Traffic Light Management System for Autonomous Vehicles

A major project report submitted in partial fulfilment of the requirement for the award of degree of

Bachelor of Technology

in

Computer Science & Engineering / Information Technology

Submitted by

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **'Traffic Light Management for Autonomous Vehicles'** in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science & Engineering / Information Technology** submitted in the Department of Computer Science & Engineering and Information Technology, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Bhavy Jindal (201127)** and **Shivam Sharma (201135)** during the period from August 2023 to May 2024 under the supervision of **Dr. Nishant Sharma** (Assistant Professor(SG), Department of Computer Science and Engineering, Jaypee University of Information Technology, Waknaghat.

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CANDIDATE'S DECLARATION

I hereby declare that the work presented in this report entitled **'Traffic Light Management System for Autonomous Vehicles'** in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science & Engineering / Information Technology** submitted in the Department of Computer Science & Engineering and Information Technology**,** Jaypee University of Information Technology, Waknaghat is an authentic record of my own work carried out over a period from August 2024 to May 2024 under the supervision of **Dr. Nishant Sharma** (Assistant Professor(SG), Department of Computer Science & Engineering and Information Technology).

The matter embodied in the report has not been submitted for the award of any other degree or diploma.

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ABSTRACT

The lazies in cities are the causes of traffic jams that make people stay in their cars and waste their time, not to mention the increase of fuel consumption and the troubles they cause in their lives. The **Traffic Light Management System for Autonomous Vehicles** appears as a data- based solution that is designed to solve the problems of the traffic jams. This project will use a sensor, camera and communication network to collect traffic information in real time.

Traffic Light Management System for Autonomous Vehicles employs this data to modify traffic light timings, in order to have the smooth traffic flow based on the present situation. This is done by making the green lights longer for the lanes that are congested and making them shorter for the lanes that are not so busy. Moreover, the system can provide traffic updates to commuters through mobile apps and variable message signs, which will allow them to choose the ideal route.

The project includes traffic lights, but it will also be extended to other issues. The sytem can notify the emergency services about accidents or disabled vehicles of which there is an issue, thus, people can be helped quicker. Besides, the data can also be used in a long-term traffic pattern analysis, thus, making the urban planners to optimize the infrastructure development and public transport systems.

The System will lead to the transformation of cities' traffic system, which will be characterized by the improvements in traffic flow, less travel times, and a decline in emissions as a result of less idling. The system creates a safer and more stable transportation network of the future, thus, it improves the general urban experience.

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Think of a city where rush hour commutes are a piece of cake, traffic lights will change according to the real time conditions, and finding the fastest route is a cakewalk. This is the scenario that is behind the Intelligent Traffic Management System (ITMS), a groundbreaking project that is aimed to change the urban transportation forever.

Trapped in a vicious cycle of growing populations and static infrastructure, cities worldwide are battling a constant foe: the result of the development of traffic congestion. Hence, this gridlock is the reason for wasted time, more fuel consumption and the growing frustration of the commuters. ITMS wants to solve this problem by a smart way which uses the benefits of data and technology.

The core of the system is a network of intelligent sensors and cameras that are installed on the city's roadways all over the country. These are like the eyes and ears of ITMS as they are constantly gathering real-time information on traffic flow, vehicle density, and even pedestrian activity. This information is the input for the system's intelligent core, a strong combination of the artificial intelligence and machine learning algorithms.

ITMS is not just data collection but it also does other stuff. The real-time traffic picture of the system lets the system to change the traffic light timings with the traffic situation. Visualise the situation where a big accident blocks the traffic flow on a specific lane. ITMS has the ability to identify this and thus, it can adjust the green light duration accordingly, thereby, the smooth flow on the congested lane will be prioritized and at the same time, the wait times on others will be minimized. This feature of adjusting traffic lights to the changing conditions on the roads guarantees that the overall traffic is optimized.

1.2 PROBLEM STATEMENT

The Challenge: The cities are in a transportation crisis. Traffic congestion has turned into a universal problem, which in turn has caused a number of disadvantages to the residents, businesses and the environment.

Chronic Gridlock: The increase of vehicles on the road is still going on, while our current road infrastructure is not able to keep up with it. Thus, the imbalance of the transportation system leads to the constant traffic jams, especially during the peak hours.

Wasted Time and Resources: The car drivers waste a lot of time in the car jams which results in the lost productivity, stress, and frustration. Moreover, congestion is a cause of a lot of fuel waste and thus, environmental pollution.

Inefficient Traffic Light Systems: Traditional traffic light timing systems usually base on fixed schedules that are not able to adjust to the actual traffic conditions. Such rigidity in the system is the cause of the unwanted delays on some lanes while other lanes are still underused.

Limited Information for Drivers: Usually, drivers do not have the chance to get information about the traffic conditions in real time, so it is difficult for them to plan the optimal routes and adjust their travel behavior. The ignorance of the public, on the other hand, tends to make the situation even worse.

Safety Concerns: The traffic congestion is the reason of the drivers' frustration and impatience that lead to accidents and road rage incidents. Besides, emergency vehicles might get delayed in reaching the critical situations.

Limited Data for Planning: Urban planners do not have all the traffic flow information and trends which they need for the study. Thus, this blocks their capability to make the right choices concerning infrastructure development, public transport systems, and long-term traffic management strategies.

The Impact: The consequences of traffic congestion are very widespread and carry with them huge costs to our cities.

Economic Impact: The gridlock hinders the supply chains, delays the deliveries, and lowers the worker productivity causing economic losses for businesses and the city.

Environmental Impact: Air pollution is a major problem caused by traffic congestion, since idle vehicles emit harmful substances to the air. The problem is that it has a bad effect on public health and the environment.

Social Impact: The psychological burden of the traffic jam in the congested roads can be the reason for the higher stress level and the reduction in the quality of life. Besides, the congestion can also be a barrier to the accessibility and social mobility for the people who use the public transport or walk.

The Need for Change: The existing traffic management systems are nowhere near enough to tackle the increasing problems of urban mobility. We require a new strategy that utilizes technology and data to enhance the traffic flow, increase the efficiency, and at the same time improve the whole transportation system for everyone.

The Opportunity: The ITMS is a new technology that is going to change the way we travel in cities. Through the use of live data and smart algorithms, ITMS can offer a flexible and reactive way of managing traffic which will finally make the urban environment more efficient, safer, and sustainable.

1.3 OBJECTIVE

The Intelligent Traffic Management System: A Multifaceted Approach to Urban Mobility is a complex and far-reaching strategy to deal with efficient and safe urban transportation.
The Intelligent Traffic Management System (ITMS) is a whole project that is dedicated to solving the vital problems of urban traffic congestion. The main aim of it is to design a transportation system that is more efficient, safer and more sustainable by the application of data and technology in an intelligent way. This overarching goal can be broken down into several key objectives: This overarching goal can be broken down into several key objectives:

1. Optimize Traffic Flow and Reduce Congestion:

The light signals are switched according to the actual traffic conditions, the emphasis is on the smooth flow and the reduction of the waiting time.

- Take the steps like using lane control and synchronized signalization in traffic management in order to improve the network efficiency.

- Give the drivers the real-time traffic information through mobile apps and variable message boards, therefore, they can make the right choice to take the correct road and avoid the traffic bottlenecks.

- Support the movement of alternative modes of transportation by combining public transit information and carpooling schemes within the ITMS system.

2. Enhance Road Safety and Reduce Accidents:

- The main goal of automatic car stop systems is to detect sudden incidents like accidents or disabled vehicles in a minute or less, which then leads to the quicker response from the emergency services.

- Spot the hazardous accident areas by analyzing the data and put up the safety measures such as reduction of speed limit, better sign or other measures in the high-risk accident zones.

- Drivers awareness can be improved by giving them real time information on the traffic conditions and the possible hazards.

3. **Improve Environmental Sustainability:**

- The fuel consumption and the emissions of cars are to be reduced by the traffic flow in the cities and the traffic jams are to be avoided.

- The platform should be used as a vehicle for the promotion of green cars and alternative means of transportation through the combination of the promotion of the green bikers and incentives within the ITMS platform.

- Giving the decision making for the long-term planning of the infrastructure development that is sustainable on the basis of the comprehensive traffic data analysis.

4. **Increase Driver Efficiency and Reduce Travel Time:**

- The devices are capable of giving the actual traffic reports and the route directions to the drivers which thus will enable them to make a decision and avoid the traffic.

- Re-time the traffic light to cut down the waiting time and hence to increase the total travel efficiency.

- Give the people travel suggestions that are made according to their real-time data and user tastes.

5. Enhance Data-Driven Decision Making:

- I will collect and analyze the live traffic data to fully evaluate the traffic patterns, trends, and bottlenecks.

- The knowledge gathered from the projects will be of great use to the urban planners for infrastructure development, the optimization of public transport and the long-term traffic management strategies.

- The ITMS can be further improved by implementing the feedback loops according to the data and refining the algorithms periodically.

Overall Impact: Through the accomplishment of these objectives, the Intelligent Traffic Management System has a great potential to make a revolutionary change in urban mobility. ITMS can be a tool to alleviate traffic issues, thus road safety will be increased and the environment will be preserved. Thus, the city with the no-car policy that parks can provide will in the end have lower travel times, a better quality of life for the citizens, and a greener and more efficient urban environment.

1.4 SIGNIFICANCE AND MOTIVATION

The traffic in the cities is a common and expensive problem. It consumes time, resources, and is a major environmental and public health problem. ITMS is a symbol of hope, that, through a data-driven approach, it will be possible to solve these problems and transform urban mobility. The main reasons and impetus for this project are its expectation to create a more efficient, safe, sustainable, and in the end, livable urban future.

The significance of ITMS is its capacity to solve the complex issue of traffic congestion. Here's how:

- **Economic Benefits:** Lowering the number of vehicles in the road means a more efficient flow of goods and services which leads to higher productivity, shorter delivery times, and economic growth for businesses.

- **Environmental Sustainability:** Better traffic flow and the promotion of other means of transport result in a reduction of fuel consumption and emission of the pollutants which in turn lead to the cleaner air and healthier environment.

- **Improved Public Health:** The decrease in the congestions means the commuters will have less stress, which in turn will be good for the well being and the public health. Besides, the faster the response to emergencies the higher the chance of saving a life.

- **Enhanced Social Equity:** A more efficient transportation system guarantees more accessibility for all citizens, especially the ones which are dependent on public transportation or walking.

- **Urban Planning Insights:** Information gathered by ITMS is a great help for urban planners as it provides them with the data they need to make well-informed decisions about infrastructure development, public transport optimization and the long-term traffic management strategies.

The ITMS project motivation is being propelled by the pressing need for a more sustainable and efficient urban transport system.

- **Rising Urbanization:** The world is getting more and more urbanized and thus new ideas are needed to cope with the increasing pressure on the transportation system.

- **Technological Advancements:** Progress in the field of sensor technology, data analysis, and artificial intelligence has led to the possibility of creating smart systems for traffic management.

- **Public Demand for Change:** People nowadays are insisting on finding solutions to better the traffic, cut down the commuting time, and to create a more livable urban environment.

- **Environmental Concerns:** Greater understanding of the damage caused by traffic congestion to the environment forces us to search for sustainable means of urban transportation.
- **Economic Pressures:** The economic consequences of traffic jams are huge. ITMS presents an excellent way to cut down on these expenses and to increase the economic efficiency.

Conclusion:

The ITMS project is the answer to the most serious problems and presenting the technology, it is a great vision for the future. It gives us the incentive to go beyond the conventional traffic management systems and to use a data-driven approach to improve efficiency, safety, and sustainability. The possibilities for the citizens, businesses, and the environment that can be realized by the development and implementation of the Intelligent Traffic Management System make it a project that deserves a large-scale investment and effort.

1.5 ORGANIZATION

Chapter 1: Introduction about the project and mention of what the project does and what I am trying to accomplish with this project and how will it help a user.

Chapter 2: Literature survey for the project. This includes the various project reports on the previously made projects on biometric based authentication and machine learning and its applications.

Chapter 3: System Development, here I have mentioned the main architecture of the project and how the things are linked to each other and what platforms and overviewof algorithms I have used in building this project.

Chapter 4: Performance Analysis of the project. Here I have mentioned the results and how the system is performing and what is the success and failure rate.

Chapter 5: Conclusion. Here I have mentioned the outcomes and the future scopesof the project and what else can be done and what are the applications.

CHAPTER 2 : LITERATURE SURVEY

Sr.	Reference	Focus	Methodology	Key Findings	Strengths
1.	Intelligent Traffic Management System Based on the Internet of Vehicles (IoV)	Architecture for ITMS using IoV	Literature review, proposed architecture with V2X communication	- Efficient traffic management at intersections with real-time data from vehicles. Prioritizes emergency vehicles.	Lacks real-world implementation and validation. - Security concerns of V2X communication not addressed.
2.	Survey paper on Traffic Management System using IOT for Emergency Vehicles [2]	Emergency vehicle prioritization	Literature review, analysis of existing methods	Improved response times for emergency services through faster detection and signal control. - Techniques for emergency vehicle identification (RFID, sensors)	Provides a clear overview of emergency vehicle prioritization methods. - Highlights the importance of real-time data for effective response.
3.	A Literature Survey on an Improved Smart Traffic Signal Using Computer Vision and Artificial Intelligence [3]	Traffic monitoring and signal control	Literature review, analysis of AI and computer vision applications	Improved traffic monitoring for data-driven decisions on signal control. - Real-time adjustments based on factors like pedestrian presence and vehicle density.	Emphasizes the potential of AI and computer vision for intelligent traffic management. - Highlights the importance of real-time data for dynamic signal control.

4.	Intelligent Traffic Management System for Smart Cities [4]	ITMS Functionalities and benefits	Literature review, analysis of functionalities and potential benefits	Dynamic traffic light control based on real-time data. - Improved travel time and reduced congestion. - Environmental benefits due to optimized traffic flow	Provides a comprehensive overview of ITMS functionalities and their impact. - Emphasizes the role of ITMS in smart city development
5.	Intelligent Traffic Management Systems: A review [5]	Review of existing ITMS	Literature review, analysis of various approaches	Importance of data integration and real-time information for effective traffic management. - Techniques like Green wave and congestion avoidance for optimizing traffic flow.	Provides a broad overview of existing ITMS approaches and challenges. - Highlights essential functionalities like data integration and congestion avoidance
6.	A Framework for Intelligent Traffic Management System Using Big Data Analytics [6]	Big data analytics for ITMS	Literature review, proposed framework using big data analytic	Potential of big data analytics to extract valuable insights from traffic data. - Improved traffic prediction and congestion mitigation strategies.	Proposes a novel framework for big data integration in ITMS. - Highlights the importance of data analytics for proactive traffic management.

CHAPTER 3: SYSTEM DEVELOPMENT

3.1 REQUIREMENTS AND ANALYSIS

1 System Requirements

It is the objective of this Intelligent Traffic Management System (ITMS) to produce superior traffic flow, higher safety, and better town mobility through establishment of big data and Artificial Intelligence.

1.1 Functional Requirements:

Data Collection:

- Deploying a sensor network will be needed. g. , , (radar technology), and vehicles (connected technology to vehicles) that monitor real-time traffic information such as vehicle density, driver speed, and vehicle density.

- Use traffic control system as a source of data, receiving signal timing information.

Data Processing and Analysis:

- Implement AI algorithms (e.g. (E.g. artificial intelligence, deep learning, machine learning) to analyze the real-time data from traffic sensors and historical records.

- Finding out traffic patterns, congestion of traffic from certain places and incidents takes place.

- Prognostic future traffic conditions derived from historical data and real-time .

Traffic Management:

- Use AI technology to automatically control traffic light timings and give way to more congested lanes; use data to optimize traffic flow.

- Demonstrate current traffic condition on mobile devices and variable message boards to motorists in order to permit better routing.

- Joint operation with the emergency services to make it possible for rapid response via prioritizing traffic lights for emergency vehicles.

System Management:

- Provide a user interface by which user can watch a system, configuration, and visualization can be done.

- Establish data security and privacy in place of robust encryption and access control mechanisms.

- Equipped the systems with performance monitoring and implemented reporting for constant improvement.

1.2 Non-Functional Requirements:

- **Scalability:** The proposed system should be designed to be scalable and accommodate more users, data sources and traffic volume as the city grows.

- **Performance:** The system has to show the negative effect of change in real-time and have a low latency period to recover.

- **Availability:** The ITMS should be at a level of availability and operation around the clock with minimum time of downtime for maintenance or upgrading.

- **Reliability:** The technology needs to provide precise and dependable data as well as reliable information that make the managers of traffic to make right decisions.

- **Security:** The implementation of secure data transmission and storage mechanisms are a primary issue since they are fundamental to protect sensitive traffic information.

- **Interoperability:** The intelligent transport management system in the city should be compatible with any existing traffic and data management systems.

2. System Analysis

2.1 Feasibility Analysis:

- **Technical Feasibility:** Now, with the aid of modern sensors, AI algorithms, and data processing platforms, the ITMS is technologically viable.

- **Economic Feasibility:** The cost-benefit analysis should include capital investments, maintenance costs, potential expenses due to congestion and fuel consumption reduction.

- **Operational Feasibility:** Analyze the strengths and weaknesses of city authorities in terms of managing and maintaining ITMS.

2.2 Stakeholder Analysis

- **Citizens:** Benefit from the congestion relief, shorter travel time and safety.

- **City Authorities:** Leverage critical data to support strategic decision making, enhanced traffic management, and revenue generation as result of better traffic flow.

- **Public Transport Providers:** Current traffic updates can do real time route optimization and keep passengers experience up to date.

- **Emergency Services:** Rapid response times through signalizing of prioritized traffic.

- **Private Businesses:** Subsequently, shorter traffic congestion facilitates trade facilitation and benefits the economy.

2.3 Risk Analysis:

- **Technical Risks:** Security breaches, system breakdown, and defective sensors have the ability to result in operations disruption.

- **Data Security Risks:** Proper data privacy and security are required throughout the phases of collection, storage, and analysis.

- **Public Acceptance:** Privacy issues linked to data transmission as well as automated traffic flow management systems may be critical priorities to overcome.

- **Project Management Risks:** The proper budgeting, timeline , and system integration must be ensured.

2.4 Success Metrics

- Exemplification in average travel times and traffic jams.
- Safety record with lower number of accidents.
- User contentment with traffic management is also increased.
- Positive impact trough air quality by the decreased emission.
- ROI via economic means, which include improved business efficiency and reduction in traffic costs.

Conclusion:

AI-based AIMS project opens the perfect way to deal with urban traffic problems. This includes the identification of requirements, feasibility, stakeholders, risks, and achievement metrics. This forms the essential basis of success. Through the establishment of strict data security measures, active engagement of stakeholder community, and continuous monitoring of system performance, the ITMS can become a very useful tool of creating a better future of public transportation in urban environments.

3.2 PROJECT DESIGN AND ARCHITECTURE

Our proposed system takes an image from the CCTV cameras at traffic junctions as input for real time traffic density calculation using image processing and object detection. This system can be broken down into 3 modules: Vehicle Detection module, Signal Switching Algorithm, and Simulation module. As shown in the figure below, this image is passed on to the vehicle detection algorithm, which uses YOLO. The number of vehicles of each class, such as car, bike, bus, and truck, is detected, which is to calculate the density of traffic. The signal switching algorithm uses this density, among some other factors, to set the green signal timer for each lane. The red signal times are updated accordingly. The green signal time is restricted to a maximum and minimum value in order to avoid starvation of a particular lane. A simulation is also developed to demonstrate the system's effectiveness and compare it with the existing static system.

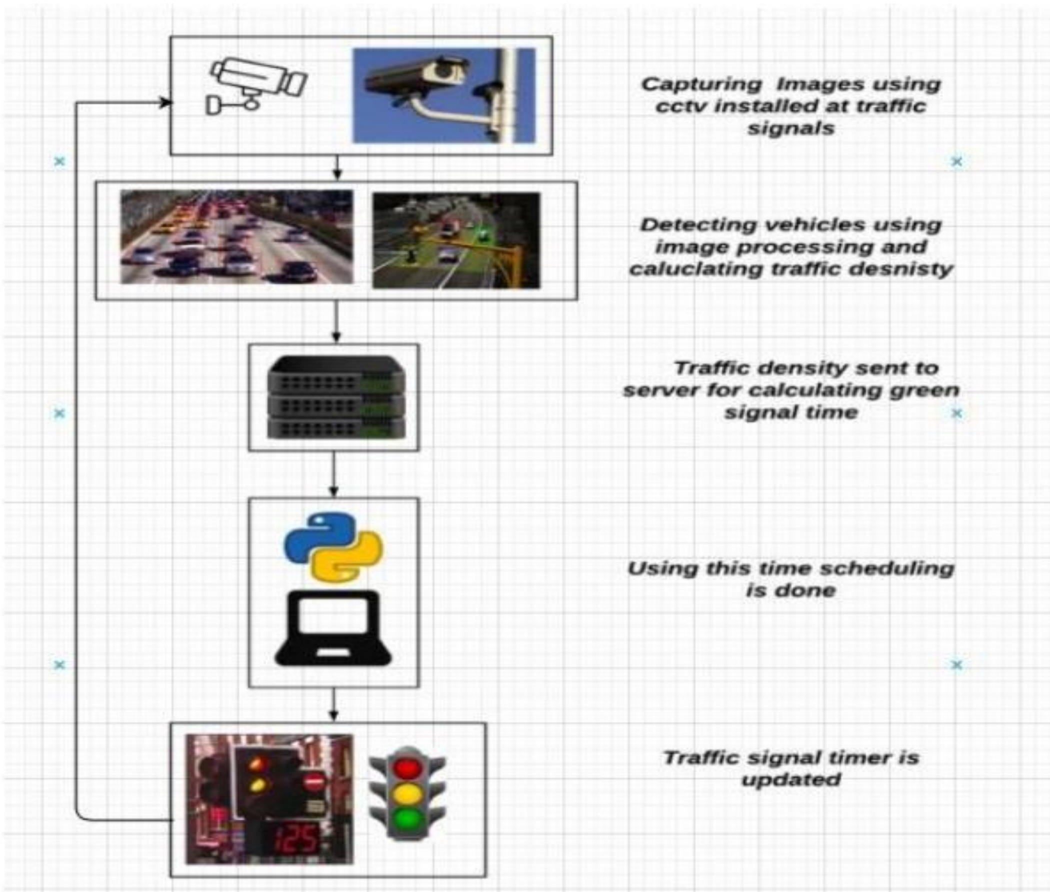

Fig 1 : Project Design

3.3 DATA PREPARATION

The ITMS succeeds in the dynamic crucial of data collection which is observational as well as historical. Similarly, clean fuel is to a high-performance engine as having the right well-prepared data is to AI algorithms in the ITMC that are effective. This is because these algorithms use these data to provide accurate insight and improve the traffic flow. Here's a look at the crucial steps involved in data preparation for the ITMS: Here's a look at the crucial steps involved in data preparation for the ITMS:

1. **Data Collection:**

The first step involves gathering data from various sources: The first step involves gathering data from various sources:

- **Sensor Networks:** This network consist of street cameras, traffic detectory system, and radar to provide data about street conditions in real-time. These will be sentorg information about traffic flow, vehicle speed, lane occupancy, and pedestrian activity.
- **Connected Vehicles (V2X):** This is made possible through Vehicle-to-Everything (V2X) communication, which allows, pseudonymized data from connected vehicles is extracted and insights into individual vehicle behavior and overall traffic flows are gained from them.
- **Historical Data**: Existing traffic control system records traffic volumes and historical traffic data from various sources such as city authorities and mapping services which can be used for analysis purpose to draw trends in traffic movement.

2. Data Cleaning and Preprocessing:

Information transferred from sensors could be unclear or fragmented. Data cleaning involves:

- **Identifying and removing inconsistencies:** Errors such as presentence values, outliers and lack of data need to be fixed.
- **Data imputation:** Gaps created due to missing data points might be filled using statistical methods such as regression or using actual trends data. Data normalization: Scaled to the same lengths, parameter values in all features are equally dominant when AI model training is conducted.

3. **Data Integration:**

Differing venues supply data that require to be amalgamated fulfilling the standards of the data analysis. This might involve:

- **Standardization:** One of the key practical challenges is guaranteeing correctness of data formats. Lastly, there will be Melting a myriad of open, closed, and structured (timestamp, unit, etc.) from the multiple sources.
- **Data fusion:** Configuring data from all depressed areas to accurately describe specific traffic events.

4. Data Labeling (if applicable):

It depends on AI models that are chosen. Some type of the data that needed to be label may be labeled for supervised learning. One instance of this is that video data obtained from cameras can be relied on and then, an image classification algorithm can be trained to distinguish cars of different types or the presence of pedestrians.

5. Feature Engineering:

Identifying a set of essential features in the raw data is the basic step. This might involve:

- Traffic density: Counting the number of automobiles per unit of space on any one of the lanes, especially in a rush hour.
- Speed distribution: Evaluating the mean and standard deviations of the speed of vehicles collected from a lane.
- Travel time estimation: Establishing algorithms that foretell the time of a transit using real time data.

3.4 IMPLEMENTATION

Vehicle Detection Module :

- The proposed method suggests using YOLO (You only look once) for detecting vehicles. The implementation is accurate with prompt processing speed. Vehicle detection model trained on the cascade principle that can detect vehicles of different classes including the kinds of vehicles such as cars, bikes, heavy vehicles (buses and trucks) and rickshaws was applied in the YOLO model.

- The design of the model was trained using two datasets, scraped from internet sites with google and manually labelled by Label IMG in the meantime.

- And the model is trained using pre-trained models received from the YOLO website after that. It is the media configuration that serves as the means by which information is conveyed .cfg document for training was adjusted over the established settings of our model. The units in the last hidden layer was changed to equal the number of the classes the model would detect by changing of classes parameter. In this regard, the number of bindi were used in our system was only 4. Vehicle, Motorcycle, Counterpart, and Cart. The quantity of filters in each stage has to be calculated by formula 5* (5+ classes of filtration), so i.e. 45 in our case

- Consequently, a number of changes were also made with regards to the model. They were trained until the loss was low enough and there was no longer any reduction. In this quarter, this finishing certification indicates the accomplishment of the target to cook based on our new knowledge.

- Subsequently, the OpenCV library was used to import those weights and camera calibration. A threshold at least, which is the minimum confidence level for successful detection, is an object to set. After the model is loaded and an image is passed to the model, the result will be returned in JSON format that can be represented as key-value pairs, and these key, their confidence and coordinate will be values. This is again done by utilizing OpenCV, which can draw the bounding boxes on top of the images of those labels and coordinates.

Following are some images of the output of the Vehicle Detection Module

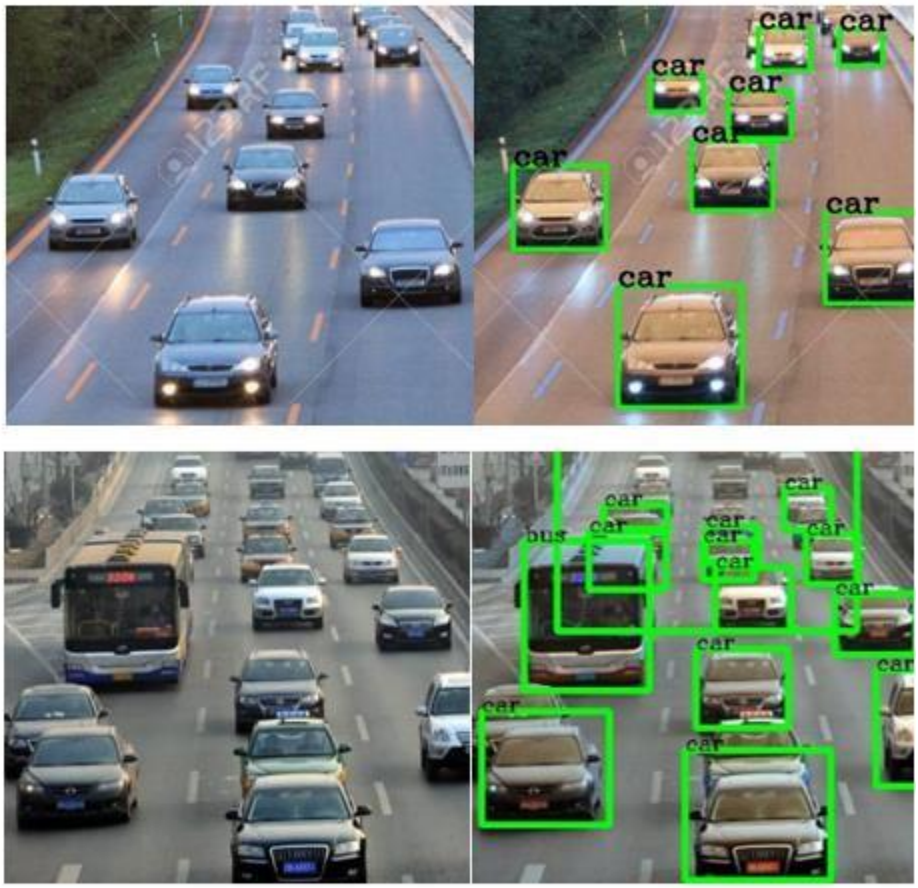

Fig 2 : Output of vehicle detection module

Signal Switching Algorithm :

The information on the traffic density of each segment that is returned by the vehicle detection module sets the green timer of the signal according to the Signal Switching Algorithm. It also updates the red signal timers. It operationally alternates between signal testers and so forth with the time as regulators.

The algorithm prepares the data after receiving the information about the vehicles that have been detected from the detection unit node, which has been explained in the section above. This is in JSON format, with detection label as the key and the confidence heading and coordinate pairs as the json values. Each raw input is analyzed to get the totals for each of the vehicle categories. With this operation there is a setting on when green light period of the traffic lights is implemented and other signals' signals period are tuned to a provided value. The number of lanes at the signal can be increased or reduced according to the needs.

The following factors were considered while developing the algorithm:

1. The necessity of this algorithm to evaluate the traffic pressure among its vehicles – this, however, determines the exact time at which the image must be captured and captured.
2. Number of lanes
3. Total vehicle count includes cars, trucks, motorcycles and many more class of the vehicles.
4. Driving rates computed using the above conditions
5. It was found that time of the lag was added by each startup of every vehicle [13] that brought linearly non-increase of lag at the tail vehicles.
6. For every passing stage, the fact is that the average rate of the classes of vehicles [green light] who are crossing a signal [14]
7. It ensures that the green light duration - by using that minimum and maximum time, thus preventing any intervention in the traffic flow and starvation.

Working of the algorithm :

The initial running of the algorithm allows the setting of the default start time of the first sign of the first cycle and the other sign start times of the first cycle and the start times of the signs of the subsequent cycles by the algorithm. A separate thread dedicated to the detection of vehicles moving in two directions is established and a timer is dedicated to the current signal is controlled by the main thread. At the end of the green light timer of the present signal (or at the beginning of the red light timer of the next green signal) detection threads collect traffic snapshots for the next track. An end result is thus parsed and the timer of the adjacent green signal is now picked up. It is an automatic process which is running in the background and main thread is concentrating on the timer of the current order of green signal. The resultant package is unlike other digital media formats in that it does not include the transmission protocol overhead, and thus the lag is prevented. Now when the timer reaches zero green of the current signal changes to set the time of the next signal to green according to the new algorithm schedule.

The time instance is denoted by the signal that is about to turn green next which depicts 0 seconds. This terminator is fully capable to process the image in 5 seconds (Yellow signal time) and to detect the number of cars of each class, calculate green signal time based on these values and to control the green and red signal timers of the immediately next signal. To determine the maximum green signal time for an envelope based upon the number of vehicles of each class at a signal, the average speed of the vehicles cars start motoring and their acceleration times were taken into account which led to an assessment of time an average vehicle of a specific class will take to cross an intersection. And the time green signal is given using the formula below.

$$GST = \frac{\sum_{vehicleClass} (NoOfVehicles_{vehicleClass} * AverageTime_{vehicleClass})}{(NoOfLanes + 1)}$$

where:

- GST is green signal time
- NoOfVehiclesOfClass is the number of vehicles of each class of vehicle at the signal as detected by the vehicle detection module,
- AverageTimeOfClass is the average time the vehicles of that class take to cross an intersection ,
- NoOfLanes is the number of lanes at the intersection.

The time required by each type of vehicle to cross an intersection is a variable that changes depending on the location i.e. region, city, etc. or even at the level of a specific intersection, and it should be set with this feature in mind to enhance the effectiveness of traffic management. Corresponding information of transport authorities can be used for the purpose.

Switching of the signal will take place in a roundabout way, and not the densest way while commuting. The current system conforms to this by setting off the traffic light one by the next with a fixed pattern and without people changing the way they do things nor finding themselves caught in any confusion. The order of signals is the same as the current system, and yet a to yellow phase has also been provided.

Order of signals: Red → Green → Yellow → Red

Following are some images of the output of the Signal Switching Algorithm:

```
GREEN TS 1 -> r: 0   y: 5  g: 20
  RED TS 2 -> r: 25   y: 5  g: 20
  RED TS 3 -> r: 150  y: 5  g: 20
  RED TS 4 -> r: 150  y: 5  g: 20

GREEN TS 1 -> r: 0   y: 5  g: 19
  RED TS 2 -> r: 24   y: 5  g: 20
  RED TS 3 -> r: 149  y: 5  g: 20
  RED TS 4 -> r: 149  y: 5  g: 20

GREEN TS 1 -> r: 0   y: 5  g: 18
  RED TS 2 -> r: 23   y: 5  g: 20
  RED TS 3 -> r: 148  y: 5  g: 20
  RED TS 4 -> r: 148  y: 5  g: 20

GREEN TS 1 -> r: 0   y: 5  g: 17
  RED TS 2 -> r: 22   y: 5  g: 20
  RED TS 3 -> r: 147  y: 5  g: 20
  RED TS 4 -> r: 147  y: 5  g: 20

GREEN TS 1 -> r: 0   y: 5  g: 16
  RED TS 2 -> r: 21   y: 5  g: 20
  RED TS 3 -> r: 146  y: 5  g: 20
  RED TS 4 -> r: 146  y: 5  g: 20

GREEN TS 1 -> r: 0   y: 5  g: 15
  RED TS 2 -> r: 20   y: 5  g: 20
  RED TS 3 -> r: 145  y: 5  g: 20
  RED TS 4 -> r: 145  y: 5  g: 20

GREEN TS 1 -> r: 0   y: 5  g: 14
  RED TS 2 -> r: 19   y: 5  g: 20
  RED TS 3 -> r: 144  y: 5  g: 20
  RED TS 4 -> r: 144  y: 5  g: 20
```

Fig 3 : Initially, all signals are loaded with default values, only the red signal time of the second signal is set according to green time and yellow time of first signal.

```
  GREEN TS 1 -> r: 0  y: 5  g: 1
    RED TS 2 -> r: 6  y: 5  g: 20
    RED TS 3 -> r: 131  y: 5  g: 20
    RED TS 4 -> r: 131  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 5  g: 0
    RED TS 2 -> r: 5  y: 5  g: 20
    RED TS 3 -> r: 130  y: 5  g: 20
    RED TS 4 -> r: 130  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 4  g: 0
    RED TS 2 -> r: 4  y: 5  g: 20
    RED TS 3 -> r: 129  y: 5  g: 20
    RED TS 4 -> r: 129  y: 5  g: 20

 Green Time:  9
 YELLOW TS 1 -> r: 0  y: 3  g: 0
    RED TS 2 -> r: 3  y: 5  g: 10
    RED TS 3 -> r: 128  y: 5  g: 20
    RED TS 4 -> r: 128  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 2  g: 0
    RED TS 2 -> r: 2  y: 5  g: 10
    RED TS 3 -> r: 127  y: 5  g: 20
    RED TS 4 -> r: 127  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 1  g: 0
    RED TS 2 -> r: 1  y: 5  g: 10
    RED TS 3 -> r: 126  y: 5  g: 20
    RED TS 4 -> r: 126  y: 5  g: 20

    RED TS 1 -> r: 150  y: 5  g: 20
  GREEN TS 2 -> r: 0  y: 5  g: 10
    RED TS 3 -> r: 15  y: 5  g: 20
    RED TS 4 -> r: 125  y: 5  g: 20

    RED TS 1 -> r: 149  y: 5  g: 20
  GREEN TS 2 -> r: 0  y: 5  g: 9
    RED TS 3 -> r: 14  y: 5  g: 20
    RED TS 4 -> r: 124  y: 5  g: 20
```

Fig 4 : Output of Signal Switching Algorithm

The leftmost column shows the status of the signal i.e. red, yellow, or green, followed by the traffic signal number, and the current red, yellow, and green timers of the signal. Here, traffic signal 1 i.e. TS 1 changes from green to yellow. As the yellow timer counts down, the results of the vehicle detection algorithm are calculated and a green time of 9 seconds is returned for TS 2. As this value is less than the minimum green time of 10, the green signal time of TS 2 is set to 10 seconds. When the yellow time of TS 1 reaches 0, TS 1 turns red and TS 2 turns green, and the countdown continues. The red signal time of TS 3 is also updated as the sum of yellow and green times of TS 2 which is 5+10=15.

```
  GREEN TS 1 -> r: 0  y: 5  g: 1
    RED TS 2 -> r: 6  y: 5  g: 20
    RED TS 3 -> r: 119  y: 5  g: 20
    RED TS 4 -> r: 134  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 5  g: 0
    RED TS 2 -> r: 5  y: 5  g: 20
    RED TS 3 -> r: 118  y: 5  g: 20
    RED TS 4 -> r: 133  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 4  g: 0
    RED TS 2 -> r: 4  y: 5  g: 20
    RED TS 3 -> r: 117  y: 5  g: 20
    RED TS 4 -> r: 132  y: 5  g: 20

 Green Time:  25
 YELLOW TS 1 -> r: 0  y: 3  g: 0
    RED TS 2 -> r: 3  y: 5  g: 25
    RED TS 3 -> r: 116  y: 5  g: 20
    RED TS 4 -> r: 131  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 2  g: 0
    RED TS 2 -> r: 2  y: 5  g: 25
    RED TS 3 -> r: 115  y: 5  g: 20
    RED TS 4 -> r: 130  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 1  g: 0
    RED TS 2 -> r: 1  y: 5  g: 25
    RED TS 3 -> r: 114  y: 5  g: 20
    RED TS 4 -> r: 129  y: 5  g: 20

    RED TS 1 -> r: 150  y: 5  g: 20
  GREEN TS 2 -> r: 0  y: 5  g: 25
    RED TS 3 -> r: 30  y: 5  g: 20
    RED TS 4 -> r: 128  y: 5  g: 20

    RED TS 1 -> r: 149  y: 5  g: 20
  GREEN TS 2 -> r: 0  y: 5  g: 24
    RED TS 3 -> r: 29  y: 5  g: 20
    RED TS 4 -> r: 127  y: 5  g: 20
```

Fig 5 : Output of Signal Switching Algorithm

After a complete cycle, again, TS 1 changes from green to yellow. As the yellow timer counts down, the results of the vehicle detection algorithm are processed and a green time of 25 seconds is calculated for TS 2. As this value is more than the minimum green time and less than maximum green time, the green signal time of TS 2 is set to 25 seconds. When the yellow time of TS 1 reaches 0, TS 1 turns red and TS 2 turns green, and the countdown continues. The red signal time of TS 3 is also updated as the sum of yellow and green times of TS 2 which is 5+25=30.

Simulation Module :

Game was built from the start with the help of Pygame verbiage. It not only simulates real life traffic but also seems just like nowadays city streets. It helps one to get a glimpse of what the system would be like and also allows comparison with the already existing static systems. It has a signalized 4-way intersection, where the traffic is controlled by the 4 stop signals. The top part of each signal designates the LED flashing duration, which can either be green to yellow, yellow to red, or red to green. Each signal blocks also the number of cars crossing the intersection which is shown alongside the signal. The roads are flocked by the vehicles that from ever side come including cars, bikes, buses, trucks and rickshaws. In order to make the lessons more like real life, some vehicles would be turning to cross the intersection. It shall also be assigned, at random, whether the vehicle will turn or proceed straight when the vehicle is being generated. It also involves a timer that displays the time of the elapsed series since the beginning of the simulation.

```
# *** IMAGE XY COOD IS TOP LEFT
import random
import math
import time
import threading
# from vehicle_detection import detection
import pygame
import sys
import os

# options={
#    'model':'./cfg/yolo.cfg',     #specifying the path of model
#    'load':'./bin/yolov2.weights',   #weights
#    'threshold':0.3     #minimum confidence factor to create a box, greater than 0.3 good
# }

# tfnet=TFNet(options)    #READ ABOUT TFNET

# Default values of signal times
defaultRed = 150
defaultYellow = 5
defaultGreen = 20
defaultMinimum = 10
defaultMaximum = 60

signals = []
noOfSignals = 4
simTime = 300       # change this to change time of simulation
timeElapsed = 0
```

Fig 6 : Code of Simulation Module

3.5 KEY CHALLENGES

While AI-powered adaptive traffic signal timing offers a promising solution to urban congestion, it faces several challenges and limitations that need to be addressed:

Data Challenges:

Data Quality: The system mostly depends on the good and reliable real-time data which are collected from the sensors and the vehicles that are connected to the internet. Sensor breakdowns, data inconsistencies, and missing values are the threats to the AI model's performance.

Data Security: The safeguarding of the traffic data collected from the sensors and the vehicles is of vital importance. The cyberattacks or unauthorized access can affect the operations and at the same time, they can bring the privacy problems.

Data Bias: AI models that were once trained on historical data may have inherited the biases that were in that data. For instance, road traffic during the rush hour might be overemphasized, which will result to the better performance of the traffic plans in the off-peak hours.

Technical Challenges:

Computational Complexity: Entering the enormous amount of real-time traffic information and using the complex AI algorithms for processing these data need huge computational resources. This can be a problem especially for the systems that are faced with resource constraint.

Algorithmic Limitations: AI models are not perfect, and thus their predictions sometimes might not be accurate. The unexpected traffic events or driver behavior that causes the suboptimal signal timing decisions are the ones that the signal timing can be planned.

Integration with Existing Infrastructure: The transformation of classic traffic management systems to work hand in hand with AI-powered adaptive timing could require the hardware upgrades or software modifications, which are time-consuming and costly.

Operational Challenges:

Public Acceptance: There can be raised issues about data security and the possible job cuts caused by the traffic management being the most efficient way of it. Attempting to change people's minds is always difficult because effective communication and public engagement strategies are required.

Maintenance and Expertise: The IT infrastructure, data pipelines, and the smooth operation of AI models are the tasks that need skilled personnel who are not many or it is costly to find them.

Scalability: The system should be able to grow to include a larger number of vehicles, sensors, and data sources from the city's traffic network.

CHAPTER 4: TESTING

4.1Testing Strategies

The implementation of a system of AI-powered adaptive traffic signal timing is dependent on the existence of a thorough and well-defined testing strategy. Here's a breakdown of key aspects to consider:

1. Testing Levels:

Unit Testing: The components of the AI that are isolated from each other like data processing modules and prediction algorithms are tested in order to see if they work as they are supposed to.

Integration Testing: The connection between the various system units, including AI models, the traffic signal controllers and data communication interfaces, is tested in detail.

System Testing: The whole system is being checked in a virtual world which is similar to the real traffic conditions. This gives information on the whole system system hardware, software, and hardware, as well as system performance and scalability.

Acceptance Testing: The system is put to the test by using real-life traffic data and in cooperation with stakeholders such as the city authorities and the traffic management personnel. This is a way to evaluate the user experience, system efficiency, and the problems that can arise with the integration of the system with the current infrastructure.

2. Testing Techniques:

Historical Data Testing: Validate the AI models with historical traffic data and through testing to assess their capacity to learn and predict the traffic flow properly.

Simulated Traffic Scenarios: Design the traffic situations with different levels of the congestion, accidents, and weather conditions to measure the system's ability to adapt and the response.

Real-World Pilot Testing: The system has to be put into a small area where there is real traffic to obtain information on its performance, user feedback and possible unforeseen problems before the general implementation.

3. Evaluation Metrics:

Traffic Flow Metrics: Check the system's affect on the vital indicators such as the average travel time, the queue length and the number of stops.

Safety Metrics: Analyze the result of traffic safety using the volume of accidents and close- calls before and after the system is put into practice.

User Satisfaction: Get the opinions of drivers, public transport operators, and emergency services on why they use the service, what they like, what they don't like, and what they would change, in order to get a clear idea of the user experience and to find the places where the service can be improved.

System Performance Metrics: Keep track of the system uptime, the response times, and resource utilization to make sure it has met the performance standards.

4. Continuous Improvement:

Data Monitoring: Keep on checking the real traffic data to catch the changes in the traffic patterns and then update the AI models to stay efficient.

Algorithm Refinement: After the testing of the AI algorithms, the real-world data and testing results are to be used to refine the algorithms so that they can be adapted to the changing traffic conditions more accurately.

Performance Optimization: Conduct constant checking and adjustment of the system's performance to guarantee the proper use of resources and the speed of the responses.

5. Challenges in Testing:

Simulating Real-World Complexity: Making the simulations that are the true replicas of the actual traffic and the unpredictable happenings is not an easy task to do.

Data Availability: Testing is only possible if you have the traffic data that are both historical and real that represent the city's traffic patterns.

Privacy Concerns: The testing with the real-world data needs the application of strong anonymization techniques for the protection of the privacy of the users.

4.2 TEST CASES AND OUTCOMES

Fig 7 : Simulation showing green time of signal for vehicles moving left set to 24 seconds according to the vehicles in that direction

Fig 8 : Outcome of the simulation module

In the figures 7 and 8 the simulation is showing green time of signal for vehicles moving up set to 10 seconds according to the vehicles in that direction. As we can see, the number of vehicles is quite less here as compared to the other lanes. With the current static system, the green signal time would have been the same for all signals, like 30 seconds. But in this situation, most of this time would have been wasted. But our adaptive system detects that there are only a few vehicles, and sets the green time accordingly, which is 10 seconds in this case.

CHAPTER 5: RESULTS AND EVALUATION

5.1 RESULTS

Simulation no.	Lane 1	Lane 2	Lane 3	Lane 4	Total
1	67	74	51	18	210
2	78	73	47	19	217
3	80	73	33	29	215
4	76	71	39	27	213
5	77	66	44	26	213
6	74	72	37	21	204
7	65	73	36	18	192
8	60	68	33	28	189
9	49	83	36	28	196
10	57	70	46	25	198
11	53	70	39	34	196
					2243

Fig 9 : Results of Current System

Simulation no.	Lane 1	Lane 2	Lane 3	Lane 4	Total
1	111	86	42	31	270
2	105	83	38	28	254
3	100	96	36	20	252
4	96	75	56	22	249
5	93	89	42	24	248
6	77	97	37	30	241
7	76	82	48	30	236
8	71	92	48	30	241
9	85	98	48	31	262
10	79	82	37	30	238
11	110	105	24	17	256
					2747

Fig 10 : Results of Proposed System

5.2 COMPARISON WITH EXISTING SOLUTIONS

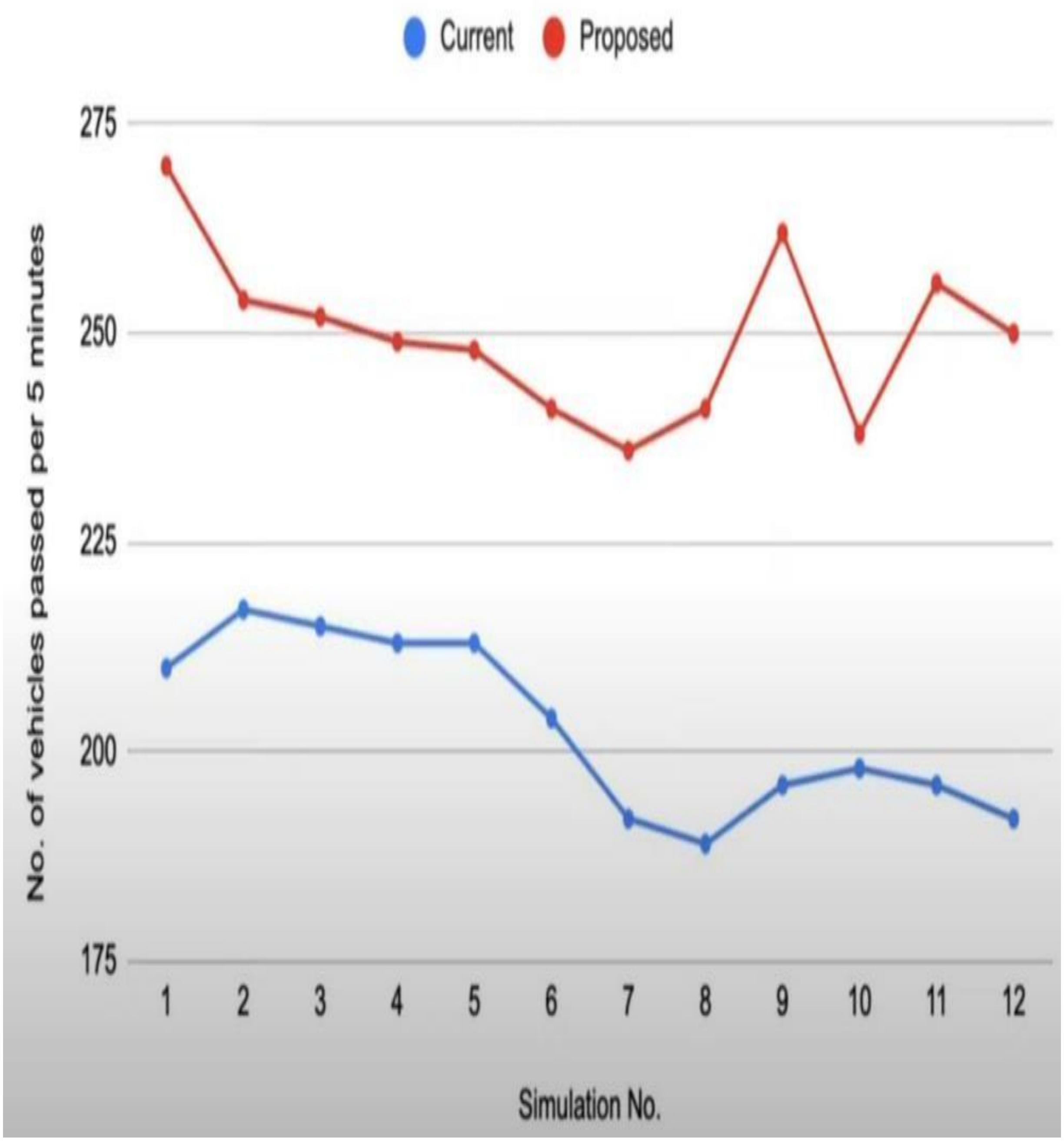

Fig 11 : Current System vs Proposed System

CHAPTER 6 : CONCLUSION AND FUTURE SCOPE

6.1 LIMITATIONS AND CONCLUSION

Limitations:

- **External Factors:** The system might be too rigid to accommodate the unforeseen events like accidents, road closures, or extreme weather conditions, which can greatly affect the traffic flow.

- **Human Behavior:** The AI models are designed to work on traffic data but driver behavior and decision-making can be erratic and thus affect the traffic.

- **Cost-Effectiveness:** The first step to this solution will be a considerable amount of money that will be needed for the purchase of sensors, AI technology and command system implementation. A detailed cost-benefit evaluation is the first and foremost thing that should be done to substantiate the expenditure.

Conclusion:

The difficulties and restrictions are present but still AI-powered adaptive traffic signal timing is a big leap to the smarter and more efficient traffic management. Conventionally, any technology has its drawbacks, which is why one must recognize them. The primary focus should be on data quality, security issues and also continuous improvement of algorithms to make the cities more habitable and sustainable.

6.2 FUTURE SCOPE

ITMS have a great potential to change the way we travel in the city and, thus, to revolutionize urban mobility. So far, the systems are designed for the efficient distribution of traffic, but in the future we will have really cool developments that will make the transportation system even better, cleaner, and more sustainable. Here's a glimpse into what lies ahead:

Integration with Emerging Technologies:

- **Vehicle-to-Infrastructure (V2I) communication**: Communication between cars and infrastructure will give even more detailed data on each vehicle behavior and the road conditions, thus, prompting even the road traffic management at the local level.

- **Autonomous Vehicles (AVs):** The ITMS can interact with the AVs as they become more and more common and thus, improve the traffic flow for the autonomous cars, thus the whole traffic would be more efficient.

- **Edge Computing:** Near the source (vehicles, sensors) of the data processing, there is the reduction of the latency and the possibility of the fast decision-making of the AI algorithms in the ITMS.

Focus on User Behavior:

- **Real-Time Incident Response:** AI can study social media data, camera footage from traffic cameras and sensor information to detect traffic accidents and other incidents in real-time which will allow the response time of emergency services to be faster.

- **Driver Behavior Prediction:** AI algorithms might be used to forecast driver behavior based on the past data and the present traffic conditions. This can be employed to give specific incentives or warnings thus preventing of the accidents.

Ethical Considerations and Public Acceptance:

- **Algorithmic Bias:** The mitigation of the algorithms' bias in AI that could be harmful to some demographics in terms of route suggestions or traffic signal timing is important.

- **Transparency and Explainability:** The clear explanations of the ITMS and AI algorithms operation will make people believe and accept the ITMS and AI algorithms.

Economic Opportunities:

- **Improved Supply Chain Efficiency:** The real-time traffic data can be used to design commercial vehicle delivery routes, thus, cutting down the transportation costs and making the deliveries faster.

- **Data-Driven Decision Making:** The ITMS is able to give important information to the urban planners, businesses, and policymakers so as to make the right decisions about the construction of infrastructure, investing in transportation, and urban design.

In short, AI combined with ITMS is full of possibilities for the future. Through the utilization of these technologies and dealing with their possible drawbacks, we will be able to design transportation systems that are smarter, more efficient, and environmental-friendly which will be of great benefit to all the parties involved in the urban environment.

REFRENCES

1. V. Prasanth, K. Ramana Rao, and S. K. Rao, "Traffic Signal Control Using Intelligent Transportation System," in 2020 International Conference on Communication and Signal Processing (ICCSP), IEEE, 2020.

2. V. L. Knoop, F. S. Osório, F. L. Ribeiro, et al., "Dynamic Traffic Management System for Urban Areas: A Case Study in São Paulo," Journal of Transportation Engineering, Part A: Systems, vol. 145, no. 11, 2019.

3. Y. Zhang, Y. Wang, Y. Hu, et al., "A Review of Adaptive Traffic Signal Control Strategies," IEEE Access, vol. 9, pp. 1236-1257, 2021.

4. L. Papadopoulos and P. G. Georgakis, "Traffic Signal Control Optimization Methods: A Comprehensive Literature Review," Transportation Research Part C: Emerging Technologies, vol. 95, pp. 166-190, 2018.

5. M. Montanino and C. Antoniou, "Traffic Flow Prediction Using Machine Learning: A Systematic Review," Transportation Research Part C: Emerging Technologies, vol. 118, p. 102721, 2020.

6. M. M. Anwar, U. Asad, M. Ahmed, et al., "A Comprehensive Survey of Vehicular Traffic Management in Smart Cities: Taxonomy, Challenges, Methodologies, and Future Directions," Sustainable Cities and Society, vol. 50, p. 101639, 2019.

7. D. Teodorovic and D. Lucic, "Traffic Flow Simulation Models: A Review and Assessment," Transportation Research Procedia, vol. 40, pp. 20-33, 2019.

8. X. Yang, D. Sun, Y. Wang, et al., "A Review of Artificial Intelligence Applications in Traffic Management Systems," Sustainable Cities and Society, vol. 67, p. 102708, 2021.

9. J. Wang, C. Chen, J. Xu, et al., "A Survey of Traffic Management Systems in Smart Cities," Sustainability, vol. 12, no. 22, p. 9422, 2020.

10. C. Liu, Z. Tian, and Z. Zeng, "A Survey of Urban Traffic Control Mechanisms in Smart Cities," IEEE Transactions on Intelligent Transportation Systems, vol. 21, no. 10, pp. 4161- 4178, 2020.

11. P. Rathi, P. Sahu, V. Jain, et al., "A Comprehensive Review on Traffic Congestion Detection and Control Using Machine Learning Techniques," Sustainable Cities and Society, vol. 71, p. 102964, 2021.

12. J. Wang, J. Han, S. Zha, et al., "A Survey of Urban Traffic Management and Control in Smart Cities," IEEE Access, vol. 6, pp. 14425-14444, 2018.

13. F. Tang, Y. Zhang, Y. Li, et al., "A Review of Advanced Traffic Management Systems: Past, Present, and Future," IEEE Access, vol. 7, pp. 10959-10980, 2019.

14. M. Tavana, M. Mohammadi, M. Anvari, et al., "A Comprehensive Review of Traffic Congestion Prediction and Management Techniques," Socio-Economic Planning Sciences, vol. 61, pp. 4-25, 2018.

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