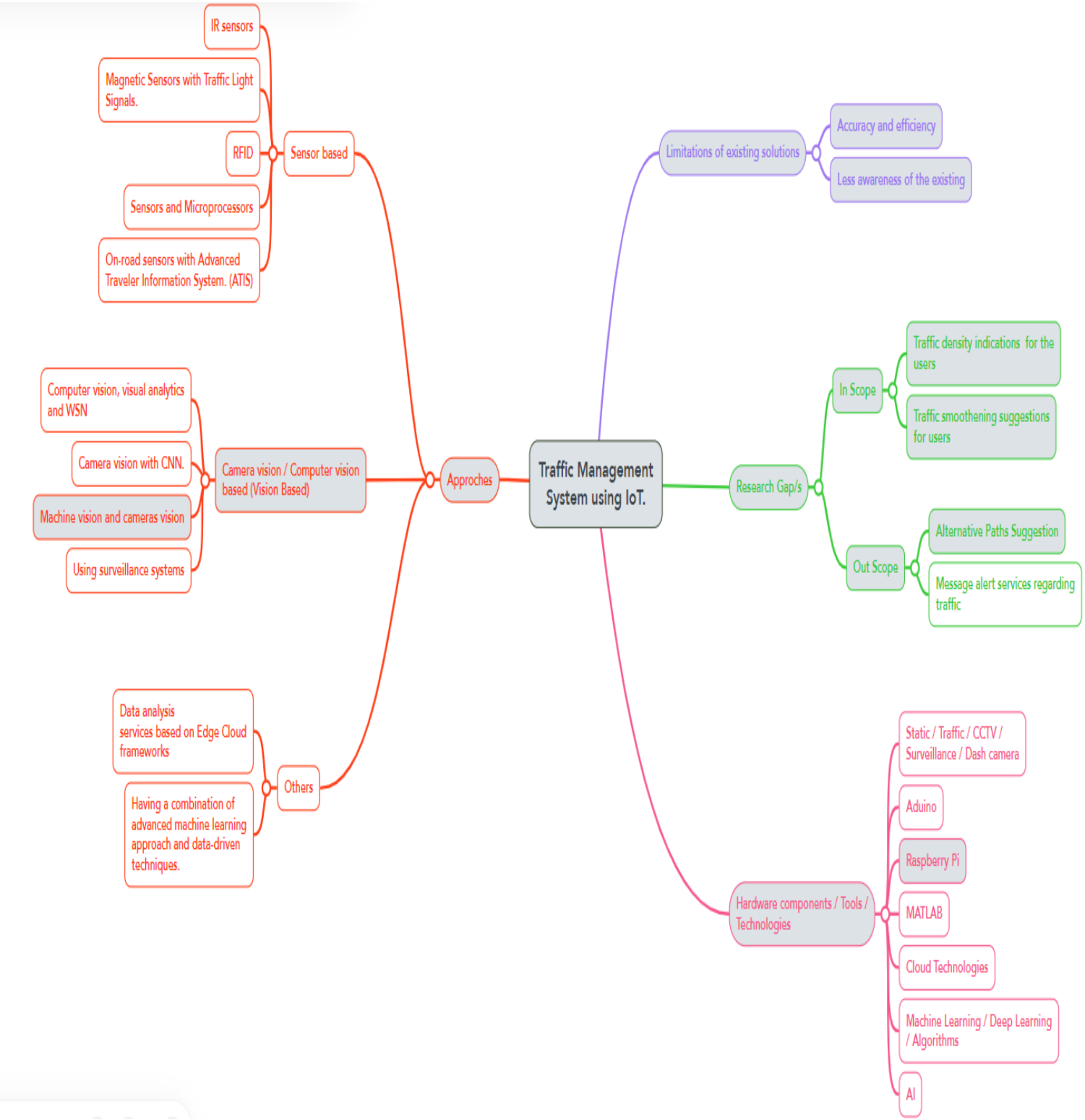
APPENDICES

Appendix A - Concept Map



Appendix B - Learning Outcomes

Learning outcomes

By the end of the module the successful student will be able to:

LO1 - Select, justify and apply appropriate methods, techniques and tools for tackling a large problem;

LO2 - Develop a project plan, organize own activities and manage time and workload within the given timescale;

LO3 - Collect and analyses project requirements, using appropriate tools and techniques;

LO4 Research and collate relevant information from various sources and critically evaluate the findings;

LO5 - Work autonomously to learn new skills/enhance existing knowledge and produce deliverables agreed with the

supervisor;

LO6 - Identify and take into account any legal, social, ethical or professional issues related to the problem and its solution;

LO7 - Produce an extended piece of practical work (software, process, model, experimental study);

LO8 - Produce a coherent report that documents and critically evaluates the practical work, the new skills and the

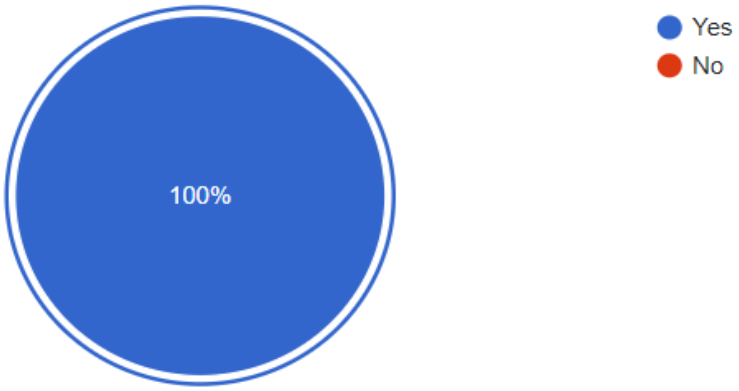
effectiveness of the project plan;

LO9 - Demonstrate and defend their work at a viva voce examination.

Appendix C - Findings from the survey

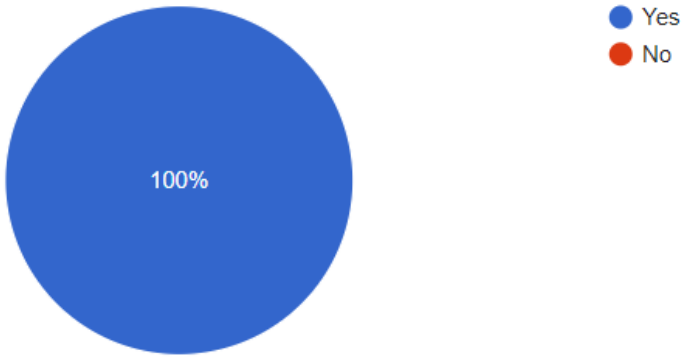
Have you read the Introduction given above or in the WhatsApp message and understood the purpose of conducting this questionnaire?

101 responses



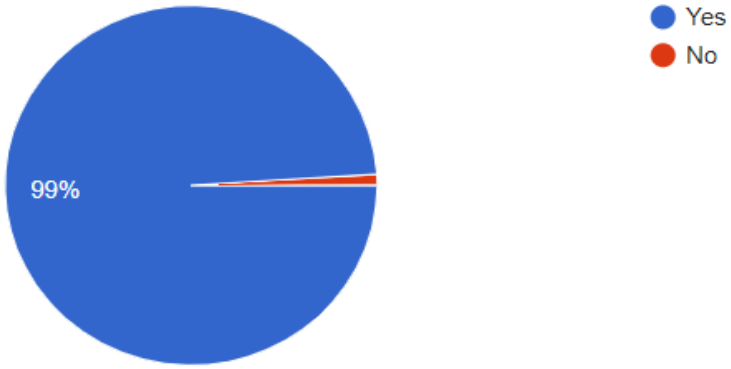
Do you understand that you have the right to not to participate in this study and understand that you are free to withdraw from the study at any time, without having to give a reason?

101 responses



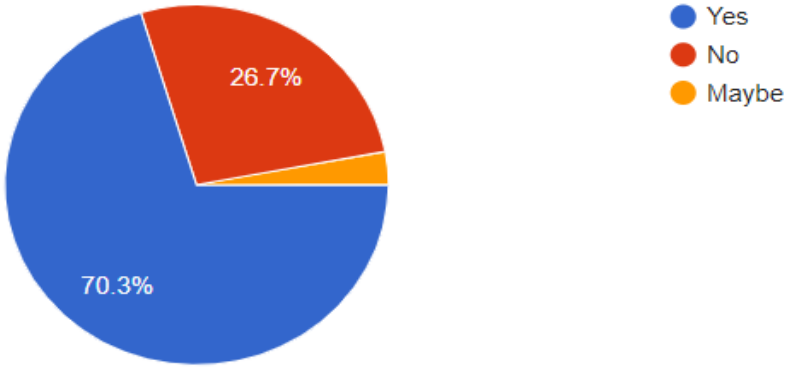
Do you agree to take part in this questionnaire?

101 responses



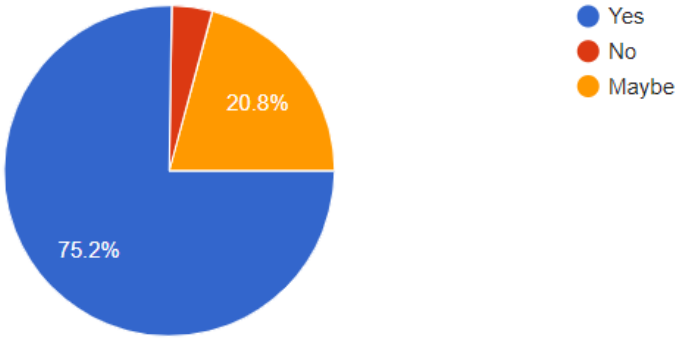
Do you have driver's license and do you drive?

101 responses



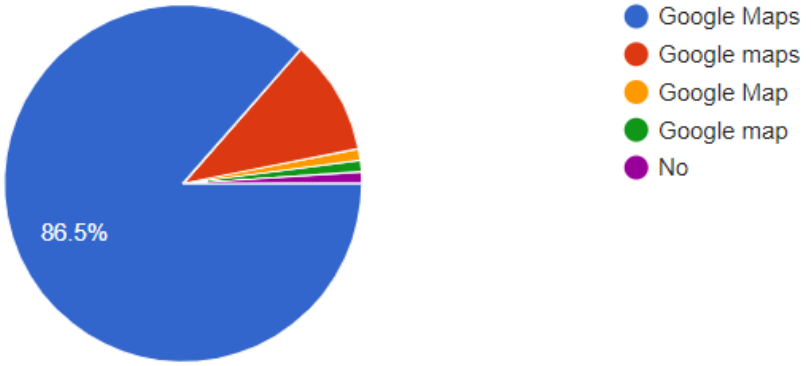
In you daily travels for Traffic Management do you use any software tool like Google Maps?

101 responses



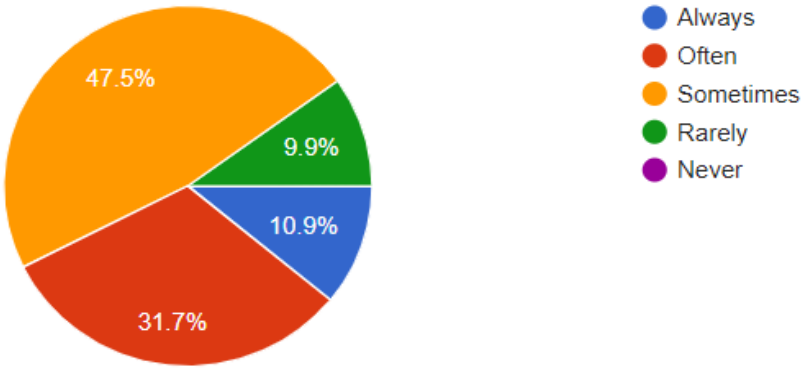
If yes please mention the name of the software tool that you use.

96 responses



What is the frequency of using that software tool?

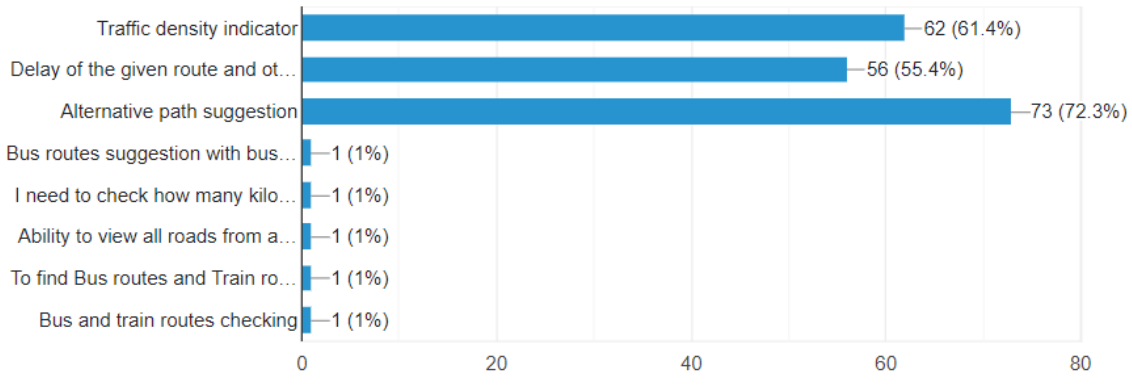
101 responses



From the software tool that you use for Traffic management in your daily travelling what is most using feature in that software tool?

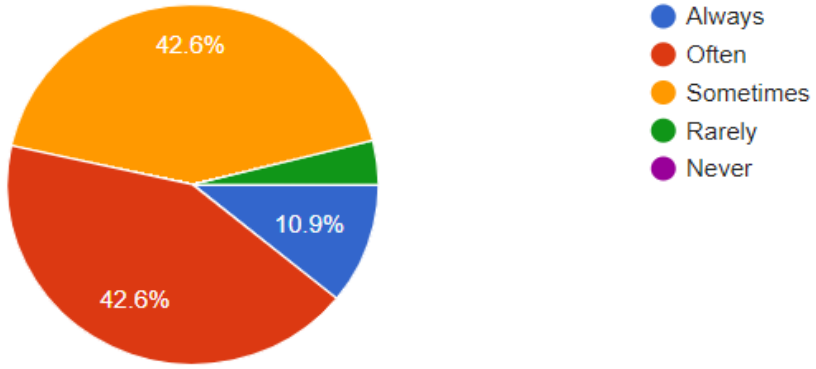
Copy

101 responses



Is that given data accurate?

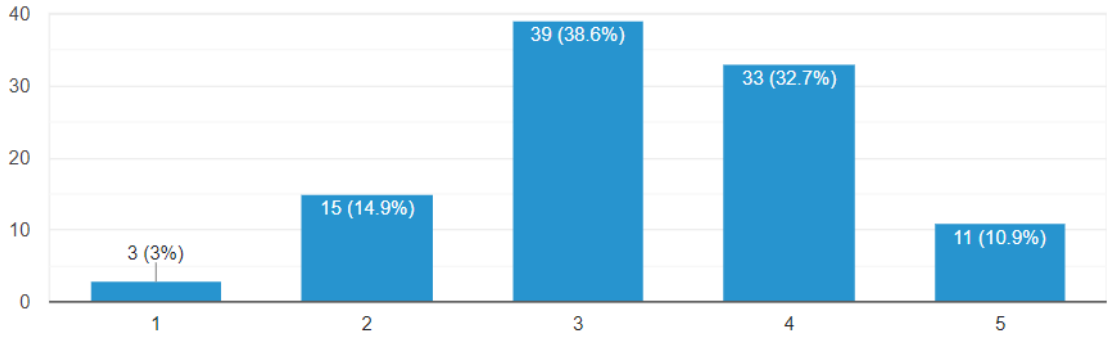
101 responses



How much do you satisfied with that given data?

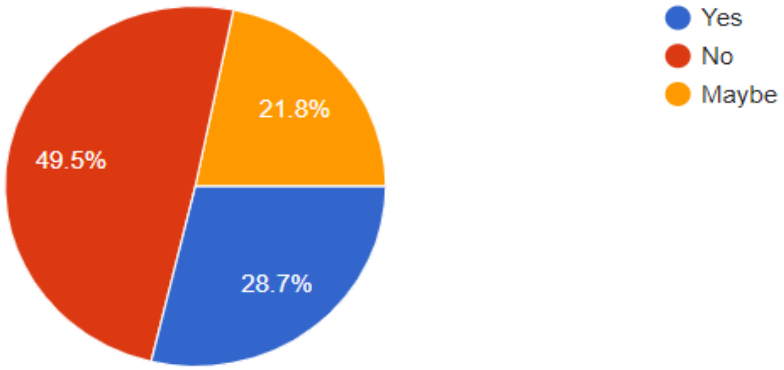
Copy

101 responses



Are you aware about IoT(Internet of Things)?

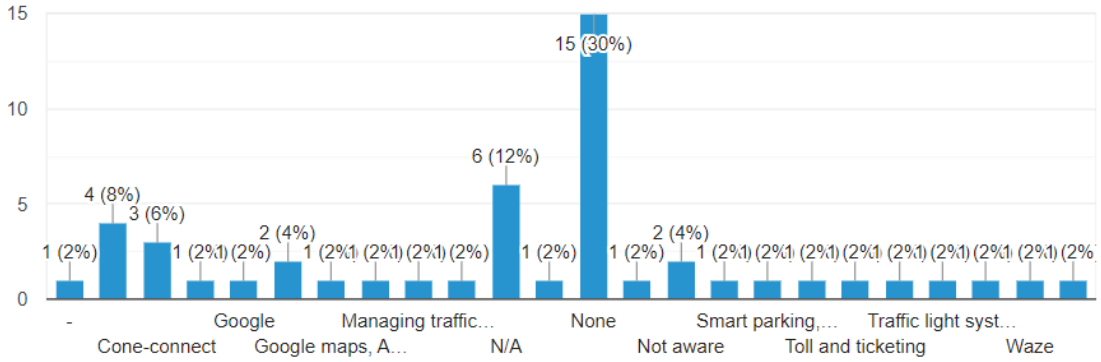
101 responses



If yes please tell what are the traffic management systems that you aware using IoT(internet of things)?

Copy

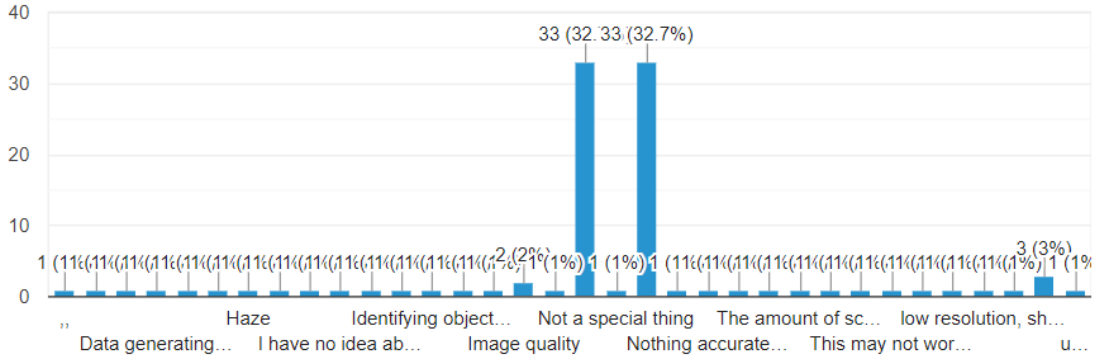
50 responses



In your opinion, what are the background limitations of camera vision based IoT Traffic Management Systems? (If you are not aware please state it below as the answer as **Not Aware**)

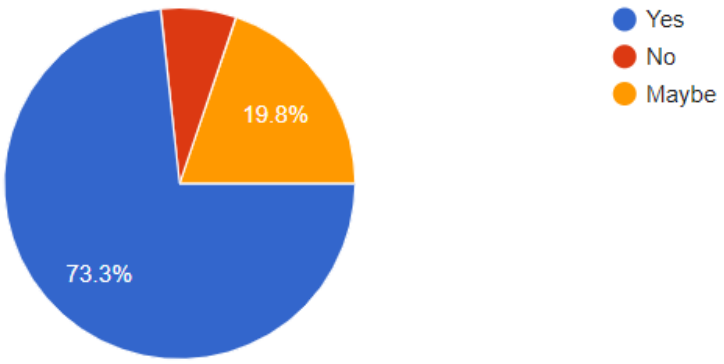
Copy

101 responses



Are you comfortable in using software tool which is connected with a dash cam (Dashboard Camera)?

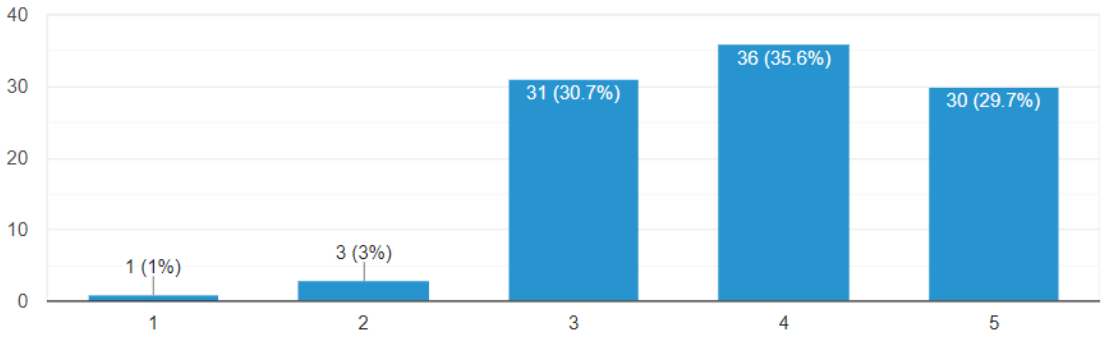
101 responses



The yet to be implemented Traffic Management System mainly include the features while capturing the real time traffic using a dash cam.
1. Traffic density indication.
2. Calculating other traffic details like time delay.
3. Traffic smoothen suggestions.
In your point of view are you satisfied with the given features?

Copy

101 responses



Give reason/s for the selection you made in above question.

101 responses

None
N/A
.
Might fully satisfied upon testing/ result
Traffic smooth
it saves the time to reach the destination
Travel time is the most important thing in the traffic management system
Like to see them in a separate device like dashcam other than the mobile phone since it drains mobile phone battery a lot.
Satisfied

Experience
Because it is extremely convenient for people who are in a hurry to travel from one location to another.
It will make driving much more easier and stress free
To saving our time
Google maps traffic is calculated on the number of devices in a particular area, which in most cases not reliable in a country like sri lanka, because not all persons use smartphones or has access 24/7 to internet
These features are among the very useful ones to manage traffic so I think I'm satisfied with those.
The given features satisfies the requirement of the system
Seems like the same features that are available on google maps

Can utilize on-the-ground information through the camera feed instead of tracking mobile devices for traffic density calculations.
,
As they can be the most reliable features which is lack in the existing systems
As some of the exsiting systems not giving accurate requested information on time, a new technology like IoT and this system will provide a suitable answer for that.
Yes, I like it. It has advancements compared to existing traffic management systems.
The above features already exist in other apps such as google maps. But, Capturing real-time traffic using dash cam will improve the outcome. Therefore I'm satisfied with the given features.
It will be convenient for the drivers in daily travelling If the above is implemented
Those are the features which existing systems sometimes shows inaccurate data.

Features are good
Personal preference
suggestions will save the users time and it will be effactive
Not interested
It fasten our wrk
By these it easier for the driver to navigate to roads with lesser traffic
Data would be more accurate
Because i' Satisfied
Along with the dash cam the traffic in front of the vehicle will be captured and the amount of dehazed image generation will be reduced as IoT has high capability of doing that.

helpful in this current situation in roads
As the information will be provided easily rather than selecting the options separately.
Much needed and lacking in the exsiting systems are mentioned
I do not understand the features of the proposed system clearly
Traffic Management is already available on google maps
The data that will be given are not directly giving by the Google maps. This product is specifically made for traffic and as the dashcams are already being installs in most of the vehicles this product will have high usage and will be highly beneficial for the users.
Because I use google maps most of the time. It works well for me but the problem is sometimes it takes time to load may be IIT is due to connection issues in rural areas.
Can got to know about real time traffic

Maybe camera base system should help to get real time idea of traffic going on
It changes rapidly
Caculating traffic delay
It save my time.
Its good
Not specific
Should consist in an alternative traffic management
Not aware
It will be easier to manage time

Capturing real-time traffic provides more accurate data than Google maps
It would be very helpful
Accurate information can be taken . And traffic smoothen suggestion is an interesting and needed feature
Is it a management system or indicating system. I am not sure about that.
It consumes little bit time
Loss of privacy
They will be very useful
Most vehicles do not have a camera. There is a camera but they are not connected to the internet. Internet facilities in Sri Lanka are not uniform throughout the country
It's always traffic

Importent features included
Will ease a lot of tasks and as time is a crucial factor this will help save it for all of us
Traffic density indication is important
-
...
Neutral
It will be beneficial
Improvement of Efficiency & Productivity
Covers most of the functionalities provided by what is currently used by me. And if mobile device movement can so accurate I believe that IOT enabled infrastructure can bring in a lot more.

No reason
Even though none of the above mentioned ones function perfectly, it is still better to use them because we can at least gain a general idea.
What is needed included in there
According to the knowledge that I have implementing these features with IoT can deliver better performance.
With IoT the features results might contain in high accuracy
Hoping that new technology approach like IoT will provide better data and performances

Along with the remaining features in the exsiting systems what are the new features that you would like to be include in the yet to be implemented? What suggestions can you make regarding the system?

63 responses

N/A

None

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Giving tips of traffic police within a range might be useful

giving resturent and filling stations indications in the selected routes

Good to have these functions offline if possible since some areas, Internet connection cause wrong routes.

Nothing in particular

Nothing

add the same features if a user wants to check for future routes. (like when you want to check the traffic for the following day) and bring down its delay time range , unlike in google maps where it shows 50min to 2 hours (which is hard to calculate the time taken to travel)

Driver alerts (since it is already using a dashcam) for "road crossing up ahead", "do not attempt to overtake on single/double lines", etc.

,

In the selected route try to indicate emergency services available near by like service stations, gas stations, hospitals, etc. and the contact details from a click without losing the map or the app window.

Alternative paths to get to the destination.

Think about both accuracy and speed of the processing in camera capturing

Should be user friendly

Alternative routes in traffic
forecast the traffic prior by using the gathered data
Information about road safety. For example stopped cars , flooding etc
If possible try to display the emergency services and personally interested places along the route.
keep it up
All are included. Nothing to add.
I am not clear about the purpose of the proposed system
Autonomous driving
All the necessary features are included.

It is better and marvelous if the app can tell where police is. Eg; like police waiting to catch high speeders. If there is something like that in the app. Many Sri Lankans will delete the google maps and opt for the new app.
-
Suggesting less traffic path
Not aware
Yes
Vehicle speed monitoring
No comments.
The first thought of mine was after reading the heading, this may be a kind of traffic light system with cameras to measure heaviness and adjust its timing according to the length. Something like that.

Nothing special
If it's possible to get to know about road accidents and road blocking updates would be important
All are needed included, So N/A

Appendix D – Grantt Chart