| **PROJECT REQUIREMENTS SPECIFICATION**  **Traffix:** Dynamic Scheduling of Traffic Signals Using Machine Learning  **UE21CS390A – Project Phase – 1**  ***Submitted by:***  ***Kushaagra Shrivastava PES2UG21CS917***  ***Harshita Khajuria PES2UG21CS194***  ***Rishab A Kumar PES2UG21CS429***  ***Rahul G Pai PES2UG21CS414***  Under the guidance of   | **Dr. Mannar Mannan**  Associate Professor  PES University | | --- |   **January - May 2024**  **DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING**  FACULTY OF ENGINEERING  **PES UNIVERSITY**  (Established under Karnataka Act No. 16 of 2013)  Electronic City, Hosur Road, Bengaluru – 560 100, Karnataka, India |
| --- | --- |

**TABLE OF CONTENTS**

| 1. Introduction | 3 |
| --- | --- |
| 1.1 Project Scope and Motivation | 3 |
| 1. Literature Survey or Existing System | 3 |
| 1. Product Perspective | 3 |
| 3.1 Product Features | 3 |
| 3.2 User Classes and Characteristics | 3 |
| 3.3 Operating Environment | 3 |
| 3.4 General Constraints, Assumptions and Dependencies | 3 |
| 3.5 Risks | 4 |
| 1. Functional Requirements | 4 |
| 1. External Interface Requirements | 4 |
| 5.1 User Interfaces | 4 |
| 5.2 Hardware Requirements | 4 |
| 5.3 Software Requirements | 4 |
| 5.4 Communication Interfaces | 5 |
| 1. Non-Functional Requirements | 5 |
| 6.1 Performance Requirements | 5 |
| 6.2 Safety Requirements | 5 |
| 6.3 Security Requirements | 5 |
| 1. Other Requirements | 5 |
| Appendix A: Definitions, Acronyms and Abbreviations | 5 |
| Appendix B: References | 5 |

# **Introduction** The project aims to solve the problem of traffic congestion at signals by dynamically scheduling signals using machine learning and real time data processing. This enhances traffic efficiency, reduce congestion, and improve overall transportation system performance.

# **Project Scope**

Purpose: The project's key focus is on dynamically adjusting traffic signal timings in real-time, ensuring optimal responses to changing traffic conditions, minimizing congestion, and promoting an efficient flow of vehicles.

Benefits:

* Improve traffic flow and reduce congestion.
* Enhance emergency vehicle response times.
* Provide data-driven decision-making insights.
* Optimize resource utilization in the transportation system.

Objectives:

* Develop real-time data integration.
* Implement adaptive traffic signal control.
* Make it adaptive for emergency response systems.
* Design a user-friendly interface for project showcases.
* Ensure scalability, reliability, and security.

Goals:

* Reduce average commute times by a specified percentage.
* Minimize traffic congestion during peak hours.
* Improve emergency response times by optimizing traffic flow for emergency vehicles.
* Enhance overall transportation system efficiency and resource utilization.

Coverage:

The system will cover urban and suburban areas with a focus on intersections, traffic signals, and road segments. It will encompass a comprehensive network that integrates with existing traffic infrastructure and emergency response systems.

Limitations:

* The system's effectiveness may be limited by the availability and accuracy of real-time data from external sources.
* Unpredictable events or emergencies may challenge the system's ability to optimize traffic flow completely.
* Integration with existing traffic infrastructure may require cooperation from local municipalities and regulatory bodies.
* The success of the project may depend on the willingness of the community to adopt and adapt to dynamic traffic scheduling practices.

# **Literature Survey or Existing System**

**Paper 1**

**Smart Traffic Management and Control System**

By-

Abhay KP, Bhavik M, Narendra M, Saket CS, Prof. Ruby Dinakar

Abstract-

The rapid increase in urbanization and population growth has led to an exponential increase in the number of vehicles on the road. This leads to higher traffic congestion. Traditional systems have struggled to keep up with this growth. Traditional traffic management systems are static in nature, they cannot adapt to incoming traffic in real time.

This system uses real time data and algorithms to calculate and assign efficient traffic signal timings based on incoming traffic flow.

This is done using image processing with the help of YOLO, and a traditional algorithm to assign signal timings.

Advantages-

Categorizing of vehicles into Big, Medium, Small using YOLO’s image recognition, assigning different weights to each class of vehicle and calculating how much traffic they would cause, then aggregating .it all to get increase in signal timing

Disadvantage-

* The algorithm is only applied where the signal is already green, and it would modify timings there.
* It also only calculated traffic until a certain point which could be extremely close to the signal itself.
* Its not reprioritizing lanes as traffic builds up in other lanes

**Paper 2**

**Smart Traffic Detection and Control using Machine Learning Techniques**

By-

Sai Charan Kanigolla, Chaitanya kumar Avala, Likhith Sai kuna, K.L.V. Sai Prakash Sakuru

Abstract-

In the modern era, with the rise in vehicles and population, many urban cities have faced traffic problems like traffic congestion, which causes travel delays. The main reason for the delay is that current traffic systems use fixed signal timers at the traffic signal intersection. These unnecessary delays at the traffic signals lead to excessive fuel consumption and increased pollution. This paper uses vehicle detection methods through surveillance cameras and machine learning to predict traffic based on historical data in a region. Finally, optimizing traffic by utilizing the predicted data and proposed methodology reduces the average wait time of travellers.

Done using Object detection.

Advantages-

Dynamically allocates signal time for a given lane using a traditional algorithm

Disadvantages-

* Done only for one lane at a time, i.e., only 1 lane is free at a time and not multiple, the way it works in the real world
* Done only for a up front POV

**Paper 3**

**Image Processing and IoT Based Dynamic Traffic Management System**

**By-**

Nitin N. Sakhare, Subhash B. Tatale, Dr. S. R. Sakhare, Hemant Dusaane, Mamta Puri, Pratika Girme, Rutuja Sankpal, Padmavati Ghule

Abstract-

Due to rise in number of vehicles the traffic management has become a major problem. Manual traffic system is not efficient. This paper presents adaptive traffic management system using Internet of Things (IoT) and Image processing. The proposed system has capability to analyze real time data using image processing. Using cameras, different lanes are monitored constantly. The data obtained from different lanes are examined. Detection and counting of number of vehicles in each lane is done by using image processing. The count from each lane is sent to the central processing unit. According to the count of vehicles algorithm calculates waiting time for each lane, then the signal lights will be decided. This system reduces the average waiting time and increases the efficiency of traffic clearance. The system also reduces the pollution due CO2 emission and useful in emergency situations, thus being adaptive traffic management using Internet of Things (IoT)

Methodology-

Detects and counts number of vehicles from camera

Calculates wait and go time based on that

Advantages-

Algorithm to greenlight lanes is present

Dynamic adjustment of traffic lights for all lanes is present

Disadvantages-

Only greenlights 1 lane at a time.

# Paper 4 - Deep Reinforcement Learning with Vehicle Heterogeneity Based Traffic Light Control for Intelligent Transportation System

Objective of paper - to make dynamic traffic lights using deep reinforcement learning.

Models - deep reinforcement learning using cnn and relu activation function.

Advantages - It gives a basic idea of how reinforcement learning works for our project and how we can implement it on our test data.

Has a pretty good result with 32% reduction in average wait time(validated through simulation.)

Limitations - data is from a radio - frequency identification sensor which isnt easy to use and gives digital signals which needs to be read and deciphered.

They havent taken into account the size of vehicles and only taken position and speed of a vehicle. The size of a vehicle plays an important role in the traffic congestion.

**Paper 5 - How Well Do Reinforcement Learning Approaches Cope With Disruptions? The Case of Traffic Signal Control**

Objective of the paper - to check how well reinforcement models work in cases of disruptions.

(if a road is under construction etc.)

Models - Reinforcement learning algorithms.

Advantages - It tells about the reinforcement model and how it is prone to disruptions and gives the solutions to the problem.(Analytic+ method is found to be the best).

Analytic+: An adaptive, self-organizing method relying on optimization and stabilization rules. Green times are varied

Limitations - It is only a research paper on the limitations of reinforcement learning algorithms.

Does not provide adequate insight on the models itself.

It does not implement analytic+ method into ML models to test how well it integrates with existing models.

# Paper 6 - Data-Driven Model for Traffic Signal Control

Objective of paper - to reduce the congestion time at traffic signals.

Models - Hidden markov model.

Advantages - It gives us a basic idea of how HMM can be used for our problem statement.

They use HMM to get a dynamic approach which is what we are trying to implement.

Works well for highly congested data.

Limitations - they are using a prediction based approach to calculate the traffic congestion at a given time(which may or may not be true).

# **Product Perspective** Originating from the growing need for more efficient, adaptive traffic solutions, this product arises in the context of urbanization, increasing traffic volumes, and the desire to harness technology for improved transportation dynamics.

Context and Origin:

* Urbanization Demands:

- Originating from rapid urbanization, the product addresses increased demands on transportation infrastructure in expanding cities.

* Tech Advancements Drive:

- Capitalizing on advancements in machine learning and communication tech, the product responds to the potential for a more intelligent and responsive traffic management system.

* Escalating Traffic Challenges:

- Motivated by the complexity of traffic issues, especially during peak hours and emergency situations, the product is designed to dynamically optimize traffic flow.

* Community and Environmental Focus:

- With a focus on improved commuting and environmental sustainability, the product emerges to minimize congestion and create a more sustainable urban environment.

# **Product Features**

* Real-Time Traffic Monitoring:

- Continuous monitoring of traffic conditions through real-time data integration from various sources, GPS, etc

* Dynamic Traffic Signal Control:

- Adaptive traffic signal control that dynamically adjusts signal timings based on real-time traffic patterns, optimizing flow and minimizing congestion.

* Machine Learning algorithms:

- Utilization of machine learning algorithms for enabling proactive adjustments to optimize signal timings.

* Emergency Vehicle Priority:

- Integration with emergency response systems to prioritize the passage of emergency vehicles, ensuring swift and efficient responses during critical situations.

* Scalable Architecture:

- Implementation of a scalable system architecture to handle growing data volumes and ensure seamless integration with evolving urban infrastructure.

* Secure Communication Protocols:

- Definition and enforcement of secure communication protocols to facilitate efficient and protected data exchange between the central control system and individual traffic signals.

* Traffic Simulation:

- Integration of traffic simulation capabilities to model and test the impact of changes in signal timings and other parameters before implementation.

* Resource Optimization Algorithms:

- Deployment of algorithms for optimizing resource utilization, minimizing delays, and enhancing overall efficiency in the transportation system.

# **User Classes and Characteristics**

Traffic Management Authorities:Full control for real-time monitoring and traffic signal adjustments.

Emergency Services Personnel:Priority access for emergency vehicle passage and real-time traffic updates.

City Planners and Analysts:Access to historical data and simulation tools for urban planning.

Regular Commuters:Manages traffic signal efficiently, hence regular commuters benefit from it.

# **Operating Environment** Hardware and Software Components

* The system is designed to operate on standard server infrastructure, with a preference for high-performance servers to handle real-time data processing and adaptive traffic control algorithms efficiently.
* Compatibility with both on-premises hardware and cloud-based solutions, ensuring flexibility in deployment.
* Operating system: Windows/Linux/Mac
* database: Mysql database

# **General Constraints, Assumptions and Dependencies**

**Constraints:**

* Regulatory Policies: Adherence to local and national traffic regulations and policies may limit the flexibility of certain features, particularly in areas with strict regulatory control over traffic signal operations.
* Hardware Limitations: Signal timing requirements and limitations of existing traffic signal controllers may constrain the system's ability to implement certain adaptive traffic control strategies.
* Dependencies on simulation programs may impose constraints on the accuracy and flexibility of traffic modeling.

**Assumptions:**

* Parallel Operations: Assumes parallel operations of the existing traffic management systems, and the dynamic traffic scheduling system will complement rather than replace traditional static systems during the initial implementation.
* Criticality of Application: Assumes a critical need for real-time traffic management but acknowledges that the dynamic system may not be the sole solution for all scenarios, and traditional methods may still be required in certain situations.
* Safety and Security Considerations: Assumes a commitment to safety and security considerations, emphasizing the implementation of secure communication protocols and measures to prevent unauthorized access and malicious activities.

**Dependencies:**

* Data Sources: The system depends on the availability and accuracy of real-time data from various sources, including GPS devices
* Interfaces to Other Applications: Interfaces with emergency service systems, city databases, and external data providers are crucial dependencies for the system's effectiveness, requiring ongoing collaboration and coordination.
* Regulatory Compliance: Dependency on compliance with regulatory policies and standards, necessitating continuous monitoring of changes in traffic regulations and adjustments to the system as needed.
* Hardware and Software Updates: The system's performance is dependent on the compatibility with updated hardware components, operating systems, and third-party software. Regular updates are assumed to maintain optimal functionality.
* Community Acceptance: Assumes community acceptance and cooperation for the successful implementation of dynamic traffic scheduling practices, as user behavior influences the effectiveness of the system.

# **Risks**

* Data Reliability: The risk of compromised traffic management due to inaccuracies or delays in real-time data from various sources.
* Community Acceptance: Resistance or slow adoption by the community may hinder the effectiveness of dynamic traffic scheduling practices.
* Security Vulnerabilities:Potential breaches may compromise the confidentiality and integrity of sensitive traffic data, posing risks to system security.

# **Functional Requirements**

* Valid Inputs: The system checks if the incoming data makes sense and is correct. If there's a mistake, the system knows how to handle it.
* Step-by-Step Process: When the system gets real-time data, it follows a set of steps to make decisions. This includes looking at the information, using predictions, and adjusting traffic signals accordingly.
* Fixing Mistakes: If something goes wrong or if there's a problem with the data, the system is smart enough to fix it. It keeps everything running smoothly.
* Changing with the Situation: When things like emergencies or heavy traffic happen, the system knows how to change the traffic lights to make things better. It pays attention to what's going on and makes adjustments to keep traffic moving well.

# **External Interface Requirements**

# **User Interfaces**

Web app based for demonstration of the project. final project wont have a defined GUI for the users

# **Hardware Requirements**

* CPU: A processor with capabilities equivalent to or surpassing the Intel Core i5 6th Generation.
* RAM: Minimum 8GB RAM to ensure smooth operation and efficient handling of real-time traffic data.
* Operating System: Compatibility with Windows 10 or higher versions for optimal performance.
* GPU: NVIDIA GeForce GTX 960 or a superior graphics processing unit to support advanced visualizations and simulations.

# **Software Requirements**

* MySQL Database / Cloud Bucket Storage
* Python 3.10+
* PyTorch OR TensorFlow APIs
* Cloud Compute Architecture

# **Communication Interfaces**

* Communication standard required is 802.11 Wi-Fi protocol
* We also require a UDP/TCP connection

# **Non-Functional Requirements**

# **Performance Requirement**

* Capable of real time data processing
* Reliable signal time output

# **Safety Requirements**

* Don’t let 2 lanes that could probably collide go green at the same time

# **Security Requirements**

* Should be invulnerable to attacks trying to feed wrong data to models to mess up traffic signal timings
* Dataset should be from accurate source

# **Other Requirements**

* Portable - Should work on Lightweight Thin Hosts
* Scalability - Architecture should be able to handle multiple similar requests from different traffic signals
* Response Time - Should be capable of real time data processing

# **Appendix A: Definitions, Acronyms and Abbreviations**

* GPS - Global Positioning System.
* IoT - Internet of Things.
* CO2 - Carbon dioxide.
* ML - Machine Learning.
* CNN - Convolutional Neural Network.
* ReLU - Rectified Linear Unit.
* HMM - Hidden Markov Model.
* UDP - User Datagram Protocol.
* TCP - Transmission Control Protocol.
* GUI - Graphical User Interface.
* IEEE - Institute of Electrical and Electronics Engineers.

# **Appendix B: References**

* <https://ieeexplore.ieee.org/document/10100954>
* <https://ieeexplore.ieee.org/document/10201549>
* <https://www.researchgate.net/publication/340458873_Image_Processing_and_IoT_Based_Dynamic_Traffic_Management_System>
* <https://ieeexplore.ieee.org/document/9065034>
* <https://ieeexplore.ieee.org/document/8483054>