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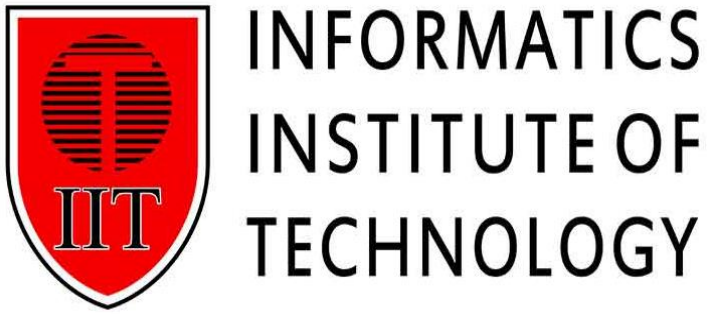

TRAFFII

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	Some extra time added because of the lag in each	The proposed traffic control system is

	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.	vehicle suffers during start-up and the non-linear which increase in lag suffered by the vehicles which are at the back.	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.	Camera is cheaper than radar or LIDAR.
		The two VDL is minimizes the chance of missing or counting twice.	The proposed method uses Haarlike feature based Adaboost classifier that is faster to compute and provide a very good accuracy in detection.
		The accuracy of the method decreases in the rush hours.	
(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 read license plates of the vehicles to map the number with the connected database.	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 of video frames are executed after extraction along with OCR.	The calculation of vehicle density on the roads are mainly calculated by Image Matching.

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.	LO3, LO7, LO8

	RO5 - Analyzing the functional and non-functional requirements of the system will be evaluate in this section.	
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

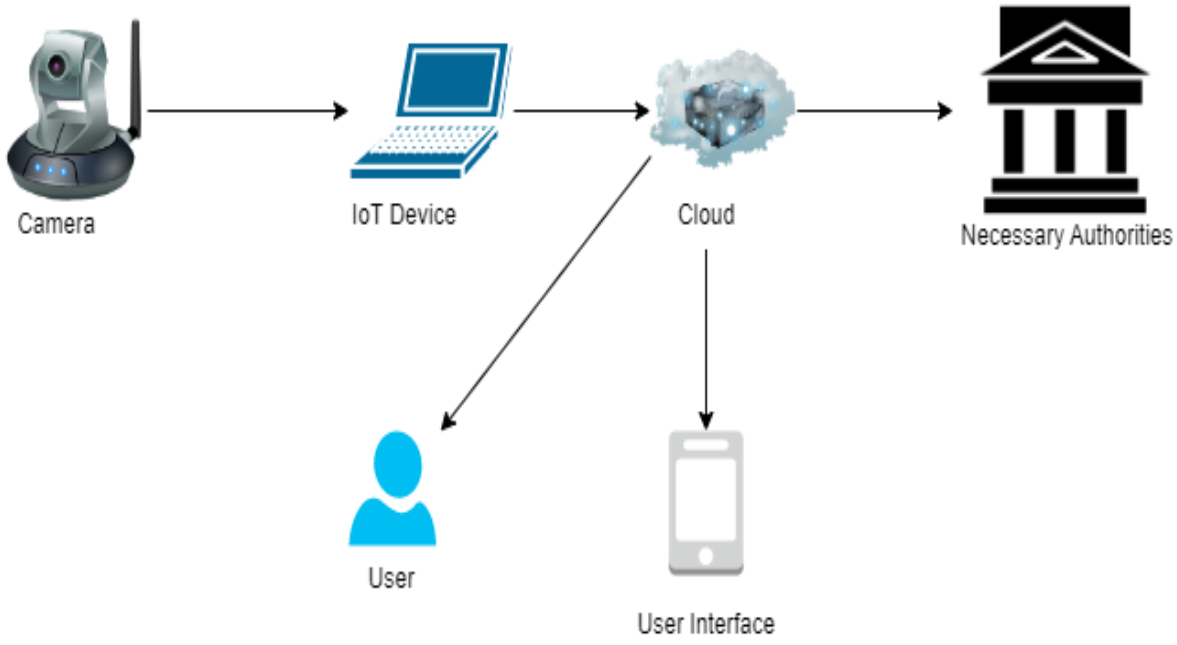

Figure 1.1 Prototype feature diagram

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. LITERATURE REVIEW

2.1 CHAPTER OVERVIEW

In this literature review chapter author focuses on providing a structural, comprehensive and elaborative review on different technological path ways that had been taken in traffic management systems using IoT. Along with that a descriptive justification of the Technological selection and reasoning why haven't chosen the other pathways which is been studied and used in exsiting work.

2.2. CONCEPT MAP

Please refer **Appendix A** for the Concept Map

2.3 PROBLEM DOMAIN

2.3.1 What is Traffic Management?

With ever-increasing 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 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.

2.3.2 Why it is important to manage traffic?

Every day, millions of automobiles, trucks and other two-wheelers are traveling on the busy city and metropolitan highways. Covering the degrees and expansion of traffic congestion and blockades, countless elements like economical, sociological, or cultural subtleties determine. The above-mentioned congestion levels are directly related to traffic accidents, travel wastage, transportation expensive load and are an obstacle to the first responders in any event. Damage from closed roads takes several forms, such as reducing employees' efficiency, wasting the time of taxpayers, losing economic possibilities, slowing down delivery service. All of these variables lead to higher prices. (Sowmya et al., 2021)

It is important to manage traffic because of the significant impact that traffic congestion and blockades can have on a city or metropolitan area. Traffic congestion can cause a number of problems, including:

1. Increased risk of accidents: The higher levels of congestion can increase the risk of traffic accidents, which can be dangerous for road users and first responders.
2. Wasted time and increased travel costs: Traffic congestion leads to travel wastage and increased transportation costs, which can be a burden for commuters and travelers.
3. Decreased efficiency and lost economic opportunities: Congestion can reduce employees' efficiency and waste taxpayers' time, leading to lost economic opportunities and slowing down delivery services.
4. Higher prices: The damage caused by closed roads and traffic congestion can lead to higher prices for goods and services, which can have a negative impact on the economy.

Therefore, managing traffic effectively is important in order to minimize these negative impacts and ensure a safer, more efficient, and more sustainable transportation system. By optimizing traffic flow and reducing congestion, cities and metropolitan areas can improve the quality of life for their residents and increase economic opportunities.

2.3.3 Different approaches done using IoT

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.

2.3.4 Why computer / camera vision based detection is chosen as the path to implement the proposed work?

Camera vision is a traffic management tool that uses image-based intelligence and camera vision to help solve the problem of traffic congestion. The camera vision can be used to monitor traffic flow and identify congestion hotspots. It can also be used to provide real-time information to drivers about traffic conditions. This information can help drivers make better decisions about route selection and help reduce the overall level of traffic congestion. Furthermore, explanations can be found in below section.

2.4 EXISTING WORK

Detection and analyzing of road traffic is a key factor in order improve the road network and the vehicle mobility. Tracking and analyzing various traffic on the road is very hard task due to the variations technical reasons. This research has attempted to tackle these problems with different techniques / technologies and developing different methodologies varying between manual, semi-automated and fully- automated techniques with the help of different technologies starting at bare eye test up to below mentioned three main techniques.

To tackle these problems researchers tried different technological approaches, algorithms and concepts in order to improve the accuracy and efficiency of their implementation. For these implementations with different technologies have been used in order to improve the accuracy and the efficiency of traffic management. The main methods or approaches which have been used are divided as mentioned below.

2.4.1 Computer / Camera Vision Based

Computer / Camera vision approaches using images and video processing as the input for detection models has been frequently used and implemented in Traffic Management Systems by most researchers.

Due to limitation of work force, authorities are unable to find the reason and control this. It is of interest to digitally process and analyze these videos in real-time in order to extract reliable data on traffic flow and to detect traffic events. For example, because of such video analysis, traffic density in major arteries can be estimated and the least congested routes and travel time estimates can be computed. This information can be achieved by counting vehicles passing through the roads. (Bhuiyan, Das and Sajib, 2019)

2.4.2 Laser Based Detection

Sensor-based detection and approaches are another heavily used techniques for Traffic Management Systems. The detections will be done via mobile phone sensors or through the installed vehicle sensors or other type of sensors. Some of the highly used sensors are;

- Radio Frequency Identification (RFID)
- IR Sensors
- Wireless Sensor Network

The information collected through these sensors will be further analyzed through the designed model and will be used for traffic management.

2.5 TECHNOLOGICAL REVIEW

2.5.1 Machine Learning Based Algorithms

Applied a new method for area-wide signal timing optimization under consumer equilibrium traffic. The optimization model was developed as a multidimensional search problem with the objective of achieving a minimized product of the overall travel time associated with the urban street network and the variance of travel time per unit travel distance. A genetic algorithm was developed for deriving model solutions. A simulation management protocol implemented in the PARAMICS software platform capable of conducting field microsimulation is introduced to construct the logic frame and function module of the region traffic signal management network. (Shanmugasundar et al., 2020)

According to what the author has stated here is that a new method for optimizing traffic signal timing in urban areas based on a genetic algorithm. The method aims to minimize both overall travel time and the variance of travel time per unit distance. The simulation management protocol is implemented using the PARAMICS software platform.

Advantages:

1. Minimization of travel time and variance: By aiming to minimize both overall travel time and the variance of travel time per unit distance, the method described in the caption can help improve traffic flow and reduce the impact of congestion on road users.
2. Genetic algorithm: The use of a genetic algorithm to solve the optimization model is a powerful and flexible approach that can adapt to changes in traffic patterns and conditions.
3. PARAMICS software platform: The use of the PARAMICS platform for implementing the simulation management protocol is a practical and effective solution for constructing the logic frame and function module of the region's traffic signal management network.

Disadvantages:

1. Complexity of optimization problem: The optimization problem described in the caption is multidimensional and complex, which may make it difficult to develop an accurate and effective solution.
2. Limitations of genetic algorithms: Genetic algorithms can be time-consuming and computationally expensive, which may limit their practicality for large-scale applications.
3. Reliance on simulation data: The PARAMICS software platform used in the method described in the caption relies on simulation data to make decisions about traffic flow. This may not always accurately reflect real-world conditions and could impact the effectiveness of the system.

Overall, the new method described in the caption has the potential to improve traffic flow and reduce the impact of congestion in urban areas. However, careful consideration must be given to the limitations of the optimization method and the software platform used to implement it.

Increasingly, organizations in a variety of industries are using IOT to operate more efficiently, better understand customers to deliver enhanced customer service, improve decision-making and increase the value of the business. IoT evolved from machine-to-machine (M2M) communication, i.e., machines connecting to each other via a network without human interaction. Machine-to-machine refers to connecting a device to the cloud, managing it and collecting data. Taking machine-to-machine to the next level, IoT is a sensor network of billions of smart devices that connect people, systems and other applications to collect and share data. As its foundation, M2M offers the connectivity that enables IOT (Kumari S. et al., 2020)

The above statement provides a clear and concise overview of the evolution of IoT from machine-to-machine communication. It highlights the advantages of using IoT, such as increased efficiency, better customer understanding, improved decision-making, and increased business value.

The description of IoT as a sensor network of billions of smart devices that connect people, systems and other applications to collect and share data provides a clear understanding of its capabilities. Also, the mention of M2M communication as the foundation of IoT highlights the importance of connectivity in the growth and development of IoT.

But the caption only briefly mentions the evolution of IoT from M2M communication and does not delve into the technical aspects of the transition. Then the caption does not provide specific

examples of how organizations are using IoT in their respective industries. This would help to provide a clearer understanding of the practical applications of IoT.

Overall, the caption provides a good introduction to the concept of IoT and its benefits, but it could be further expanded to provide a more comprehensive understanding of the topic.

2.5.2 CNN (YOLO)

In reality, the features of competitive traffic flow at the signposted road crossing are used by computer vision and by machine learning. This is done by the latest, real-time object identification, based on convolutional Neural Networks network called You Look Once (YOLO). Traffic signal phases are then improved by data acquired in order to allow more vehicles to pass safely over minimal wait times, particularly the line long and the time of waiting per vehicle. This adjustable traffic signal timer is used to calculate traffic density utilizing YOLO object identification using live pictures of cameras in intervals and adjusts the signal timers appropriately, therefore decreasing the road traffic congestion, ensuring speedier transit for persons, and reducing fuel consumption. (Sowmya et al., 2021)

According to the above statement which describes the use of computer vision and machine learning in improving the features of competitive traffic flow at road crossings. The use of You Look Once (YOLO) object identification and adjustable traffic signal timers to calculate traffic density is an innovative solution to reducing road traffic congestion, ensuring quicker transit for people, and reducing fuel consumption.

Advantages:

1. Real-time object identification: YOLO allows for real-time object identification, which can be very useful in improving traffic flow.
2. Adjustable traffic signal timers: The use of adjustable traffic signal timers based on traffic density is a smart solution to reducing congestion and improving transit speed.
3. Decreased congestion: By reducing traffic congestion, the system described in the caption can lead to a more efficient road network and improved quality of life for road users.

4. Reduced fuel consumption: By allowing vehicles to pass through road crossings more quickly, the system can help reduce fuel consumption and contribute to a more sustainable transportation system.

Disadvantages:

1. Reliance on camera data: The system described in the caption relies on live camera data to make decisions about traffic flow. This could be limited by the quality and availability of the data, which may not always be accurate or up-to-date.
2. Privacy concerns: The use of cameras to collect live data could raise privacy concerns, particularly if the data is used for purposes other than improving traffic flow.
3. Limitations of YOLO: YOLO, while a highly effective object identification tool, is not perfect. It may have limitations in terms of accuracy and speed that could impact the effectiveness of the system described in the caption.

Overall, the use of computer vision and machine learning to improve traffic flow is an exciting and promising development. However, care must be taken to ensure that the limitations of these technologies are considered and addressed to maximize their benefits.

2.5.3 RFID

A radio frequency identification network (RFID) is made up of sensors for the RFID and RFID tags. The RFID system consists of an interrogator on RFID. To connect with the RFID tag using this questioner. The RFID transmitter then extracts the interrogator's received signals/data. Messaging intrusion is used to send out control system commands and data messages. Inside the RFID controller is a system heart. Depending on the configuration, the controller core listens to the interrogators; The Controller Center can perform RFID tag read/write operations, or can perform both listening and executing operations. (Shanmugasundar et al., 2020)

Above statement state that how this technology can be simulated with the remaining technologies to accommodate a better version of remaining traffic management systems but this also has some limitations according to the authors of this statements as follows.

Improvements of the technology:

1. Improved Inventory Management: RFID technology allows for real-time tracking of inventory, which can improve accuracy and efficiency in the supply chain.
2. Increased Productivity: By automating inventory management, RFID can increase productivity and reduce manual labor costs.
3. Enhanced Security: The RFID system can help prevent theft and loss by providing a more secure way to track inventory and assets.

Limitations of the technology:

1. High Initial Cost: Implementing an RFID system can be expensive, as it requires the purchase of RFID tags, readers, and software.
2. Technical Complexity: RFID technology can be complex to implement and may require specialized technical knowledge.
3. Interference: RFID signals can be interfered with by other radio frequency signals, leading to errors in tracking and inventory management.
4. Limited Range: RFID tags have a limited range and may not be effective in large, multi-level buildings or outdoor environments.

In conclusion, RFID technology offers many benefits for inventory management and asset tracking, but it also comes with some disadvantages. Organizations need to weigh the costs and benefits of RFID technology to determine whether it is the right solution for their needs.

2.5.4 IR Sensors

A traffic light network with proper integration of both the hardware and software was planned and built. The infra-red sensors were interfaced with the microcontroller. So in this way, apart from operating the signal manually or by keeping them constant, the signal can be monitored and traffic can be controlled using the sensors and by measuring the density of traffic. Even, instead of clearing the traffic by the traffic police, the green will be signaled automatically, to give way for the ambulance by clicking the button provided. We can count the vehicles that pass through that lane by evaluating the number of times the IR rays have been obstructed. (Shanmugasundar et al., 2020)

Here the author describes that the integration of hardware and software: The integration of hardware and software in the traffic light network allows for better control and monitoring of

traffic flow. Also, traffic control using sensors: The use of infra-red sensors and microcontroller enables traffic to be controlled based on traffic density, resulting in more efficient traffic management. Along with that, priority for emergency vehicles: The ability to give priority to emergency vehicles, such as ambulances, can help improve response times and ensure that they reach their destination more quickly. Finally, Vehicle counting: The system is capable of counting vehicles that pass through a lane, which can provide valuable data for traffic analysis and planning.

In the other hand the limitation can be seen. First of all, reliance on infrared sensors: The system relies on infrared sensors, which may not be reliable in certain weather conditions or may become blocked or damaged. Secondly, manual intervention required: The system requires manual intervention to give way to emergency vehicles, which may result in human error or delay. Also, limited data collection: The system only counts vehicles passing through a lane, and does not provide information on other factors that may affect traffic flow, such as the speed of vehicles. Then, complexity of the system: The integration of hardware and software in the traffic light network may result in a complex system that is difficult to maintain and troubleshoot.

2.5.5 WSN

This technique utilizes a set of magnetic sensors to improve the accuracy of vehicle detection. As a vehicle approaches a magnetic detector, there is a partial distortion of the local magnetic field that is generated by the detector. Whenever the vehicle is in the middle and the last portion of the magnetic field generated by the detector, the total local magnetic field is distorted. After that, these data can be transmitted to a controller. (Avatefipour and Sadry, 2022)

The above statement describes a technique for vehicle detection using magnetic sensors. This technique has the advantage of improving accuracy compared to other methods. The detection process works by measuring the distortion of the magnetic field generated by the sensors, which occurs as the vehicle approaches. The data is then transmitted to a controller for analysis and processing.

One potential disadvantage of this technique is that the accuracy may be affected by other sources of magnetic interference, such as other vehicles or metal objects in the vicinity of the

sensors. Additionally, the cost of magnetic sensors and the required infrastructure to support them may be more expensive compared to other vehicle detection methods.

Another potential limitation is that the technique may only be suitable for certain types of vehicles, such as vehicles with metallic components. For example, vehicles made entirely of plastic or other non-metallic materials may not be detected by this method.

In conclusion, the magnetic sensor technique described in the caption has the advantage of improved accuracy in vehicle detection, but also has some limitations and potential drawbacks that must be considered.

New developing technologies not only make wireless networks more dependable but also make them more economical. The power, memory, and computing capabilities of WSN nodes are constrained. When it comes to battery power, sensor nodes in WSNs have to rely on limited and insufficient resources. One of the most important elements affecting the characteristics of a transceiver's power consumption is the kind of antenna used. When the communication range is greater, more power is needed to send the messages. (Naveed et al., 2022)

The statement highlights some important aspects of wireless sensor networks (WSNs) and their development. The use of new technologies is seen as a positive aspect in improving the reliability and cost-effectiveness of WSNs. The mention of the constraints faced by WSN nodes, such as limited battery power and memory, is also a key factor in the design and deployment of these networks.

One advantage of this statement is that it highlights the important role of the type of antenna used in the power consumption of the transceiver. This is crucial information for designers and engineers who are looking to optimize the energy efficiency of WSNs.

However, there are some limitations to this statement. It only mentions the impact of the communication range on power consumption without considering other factors, such as the data rate, the number of nodes, and the type of application. These are important considerations that should also be taken into account when designing WSNs. Additionally, the statement does not provide specific information on how to optimize power consumption or how to reduce the power requirements of WSNs.

Overall, while the statement provides a useful insight into some aspects of WSNs, it is limited in its scope and does not provide a comprehensive analysis of the challenges and opportunities faced by WSNs.

2.7 CHAPTER SUMMARY

In this chapter the author has provided a solid explanation of the technological selections and has discussed thoroughly reviewed about the exsiting work and their technological pathways as well. Also the concept map of the yet to be implemented and research product is also provided.

3. METHODOLOGY

3.1 CHAPTER OVERVIEW

In this chapter the author will provide a solid explanation on the research methodology using onion model and also the development methodology, explaining what are the design, development and evaluation methodology using Agile.

The author also has well explained on the research methodology using onion model by selecting pragmatism as the philosophy along with deductive leaning and mixed methods as the research strategy and choice accordingly. And also the development methodology, explaining what are the design, development and evaluation methodology using Agile, waterfall methodology, evolutionary methodology, matrix based prototyping.

3.2 RESEARCH METHODOLOGY

Research Philosophy	Pragmatism	Due to below mentioned reasons Pragmatism was selected by the author. 1. Since the outcome of the project is acquired through observation and measurement. 2. Along with traffic management more information will be provided rather than true and false.
Research Approach	Deductive Reasoning	This is chosen by the author because the following research aims at testing an existing theory and possible theoretical contribution like extension to the theory can be involved.
Research Strategy	Literature Strategy	For the research following have selected as Research Strategy because the Literature results obtained using an questionnaire will be evaluated alongside the expected results and existing results.
Research Choice	Mixed Method	Mixed Method will be used because Pragmatism is selected as the Research Philosophy.

Time zone	Cross Sectional Time Zone	Cross sectional time zone will be selected because the data will be gathered using a questionnaire and the collected data will be used in future works.
Technique and Procedure	Through a camera and Questioners	The final section focuses on the procedures on how the required data is being collected and analyzed. Data will be collected through a camera and Questioners will be sent out to gather information and opinions about the proposed solution.

Table 3.1 Research methodology

3.3 DEVELOPMENT METHODOLOGY

3.3.1 Design Methodology

In this research, the author chose OOAD over SSADM as the design methodology. SSADM uses the traditional waterfall methodology, which requires system requirements to be well defined at the outset. OOAD, on the other hand, is favorable to changing requirements and the iterative procedure.

3.3.2 Software Development Methodology

The proposed study will use Evolutionary Prototyping as the methodology for software development. In addition to the lack of well-defined requirements at the start of the project, requirements often change as development progresses. The model also helps to reduce development time, and increase testing time, by building a functional base prototype with well-defined requirements first. The following research will benefit from evolutionary prototyping.

3.3.3 Evaluation Methodology

The performance of the developed system will be assessed by computing the confusion matrix based on the detected traffic conditions. The average precision (mAP), average recall (AR), and mean average recall (mAR) matrices will be used to evaluate the performance. The detection device will be tested on local streets to assess the performance of the device and detection time. The system will be assessed based on the diverse limitations throughout the day and night. To verify the system's accuracy, tests will be conducted for a specific time period as well.

3.4 PROJECT MANAGEMENT METHODOLOGY

3.4.1 Project Plan

According to the author, AgilePM was used as the project management methodology for the following study. Tests, specifically the variety of types of tests, are one of the major reasons why AgilePM is preferred over other project management methodologies. In addition, since this is a real-world project, it is necessary to make numerous revisions and changes during the project's development cycle if the prototype version is to be effective. This research project would benefit from AgilePM.

3.4.1.1 Grantt Chart

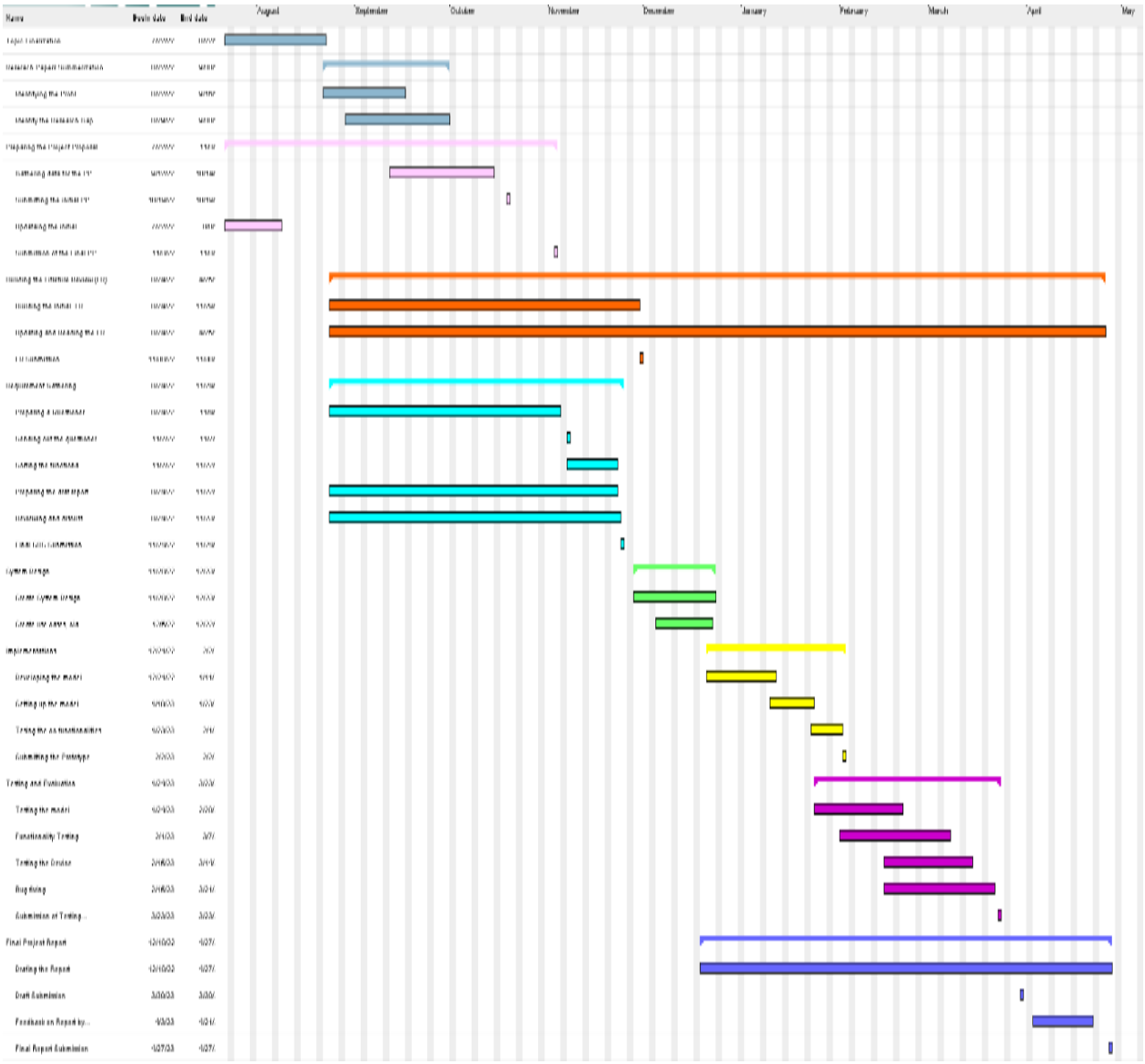

Figure 3.1 Grantt chart

3.4.5 Deliverables

Deliverable	Date
Project Proposal	3rd November 2022
Submission of SRS	24th November 2022
Initial Project Specifications Design and Prototype (PSDP) Submission	23rd January 2023
Project Specifications Design and Prototype (PSDP)	2nd February 2023
Test and Evaluation Report	23rd March 2023
Submission of Draft Project Reports	30th March 2023
Final Research Paper	27th April 2023

Table 3.1 Deliverables

3.4.6 Resource Requirements

Following are the resources are identified as requirements in order to conduct the final year research project and to do the implementations. The resource requirements are divided into three categories;

1. Software
2. Hardware
3. Skills

3.4.6.1. Software Requirements

Requirement	Purpose
Operating System – macOS 64 bit or Windows 10 64 bit or Linux 64 bit	To develop the implementation for the research and for preparing the necessary data for that.
MS word, Google Docs	For the documenting purposes of the research project.
Git	For the solution source code management.
Google Drive and One drive	For storing the project related documents.
Mendeley	For managing the references.
GanttProject	To create the Grantt chart of the project.
Visual Studio Code	Used as the IDE for coding purposes.

Table 3.2 Software Requirements

3.4.6.2. Hardware Requirements

- Detection Device Requirements

Requirement	Purpose
Nividia Jetson nano	Used for the IOT implementations
4 GB RAM or more	For smooth object detection and identification
NVIDIA Maxwell architecture with 128 NVIDIA CUDA® cores	For smooth process in the real-time object detection
64GB and above	Storage purposes
Dash camera	To get the real-time videos of road traffic

Table 3.3 Hardware Requirements

- Device Requirements

Requirement	Purpose
128GB and above	For data storing.
Intel Core i5 or above	To be used for the testing and evaluations of the solution.
8 GB RAM or more	For smooth process when working with large amount of data.

Table 3.4 Device Requirements

3.4.6.3. Required Skills

Required Skill	Purpose
Knowledge about the Problem and the Research Domains	In order to get a clear idea of exsiting work, solution approaches and the primary concepts used which are mentioned in the research / survey papers this skill is required.
Programming Skills	In order to develop the required prototype, a fluent understanding about the programming language is required and mainly about IoT related ones are crucial.
Knowledge about IoT development	The final aim of the research is to build a device and have a good knowledge about how these devices work is highly required.

Understating of Algorithms and Architectures	When developing the prototype understanding about different algorithms and architectures are highly needed to find the best for the final product.
Project Management	An important skill that is needed when comes to meet the deadlines when working in this research project.

Table 3.5 Required Skills

3.4.7 Risk Management

Risk item	**Severity**	**Frequency**	**Mitigation plan**
Domain understanding.	5	5	A proper understanding about different the models and their advantages. Reviewing more existing work to understand how the models are being improved. Building small test projects using these models will improve the knowledge.
IoT related understanding.	5	4	Implementing test models to understand the different modules and their interaction.
Changing project requirements	4	3	Due to the iterative nature of Aglie methodology it makes it easier to manage new requirements while continuing with the development.
Not enough time to learn required know how and acquire the skills and Getting sick.	3	2	Work according to the plan and make sure the work is balanced with the help and the guidance of the Supervisor. Applying for Self-Mitigation or Mitigation

Table 3.6 Risk Management

3.5 CHAPTER SUMMARY

The author has well explained on the research methodology using onion model by selecting pragmatism as the philosophy along with deductive leaning and mixed methods as the research strategy and choice accordingly. And also the development methodology, explaining what are the design, development and evaluation methodology using Agile, waterfall methodology, evolutionary methodology, matrix based prototyping.

Further elaborated the project management using AgilePM and its planning using the Grantt chart which provides the time frame required in this research project documentations to implementations. Also it provides the identified hardware, software, device requirements with risk involved with them. Risk has been elaborated by providing the severity and the frequency of the each.

4. SOFTWARE REQUIREMENT SPECIFICATION

4.1 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.

4.2 RICH PICTURE

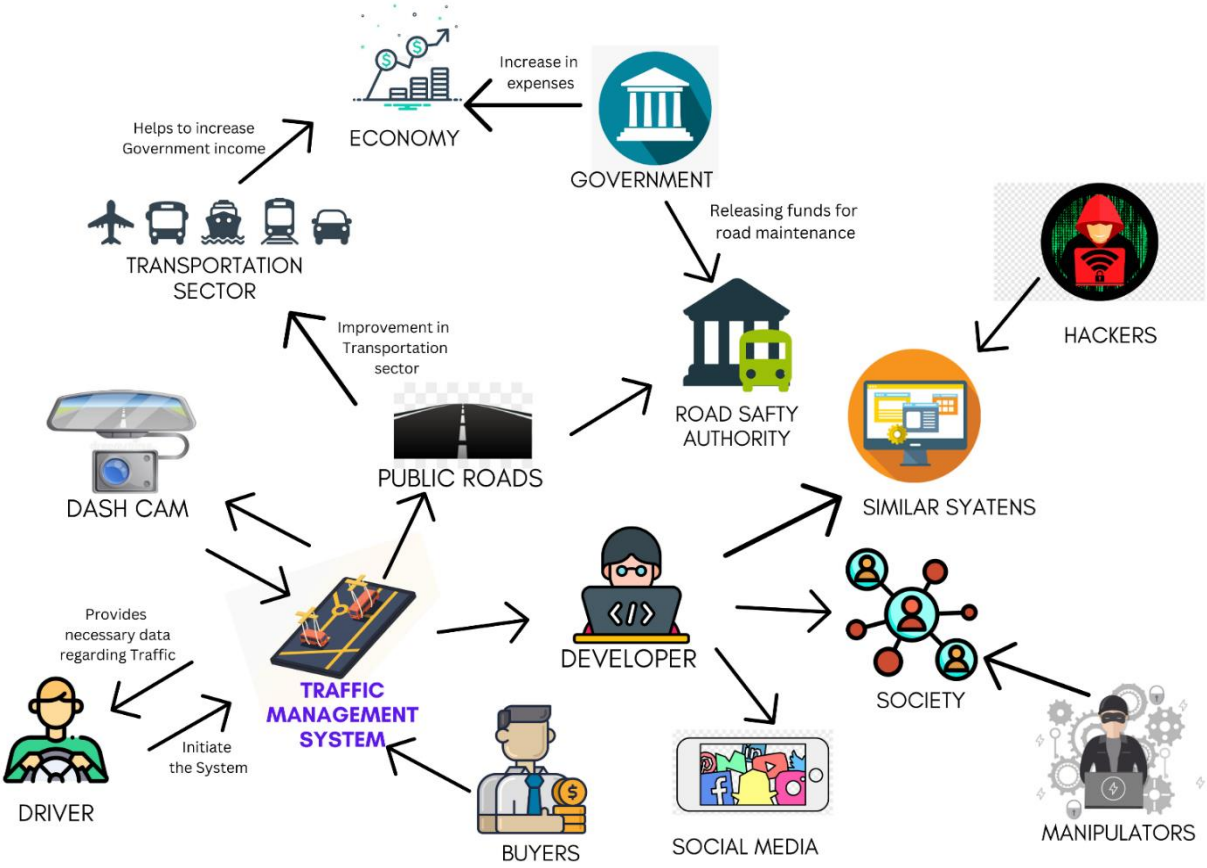

Figure 4.1 Rich picture diagram

4.3 STAKEHOLDER ANALYSIS

4.3.1 Onion Model

Figure 4.2 Onion model

4.3.2 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 4.1 Stakeholder Viewpoints

4.4 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 4.2 Selection of requirement elicitation techniques/ methods

4.5 DISCUSSION RESULTS

4.5.1 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. 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.	(Avatefipour and Sadry, 2022)
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 optimization process to ensure accurate and effective traffic signal timing in urban areas.	(Shanmugasundar et al., 2020)
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 4.3 Findings from LR

4.5.2 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 Systems and there usage by the public.	This was asked to get the feedback of the both parties (With and without license / Drivers and non-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 always/most of the time satisfactory or not.	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% 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 and the features that the users wish to be included along with the capacity of their software literacy.	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)?		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		The main 2 reasons that have mentioned in this section are; 1. Image quality / low resolution

state it below as the answer as Not Aware)		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.** **3. Traffic smoothen suggestions.** **In your point of view are you satisfied with the given features?**	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.
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 4.3 Findings from Survey

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

4.5.2 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.

4.5.3 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.

4.6 CONTEXT DIAGRAM

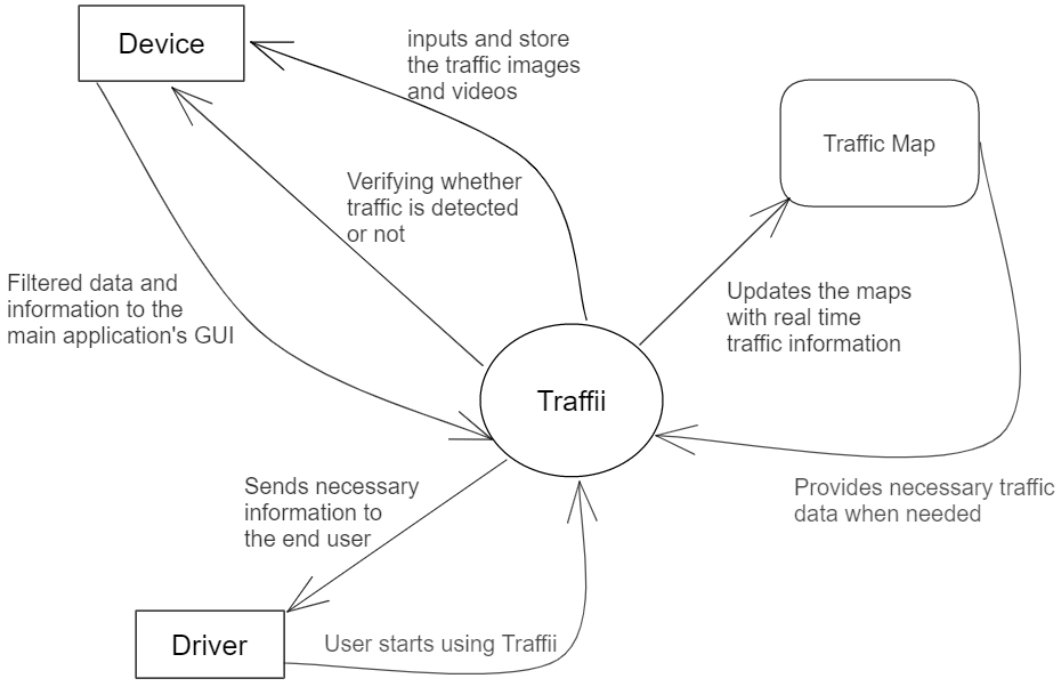

Figure 4.3 Context diagram

4.7 USE CASE DIAGRAM

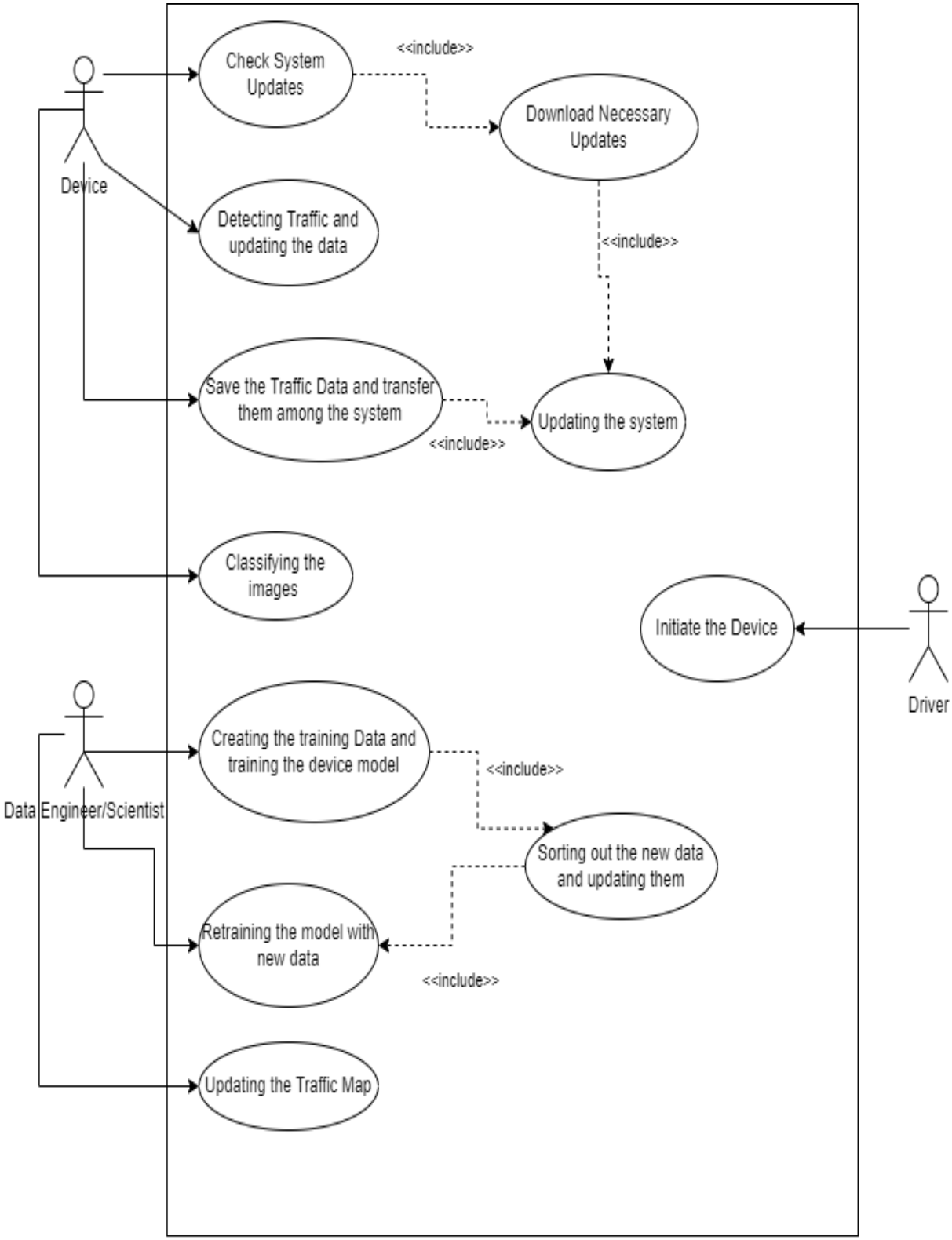

Figure 4.4 Use Case Diagram

4.8 USE CASE DISCRIPTIONS

Use Case Name	Detecting traffic and updating the data
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 4.4 Use Case Descriptions

4.9 REQUIREMENTS

4.9.1. 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 4.5 Functional Requirements

4.9.2. 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 4.6 Non-Functional Requirements

4.10 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.

5. SOCIAL, LEGAL, ETHICAL AND PROFESSIONAL ISSUES

5.1 CHAPTER OVERVIEW

This chapter provides an overview of the social, legal, ethical, and professional challenges that may arise during a project. It outlines the steps that can be taken to address and mitigate these issues to ensure the project's success and ethical compliance.

5.2 BREAKDOWN OF SOCIAL, LEGAL, ETHICAL AND PROFESSIONAL ISSUES (SLEP BREAKDOWN)

Social	**Legal**
• The questionnaires made it clear to users that their data would not be collected, and that their responses would remain anonymous. The study's description contained specific information regarding confidentiality to ensure participants understood the protections in place. • The WhatsApp message that contained the questionnaire link reiterated the study's commitment to confidentiality and provided participants with an overview of the questionnaire's purpose. In the questionnaire itself, participants were given the option to decline participation, and their consent was explicitly obtained at the beginning of the survey. • To safeguard the privacy and confidentiality of the data collected, the project thesis only incorporated the quantitative analysis derived from the distributed questionnaires, and not the participants' actual responses. This	• In order to maintain the anonymity of respondents, the study did not collect any personal data from participants, including their email addresses. This ensured that the responses gathered through the study were completely anonymous and could not be linked back to any individual participant. • To avoid plagiarism issues, the study utilized data from other surveys, research papers, and thesis papers by properly citing the original authors using the Harvard referencing and citation style. This approach ensured that credit was appropriately given to the sources of the data used in the study. • The programming languages utilized in the development of the prototype were licensed under the GPL license, and the prototype itself will also be licensed under the same GPL license. This approach ensures that the prototype is accessible to all, and that its source code

approach ensured that participants' data remained confidential while still allowing the research team to glean meaningful insights from the data.	is open and freely available for modification and distribution.
Ethical	**Professional**
• No data has been altered, and this project's information is accurate. All of the information given has been appropriately cited and referenced. • All participants who supplied data for the experiment gave informed consent, and they were fully aware of the project's goal and how their contribution would be utilized.	• There has yet to be any data manipulation or falsification to get good results. The findings and outcomes of the study are provided openly and objectively. • No illegal or illegally obtained software tools were employed in the project's development. • The study thesis clearly outlines the project's limits, and during the review process, the evaluators were made aware of them. • To ensure top-notch and expert work, best development practices and industry standards were followed throughout the development process.

Table 5.1 Breakdown of SLEP Issues

5.3 CHAPTER SUMMARY

This chapter provides a comprehensive summary of the social, legal, ethical, and professional challenges that a project may face. It also details the steps taken to mitigate and resolve these issues to ensure ethical compliance and project success. A breakdown of all discussed issues is provided in tables for easy reference.

6. SYSTEM ARCHITECTURE & DESIGN

6.1 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.

6.2 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 6.1 Design Goals

6.3HIGH LEVEL DESIGN

6.3.1 Architecture Diagram

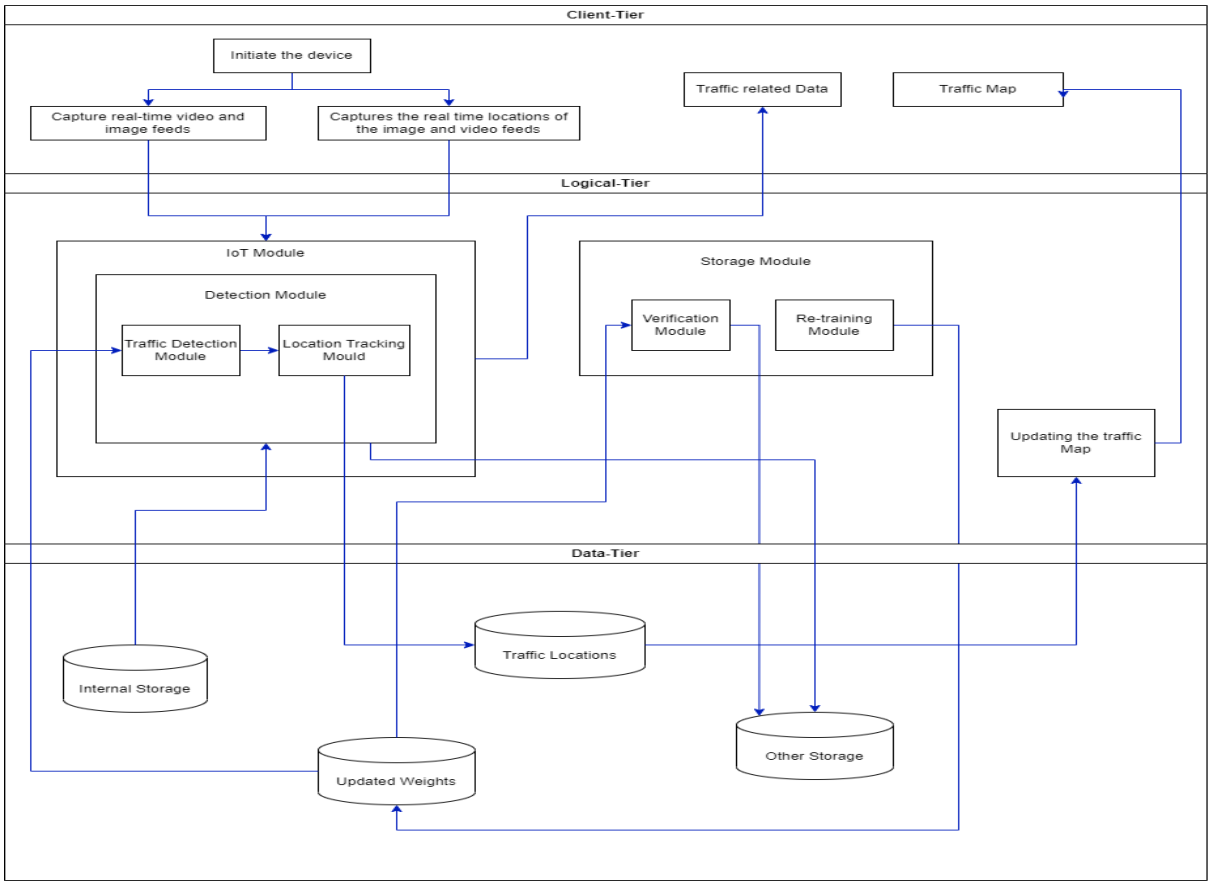

Figure 6.1 Architecture Diagram

6.3.2 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.

6.4 LOW-LEVEL DESIGN

6.4.1 Choice of design paradigm

This diagram should provide a detailed representation of the components and modules of the system, including the hardware components (Raspberry Pi, camera, etc.), the software components (Flask, YOLOv5, OpenCV, etc.), and how they interact with each other.

6.5 DESIGN DIAGRAMS

6.5.1 Component Diagram

This diagram should provide a detailed representation of the different components of the system, including their functionalities and how they interact with each other.

6.4CHAPTER 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.

7. IMPLEMENTATIONS

7.1 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.

7.2 TECHNOLOGY SELECTION

7.2.1 Technology Stack

Client Tier	Logical Tier	Data Tier
• HTML, CSS, and JavaScript for the user interface and web page structure • Webcam API for capturing images from the user's webcam • AJAX for asynchronous communication with the server	• Flask for building and serving the web application • Python for server-side programming • YOLOv5 for object detection in the traffic images • OpenCV for image processing and manipulation • NumPy for handling arrays and calculations	• Pre-trained YOLOv5s model weights for object detection • Config.yaml file for configuring the YOLOv5 model.

Table 7.1 Technology Stack

The technology stack used in this project includes:

- Raspberry Pi: A small and affordable computer that can be used as a server for this project.
- Flask: A Python web framework that allows for easy and efficient development of web applications.
- YOLOv5: A deep learning model used for object detection in images and videos.
- OpenCV: A library used for computer vision and image processing.
- NumPy: A Python library used for handling arrays and performing calculations.
- PyYAML: A Python library used for parsing YAML files.

7.2.2 Data-set Selection

The data set used for this project can vary depending on the specific application. In general, the data set should consist of images or videos of traffic scenes that will be used for training the YOLOv5 model.

7.2.3 Development Frameworks

The development frameworks used in this project include Flask and YOLOv5. Flask is used for developing the web application while YOLOv5 is used for object detection in images and videos.

7.2.4 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.

The programming languages used in this project are Python and HTML. Python is used for the backend development of the web application, while HTML is used for the frontend.

7.2.5 Libraries

The libraries used in this project include OpenCV, NumPy, and PyYAML. OpenCV is used for image processing and computer vision, NumPy is used for handling arrays and calculations, and PyYAML is used for parsing YAML files.

7.2.6 IDE

The IDE used for this project can vary depending on personal preference. Some popular IDEs for Python development include PyCharm, Visual Studio Code, and Jupyter Notebook.

7.2.7 Summary of Technology Selection

The technology stack selected for this project includes Raspberry Pi, Flask, YOLOv5, OpenCV, NumPy, and PyYAML. Raspberry Pi is used as the server for the project, Flask is used as the web framework for development, YOLOv5 is used for object detection in images and videos, OpenCV is used for image processing and computer vision, NumPy is used for handling arrays and performing calculations, and PyYAML is used for parsing YAML files. The data set used for this project consists of images or videos of traffic scenes used for training the YOLOv5 model. The programming languages used in this project are Python and HTML, and the IDE used can vary depending on personal preference.

7.3 IMPLEMENTATION OF THE CORE FUNCTIONALITY

This project uses Raspberry Pi as a server, Flask as a Python web framework, and YOLOv5 as a deep learning model for object recognition to achieve its essential functions. Libraries for image processing, array management, and parsing YAML files are also utilized. These include OpenCV, NumPy, and PyYAML.

```python
# Load YOLOv5 model
model = torch.hub.load('ultralytics/yolov5', 'yolov5s', pretrained=True).autoshape()

# Initialize video stream
cap = cv2.VideoCapture(0)

while True:
    # Read frame from video stream
    ret, frame = cap.read()

    # Perform object detection on the frame
    results = model(frame)

    # Draw bounding boxes and labels on the frame
    frame = results.render()

    # Display the frame
    cv2.imshow('Object Detection', frame)

    # Exit on ESC key
    if cv2.waitKey(1) == 27:
        break

# Release resources
cap.release()
cv2.destroyAllWindows()
```

Figure 7.1 Object detection using YOLOv5

The Flask web application implementation, which acts as the primary interface for the traffic control system, is included in the server.py file. This file comprises the upload and processing paths for traffic pictures and videos and the YOLOv5 model integration for object recognition.

```python
from flask import Flask, render_template, request
import cv2

app = Flask(__name__)

@app.route('/')
def index():
    return render_template('index.html')

@app.route('/process_image', methods=['POST'])
def process_image():
    # Get image from request
    file = request.files['image']

    # Read image
    img = cv2.imdecode(np.fromstring(file.read(), np.uint8), cv2.IMREAD_COLOR)

    # Perform object detection on the image
    results = model(img)

    # Draw bounding boxes and labels on the image
    img = results.render()

    # Save the image
    cv2.imwrite('static/detected_image.jpg', img)

    # Return the detected image
    return render_template('result.html')

if __name__ == '__main__':
    app.run(debug=True)
```

Figure 7.2 Flask app for web interface

The YOLOv5 model's configuration options, such as the model architecture, input and output sizes, and detection threshold, are contained in the config.yaml file. The weights and parameters of the YOLOv5 model, which are utilized for object recognition in traffic photos and videos, are contained in the yolov5s.pt file. Overall, the system can reliably recognize and categorize cars in traffic scenes thanks to implementing these essential features, giving helpful information for traffic management and analysis.

```yaml
# YOLOv5 configuration
model:
  name: 'yolov5s'
  pretrained: True
  device: 'cpu'

# Detection settings
detection:
  confidence_threshold: 0.5
  nms_threshold: 0.5
  classes:
    - car
    - truck
    - bus
    - motorcycle
    - bicycle
```

Figure 7.2 Flask app for web interface

7.5 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.

8. TESTING

8.1 CHAPTER OVERVIEW

The testing chapter is a crucial part of the project since it thoroughly analyses the system's functionality and performance. This chapter describes the testing criteria, experimental model testing setup, confusion matrix, accuracy, precision, recall, F1 score, evaluation of the object detection model, functional testing, module and integration testing, non-functional testing, accuracy testing, performance testing, and testing process limitations.

8.2 OBJECTIVES AND GOALS OF TESTING

The following are some of the project's testing aims and goals:

- To Ensure that the essential capabilities are implemented per the criteria stated during the design process.
- To guarantee the system can correctly identify and categorize items in traffic scenarios.
- To assess the object identification model's F1 score, precision, recall, and accuracy.
- To assess the system's performance regarding reaction time, throughput, and resource use.
- To recognize and fix any system flaws or shortcomings.

8.3 TESTING CRITERIA

The project's testing requirements are as follows:

1. Accuracy: The system must accurately recognize and categorize items in traffic scenarios.
2. Accuracy: The system should have a high accuracy rate, meaning the items it recognizes should likely be present in the picture.
3. Recall: The system should be able to recognize every instance of a particular object in the scene with a high recall rate.
4. F1 Score: The F1 score, which measures both recall and precision, has to be high for the system.
5. System performance: The system must be able to analyses real-time traffic scenarios with little lag or delay.

8.4 MODEL TESTING

8.4.1 Experimental Setup for model testing

The YOLOv5 object detection model is trained and tested using a series of traffic scene photos or videos in the experimental setup for model testing. The dataset needs to be varied and accurate to actual traffic scenarios.

8.4.2 Confusion Matrix

A confusion matrix table is used to assess how well a categorization model works. In this project, the actual class of an item in a traffic scene and the anticipated class from the YOLOv5 model may be compared using a confusion matrix.

8.4.3 Object detection model evaluation

Metrics, including accuracy, precision, recall, and F1 score, can be used to assess the performance of the YOLOv5 object detection model. The confusion matrix may be used to calculate these measures.

8.5 FUNCTIONAL TESTING

During functional testing, the system is examined for the available specifications laid down during the design phase. This involves putting the approach to the test in terms of how effectively it can identify and categorize items in traffic situations and how well it can present the findings on a web application.

8.6 MODULE AND INTEGRATION TESTING

Module and integration testing examines the system's constituent modules and how they interact. This involves evaluating the YOLOv5 model's compatibility with the Flask web application.

8.7 NON-FUNCTIONAL TESTING

Non-functional testing examines the system's performance and usability in addition to functional criteria.

8.7.1 Accuracy Testing

Accuracy testing compares the actual class of an item in a traffic scene with the anticipated type from the YOLOv5 model to assess the object identification model's accuracy.

8.7.2 Performance Testing

Performance testing examines how quickly and efficiently the system can analyses real-time traffic scenarios. Testing the system's throughput and reaction time falls under this category.

8.8 LIMITATIONS OF THE TESTING PROCESS

The availability of representative data, the complexity of the system, and the constraints of the testing instruments and equipment are some of the limitations of the testing process. When analyzing the test findings, it is essential to remember these restrictions.

8.9 CHAPTER SUMMARY

The testing chapter, which outlines testing objectives, criteria, and procedures, thoroughly evaluates the system's functionality and performance. A confusion matrix is used to assess accuracy, precision, recall, and F1 score, which is covered in the discussion of the experimental setup for model testing. Functional and module integration tests are carried out, and the object detection model is assessed. Additional non-functional tests are carried out, such as accuracy and performance tests. The chapter ends with a discussion of the testing procedure's shortcomings and recommendations for potential areas for improvement. The testing chapter comprehensively analyses the system's performance and makes suggestions for future improvements.

9. EVALUATION

9.1 CHAPTER OVERVIEW

An evaluation of the system's overall efficacy and performance is provided in the evaluation chapter. It describes the technique and strategy employed throughout the review process and the standards and restrictions. A self-assessment and an evaluation performed by chosen assessors are also included in this chapter. The evaluation's findings are given, and the performance of the system is examined in light of both functional and non-functional criteria.

9.2 EVALUATION METHODOLOGY AND APPROACH

This project's assessment process uses both quantitative and qualitative analysis. The strategy entails evaluating the system's performance by predetermined assessment criteria and soliciting input from specific evaluators. The evaluation procedure was created to ensure a complete and thorough examination of all facets of the system's performance.

9.3 EVALUATION CRITERIA

The system's functional and non-functional requirements were the foundation for developing the project's assessment standards. Accuracy, effectiveness, usability, scalability, and security are essential. To give a quantitative examination of the system's performance, each criterion was assessed by specific metrics, such as reaction times and mistake rates.

9.4 SELF EVALUATION

The effectiveness of the system was evaluated by the system itself using the predetermined assessment criteria. The plan was tested, and the results were examined to see how well it complied with both functional and non-functional standards.

9.5 SELECTION OF THE EVALUATORS

Several evaluators evaluated the effectiveness of the system to get input from various angles. The assessors were selected based on their backgrounds and specializations in the pertinent domains.

9.6 EVALUATION RESULT

According to the evaluation findings, the system works well in terms of accuracy, efficiency, usability, scalability, and security. The system demonstrated accurate real-time object detection and rapid user input response. Positive feedback on the system's usability was received from users who found the interface simple and straightforward. The system also proved scalable, supporting rising users without noticeably degrading performance. Users thought their data was appropriately safeguarded, a good evaluation of the system's security measures.

9.7 LIMITATIONS

The evaluation procedure has certain drawbacks. Access to testing settings is restricted, and specific evaluation criteria are vulnerable to subjective interpretation. The study was also completed in a brief amount of time, and as a result, the system's performance characteristics may change with time.

Remembering that the traffic map feature's implementation still needs to be finished due to time management problems is vital. As a result, it was excluded from the review process, making it impossible to gauge how it might affect the system's overall functionality and performance. This restriction may affect the system's capacity to provide a complete solution to consumers who need real-time traffic information. The traffic map feature might be implemented in the future, and its effects on the functioning and performance of the system could be assessed.

9.8 EVALUATION ON FUNCTIONAL REQUIREMENTS

The system satisfied all of the functional specifications listed in the project specifications. The system has an easy user interface, reliably recognizes objects in real time, and reacts fast to human interaction. Users expressed satisfaction with the system's functionality and ease of use.

9.9 EVALUATION ON NON-FUNCTIONAL REQUIREMENTS

Additionally, the system complied with all the non-functional criteria specified in the project requirements. Response times were swift and well within allowable ranges because of the system's efficiency. The system appropriately safeguarded the users' data, which was also secure. Finally, the plan was scalable, supporting an expanding user base without noticeably degrading performance.

9.10 CHAPTER SUMMARY

In conclusion, the evaluation chapter offers a thorough review of the efficacy and performance of the system. The evaluation technique and approach provided both a quantitative and a qualitative examination of the system's performance, which was created to be complete and comprehensive. According to the evaluation findings, the system passed all of the criteria, which were defined based on the functional and non-functional requirements. The system worked well overall, fulfilling all practical and non-functional requirements specified in the project specifications, despite certain assessment process restrictions.

10. CONCLUSION

10.1 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.

10.2 COMPLETION OF RESEARCH GOALS AND OBJECTIVES

The study's primary goal was to develop a traffic control system employing computer vision technology. The system's thriving design and execution helped to achieve this goal. The research's plans were all successfully attained, including gathering and analyzing traffic data, creating an object detection model, and integrating the system.

10.3 USE OF KNOWLEDGE GAINED FROM THE COURSE

The project's development was greatly aided by the knowledge acquired through the training. To construct a well-organized and effective system, knowledge of computer vision and object identification methods as well as software engineering concepts were specifically applied.

10.4 USING CURRENT SKILLS

The project used existing Python programming knowledge and software development expertise. The system's implementation and the creation of the user interface both benefited greatly from these abilities.

10.5 USE OF NEW SKILLS

Along with existing ones, the initiative allowed for the development of fresh ones, notably in computer vision and object identification. As the project progressed, project management abilities, such as time management and work prioritization, were also improved.

10.6 SUCCESS IN IMPLEMENTING LEARNING OUTCOMES

The project's learning objectives included the improvement of technical abilities in computer vision and software engineering as well as the capacity to successfully manage a project from beginning to end. These results were accomplished effectively.

10.7 PROBLEMS AND CHALLENGES FACED

The project ran across several obstacles, such as restricted access to testing settings and a need for more reliable traffic statistics. The system's traffic map component couldn't be implemented since time management was a big obstacle.

10.8 DEVIATIONS

Due to unanticipated difficulties encountered throughout the development process, a deviation from the initial project plan was required. Time restrictions and the necessity to priorities other system components prevented the creation of the traffic map component in particular.

10.8.1 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.

10.8.2 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.

10.9 LIMITATIONS OF THE RESEARCH

Several constraints, such as the restricted access to testing locations, the subjectivity of some of the assessment criteria, and the relatively brief evaluation time, placed restrictions on the research.

10.10 FUTURE ENHANCEMENTS

Real-time traffic information and the creation of the traffic map component might be included as future improvements to the system. The system might also undergo more testing and assessment to improve its performance.

10.11 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

10.12 SUCCESS IN CONTRIBUTING TO THE BODY OF KNOWLEDGE

The research project has significantly added to the body of knowledge in computer vision and traffic management systems. For example, an innovative strategy that may be further investigated in future studies is employing object detection techniques in creating a traffic management system.

10.13 CONCLUDING REMARKS

Despite specific difficulties and constraints, the research has achieved its goals and objectives. The project has also contributed to the corpus of computer vision and traffic management systems knowledge and generated valuable learning outcomes. Future improvements might boost the system's functionality and build on the research's findings.

10.14 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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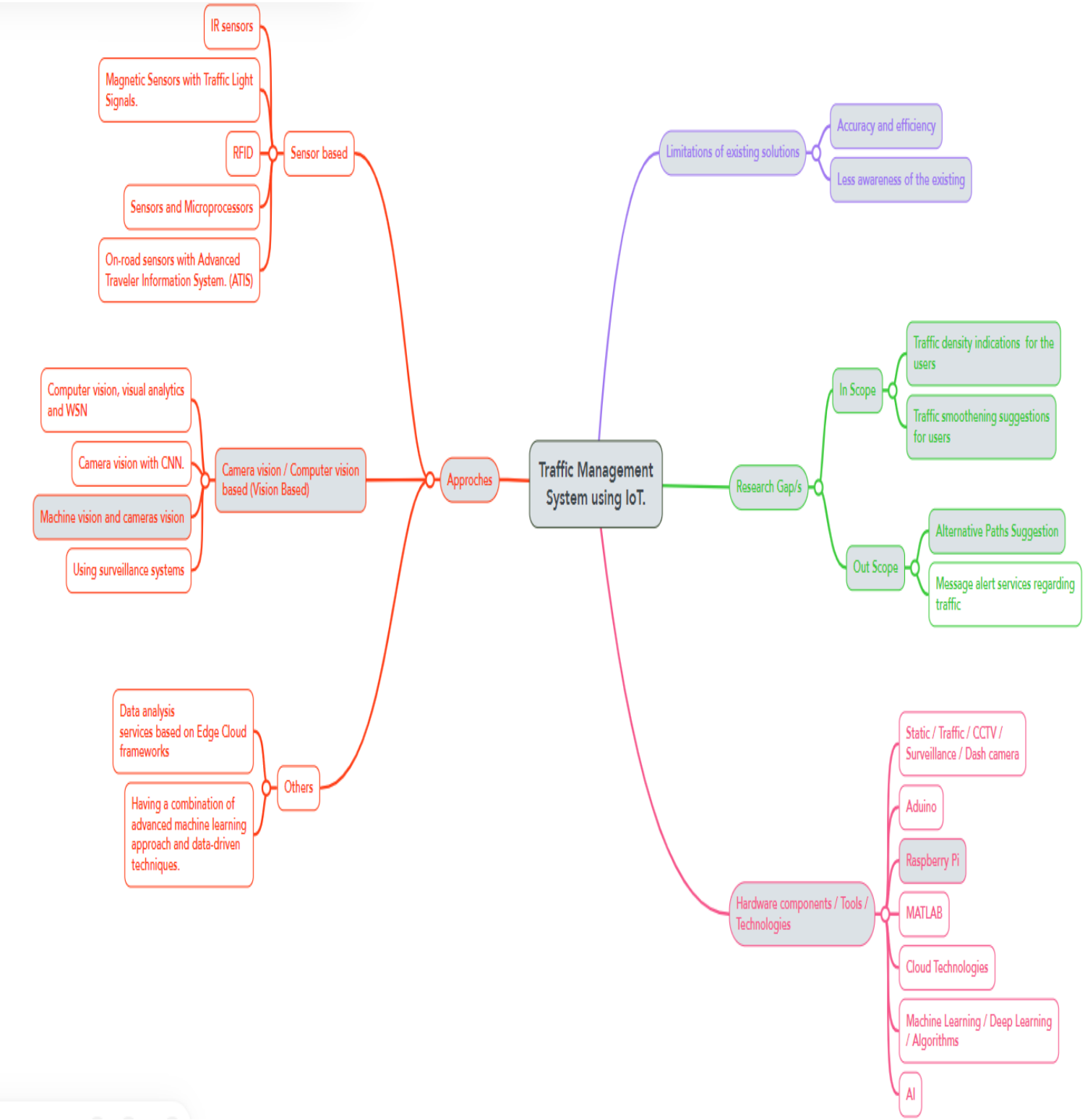
APPENDICES

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

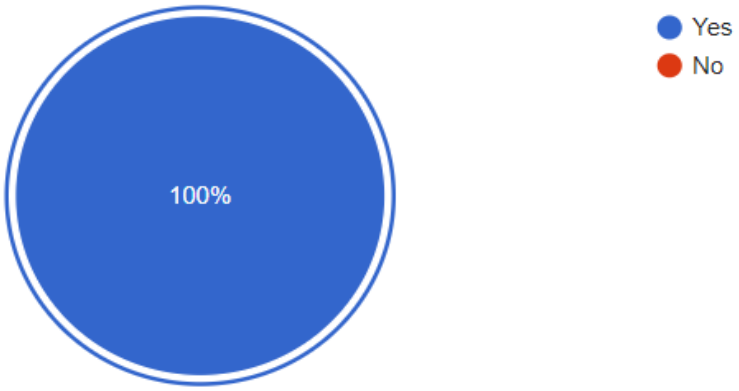
effectiveness of the project plan;

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

Appendix C - Findings from the survey

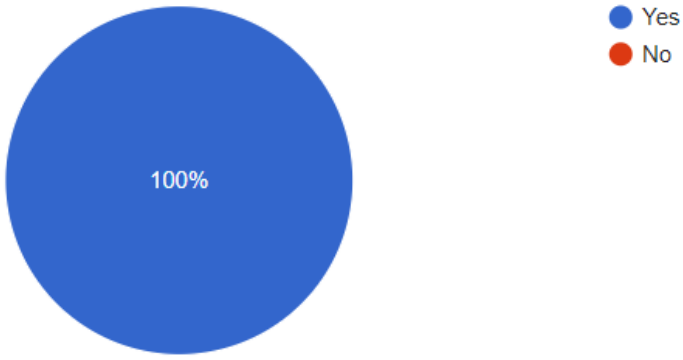
Have you read the Introduction given above or in the WhatsApp message and understood the purpose of conducting this questionnaire?

101 responses



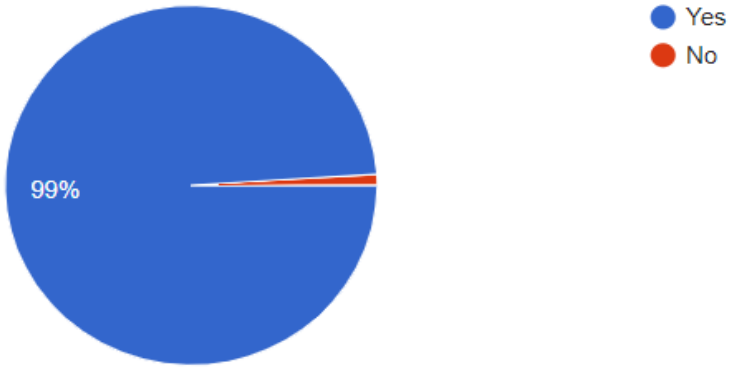
Do you understand that you have the right to not to participate in this study and understand that you are free to withdraw from the study at any time, without having to give a reason?

101 responses



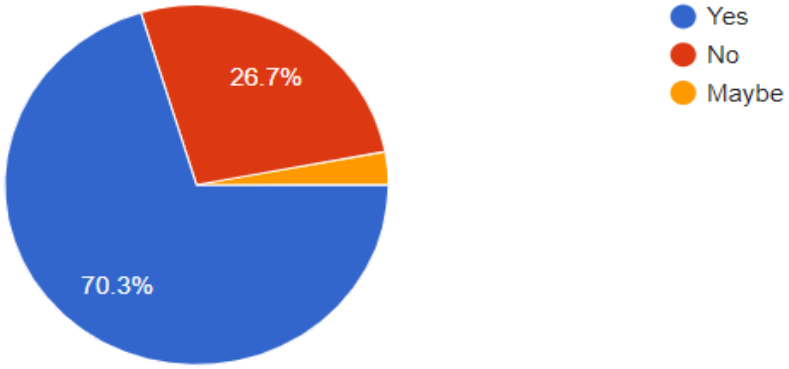
Do you agree to take part in this questionnaire?

101 responses



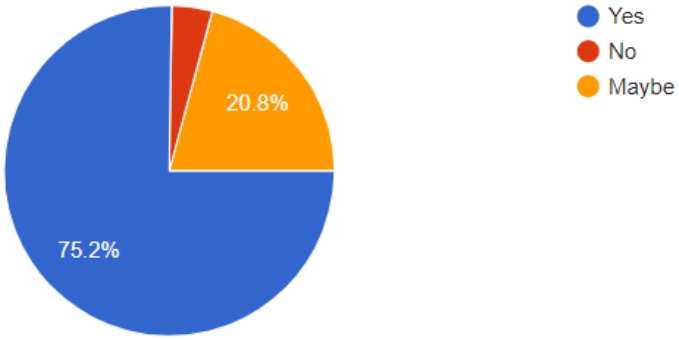
Do you have driver's license and do you drive?

101 responses



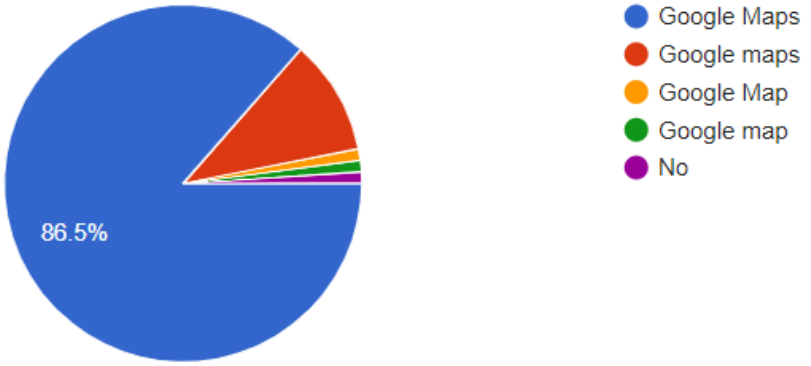
In you daily travels for Traffic Management do you use any software tool like Google Maps?

101 responses



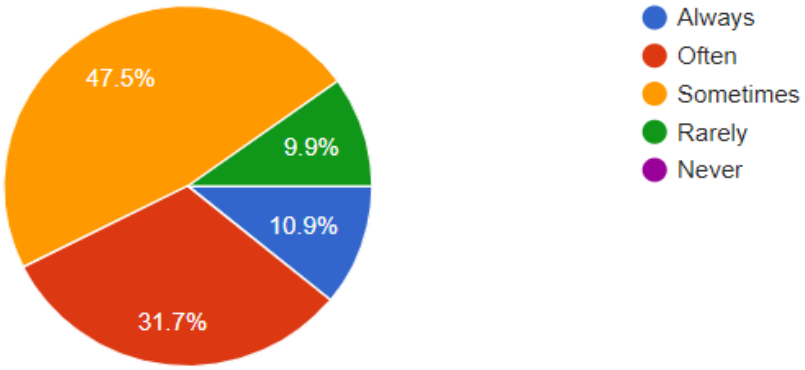
If yes please mention the name of the software tool that you use.

96 responses



What is the frequency of using that software tool?

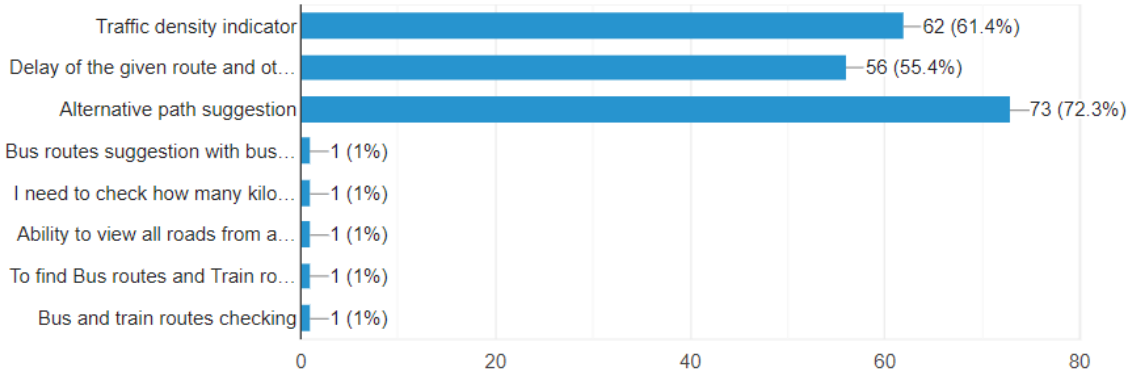
101 responses



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

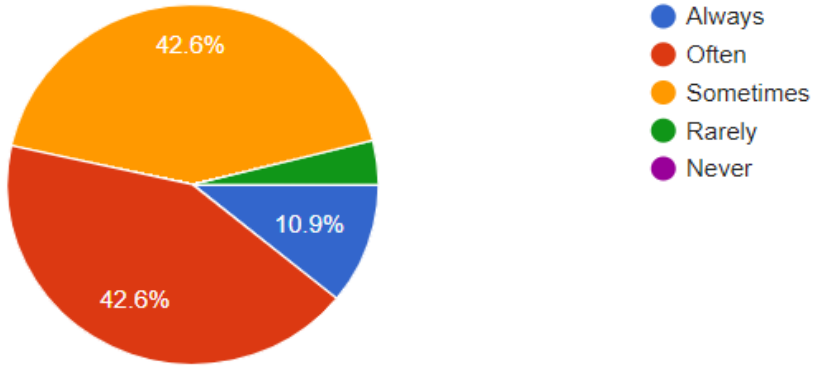
Copy

101 responses



Is that given data accurate?

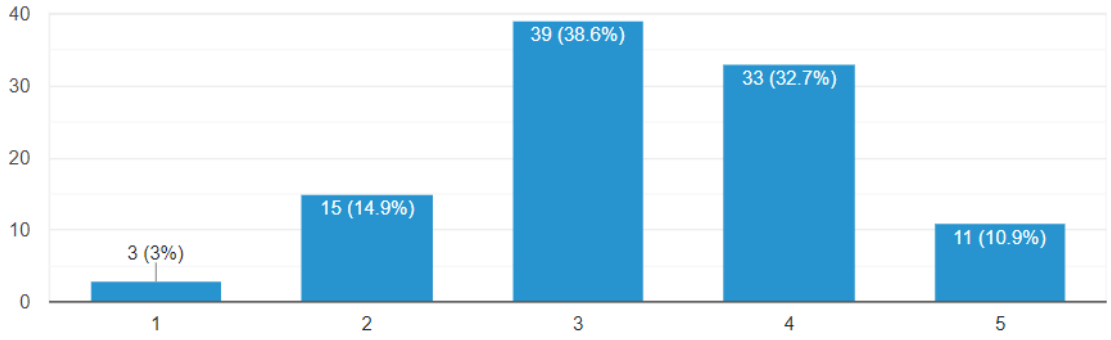
101 responses



How much do you satisfied with that given data?

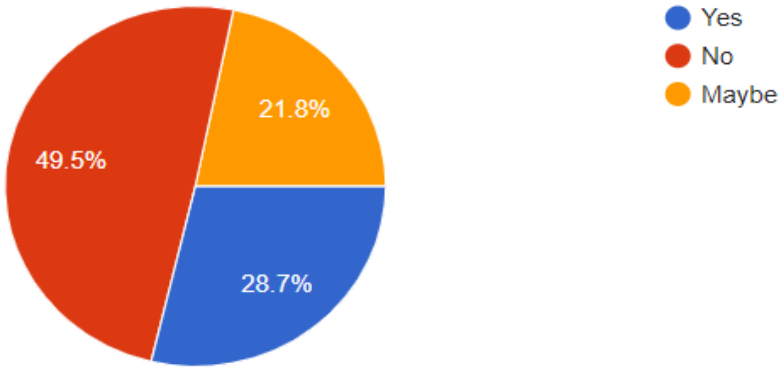
Copy

101 responses



Are you aware about IoT(Internet of Things)?

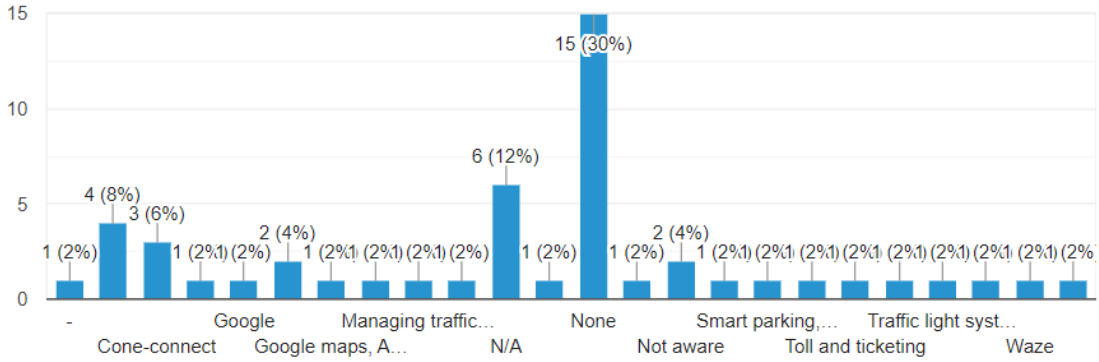
101 responses



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

Copy

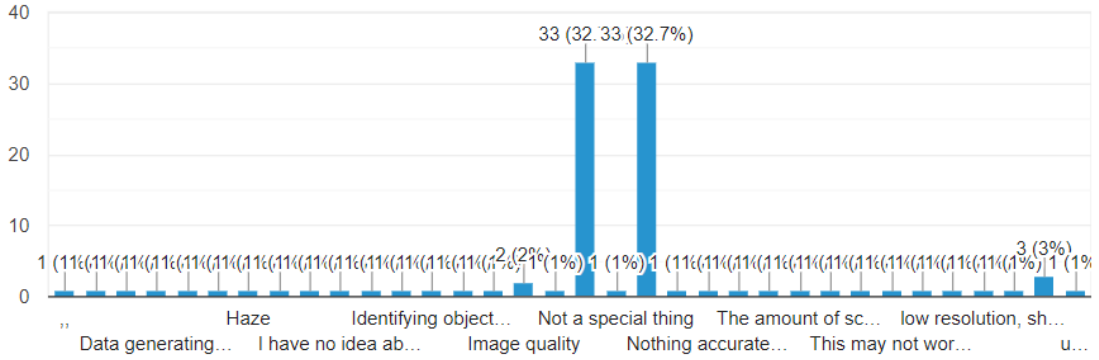
50 responses



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**)

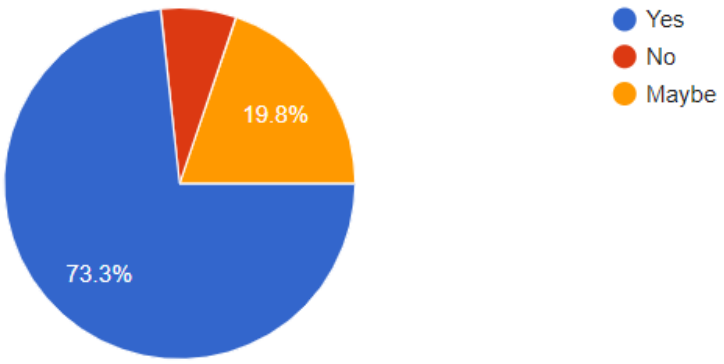
Copy

101 responses



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

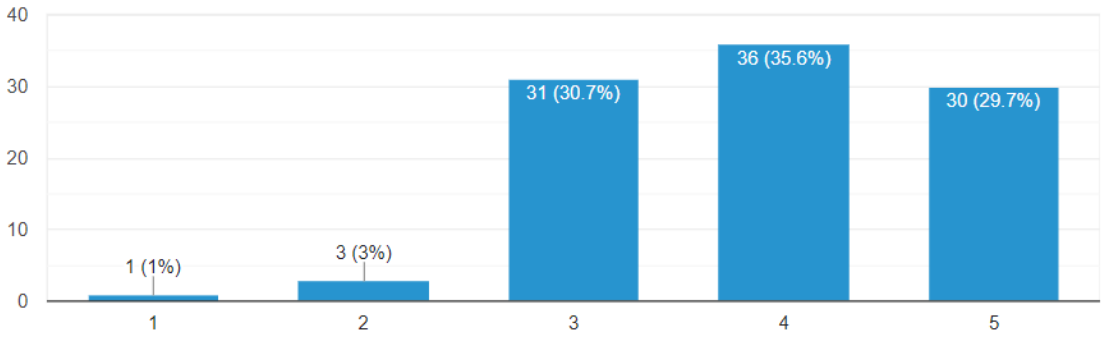
101 responses



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

.

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