Road Traffic Detection System Based on IoT

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Road Traffic Detection System Based on IoT

Jihad Salar Karim

A thesis submitted in fulfilment of the
requirements for the award of the degree of
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School of Computing
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DEDICATION

This work is dedicated to the ones who make my world brighter – my family. To my parents, whose unconditional love and sacrifices have shaped my journey. To my siblings, whose companionship and shared laughter have been a constant joy. Each page of this endeavour is imprinted with your support, understanding, and the shared moments that make life meaningful. Thank you for being the anchors in my life, inspiring me to reach new heights. This dedication is a humble tribute to the love and strength you have showered upon me.

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I would like to express my sincere gratitude to my family, whose unwavering support and encouragement have been the cornerstone of my Final Year Project. Their love, understanding, and constant encouragement have provided me with the strength and motivation to overcome challenges and pursue my goals. I am profoundly grateful for the sacrifices they have made and the belief they have shown in my abilities. Their presence in my life has been a source of inspiration, and I am truly blessed to have such a supportive and caring family. Thank you for being my pillars of strength.

ABSTRACT

As urbanization acceleration, efficient traffic management becomes imperative for sustainable urban development. This project presents a Road Traffic Detection System leveraging Internet of Things (IoT) technologies, employing ES8266 microcontrollers and ultra sonic sensors. The system is designed to detect and count the number of vehicles on roads, aiding in traffic monitoring and optimization. The architecture consists of one master node and three slave nodes, fostering a scalable and adaptable solution for varying road sizes. ESP8266 microcontrollers serve as the nodes, with ultrasonic sensors providing accurate vehicle detection. The master node orchestrates the data collection process, aggregating information from the slave nodes. The ultrasonic sensors, strategically placed along the road, utilize sound waves to detect the presence of vehicles. Data regarding traffic density and vehicle counts are transmitted wirelessly from the slave nodes to the master node, where comprehensive analysis and visualization take place. The implementation addresses the need for a cost-effective, scalable, and real-time traffic monitoring solution. This project contributes to the field of smart city development by providing a framework for intelligent transportation systems. The potential applications include traffic flow optimization, congestion management, and data-driven decision-making for urban planners. The combination of IoT and ultrasonic sensors offers a robust and adaptable solution for traffic management, making cities smarter and more responsive to the dynamic nature of urban mobility.

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LIST OF ABBREVIATIONS

IOT	-	Internet of Things
ESP	-	Event Stream Processing
LED	-	Light Emitting Diode
ITS	-	Intelligent Transportation Systems
CNNs	-	Convolutional Neural Networks
RNNs	-	Recurrent Neural Networks
LiDAR	-	Light Detection Ranging
Wi Fi	-	Wireless Fidelity
GPIO	-	General Purpose Input/Output
HC-SR04	-	High-Conductance Ultrasonic Sensor
DIY	-	Do it Yourself

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CHAPTER 1

INTRODUCTION

1.1 Introduction

With fast urbanization and a rising number of cars on the road, efficient traffic management has become a key task for transportation authority's globally (Liu et al., 2018; Zhang et al., 2019). Monitoring and comprehending traffic conditions is critical for guaranteeing road safety, improving transportation networks, and minimizing congestion. To achieve these objectives, precise and real-time detection of road traffic is required. Road Traffic Detection System Based on IOT, on the other hand, refers to the act of detecting and tracking numerous components present on roadways, such as automobiles, Pedestrians, bicycles, and other things of interest. It entails gathering and analysing data from numerous sources, such as security cameras, sensors, and intelligent transportation systems, to learn about traffic flow, density, speed, and other factors. Various approaches, ranging from classic computer vision techniques to more sophisticated deep learning-based algorithms, have been presented. These techniques make use of a wealth of accessible data, such as camera footage, traffic patterns, and historical records, to develop sophisticated models capable of handling complicated traffic scenarios (Huval et al., 2015; Redmon et al., 2018). Furthermore, the purpose of this work is to give a complete review of the available literature on Road Traffic Detection System Based on IOT. It will investigate various traffic detection strategies and techniques, such as feature-based algorithms, object identification frameworks, and deep learning architectures. Furthermore, the study will examine the constraints and limits of Road Traffic Detection System Based on IOT, such as occlusions, changing ambient conditions, and the need for real-time processing (Xu et al., 2018; Li et al., 2020). The survey will also emphasize traffic flow analysis, congestion Road Traffic Detection System Based on IOT has applications and practical effects in management, intelligent transportation systems, and autonomous automobiles (Gao et al., 2017; Chen et al., 2020). It will also examine current trends and future directions in Road Traffic Detection System Based on IOT, such as multimodal fusion, edge computing, and integration with smart city infrastructure (Gundimeda et al., 2019).

Wang et al., 2021). This research also aims to provide scholars, practitioners, and policymakers with a full understanding of the subject by assessing cutting-edge approaches and emphasizing advancements in Road Traffic Detection System Based on IOT. The study's findings might be utilized to develop new solutions to improve road safety and traffic management, eventually leading to the development of smarter and more sustainable transportation systems.

1.2 Problem Background

With rapid urbanization and an increasing number of vehicles on the roads, efficient traffic management has become a critical concern for modern cities. The traditional approaches to traffic monitoring often fall short in providing real-time, accurate, and scalable solutions. Conventional methods, such as manual counting or stationary cameras, are labor-intensive, prone to errors, and lack the adaptability required for dynamic urban environments. Furthermore, the lack of a cost-effective and scalable traffic monitoring system hinders the ability of urban planners and traffic management authorities to make informed decisions. Traffic congestion, a common consequence of inadequate monitoring, not only leads to increased commute times but also contributes to environmental pollution and energy wastage. In response to these challenges, this project addresses the need for an intelligent and scalable Road Traffic Detection System based on IoT technologies. The integration of ESP8266 microcontrollers and ultrasonic sensors provides a cost-effective solution for real-time vehicle detection and data collection. By adopting a distributed architecture with a master and multiple slave node, the system aims to cover diverse road networks, making it adaptable to various urban landscapes. This project seeks to bridge the existing gaps in traffic management systems by offering a reliable, scalable, and cost-efficient solution. The proposed Road Traffic Detection System not only counts vehicles but also provides valuable data for analyzing traffic patterns, identifying congestion points, and supporting data-driven decision-making for urban planners. The outcome of this project contributes to the ongoing efforts to build smarter cities with efficient transportation systems, ultimately enhancing the quality of urban life

1.3 Project Aim

The goal of the IOT-based monitoring and control system for signal detection project is to design and create an intelligent traffic signal monitoring and control system that will analyses real-time traffic data and change traffic lights accordingly using Internet of Things (IoT) technology. The system intends to minimize congestion, improve traffic flow, enhance the overall driving experience, and boost the traffic signal system's efficiency. Furthermore, the system delivers real-time traffic data to users, which may be utilized for planning and decision-making.

1.4 Project Objectives

The objectives of the project are:

(a) Implement vehicle Detection: Develop a reliable system for accurately detecting the presence of vehicles using ultrasonic sensors.

(b) Count and Record Vehicles: Create a mechanism to count the number of vehicles passing through the monitored area and store this data for analysis.

(c) Establish IoT Communication: Implement a seamless communication protocol between the master and slave nodes using the ESP8266, ensuring efficient data transfer.

1.5 Project Scope

The scopes of the project are:

(d) Hardware Implementation:

- Implementation of ESP8266 microcontrollers for both master and slave nodes.
- Integration of ultrasonic sensors for accurate vehicle detection.
- Design and setup of a scalable network of slave nodes along the road network.

(e) IoT Communication:

- Development of a reliable communication protocol between the master and slave nodes using the ESP8266 module.
- Implementation of real-time data transmission for continuous traffic monitoring.

(f) Data Collection and Processing:

- Accurate counting of vehicles using ultrasonic sensors.
- Real-time collection and aggregation of traffic data at the master node.
- Basic data preprocessing to filter and validate collected data.

(g) Scalability and Adaptability:

- Design to accommodate the addition of multiple slave nodes for scalability.
- Adaptability to different urban environments and road configurations.

(h) Documentation:

- Comprehensive documentation of the system architecture, hardware connections, and software algorithms.
- Generation of reports detailing the project implementation, findings, and recommendations.

1.6 Project Importance

- Better Traffic Management: Accurate and real-time Road Traffic Detection System Based on IOT allows for more effective traffic management tactics. Transportation authorities can make educated judgments about traffic signal timing, lane control systems, and congestion management by analyzing traffic flow, density, and behavior. This results in better traffic flow, shorter travel times, and greater transportation efficiency.
- Improved Road Safety: Road Traffic Detection System Based on IOT helps to improve road safety. Potential risks and dangerous circumstances can be discovered quickly by detecting and tracking automobiles, people, and other items on the road. This enables the introduction of proactive measures to prevent accidents and maintain safer road conditions, such as real-time alert systems, adaptive speed control, and collision avoidance systems.
- Congestion Reduction: Traffic congestion is a global issue that increases travel times, fuel consumption, and pollution. Road Traffic Detection System Based on IOT aids in the identification of congested regions and the analysis of traffic patterns. This data may be used to execute dynamic traffic management measures, improve traffic signal timings, and redirect traffic to less crowded routes, lowering congestion and improving overall traffic flow.
- Intelligent Transportation Systems (ITS): A critical component of Intelligent Transportation Systems is Road Traffic Detection System Based on IOT. By combining data from traffic sensors and surveillance cameras with powerful algorithms and communication networks, it is possible to monitor, analyze, and operate the transportation network in real time. This makes smart solutions like adaptive traffic signal control, dynamic route guidance, and incident management systems easier to adopt, resulting in more efficient and sustainable transportation networks.
- Environmental Impact: Effective Road Traffic Detection System Based on IOT and management help to reduce fuel use and pollution. Vehicles spend less time idling when traffic congestion is reduced, resulting in lower carbon emissions and better air quality. Furthermore, better traffic flow minimizes vehicle energy use, resulting in a more sustainable transportation ecology.

1.7 Report Organization

This chapter provides an overview of the study's overall context. It explains the fundamental reason for the study's objectives. This chapter, on the other hand, describes the scopes and highlights the significance of the study. This chapter emphasizes the broad picture of the research and its benefits; also, it offers a comprehensive summary of the problem and its solution; nonetheless, the purpose is clearly stated in the chapter outline.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Road Traffic Detection System Based on IOT is critical in modern transportation systems, with the goal of improving traffic management, reducing congestion, increasing safety, and promoting efficient mobility. With an increasing number of cars on the road globally, traditional traffic monitoring and control technologies have proven ineffective in dealing with the complexities of urban traffic. As a result, there has been an increase in interest in building advanced Road Traffic Detection System Based on IOT systems that make use of a variety of hardware and software technologies. The detection of road traffic entails the real-time identification, tracking, and categorization of vehicles. This data is a critical input for traffic management systems, allowing for effective traffic flow regulation, optimization of traffic signal timings, and accurate traffic information to commuters. Furthermore, Road Traffic Detection System Based on IOT helps to improve safety measures by making it easier to spot anomalous traffic circumstances such as accidents or congestion. This study intends to give insights into the advancements and problems in Road Traffic Detection System Based on IOT by performing a complete assessment of the literature. It will investigate the benefits and drawbacks of various hardware solutions, as well as the algorithms and approaches used for traffic detection, tracking, and categorization. The review will also emphasize the practical uses of Road Traffic Detection System Based on IOT in intelligent transportation systems, traffic management, and congestion reduction.

2.2 Case Study (If any)

According Fredianelli, L.; Carpita, S.; Bernardin (2022), the major instruments in the battle against exposing inhabitants to noise, particularly that caused by road traffic, are noise maps and action plans. Intelligent Transportation Systems (ITS) represent the present and the future of smart traffic control, although they haven't been thoroughly researched as potential noise-mitigation methods yet. However, IT'S for traffic control relies on the same models and input data used for road traffic noise mapping. Road traffic is the most impacting source. However Acoustic maps were required to determine how much noise the major sources of noise were emitting in certain locations. Acoustic maps are the initial step in determining how many people are exposed to different noise levels and, subsequently, which noise mitigation measures should be taken. When noise exposures are near to thresholds for health concerns. Models can only determine the spread of noise in the environment during the noise mapping phase if the proper input data are entered. Traffic monitoring and vehicle detection in ITS are the most crucial components. Furthermore, the most popular sensors used to detect automobiles are inductive loop detectors, radar detectors, and laser detectors. (Celik, T.; Kusetogullari, H,2010).in addition, the ITS used for traffic management employs sensors for the collection of traffic data that serve as inputs to real-time updated traffic models, with ensuing alerts to vehicles through various systems to avoid specific incidents or to be directed toward more efficient routes. Although they are distinct from one another and have distinct functionality, ITS systems and acoustic mapping offer comparable inputs. Integration of the two activities would be fascinating, for instance by enabling the ITS cameras to gather traffic data in accordance with the action plan and auditory maps, obtaining traffic data in accordance with the guidelines supplied by the end.

2.3 Current System Analysis

Road Traffic Detection System Based on IOT systems have advanced significantly in recent years, employing multiple technologies to reliably monitor and evaluate traffic situations. This current system study gives an overview of the essential components and methodologies utilized in Road Traffic Detection System Based on IOT, highlighting the strengths and limitations of present systems.

2.3.1 Hardware Component

Sensors, cameras, and communication devices are among the hardware components used in Road Traffic Detection System Based on IOT systems. These devices are strategically positioned at junctions, highways, and other crucial sites to collect real-time data on vehicle movements, speed, and density. Radar sensors, video cameras, LiDAR sensors, acoustic sensors, and magnetic sensors are all commonly used sensors.

2.3.2 Data Collection

Sensors, cameras, and communication devices are among the hardware components used in Road Traffic Detection System Based on IOT systems. These devices are strategically positioned at junctions, highways, and other crucial sites to collect real-time data on vehicle movements, speed, and density. Radar sensors, video cameras, LiDAR sensors, acoustic sensors, and magnetic sensors are all commonly used sensors.

2.3.3 Machine Learning and Artificial Intelligence

Road Traffic Detection System Based on IOT systems have been transformed by machine learning and artificial intelligence approaches. These algorithms are capable of learning patterns from massive amounts of data and making accurate predictions or choices. Convolutional neural networks (CNNs) and recurrent neural networks (RNNs) have showed promising results in vehicle identification, tracking, and classification applications.

2.3.4 Integration with Intelligent transportation System (ITS)

Intelligent transportation systems are frequently combined with road traffic sensing systems. This integration enables communication between multiple components, such as traffic management centers, mobile applications, and in-vehicle devices, to be smooth. Drivers may receive real-time traffic information, allowing them to make educated judgments and pick the optimal routes.

2.4 Comparison between existing systems

Table 2.1, Comparison between several systems based on Road Traffic Detection System Based on IOT methods.

Existing System	Road Traffic Detection System Based on IOT
Traditional Infrastructure Traditional infrastructure such as traffic lights, road signs, and road sensors are used in existing traffic systems. These systems have been in operation for many years and have established traffic management and control methods.	**IoT Infrastructure** IoT traffic signal monitoring and controller systems make use of a network of interconnected devices such as sensors, cameras, and communication devices. These sensors capture data on traffic flow, vehicle density, and environmental variables in real time.
Fixed Timing Control Traditional traffic systems often operate on fixed timing schedules for traffic signal control. The timing of traffic signals is predetermined and does not dynamically adapt to real-time traffic conditions. This can lead to suboptimal traffic flow and increased congestion.	**Real-time Adaptive Control** IoT systems offer real-time adaptive control of traffic signals. By continuously monitoring traffic data, analyzing it in real-time, these systems can dynamically adjust signal timings based on current traffic conditions, optimizing traffic flow and reducing congestion.
Limited Data Collection Existing data collection systems have limited capacities. To collect traffic data, they largely rely on simple sensors such as loop detectors. The information gathered is frequently restricted to basic characteristics such as vehicle type.	**Advanced Data Analytics** Advanced data analytics techniques are used by IoT devices to gain important insights from acquired data. This involves analyzing historical and real-time data to detect traffic trends, anticipate traffic congestion, and optimize traffic signal management systems.
Manual Control and Monitoring Traditional traffic systems need manual monitoring and control by traffic officers. Visual observations or historical data analysis are often used to make changes to traffic signal timings or management tactics.	**Intelligent Decision-making** Intelligent traffic control is made possible by IoT systems. These systems can make intelligent judgments about traffic signal control, traffic rerouting, and congestion management by combining data from numerous sources and applying machine learning algorithms.

2.5 Literature Review of Technology Used

2.5.1 ESP8266:

ESP8266: The ESP8266 is a widely used and adaptable Wi-Fi module known for its versatility and numerous functionalities. Its primary purpose is to facilitate wireless communication for devices based on microcontrollers. In the realm of Road Traffic Detection systems, the ESP8266 module plays a vital role in revolutionizing how data is collected and transmitted. Leveraging its Wi-Fi capabilities, the module can be seamlessly integrated into traffic monitoring devices and sensors strategically placed across road networks. These sensors can efficiently gather real-time data on traffic flow, congestion levels, and vehicle movement patterns. By relaying this valuable information to a central system or cloud platform, city planners, transportation authorities, and even individual drivers can make informed decisions to optimize traffic management, alleviate bottlenecks, and enhance overall road safety. The ESP8266's reliability, low power consumption, and ease of deployment have made it an indispensable component in modernizing and streamlining road traffic management solutions worldwide Below are some significant attributes of the ESP8266 module: (Microcontroller, WI-FI connection, Memory, GPIO Pins, Serial Communication, Programming, Community support.

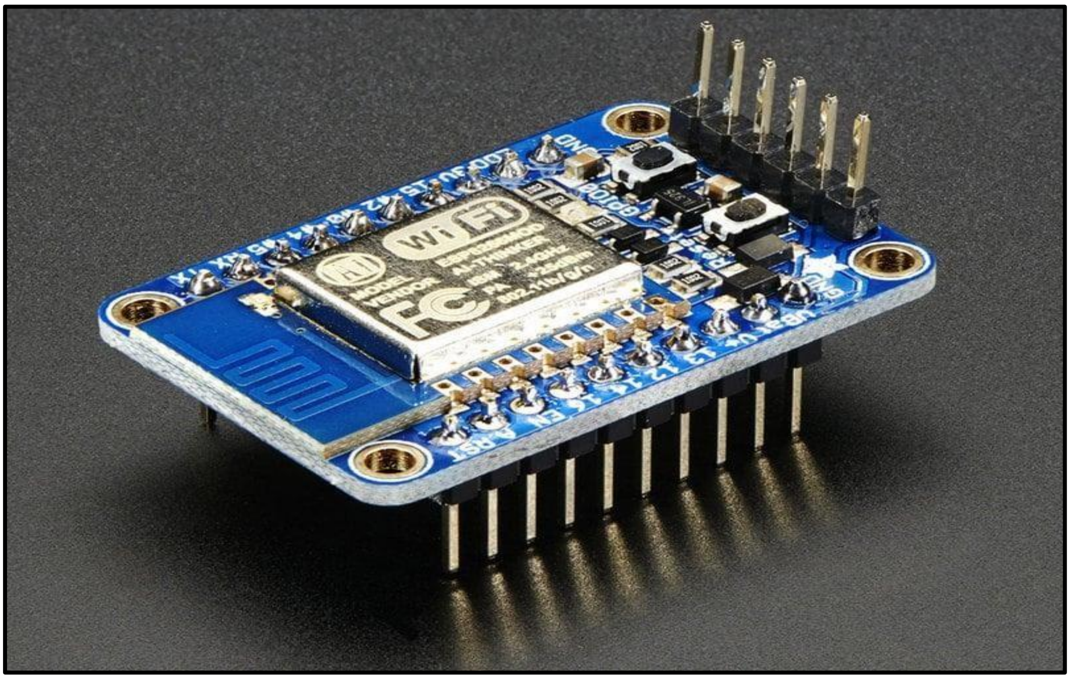


Figure 2.1 Example 1 of ESP8266

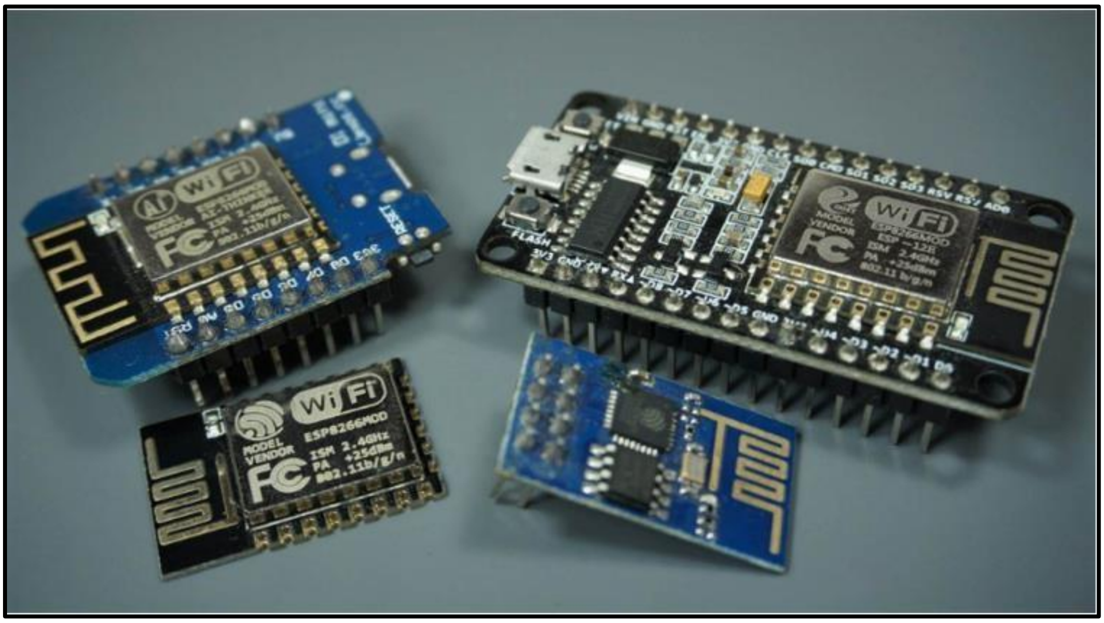


Figure 2.2 Example 2 of ESP8266

2.5.2 LED (Red, Green, Yellow):

LEDs, or Light Emitting Diodes, are electronic devices that emit light when an electric current passes through them. These devices are available in various colors, with red (R), green (G), and yellow (Y) being the most commonly used options. LEDs are highly versatile components that can be customized to suit specific applications and signaling requirements. Their popularity stems from their energy efficiency, small form factor, and long operational lifespan, making them a prevalent choice in a wide range of electronic devices, household appliances, automotive systems, and signaling applications. In the field of Road Traffic Detection and signaling, LEDs play a crucial role in modern traffic management and road safety. Equipped with the ability to produce different colors of light, LEDs are widely employed in traffic lights and pedestrian crossing signals. Red LEDs indicate drivers to stop, green LEDs signal them to proceed, and yellow LEDs warn of an imminent change in traffic conditions. The low power consumption of LEDs not only contributes to energy-saving efforts but also allows traffic lights to operate efficiently, even during power outages when backup systems are required. Moreover, the extended lifespan of LEDs reduces maintenance costs and ensures reliable signaling performance for an extended period. As smart city initiatives continue to evolve, the adaptability and efficiency of LEDs make them an indispensable element in enhancing road traffic detection and signaling systems worldwide.

Figure 2.3 Example of LED

2.5.3 HCSR-04:

The HC-SR04 represents a widely employed ultrasonic sensor module with significant applications in robotics, automation, and various electrical endeavours. Employing ultrasonic principles, it offers a straightforward and dependable means of distance measurement. Comprising two main components - an ultrasonic transmitter and a receiver - the HC-SR04 module emits ultrasonic waves (sound waves with frequencies beyond human hearing range) from the transmitter, while the receiver is responsible for detecting the waves after their reflection. the HC-SR04 ultrasonic sensor module plays a crucial role in modern traffic management and road safety. By strategically positioning these sensors at key locations along road networks, accurate distance measurements between vehicles can be obtained. This enables efficient monitoring of traffic flow, congestion levels, and safe following distances between vehicles. Incorporating HC-SR04 modules into smart traffic management systems empowers cities to gather real-time data and analyze traffic patterns, facilitating dynamic adjustments to traffic signals and optimizing overall road safety. The module's reliability, precision, and ease of implementation have established it as an essential component in enhancing road traffic detection, contributing to safer and more efficient transportation networks. Key features and specifications of the HC-SR04 ultrasonic sensor module Include (Distance Measurement Range, Measurement Principle, Operating Voltage, Trigger and Echo and Pins, Measurement Accuracy, Interfacing).

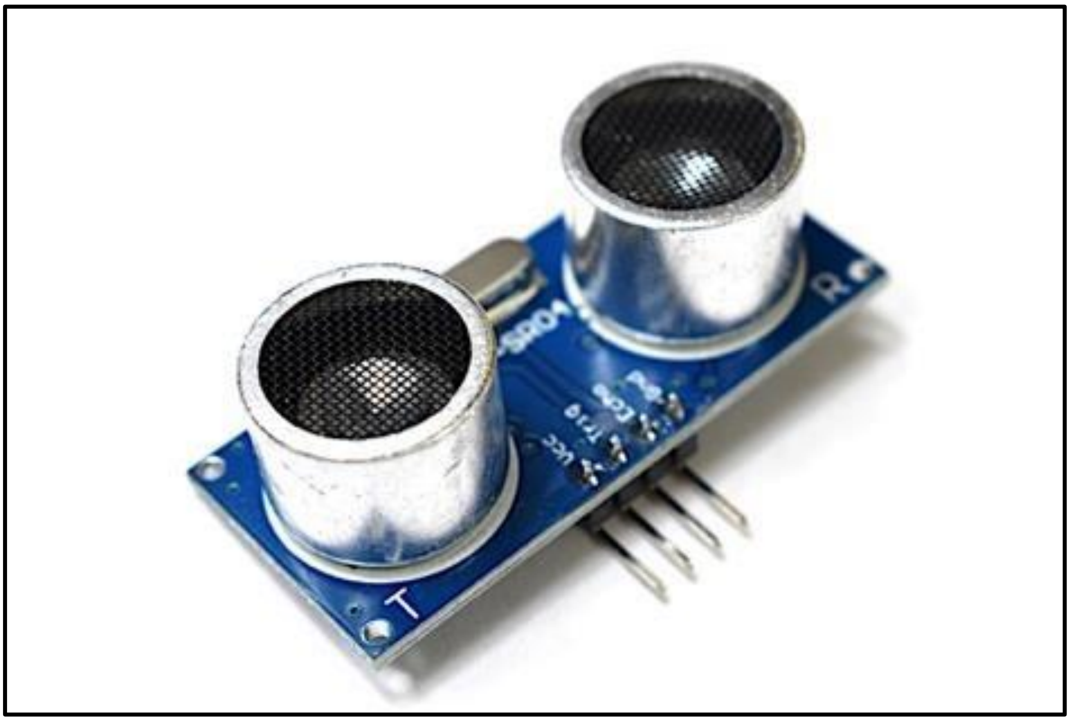


Figure 2.4 Example 1 of HCSR-04

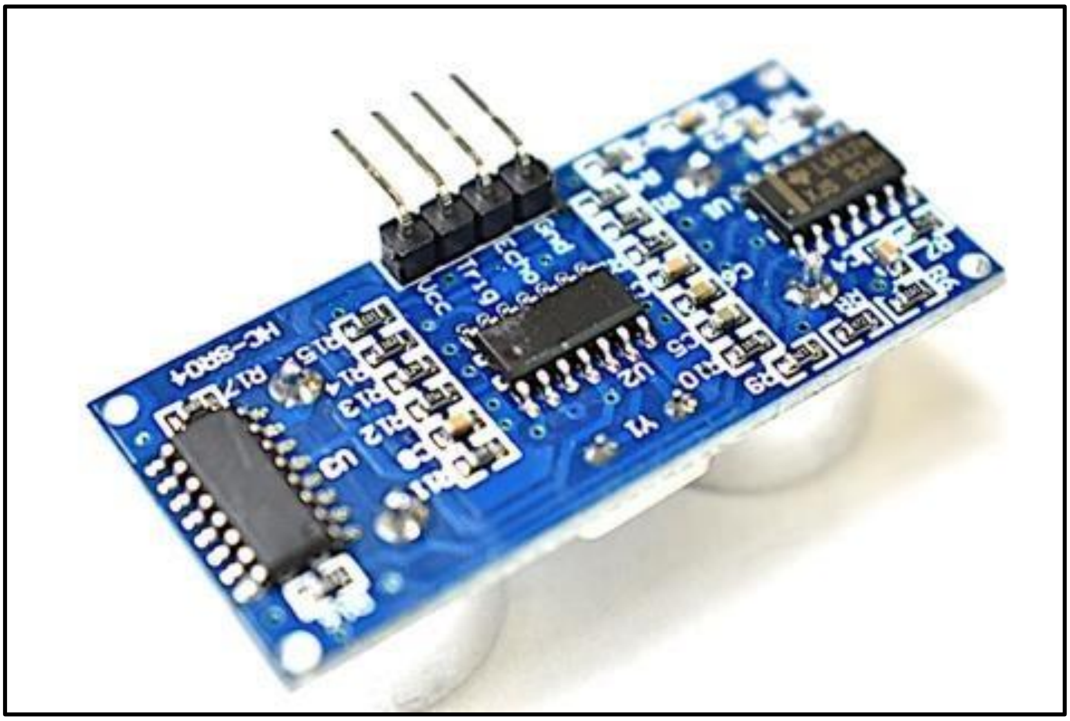


Figure 2.5 Example 2 of HCSR-04

2.5.4 Resister

A resistor is an inactive electronic component commonly present in numerous electrical and electronic circuits. Its main function is to impede the flow of electric current by providing resistance. Typically, resistors are constructed using materials with high resistance properties, such as carbon or metal sheets, which determine the level of resistance they offer. resistors are essential components in the design and functionality of traffic signal controllers. These controllers utilize resistors in conjunction with other electronic elements to regulate the timing and sequencing of traffic lights. By adjusting the resistance values, traffic engineers can precisely control the duration of green, yellow, and red signals, ensuring smooth and efficient traffic flow at intersections. Moreover, resistors contribute to the reliable operation and longevity of traffic signal systems by limiting the flow of current and preventing damage to sensitive electronic components. As part of the broader intelligent transportation systems, resistors play a significant role in enhancing road safety and optimizing traffic management for a more organized and safer driving experience.

Key characteristics and functions of resistors encompass (Resister Value, Tolerance, Power Rating, Color Coding, Voltage Drop, Current Limiting)

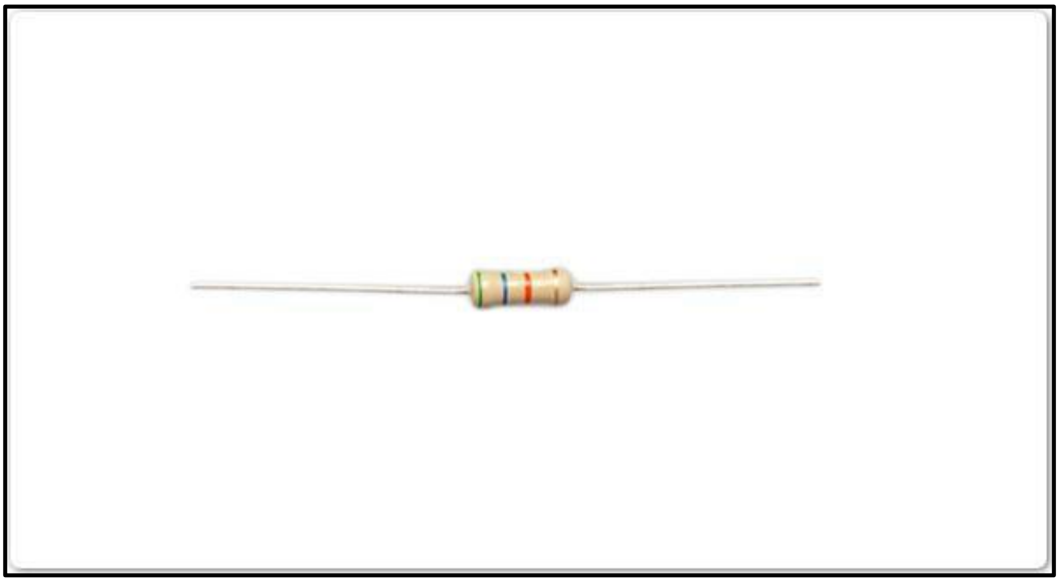


Figure 2.6 Example 1 of Resistor

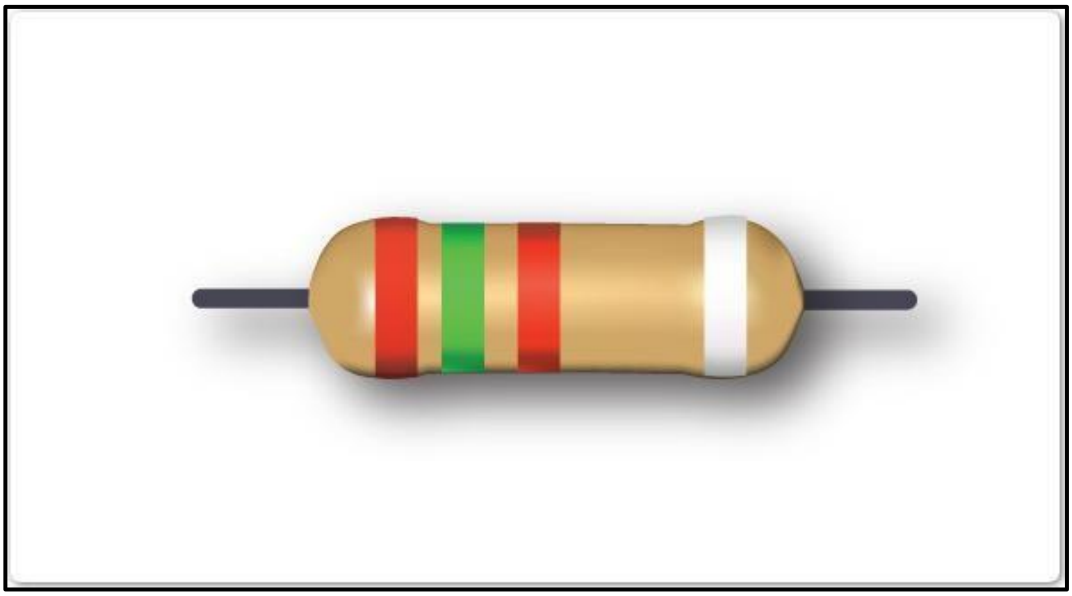


Figure 2.7 Example 2 of Resister

2.5.5 Bread-Board

The breadboard, a fundamental tool in electronics prototyping, plays a crucial role in facilitating the assembly and testing of circuits without the need for soldering. Comprising a grid of interconnected metal clips, it allows for the temporary connection of electronic components, promoting ease of experimentation and modification. With rows and columns serving as power and ground buses, respectively, and discrete holes accommodating components, the breadboard provides a user-friendly platform for designing and validating circuits. Its significance spans across educational settings, research laboratories, and hobbyist projects, fostering a hands-on approach to electronics. Despite its advantages, considerations such as signal integrity in high-frequency applications and limitations in replicating real-world conditions should be acknowledged. In the context of this literature review, the breadboard is highlighted for its instrumental role in facilitating rapid prototyping and experimentation, contributing to the iterative nature of electronics development.

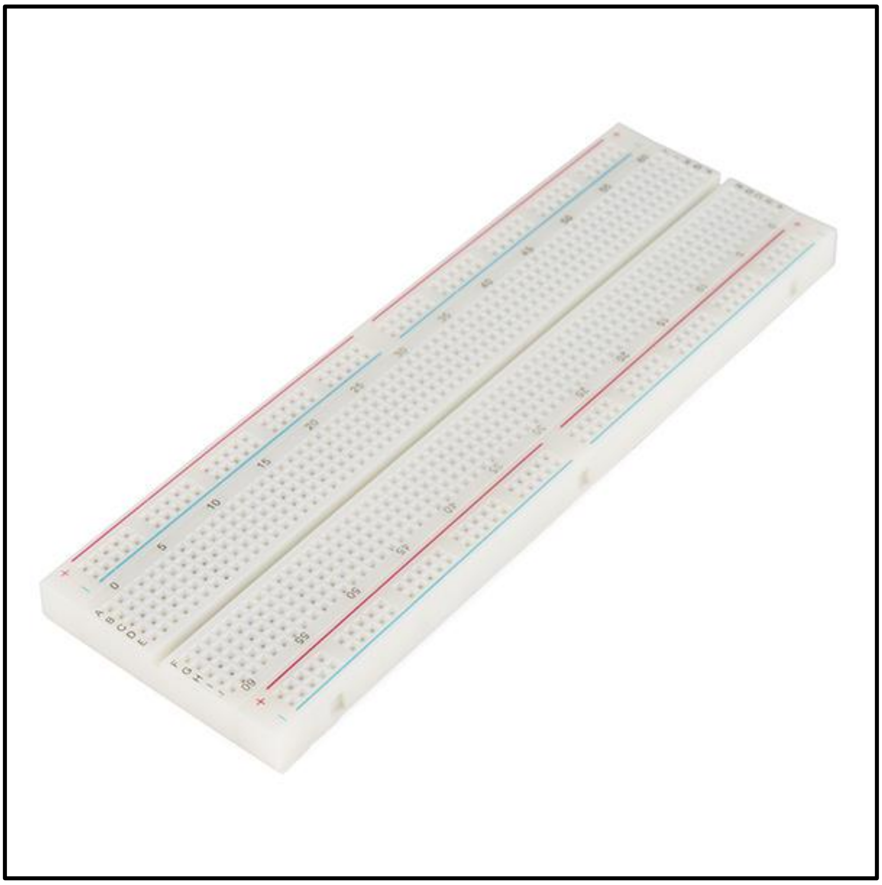


Figure 2.8 Example 1 of Bread-Board

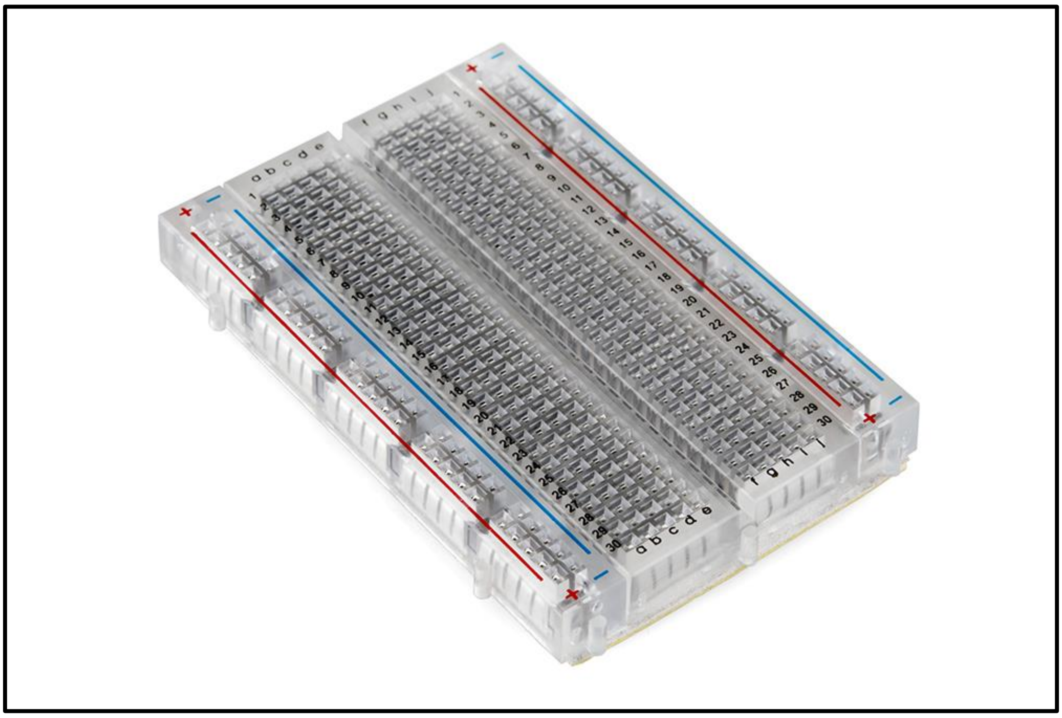


Figure 2.9 Example 2 of Bread-Board

2.6 Chapter Summary

This chapter outline the introduction road traffic dictation the system that used and the definition of it in details about Road Traffic Detection System Based on IOT systems that use multiple technologies to monitor and evaluate traffic. Such as Hardware Component, Data Collection and Processing, Machine Learning and Artificial Intelligence and Integration with Intelligent Transportation System (ITS). In this chapter provides a clear explanation on the study by providing a case study however it shows the advantages and disadvantages between traffic system and traffic dictation.

CHAPTER 3

SYSTEM DEVELOPMENT METHODOLOGY

3.1 Introduction

Creating a road traffic detecting solution capable of managing complexities within current roadway systems requires significant attention to detail. Our approach addresses this by leveraging real-time data processing techniques in conjunction with relevant tools like object recognition and tracking along with strategic analysis of ongoing highway trends. A well-defined and structured system development methodology plays an essential role throughout the entirety of our project. This powerful tool ensures each stage proceeds smoothly, thereby ensuring our final solution meets all relevant criteria for accuracy, performance, and functionality goals thus improving management efforts within transportation infrastructure frameworks. For success in developing an effective Road Traffic Detection System Based on IOT system comprehensive solution capable of monitoring highway pattern activity must be deployed; Our technique offers a systematic strategy that enables smooth evolution through developmental milestones from requirements collection phases through deployment timeframe validation steps. The Road Traffic Detection System Based on IOT system may be constructed in a methodical manner by using a well-defined system development process, enabling the timely delivery of a dependable and resilient solution. The approach helps the development team to manage requirements efficiently, apply suitable algorithms and techniques, conduct extensive testing, and make educated decisions based on stakeholder feedback. The methodology used for system development lays the groundwork for the development process, guiding the team through the essential processes and assuring a methodical and coordinated approach. It aids in the streamlining of development activities, the facilitation of team member collaboration, and the assurance that the system satisfies the needed objectives and functioning.

3.2 Methodology Choice and Justification

Choosing the correct Road Traffic Detection System Based on IOT approach is critical for the successful construction of an accurate and efficient system. There are different techniques to choose from, and the decision is influenced by a variety of criteria such as project needs, team makeup, project scale, and the nature of the problem being addressed. Here are several typical road traffic detecting methods and their rationale.

3.2.1 Agile Methodology

Agile methodologies like Scrum are a great fit for road traffic surveillance projects due to their iterative and incremental approach. Road traffic can be unpredictable, so it's important to have the ability to quickly adapt and integrate changes. Agile methodologies offer flexibility, continuous stakeholder involvement, and the ability to release functional software increments at a faster pace. This allows the development team to gather feedback, refine requirements, and make adjustments during the development process, resulting in a more precise and responsive traffic detection system

3.2.2 Waterfall Methodology

Waterfall technique is a more conventional approach, it might still be appropriate for Road Traffic Detection System Based on IOT projects in some cases. A sequential technique, such as waterfall, can provide an organized and controlled development process if the project requirements are well-defined and stable, and there is a clear knowledge of the system's objectives. This technique may be appropriate when there is a restricted scope for adjustments and a requirement for extensive documentation and planning ahead of time.

3.2.3 Hybrid Methodology

A hybrid methodology is a customized strategy that combines elements from various techniques to better suit the requirements of the project at hand. This approach is ideal for road traffic monitoring projects that have a mix of established and evolving needs, require rapid prototyping, and prioritize continuous integration and testing. By using a hybrid approach, the project team can have greater flexibility in adapting the methodology to meet specific project goals while leveraging the strengths of multiple approaches

3.2.4 Methodology Comparison

Table 3.1, Comparison between Types of Methodology.

Methodology	Advantages	Challenges
Agile Methodology	**1.** Allows for frequent feedback and stakeholder involvement, ensuring the system meets evolving needs. **2.** Enables faster delivery of working software increments, facilitating early deployment and validation. **3.** Emphasizes continuous improvement and flexibility to accommodate changes in traffic conditions and system requirements.	**1.** Requires active stakeholder participation and regular communication to maintain alignment and manage expectations. **2.** May pose challenges in terms of scope control and balancing priorities in rapidly evolving traffic environments. **3.** Documentation may be more lightweight, which can be a concern for certain regulatory or compliance requirements.
Waterfall Methodology	**1.** Well-suited for projects with stable and well-defined requirements upfront. **2.** Provides a structured and controlled development process with clear documentation at each stage. **3.** Easier to manage and track progress since each phase has well-defined deliverables and milestones.	**1.** Limited flexibility to accommodate changes once a phase is completed. **2.** May face challenges in adapting to evolving traffic conditions or dynamic requirements. **3.** Can lead to longer development cycles and delayed feedback, potentially impacting the system's responsiveness.
Hybrid Methodology	**1.** Provides flexibility to tailor the development process to specific project requirements. **2.**Allows for a combination of structured planning and documentation with iterative and adaptive development practices. **3.**Can accommodate evolving requirements while maintaining control and providing clear milestones.	**1.** Requires careful planning and integration of different practices, which may introduce complexity. **2.** Balancing the benefits of both approaches can be challenging, and it may require experienced project management to strike the right balance. **3.** The effectiveness of a hybrid approach depends on the proper selection and integration of practices from different methodologies.

The "best" approach for detecting road traffic is determined by a variety of elements and considerations. There is no one-size-fits-all solution since methodology selection is dependent on the unique project needs, team makeup, stakeholder engagement, and project context. Each approach has advantages and disadvantages. However, in the case of Road Traffic Detection System Based on IOT, the agile methodology is frequently seen as more appropriate for the following reasons:

3.2.4.1 Flexibility and Adaptability:

Road traffic conditions can be dynamic and change often. Agile approaches, such as Scrum, enable the development team to respond fast to changing needs and alter the system accordingly. This is especially useful when dealing with changing traffic patterns, developing technology, or the requirement to incorporate new data sources.

3.2.4.2 Stakeholder Collaboration:

In Road Traffic Detection System Based on IOT projects, effective stakeholder engagement is critical since the system must fulfil the expectations and requirements of traffic engineers, transportation authorities, and system users. Agile approaches promote regular and tight engagement between stakeholders and the development team, ensuring that stakeholders' input and comments are integrated throughout the development process.

3.2.4.3 Incremental Delivery and Early Feedback:

Agile techniques place a premium on delivering functional software increments at the conclusion of each sprint. This gives stakeholders early access to functional components and allows them to provide comments, allowing the development team to iteratively modify and enhance the system. The capacity to evaluate and fine-tune the system based on real-world feedback is critical for attaining accurate and dependable results in Road Traffic Detection System Based on IOT.

3.2.4.4 Continuous Improvement:

Traffic conditions and patterns change over time, requiring the road traffic monitoring system to be constantly improved and adapted. Agile approaches promote a culture of continuous improvement by allowing the development team to analyses and adapt their approach on a regular basis, adopt new techniques or algorithms, and enhance the system's performance.

3.3 Gant Chart

Gantt chart has been used as a guide to execute all tasks within a set timeline and illustrate how the project has worked. It also provides an overall look at the project timeline with the completion date for each task. By using the Gantt chart, milestones have been used for specific tasks to ensure they are done on time. The Figure below showcases the Gantt chart for PSM1, which includes a detailed timeline of the progress of PSM1 from choosing the title until the submission of the final PSM1 report

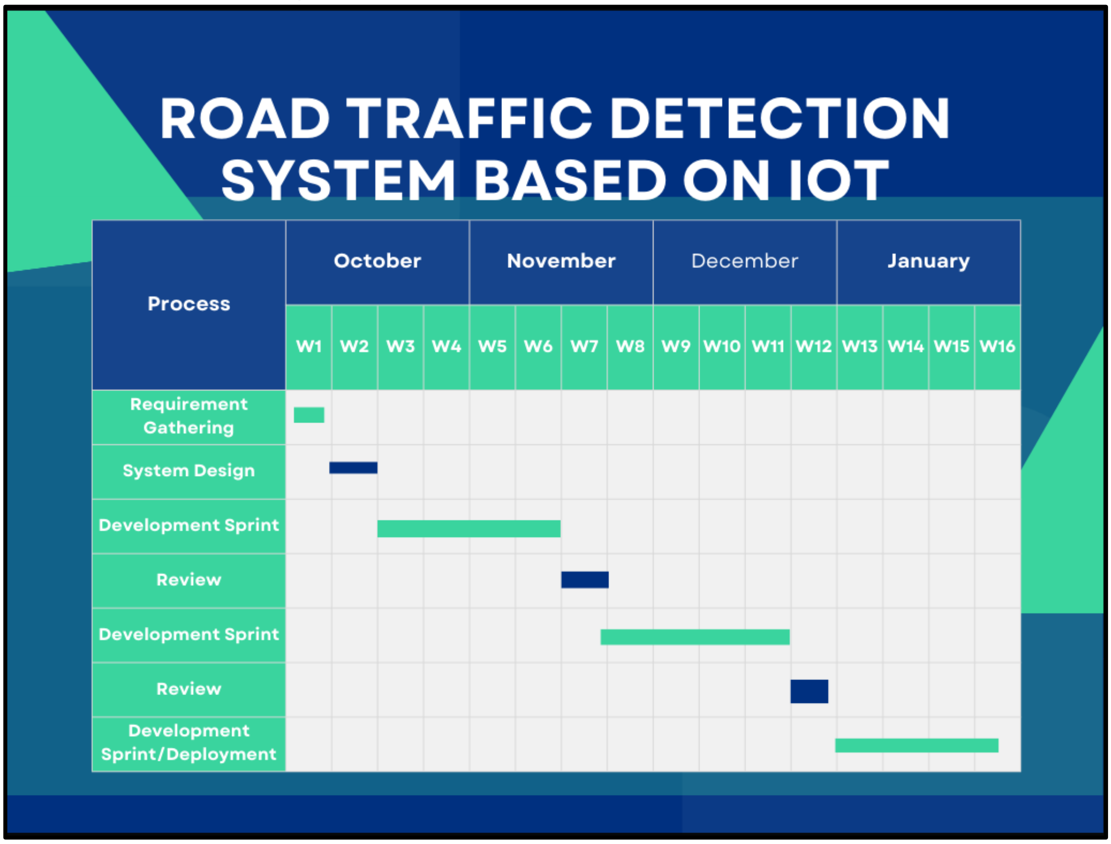


Figure 3.1 Gantt chart

3.4 Phases of the Chosen Methodology

A project generally goes through six steps or stages in agile software development: requirements, design, development, testing, deployment, and review. Let's go over each of these phases and describe them in further detail.

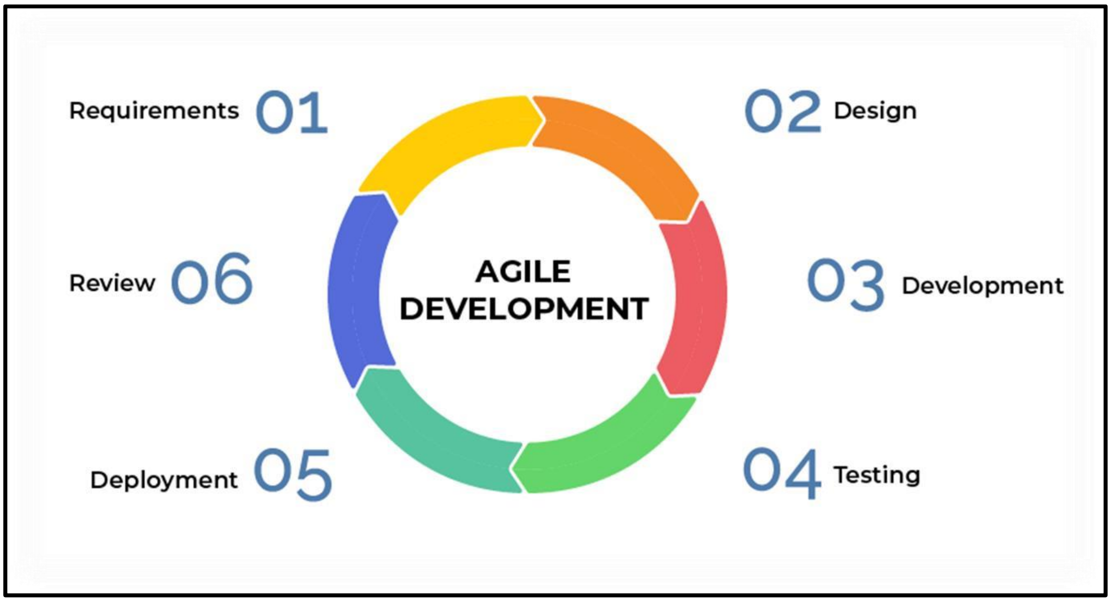


Figure 3.2 Agile Steps

3.4.1 Requirement

The requirements phase includes gathering and recording the stakeholders' needs and expectations. This phase tries to define the project's scope, identify and prioritize the desired features and functions. User stories or a product backlog are typically used to document requirements, which serve as the foundation for the development process. Requirement gathering for the project will involve conducting interviews with stakeholders and capturing user stories to understand their expectations and development priorities. Additionally, during the requirements phase, I will analyse and define various use cases for the system, aiming to clearly specify functional requirements and facilitate testing in the future. I will also look at current legacy traffic monitoring and traffic systems for requirements.

3.4.2 Design

Based on the requirements acquired in the preceding phase, the design phase focuses on building a blueprint or strategy for the software solution. The design has both high level and intricate elements. Creating an overarching architecture and defining main components and their interconnections are all part of high-level design. Breaking down the components into smaller modules and describing their implementation details is what detailed design entails. The design phase contributes to a clear knowledge of how the program will be constructed and how different components will interact. In this phase, I will break down the requirements, turn them into development goals for the development phase and add them to the backlog. This way, I will outline which requirements will take priority for the development cycles, and clearly design a development blueprint for the gathered requirements from the stakeholders.

3.4.3 Development

The software solution is produced during the development phase based on the design specifications. The development process is often iterative and incremental, with little portions of functionality produced in short sprints. The development team is in charge of creating features, writing code, and integrating various components. Regular cooperation and communication are essential throughout this phase to ensure that the development meets the criteria and that any concerns or adjustments are handled as soon as possible.
After the design phase, the development phase will begin. This phase will also repeat itself until all the requirements have met. During development, I will go through each requirement that's in the development backlog and integrate them into the system. After the requirements have been developed into working software, they will get tested by the stakeholders to gather feedback, which will lead to more requirement gathering and design and so on. This iterative process is essential to meeting stakeholder expectations.

3.4.4 Testing

During the testing process, the software is verified and validated to ensure it fulfils the intended quality and functionality. To discover problems, check for mistakes, and validate the program to the requirements, many forms of testing are conducted, including unit testing, integration testing, and system testing. Testing is a continuous process that is typically automated to speed up the feedback loop and guarantee the software remains stable and reliable.

3.4.5 Deployment

After completing testing and meeting the specified quality requirements, the software is deployed or utilized in the production environment or made available to end users. This phase includes tasks including packaging the program, creating the deployment environment, and making it available for usage.

3.4.6 Review

After the product has been deployed or utilized by end users, the review phase, also known as the retrospective phase, occurs. It entails reviewing the whole development process and determining what went well and what may be improved. The project is reviewed by the stockholders after which I will gather their feedback for the next development cycle, this phase is the most important phase during Agile development, and it is essential to meet stakeholder requirement and expectation.

3.5 Technology Used Description

Road Traffic Detection System Based on IOT is critical in intelligent transportation systems because it allows for effective traffic management, congestion reduction, and increased road safety. This literature study focuses on the hardware technology utilized for Road Traffic Detection System Based on IOT. To capture accurate and reliable traffic data, many hardware components and sensor methods have been investigated. The evaluation focuses on the improvements, strengths, weaknesses, and new trends in hardware-based Road Traffic Detection System Based on IOT systems.

3.5.1 ESP8266:

The ESP8266 is a flexible and commonly used Wi-Fi module that provides a variety of functions. Its principal role is to enable wireless communication to microcontroller-based devices.

3.5.2 LED (Red, Green, Yellow)

LEDs are electrical components that emit light when an electric current flows through them. LEDs come in a variety of hues, the most popular of which are red (R), green (G), and yellow (Y). LEDs are adaptable components whose functionality may be tailored to the exact application and signaling needs. Because of their low power consumption, compact size, and extended lifespan, they are widely utilized in a variety of electronic gadgets, appliances, automotive systems, and signaling applications. LED (R, G, Y) refers to the three distinct colors of LEDs used to signify different statuses of the traffic signal in the context of traffic signals or traffic lights:

3.5.3 HCSR-04

The HC-SR04 is a distance measuring ultrasonic sensor module that is extensively used in robotics, automation, and numerous electrical projects. Based on ultrasonic principles, it provides a simple and reliable method of measuring distances. The HC-SR04 sensor module is made up of two primary parts: an ultrasonic transmitter and a receiver. The transmitter sends out ultrasonic waves (sound waves with frequencies higher than those heard by humans), and the receiver detects the reflected waves.

3.5.4 Resistor

A resistor is a passive electronic component found in many electrical and electronic circuits. Its purpose is to add resistance to the passage of electric current. A resistor is made of a high resistance substance, often carbon or metal sheet, which affects the amount of resistance it gives.

3.5.5 Bread-Board

The breadboard holds paramount importance in electronics as an indispensable tool for rapid prototyping and circuit experimentation. Its grid of interconnected clips allows for the temporary connection of electronic components without the need for soldering, enabling engineers, students, and hobbyists to swiftly design, modify, and test circuits. This versatility makes it an essential component in educational settings, research labs, and DIY projects, fostering a practical understanding of electronics. Its ease of use accelerates the iterative design process, allowing individuals to troubleshoot and refine circuits quickly. Despite its simplicity, the breadboard's impact on the electronics ecosystem is profound, providing an accessible platform for innovation and learning.

3.6 Chapter Summary

The strategy for designing a road traffic detecting system is described in this chapter. It describes the numerous processes and tactics that go into creating a reliable and accurate traffic detecting system. However, the appropriate methodology employed in this study is Agile, and this chapter generally outlines all of the important aspects surrounding the study and line chart used in this study. It also displays the component that was utilized.

CHAPTER 4

REQUIREMENT ANALYSIS AND DESIGN

4.1 Introduction

Requirement Analysis and Design constitute fundamental phases in the lifecycle of any system development project, serving as the backbone for building robust and efficient solutions. These phases are critical in ensuring that the final product meets user needs, adheres to specifications, and operates seamlessly within its intended environment.

4.2 Requirement Analysis

Requirement analysis is a crucial phase in the development of any project. It involves gathering, documenting, and analyzing the needs and expectations of stakeholders to define the project scope. Here's a sample requirement analysis for your Road Traffic Detection System:

4.2.1 Vehicle Design

- The system should accurately detect the presence of vehicles using ultrasonic sensors.
- It should provide real-time information about the number of vehicles passing through the monitored area.

4.2.2 Data Transmission

- The master node should establish and maintain reliable communication with the slave nodes using ESP8266 for real-time data transmission.
- Data transmitted should include vehicle count, timestamp, and any relevant diagnostic information.

4.2.3 Scalability

- The system should support the addition of multiple slave nodes to cover different road segments, ensuring scalability for diverse urban environments.

4.3 Project Design

4.3.1 Flow Chart

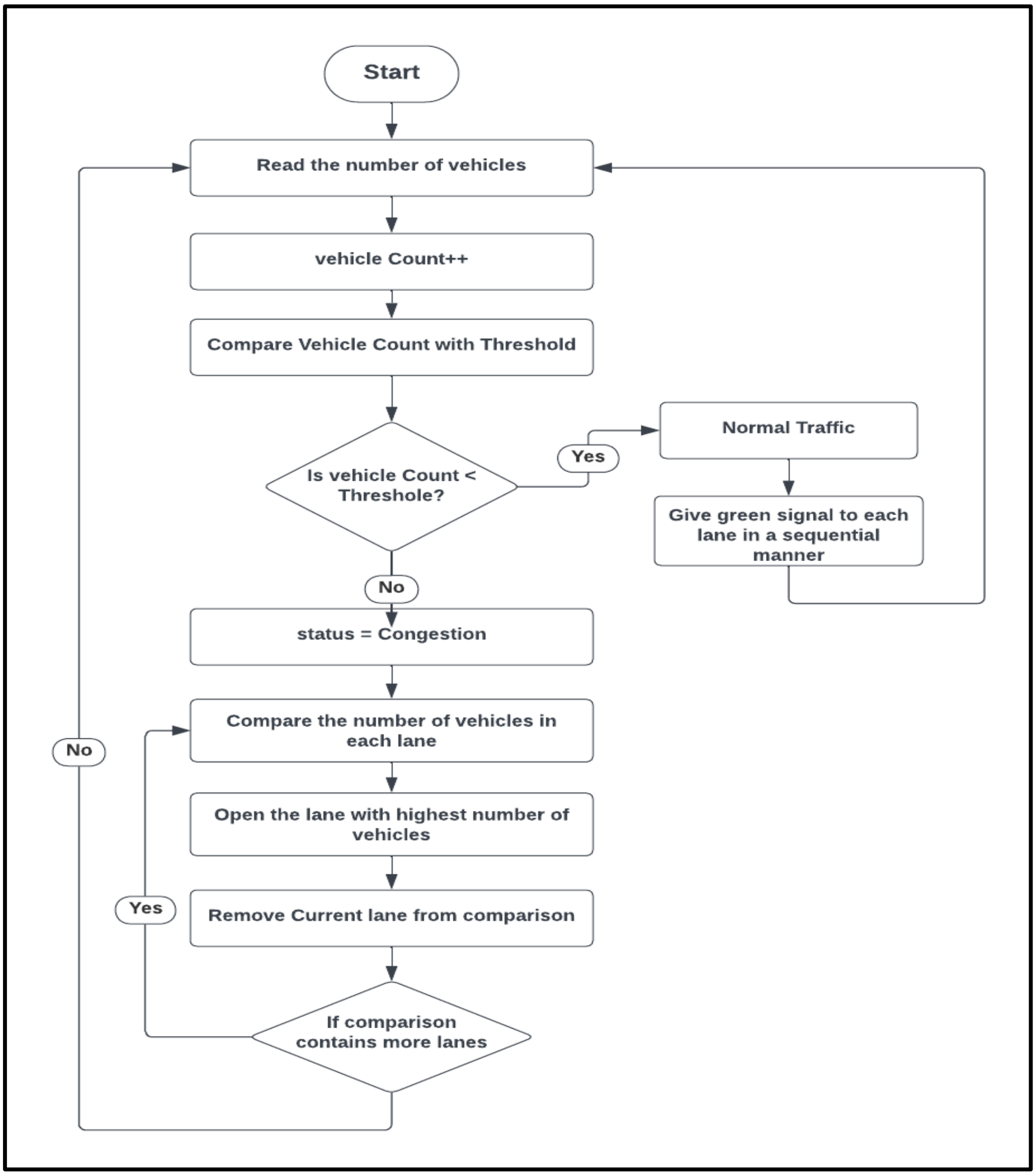


Figure 4.1 Flow Chart diagram

4.3.2 Use Case Diagram

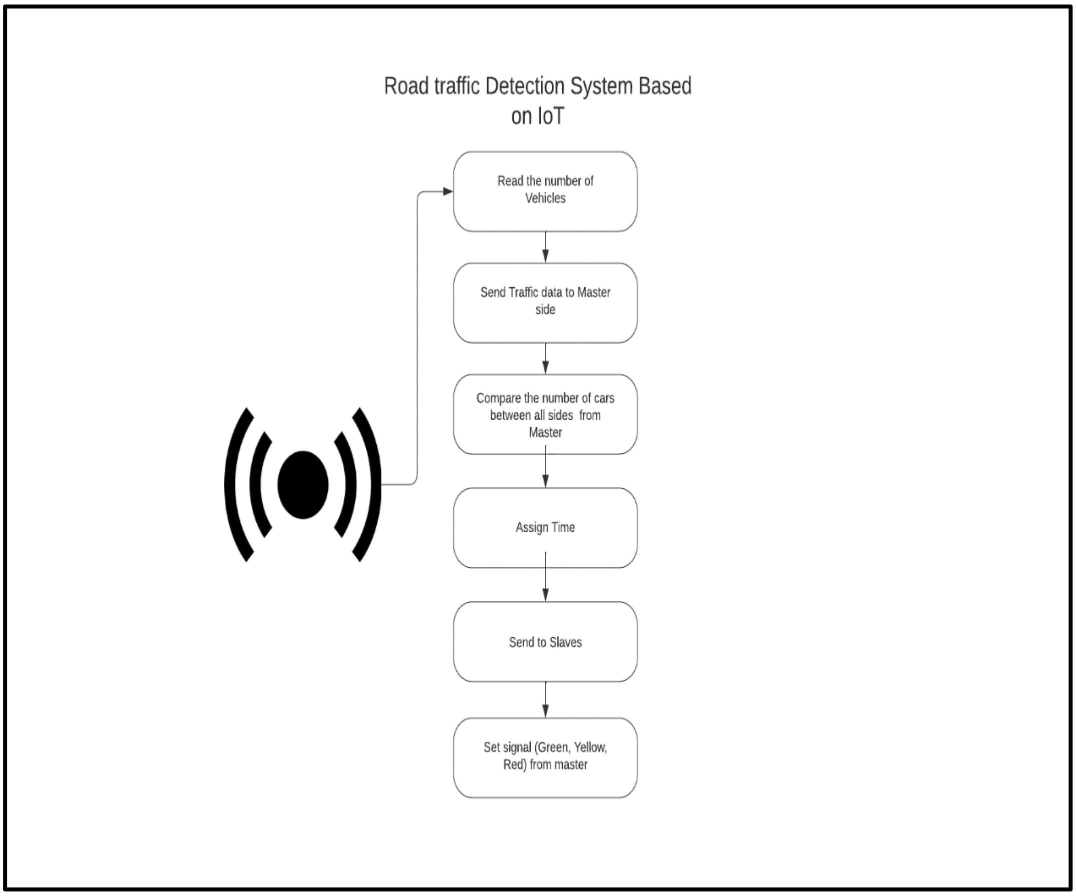


Figure 4.2 Use Case diagram

4.3.3 Sequence Diagram

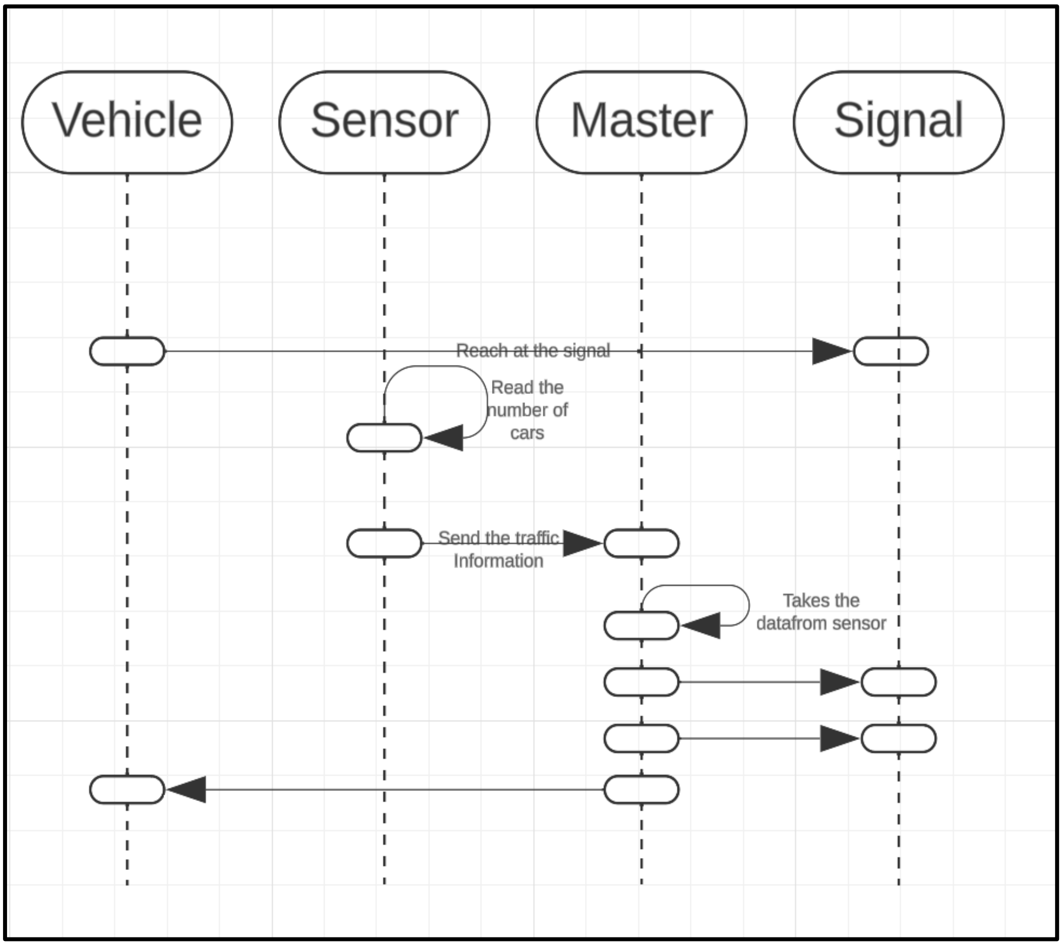


Figure 4.3 Sequence diagram

4.4 Method

In the proposed system, traffic lights are equipped with LEDs and a car counting sensor. Both components are interconnected to a Microcontroller via physical wires. This Microcontroller serves as the traffic light controller, receiving data from the sensor and efficiently managing the traffic lights by toggling between green, yellow, and red signals. The Microcontroller analyzes the sensor data to determine the number of cars present at the intersection it is monitoring. Based on these measurements, it calculates the optimal time intervals for the LEDs to ensure smooth traffic flow. To accomplish this, the Microcontroller takes the received car count as input and calculates the appropriate time duration for each light state. Subsequently, it compares this calculated time with the current actual time that the LEDs are displaying. The Microcontroller then makes a decision based on this comparison. If the actual green time is shorter than the calculated time, the decision is to increase the green time. Conversely, if the actual green time is longer, the decision is to decrease the green time. This intelligent adjustment of green time aims to optimize traffic flow and improve overall efficiency at the intersection.

4.4.1 A View of signals at different lanes

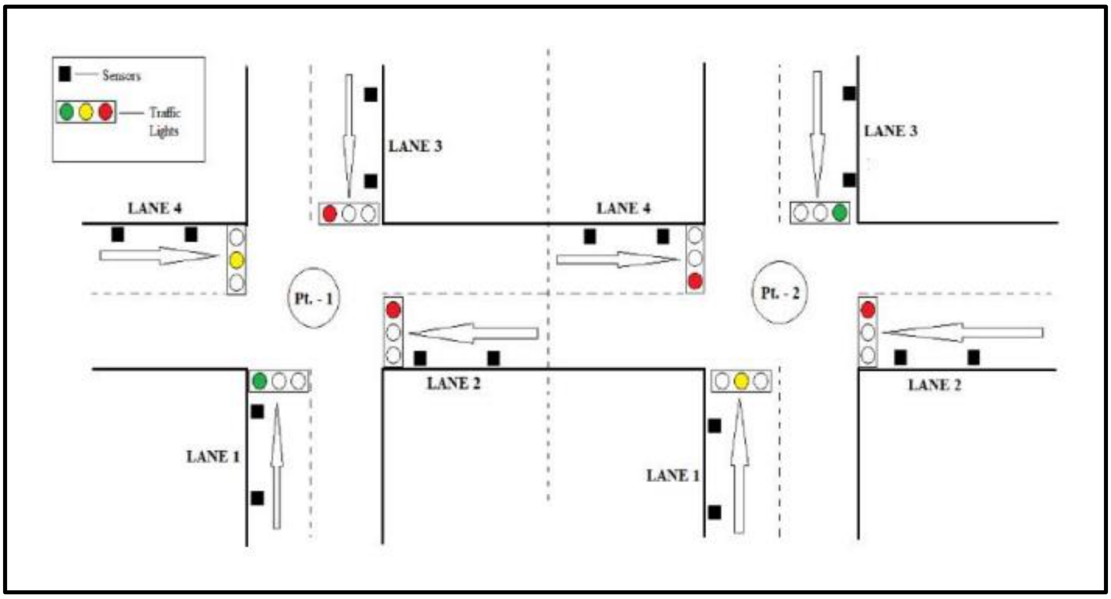


Figure 4.4 Control of previous Intersection

In the above figure, in Pt. - 1, LANE 1 is currently open with green signal and LANE 4 is ready with a yellow signal but LANE 2 and LANE 3 are blocked. In LANE 3, vehicle count is already greater than the threshold value, therefore the road coming to LANE 2 of Pt. - 1 is blocked in the Pt. - 2 itself. Thus, re-routing them through another lanes. (Assuming that Pt. - 1 is the current intersection and Pt. - 2 is the previous intersection.)

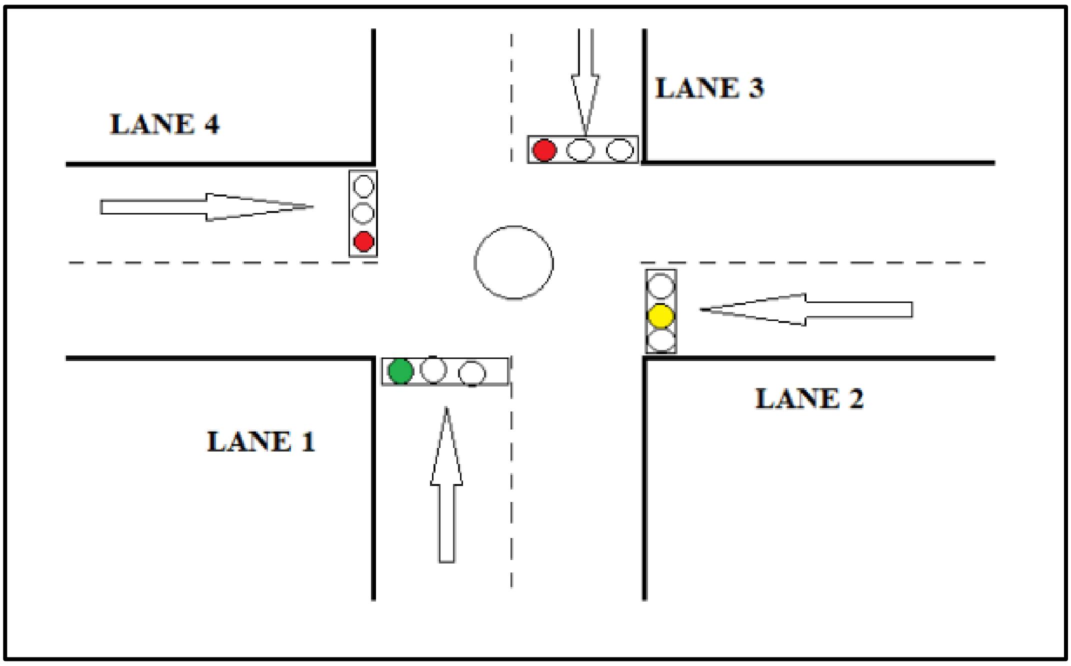
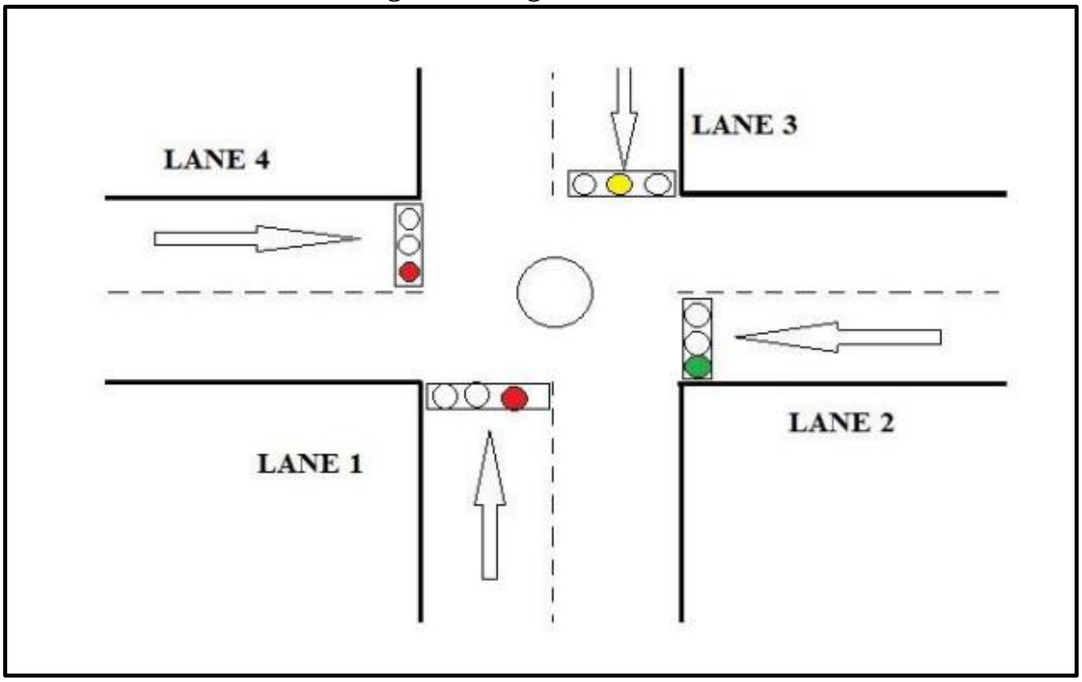


Figure 4.5 Signal at Lane 1

In the above figure, Lane 1 is open with green signal and other lanes are closed with red signal.

Figure 4.6 Signal at Lane 2



In the above figure, Lane 2 is open with green signal and other lanes are closed with red signal.

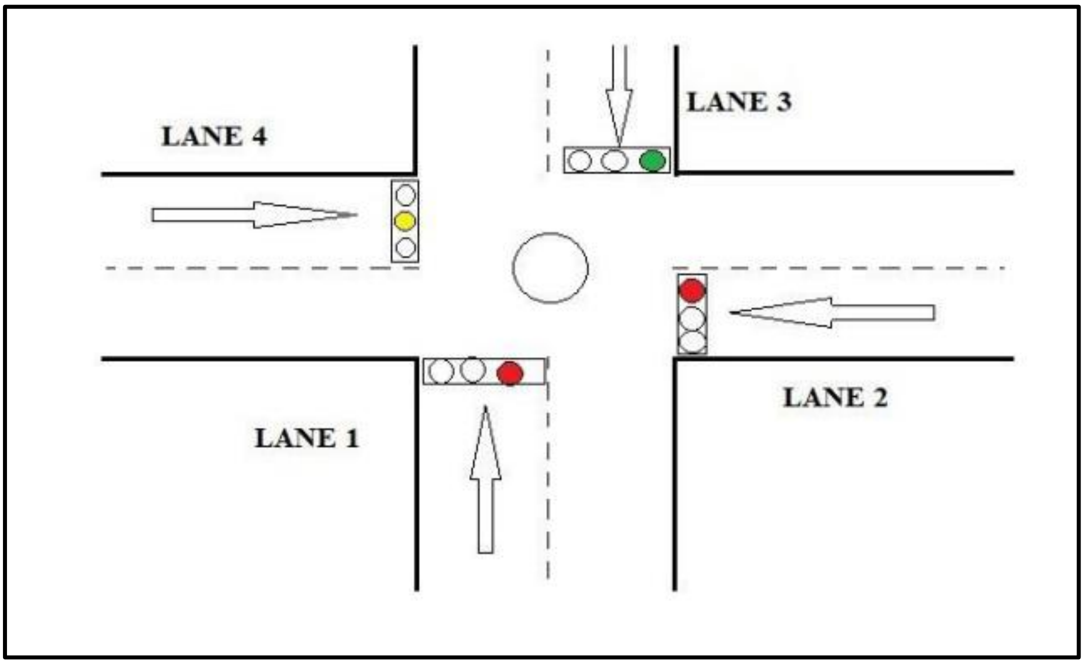


Figure 4.7 Signal at Lane 3

In the above figure, Lane 3 is open with green signal and other lanes are closed with red signal and after that Lane 4 will get the green signal automatically.

CHAPTER 5

IMPLEMENTATION AND TESTING

5.1 Introduction

In the face of rapid urbanization and a growing number of vehicles worldwide, efficient traffic management is paramount for transportation authorities. The Road Traffic Detection System based on IoT plays a vital role in monitoring and comprehending traffic conditions. This system detects and tracks various elements on roadways, utilizing data from security cameras, sensors, and intelligent transportation systems to analyze traffic flow, density, and speed. The project reviews diverse approaches, from traditional computer vision to advanced deep learning algorithms, addressing challenges like occlusions and changing ambient conditions. Emphasizing traffic flow analysis and congestion management, the study explores practical applications in intelligent transportation systems, autonomous vehicles, and overall traffic management. It also investigates current trends and future directions, such as multimodal fusion and integration with smart city infrastructure. The aim of this research is to provide scholars, practitioners, and policymakers with a comprehensive understanding of the Road Traffic Detection System based on IoT. By showcasing cutting-edge approaches and advancements, the study contributes to the development of innovative solutions, fostering smarter and more sustainable transportation systems.

5.2 Coding of System Main Functions

5.2.1 Handle Slave communication From Master

```
void handleSlaveCommunication() {
  WiFiClient client = server.available();

  if (client) {
    Serial.println("New client connected");

    String receivedMessage = "";

    long timeout = millis() + 5000;
    while (!client.available() && millis() < timeout) {
      delay(1);
    }
    while (client.available()) {
      char c = client.read();
      if (c == '\n') {
        break;
      }
      receivedMessage += c;
    }
    if (receivedMessage.length() > 0) {
      Serial.print("Received message from slave: ");
      Serial.println(receivedMessage);
      processSlaveMessage(receivedMessage);
    }
    client.stop();
    Serial.println("Connection with slave closed");
  }
  delay(100);
```

5.2.2 Send Message to Master if Communication occurred or Failed

```
void sendMessageToMaster(const String &message) {
  if (masterClient.connect(masterIP, 80)) {
    Serial.println("Connected to master");
    Serial.print("Sending message to master at ");
    Serial.println(masterIP);
    masterClient.print(message);
    masterClient.stop();
    Serial.println("Connection with master closed");
  } else {
    Serial.println("Failed to connect to the master");
  }
}
```

5.3 Testing

The testing strategy for the Road Traffic Detection System is designed to ensure the robustness and reliability of the implemented solution. A dual approach comprising black box testing and white box testing is adopted to comprehensively validate the system. Black box testing focuses on verifying external functionalities, such as accurate vehicle detection, real-time data transmission, and user interface interactions. This approach ensures that the system meets specified requirements and functions as expected from an end-user perspective. Simultaneously, white box testing delves into the internal code logic, communication protocols, and scalability, guaranteeing the correctness and efficiency of the underlying algorithms and structures. By combining both testing methodologies, the project aims to achieve a well-rounded evaluation, addressing both user-centric functionalities and intricate aspects of the system's internal workings. Continuous iteration and refinement of the testing process will contribute to the creation of a reliable and scalable Road Traffic Detection System.

5.3.1 Black Box Testing

Objective:

Validate the external functionality and ensure that the system meets specified requirements.

Test Scenarios:

- **Vehicle Detection Accuracy:**
  - ✓ Input: Simulated traffic scenarios with various vehicle speeds and distances.
  - ✓ Expected Output: Accurate detection and counting of vehicles.

- **Real-time Data Transmission:**
  - ✓ Input: Simulated communication between master and slave nodes.
  - ✓ Expected Output: Real-time transmission of traffic data without data loss.

- **Scalability Test:**
  - ✓ Input: Addition of multiple slave nodes to the system.
  - ✓ Expected Output: The system should seamlessly scale to accommodate additional nodes without compromising performance.

- **Data Analysis:**
  - ✓ Input: Varied traffic patterns and congestion scenarios.
  - ✓ Expected Output: Correct identification of traffic patterns and congestion points.

5.3.2 White box Testing

Objective:

Validate the internal logic, code structure, and paths within the system.

Test Scenarios

- **Code Path Coverage:**
  - ✓ Test various paths within the code to ensure comprehensive coverage.
  - ✓ Check that all branches, loops, and conditional statements are executed.

- **Communication Protocol Testing:**
  - ✓ Test the communication protocol between master and slave nodes.
  - ✓ Verify the correctness of data packet formation and transmission.

- **Scalability Analysis:**
  - ✓ Analyze the code for scalability and assess its ability to handle an increasing number of slave nodes.
- **Data Processing and Analysis:**
  - ✓ Review the algorithms used for data analysis.
  - ✓ Test the correctness of the algorithms in identifying traffic patterns.

5.3.3 System Flow

- **Initialization:**
  - ✓ The system begins by initializing the master node and the connected slave nodes.
- **Sensor Activation:**
  - ✓ Ultrasonic sensors in each slave node are activated to start monitoring the presence of vehicles on the road.
- **Vehicle Detection:**
  - ✓ Ultrasonic sensors detect the presence of vehicles by emitting and receiving ultrasonic waves.
  - ✓ The sensor data, including distance measurements, is collected by each slave node.
- **Data Transmission:**
  - ✓ Slave nodes transmit the collected data, including vehicle count and timestamps, to the master node through the ESP8266 communication network.
  - ✓ Real-time data transmission ensures continuous monitoring.
- **Data Aggregation:**
  - ✓ The master node aggregates the received data from all slave nodes to create a comprehensive dataset for traffic analysis.
- **Traffic Analysis:**
  - ✓ Basic data analysis algorithms are applied to the aggregated data to identify traffic patterns and congestion points.
  - ✓ The master node generates insights into the traffic conditions based on the analyzed data.
- **Scalability Check:**
  - ✓ The system checks for scalability by ensuring the seamless addition of new slave nodes for extended road coverage.
- **System Maintenance:**
  - ✓ Routine maintenance tasks, such as checking sensor functionality and ensuring network connectivity, are performed to keep the system operational.

5.3.4 Input Output Verification

Input-Output verification in Road Traffic Detection System involves validating that the system processes input data correctly and produces accurate and expected output. Given the nature of project, the inputs typically come from the ultrasonic sensors detecting vehicles, and the output includes the processed traffic data, analysis results, and visualizations. Below is an outline of Input-Output verification for project:

Input Verification:

- **Sensor Data Accuracy:**
  - ✓ **Input:** Distance measurements from ultrasonic sensors.
  - ✓ **Verification:** Ensure that the sensor data accurately represents the presence and distance of vehicles. Perform tests with known scenarios to validate the reliability of the sensor input.

- **Data Transmission Integrity:**
  - ✓ **Input:** Data transmitted from slave nodes to the master node.
  - ✓ **Verification:** Validate the integrity of the transmitted data. Confirm that data packets are correctly formed, transmitted, and received without loss or corruption.

Output Verification:

- **Data Analysis Correctness:**
  - ✓ **Output:** Results of traffic analysis algorithms.
  - ✓ **Verification:** Validate that the data analysis algorithms accurately identify traffic patterns, congestion points, and any relevant insights based on the collected data.
- **Scalability Testing:**
  - ✓ **Output:** System's ability to scale with the addition of new slave nodes.
  - ✓ **Verification:** Confirm that the system seamlessly integrates new slave nodes, extending the coverage area without compromising the accuracy of the traffic data

Testing Case

Testing Case 1: Vehicle Detection Accuracy

Test Case ID	***Test Objective***	***Test Steps***	***Expected Result***	***Pass/Fail***
TC-001	Verify accurate vehicle detection	1. Simulate multiple vehicles passing through the monitored area. 2. Observe sensor readings and recorded counts.	The system accurately detects and counts each vehicle with minimal false positives/negatives.	Pass

Testing Case 2: Data Transmission Integrity

Test Case ID	***Test Objective***	***Test Steps***	***Expected Result***	***Pass/Fail***
TC-002	Validate integrity of data transmission	1. Simulate data transmission between master and slave nodes. 2. Monitor transmitted data for completeness and correctness.	Data is transmitted without loss or corruption. Communication between nodes is stable and reliable.	Pass

5.4 Chapter Summary

In this multifaceted exploration of the Road Traffic Detection System project, key chapters were dissected to provide a comprehensive overview. The testing approach strategically combines both black box and white box methodologies, focusing on external functionalities and internal code logic. The Input-Output Verification chapter underscores the significance of validating sensor inputs for accuracy and ensuring the reliability of outputs, including real-time updates and analysis results. The System Flow chapter delineates the high-level operation, detailing vehicle detection, data transmission, analysis, and user interface interaction. Implementation brings the project to life, integrating ESP8266 microcontrollers, ultrasonic sensors, and scalable communication protocols. Data analysis algorithms provide valuable traffic insights, while a user-friendly interface aids administrators in interpreting real-time data effectively. Thorough documentation accompanies the implementation, offering a comprehensive resource for understanding the system architecture, hardware connections, and software algorithms. Collectively, these chapters provide a robust foundation for the successful development and deployment of a reliable Road Traffic Detection System.

CHAPTER 6

CONCLUSION

6.1 Introduction

As we navigate the concluding chapter of this exploration into the development of the Road Traffic Detection System, it is fitting to reflect on the journey undertaken in conceptualizing, designing, and implementing this innovative solution. Throughout this project, our focus has been on creating a robust, scalable system capable of real-time traffic monitoring. We began by formulating a comprehensive testing approach, combining black box and white box methodologies, ensuring thorough validation of both external functionalities and internal code logic. The Input-Output Verification chapter emphasized the critical role of accurate data processing and transmission, while the System Flow chapter provided a structured overview of how the system operates seamlessly. In the Implementation chapter, we translated concepts into reality, integrating hardware components, designing communication protocols, and implementing data analysis algorithms. Now, as we approach the conclusion, it is an opportunity to synthesize the insights gained, highlight accomplishments, acknowledge challenges, and envision the future trajectory of this Road Traffic Detection System. Through collaboration and innovation, we have strived to create a solution that not only meets the immediate requirements but also sets the stage for advancements in intelligent traffic monitoring. Let us delve into the concluding chapter, where we draw conclusions, offer reflections, and chart the course for future enhancements and applications of this cutting-edge system.

6.2 Achievement of Project Objectives

Throughout the course of this project, our primary objectives were clearly defined to create a Road Traffic Detection System based on IoT using ESP8266 and ultrasonic sensors. As we conclude this endeavor, it is gratifying to reflect on the significant achievements made in the pursuit of these objectives:

1. Accurate Vehicle Detection:

One of the primary goals was to achieve accurate vehicle detection using ultrasonic sensors. Through meticulous testing and refinement, the system reliably detects and counts vehicles passing through the monitored area, meeting the intended accuracy criteria.

2. Real-time Data Transmission:

The project aimed to establish seamless real-time data transmission between master and slave nodes. Through the implementation of ESP8266 communication networks, the system ensures swift and reliable data transmission, contributing to timely updates and effective monitoring.

3. Scalability:

Scalability was a critical objective to accommodate different urban environments. The system design facilitates the integration of multiple slave nodes, allowing for the extension of road coverage without compromising performance.

4. Comprehensive Documentation:

A successful achievement was the development of comprehensive documentation. This resource serves as a guide for understanding the system architecture, hardware connections, and software algorithms, facilitating future maintenance and enhancements.

6.3 Suggestions for Future Improvement

The successful implementation of the Road Traffic Detection System provides a solid foundation, yet there are opportunities for future enhancements and refinements to further elevate its capabilities. Here are suggestions for future improvement:

1. Advanced Data Analytics:

Explore the integration of advanced data analytics and machine learning algorithms to derive more sophisticated insights from the traffic data. This could include predictive analytics for traffic patterns and dynamic congestion prediction.

2. Integration of Additional Sensors:

Consider incorporating additional sensor types, such as cameras or infrared sensors, to complement ultrasonic sensors. This multi-sensor approach could enhance the system's accuracy and provide more comprehensive data for analysis.

3. Edge Computing Implementation:

Investigate the potential for implementing edge computing solutions to perform data analysis and processing directly on the nodes. This can reduce the reliance on centralized processing, leading to faster decision-making and reduced data transmission loads.

4. Adaptive Traffic Signal Control:

Explore the integration of adaptive traffic signal control systems. By leveraging real-time traffic data, the system can optimize traffic signal timings dynamically, improving overall traffic flow and reducing congestion.

5. Mobile Application Integration:

Develop a mobile application for administrators, enabling them to monitor traffic conditions remotely and receive notifications. This can enhance the accessibility and flexibility of system management.

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9in x 6in, 10(1–2), p. 5

Appendix A

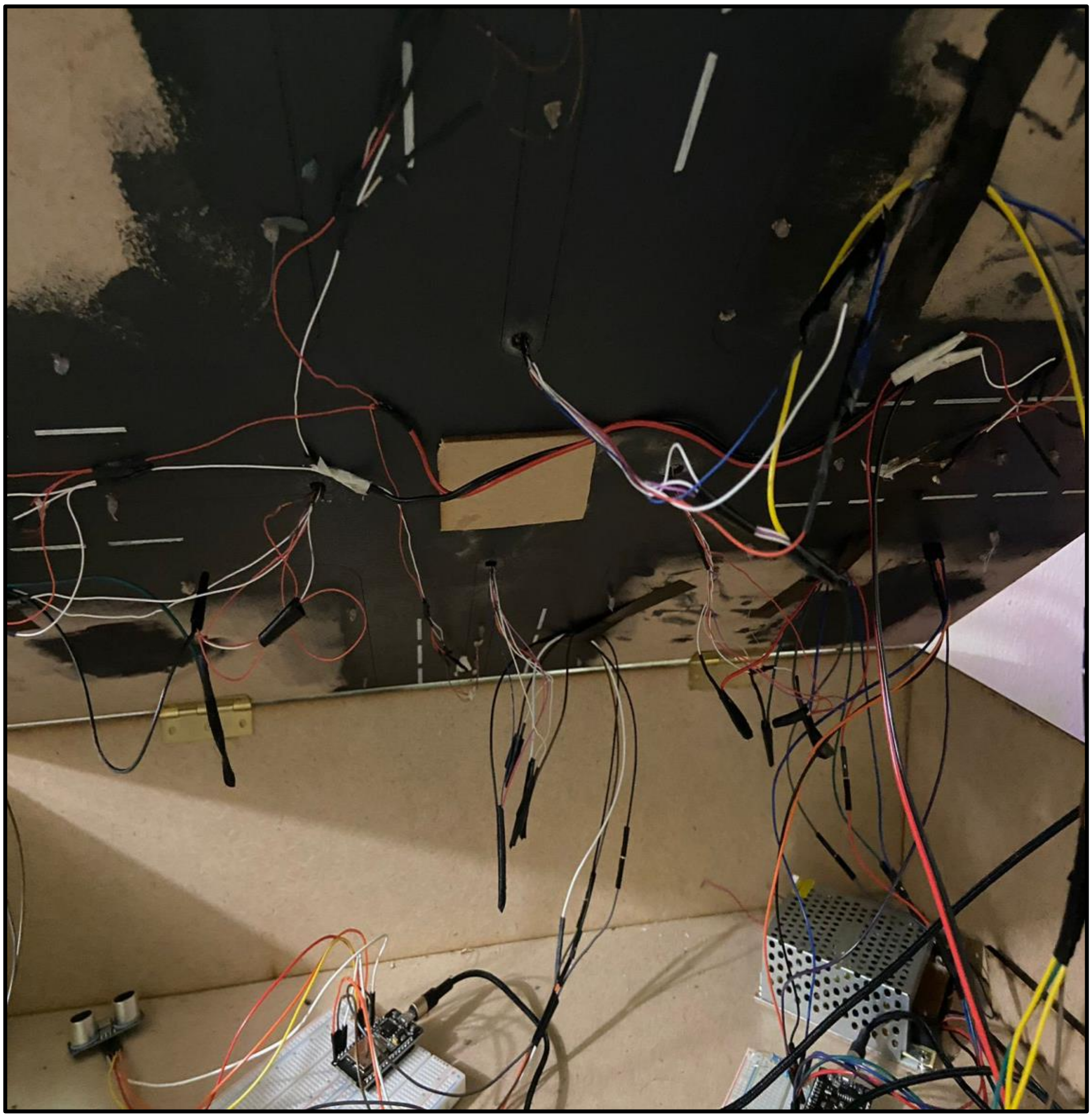

Figure A.1 Project wiring

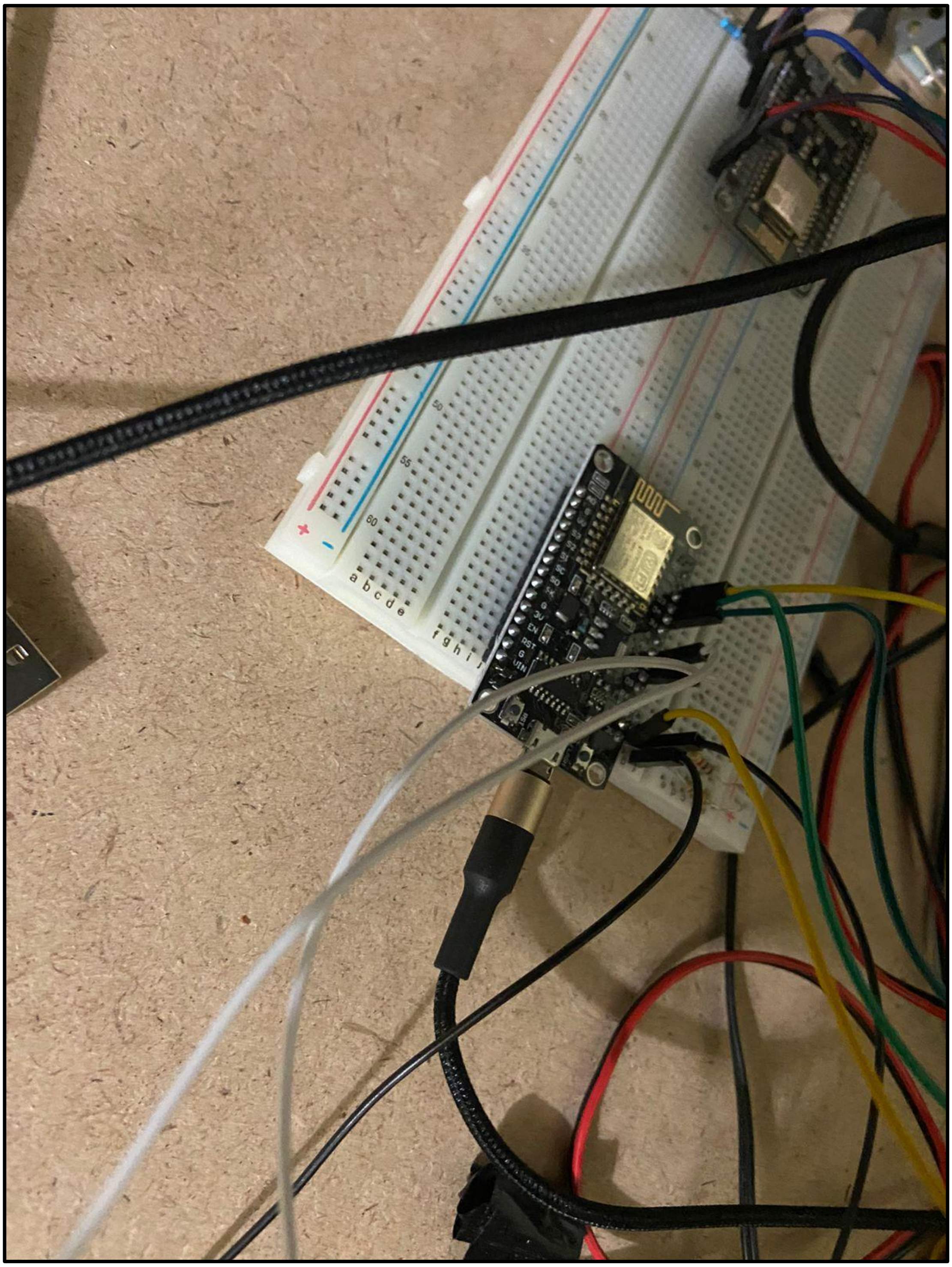

Figure A.2 ESP8266 Pins

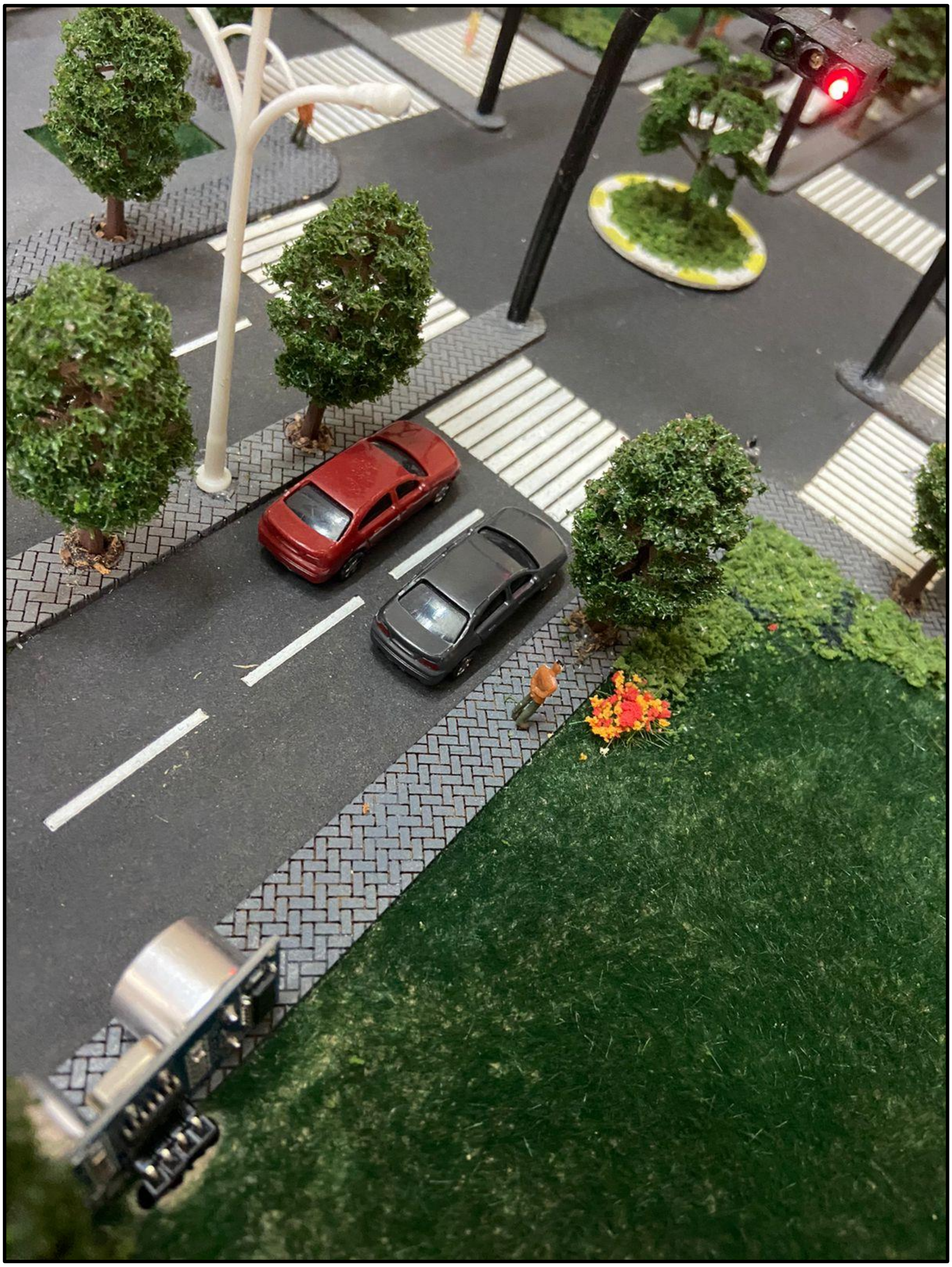

Figure A.3 Red Light is on (Stop)

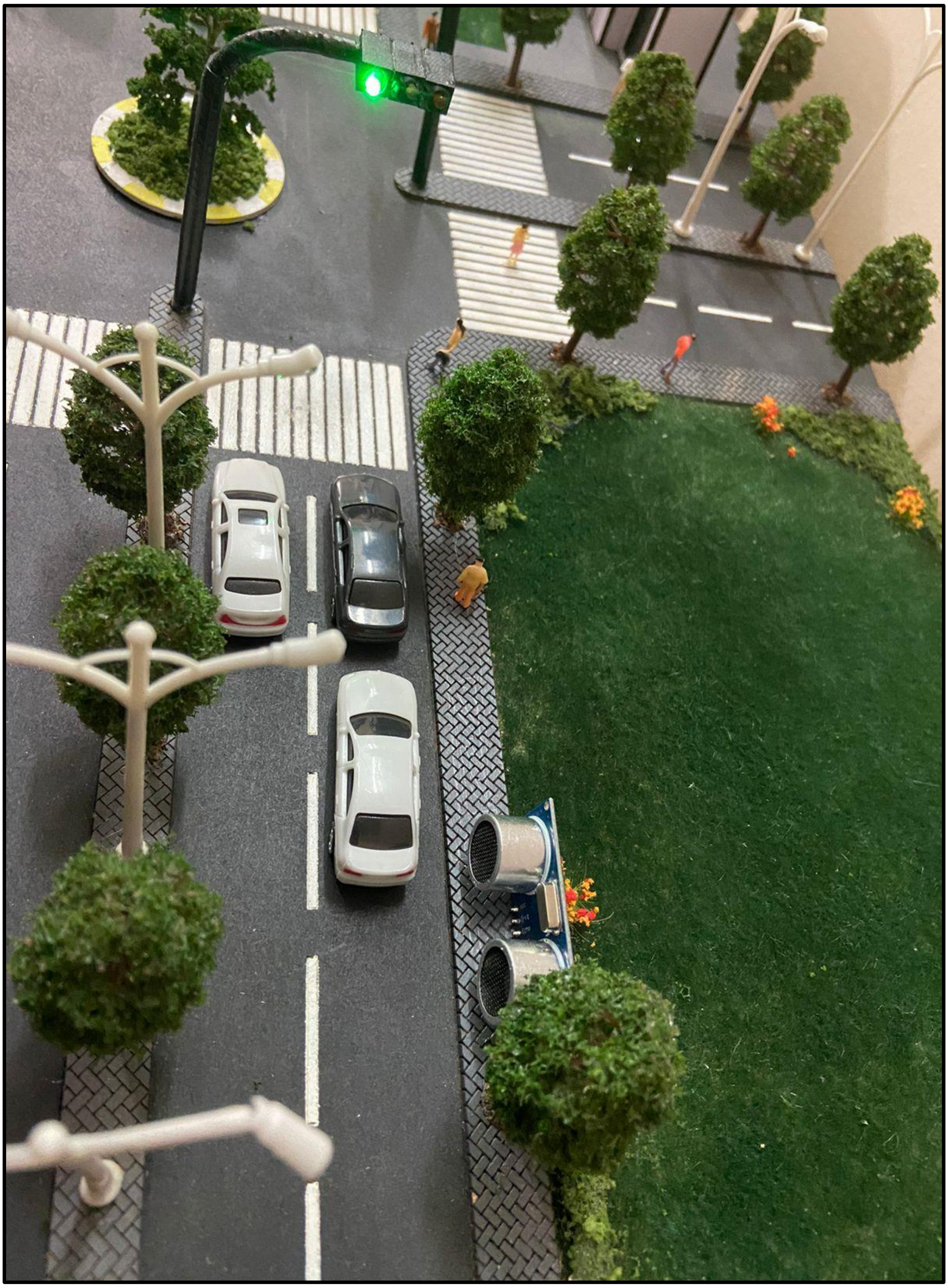

Figure A.4 Green Light is on (GO)

Appendix B Code

- B.1 Master Code

```
#include <ESP8266WiFi.h>
#include <ESP8266HTTPClient.h>

const char *        = "TP-Link_865C"
const char *            = "123@456@789"

const int                    = 5
const int                     = 4
const int                  = 16

const int              = 14
const int               = 12

IPAddress masterIP 192  168  1  203
IPAddress slaveIP 192  168  1  202

WiFiServer server 80



int                    = 0
int                     = -1

void setup
 Serial begin 115200
 Serial println "Connecting to WiFi..."

 WiFi begin

 while  WiFi status   !=
  delay 1000
  Serial print "."
```

```
  Serial println
  Serial println "Connected to WiFi"
  Serial print "IP Address: "
  Serial println WiFi localIP

  server begin

  pinMode
  pinMode
  pinMode
  pinMode
  pinMode


void loop
  delay 1000
  handleSlaveCommunication
  countObjects



  if                   !=
                       =



  delay 5000



void handleSlaveCommunication
                   = server available


  if
```

```
    Serial println "New client connected"

                        = ""

    long          = millis   + 5000
    while  !client available   && millis   <
      delay 1

    while  client available
      char    = client read
      if     == '\n'
        break

                     +=

    if  receivedMessage length   > 0
      Serial print "Received message from slave: "
      Serial println
      processSlaveMessage

    client stop
    Serial println "Connection with slave closed"

  delay 100

void processSlaveMessage String message
  Serial println "Inside processSlaveMessage"
```

```
if  message startsWith "OBJ_COUNT:"

 int                    = message substring 10  toInt

 Serial print "Number of detected objects from slave: "
 Serial println

 if                    <

   digitalWrite
   digitalWrite
   digitalWrite
   turnOnSlaveLEDs
    else if                    >

   digitalWrite
   digitalWrite
   digitalWrite
   turnOnSlaveLEDs

   turnOnSlaveLEDs
    else if                    ==

   digitalWrite
   digitalWrite
   digitalWrite
   turnOnSlaveLEDs



  else
 Serial println "Unknown message format"
```

```
void turnOnSlaveLEDs

                                = "TURN_ON_LEDS"
 sendMessageToSlave


void countObjects
 unsigned long          = millis
 unsigned long

 do
  digitalWrite
  delayMicroseconds 2
  digitalWrite
  delayMicroseconds 10
  digitalWrite

  long        = pulseIn
  int         =          * 0.034 / 2

  int                  = 30

  if          <
                      = int
   Serial println
   return


             = millis  -
  while               < 5000


                          = -1
 Serial println "No object detected within the specified time frame"
```

```
void sendMessageToSlave const String &message
 if  slaveClient connect              80
   Serial println "Connected to slave"
   Serial print "Sending message to slave at "
   Serial println
   slaveClient print

   delay 100

   slaveClient stop
   Serial println "Connection with slave closed"
    else
   Serial println "Failed to connect to the slave"
```

- B.2 Slave Code

```
#include <ESP8266WiFi.h>

const char *       = "TP-Link_865C"
const char *              = "123@456@789"

const int                           = 5
const int                             = 4
const int                        = 16

IPAddress masterIP 192  168  1  203
IPAddress slaveIP 192  168  1  202
```

```
const int      = 14
const int        = 12

int            = 0
int              = -1

void setup
  Serial begin 115200
  WiFi begin

  while  WiFi status    !=
    delay 1000
    Serial println "Connecting to WiFi..."

  Serial println "Connected to WiFi"

  pinMode
  pinMode
  pinMode
  pinMode
  pinMode


void loop

  countObjects
  delay 15000
  digitalWrite
  digitalWrite
  digitalWrite

  if             !=
    sendMessageToMaster "OBJ_COUNT:" + String
                 =
```

```
                              = getMasterMessage
  if  receivedMessage length   > 0
    processMasterMessage



  delay 1000



void countObjects
  unsigned long                = millis
  unsigned long

  do
    digitalWrite
    delayMicroseconds 2
    digitalWrite
    delayMicroseconds 10
    digitalWrite

    long            = pulseIn
    int           =              * 0.034 / 2

    int                        = 30

    if           <
                              = int
      Serial println
      return



                  = millis   -
    while                    < 5000
```

```
= -1
Serial println "No object detected within the specified time frame"


void sendMessageToMaster const String &message
 if  masterClient connect               80
   Serial println "Connected to master"
   Serial print "Sending message to master at "
   Serial println
   masterClient print
   masterClient stop
   Serial println "Connection with master closed"
    else
   Serial println "Failed to connect to the master"



String getMasterMessage

                          = ""

 while  masterClient available
   char    = masterClient read
                   +=



 return



void processMasterMessage String message
 Serial println "Inside processMasterMessage"

 if  message equals "TURN_ON_LEDS"
```

```
Serial println "Received TURN_ON_LEDS message"

digitalWrite
digitalWrite
digitalWrite
Serial.println "All LEDs turned on"

 else

Serial println "Unknown message format"
```