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# ITS: INTELLIGENT TRAFFIC SIGNAL

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**Abstract**

combat this issue. The present Traffic signal system was invented over a hundred years ago. Even though the technology has advanced greatly, the mechanism remains the same. Our outdated infrastructure has meant congestion, lost time and increased emissions. The goal is to change this and bring our systems to the 21st century. About 40% of accidents happen at road intersection; this is because the existing system is static in nature. These are the problems that we aim to alleviate to a certain extent. The biggest advantage of a dynamic system is its ability to adapt to present situation as it happens. Traffic is highly unpredictable in nature. The ability to react to these unpredictable situations is a huge advantage in any situation for everyone involved.

Computer vision is our biggest asset. Using strategically placed cameras' in an intersection we will be able to get a hold of all the vehicles on the road. An AI takes this input and counts the vehicles on each lane. Every type of vehicle has a different weightage based on its size. All these factors are taken into consideration and then the AI decides on the best course of actions to take so that the traffic flow is smooth with minimum to no issues. This ensures the good flow of traffic within the systems capabilities. The signal timings are generated by the AI based on the factors that are present and it is determined on the fly, hence a greater emphasis can be given safety and efficiency. Furthermore, emergency vehicles can be prioritized in this system quickly by assigning them the highest weightage. The System, thus can act as a traffic police to a certain extent as it can adjust to the issues on the fly.

**Keywords**: smart farming, Artificial intelligence, Internet of Things, sensors.

## I. Introduction

An Intelligent Transportation System (ITS) is an advanced application which aims to provide innovative services relating to different modes of transport and traffic management and enable users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks. Some of these technologies include calling for emergency services when an accident occurs, using cameras to enforce traffic laws or signs that mark speed limit changes depending on conditions. An important component of the intelligent transportation system is the traffic sign detection and recognition system (TSDRS) (ITS). The correct and efficient identification of traffic signs or graphics might enhance driving safety or navigation.

Traffic signals play a crucial role in regulating vehicle traffic at intersections. They guide drivers on when to proceed, when to slow down, and when to stop. This helps prevent traffic congestion and ensures the safety of both motorists and pedestrians. Traffic signals can be manually operated or controlled by sophisticated electronic systems that adjust the signal sequence based on traffic flow and time of day. While they can increase traffic capacity and reduce delays for side road traffic, they can also cause increased delays for main road traffic. However, signalized junctions have been linked to higher rates of localized air pollution, and the World

Economic Forum recommends synchronizing traffic signals and exploring alternative traffic management systems. In addition to their role in regulating traffic, traffic signals also use a simple-to understand color system of red, yellow, and green to indicate when drivers should stop, proceed with caution, or go. The use of this color system has been extended to include intermediate colors to provide a greater range of indications. Despite their benefits, drivers spend around 2% of journey time passing through signalized junctions. Moreover, the frequent acceleration and stopping at traffic lights can lead to peak particle concentrations that are up to 29 times higher than during free-flow conditions. Therefore, the World Economic Forum recommends that traffic authorities consider placing traffic lights away from residential areas, schools, and hospitals, and explore alternative traffic management systems to minimize the negative impacts of traffic signals.

Traffic signals are an essential tool for traffic engineers to manage traffic flow and reduce congestion in urban areas. They can be used in conjunction with other traffic management strategies such as roundabouts, pedestrian crossings, and public transportation systems. The use of traffic signals also has a significant impact on the environment, with signalized junctions being responsible for a substantial portion of carbon emissions from transportation. To mitigate this impact, traffic engineers are exploring the use of sustainable transportation solutions such as electric and hybrid vehicles, bike-sharing programs, and pedestrian-friendly streets. Ultimately, the effective use of traffic signals is critical for improving the safety, efficiency, and sustainability of urban transportation systems.

### 1.1 Objectives

Intelligent transport system can be defined as the technology applied to transport infrastructure (Road networks, traffic and transit systems) to: The following are the objectives are tried to achieve in the proposed system.

1. To manage traffic and reduce congestion
2. To enable users to make informed decisions
3. To Integrate technologies and expertise to create and provide innovative services
4. To Improve safety and mobility
5. To Increase the efficiency of existing transport infrastructure

## II. Literature

Khalid Ali Hussien. et al. [4] proposed Lagrange interpolation method as a new neural network learning that develops the weighting calculation in the back propagation training. This development decreases the learning time with best classification operation results. The Langrage interpolation polynomial was also used to process the image pixels and remove the noise the image. This interpolation gives the effective processing in removing the noise and error in the image layers. The main advantages of this method is to reduce the noise to minimum value by replacing the noisy pixels which are detected by Lagrange Back Propagation Neural Network (LBPNN). The results are calculated by the Lagrange interpolation with high speed processing.

Biswajit Das et al. [5] explains about the use of interpolation in real world application. By using the Newton's divided difference, interpolation formula will represent a given set of numerical data on a pair of variables by a suitable polynomial, to compute the value of the dependent variable from the polynomial corresponding to any given value of the independent variable. The formula will be derived with the numerical example as its application.

Criag B. Rafter et al. [3] discusses about the increase in traffic volumes in urban areas makes network delay and capacity optimisation challenging. However, the introduction of connected vehicles in intelligent transport systems presents unique opportunities for improving traffic flow and reducing delays in urban areas. The author proposed an algorithm called Multi-Mode Adaptive Traffic Signals (MATS) which combines position information from connected vehicles with data obtained from existing inductive loops and signal timing plans in the network to perform decentralised traffic signal control at urban intersections. The MATS algorithm is robust under non-ideal communication channel conditions, and when heavy traffic demand prevails on the road network.

Li Zhong et al. [4] describes the use of intelligent traffic signal in modern cities. Real-time traffic signal control strategies for Emergency Vehicles (EV) has been proposed. Initial step is to giving way for EV vehicles tp travel faster based on three indicators: The Emergency Response Level (ERL), the Congestion Level of the Road Section (CLRS), and the Time Urgency Level(TUL). Next step is called novel signal preemption, which combines non-intrusive preemption and intrusive preemption to provide green indicator so that EVs can pass through intersections quickly without stopping. The last step is called the recovery cycle strategy, which restores the road network to the normal situation as soon as possible by using Linear Programming (LP) to find the shortest green time in each phase after an EV passes the intersection.

## II. INTELLIGENT TRANSPORT SIGNAL

Traffic blockage is becoming more serious day by day which affects our daily lives. Population and poor economy are the major cause leading to more traffic now-a-days. Many techniques like controllers are embedded and are installed at the junction are used to control traffic.

Intelligent Traffic Signal (ITS) involves creating a complex network of hardware, software, and communication technologies to improve the safety, efficiency, and sustainability of transportation networks. The design process includes analyzing traffic data, identifying the necessary components and subsystems, and creating a scalable and reliable architecture. The goal of ITS system design is to integrate various transportation systems, such as traffic management, public transit, and vehicle infrastructure, to provide a seamless and user-friendly experience.

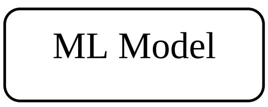
Figure 1 shows the system model of the proposed ITS system. The number of vehicles waiting to pass the signal is collected and then calculates the weight of each lane.

The weight is calculated based on the type of vehicle standing in the lane. The heavy-loaded vehicles are given with the higher weights. The priority is given to the lane which has more weight. If the ambulance is viewed in any of the lane, the highest priority is given to that particular lane by giving the more weight to ambulance.

If any of the lane come across any kind of emergency, the vehicles are diverted by sending the details of different junction to Ml model and process it to calculate the optimized time to release the traffic signal. If VIP has arrived, this system helps to deviate the vehicles.

The following methods are required for the implementation of the project.

1. Camera: provides live video of each lane.
2. OpenCV with filters and methods used to detect vehicle from video.
3. Interpolation formula, LaGrange’s and newton-divide difference formula, used to increase the size of dataset.
4. Various ML models: SVM, Linear regression, Logistic regression, Decision tree, Random forest.
5. Simulation: using Python module, pygmes to design a 2D simulation.



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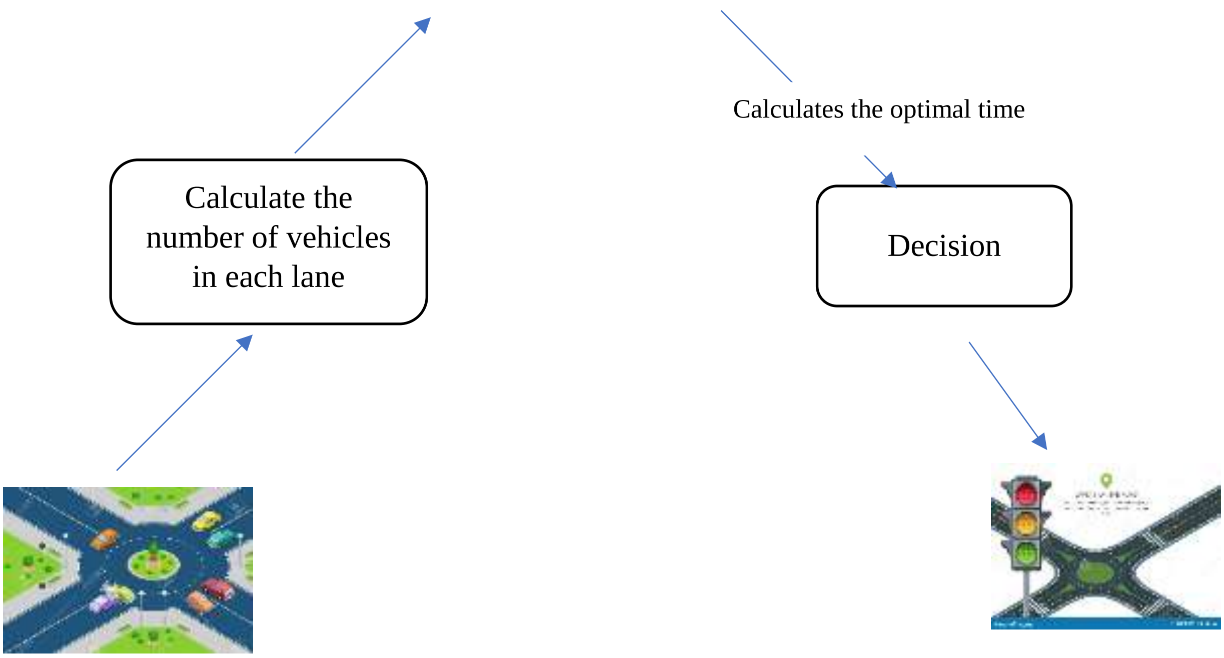


**Figure 1: ITS System Model**

### 3.1 WORKFLOW

The entire workflow of the proposed ITS system is divided into three modules:

**Detection Module:** Vehicle detection models are used to identify and locate vehicles in images or videos. These models typically use deep learning techniques, such as convolution neural networks (CNNs), to classify and localize vehicles. They may also use object detection algorithms, such as YOLO or Faster R-CNN, to detect multiple objects in an image or video frame. In this system, Haar Cascade Classifier has been used for vehicle detection. It uses machine learning techniques to identify and locate objects in images or videos.

**Processing Module:** A common processing model for numeric data involves several steps, including data cleaning, normalization, and feature engineering. After completing all these methods, we start with actual procedure of our system. By detecting and counting weight of each lane we pass this data to our custom pre-trained model for computing expected time to a lane. This time is used for optimal traffic flow on junction. Thus the function of this module is to work as the brains of the system.

**Output Module:** The time that is returned from ML model is displayed in traffic screen and traffic is directed to achieve optimal traffic flow.

## IV RESULT ANALYSIS

Intelligent Traffic Signal (ITS) is designed to be a next-generation traffic signal system that has the capabilities to improve the traffic situation in any junction to be an active in nature. This capability of the proposed system allows for increased flow of the vehicles through the junction.

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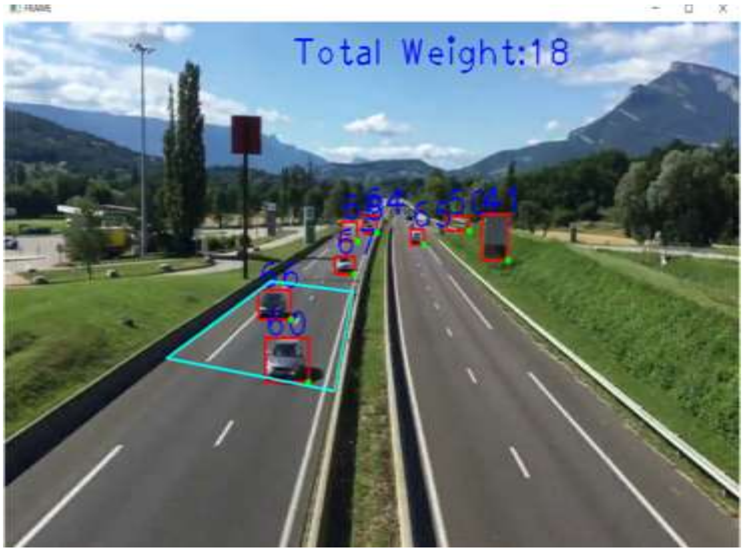


**Figure 2: Vehicle Detection Working**

Figure 2 shows the detection and count of the vehicle that are present in each lane. The cameras are placed at top of each lane that captures the real-time video footage of lane.

Figure 3 shows the dataset generated based on the equation (1) to train the Machine Learning model. The dataset consists of over 10000 data point with 4 attribute indicating the weight of each lane, the next prioritized lane and the predicted time for optimal traffic flow.

| 1 | Lane 1 | Lane 2 | Lane 3 | Lane 4 | Prefered Lane | Expected Time |
|---|---|---|---|---|---|---|
| 2 | 5 | 15 | 6 | 11 | 2 | 13.5 |
| 3 | 3 | 2 | 10 | 2 | 3 | 12.75 |
| 4 | 12 | 5 | 12 | 6 | 1 | 8.25 |
| 5 | 15 | 4 | 14 | 4 | 1 | 12 |
| 6 | 9 | 14 | 0 | 1 | 2 | 13.5 |
| 7 | 1 | 12 | 10 | 9 | 2 | 4.5 |
| 8 | 7 | 14 | 13 | 9 | 2 | 9.75 |
| 9 | 4 | 4 | 1 | 2 | 1 | 2.25 |
| 10 | 3 | 12 | 12 | 0 | 2 | 6.75 |
| 11 | 12 | 5 | 12 | 14 | 4 | 6.75 |
| 12 | 4 | 0 | 11 | 10 | 3 | 6 |
| 13 | 12 | 0 | 5 | 14 | 4 | 8.25 |
| 14 | 5 | 14 | 1 | 9 | 2 | 11.25 |
| 15 | 7 | 4 | 14 | 7 | 3 | 13.5 |
| 16 | 0 | 6 | 10 | 0 | 3 | 10.5 |
| 17 | 2 | 3 | 4 | 10 | 4 | 11.25 |
| 18 | 7 | 11 | 6 | 13 | 4 | 10.5 |
| 19 | 6 | 10 | 3 | 9 | 2 | 6 |
| 20 | 3 | 14 | 1 | 5 | 2 | 15.75 |
| 21 | 14 | 3 | 12 | 5 | 1 | 10.5 |
| 22 | 7 | 9 | 4 | 0 | 2 | 5.25 |
| 23 | 14 | 12 | 6 | 1 | 1 | 8.25 |
| 24 | 3 | 3 | 5 | 10 | 4 | 11.25 |
| 25 | 3 | 3 | 11 | 6 | 3 | 12 |
| 26 | 8 | 6 | 0 | 5 | 1 | 3.75 |
| 27 | 9 | 2 | 1 | 4 | 1 | 9.75 |
| 28 | 11 | 4 | 1 | 9 | 1 | 7.5 |
| 29 | 15 | 7 | 4 | 12 | 1 | 11.25 |
| 30 | 6 | 8 | 7 | 8 | 2 | 5.25 |

**Figure 3: Dataset to Calculate the Expected Time**

$$pt = \left(\frac{(Mwl * TC)}{Nt} in\ that\ l\right) - \left(\frac{2nd\ Mx * Tc}{Nt} in\ that\ l * 2\right) - \left(\frac{3rd\ Mxl * Tc}{Nt} in\ that\ l * 2\right) + \left(\frac{Mwl * Tc}{Nt} in\ that\ l * 2\right) \quad (1)$$

Where,

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$P_t$ – predicted time, $M_w$ – maximum weight, $T_c$ – time to cross, $N_t$ – number of track, $l$ – lane, $M_x$– maximum lane

The formula given above is used to calculate the predicted time for a lane to be allocated for a particular task. It takes into consideration various factors such as the maximum weight that can be carried, the time required to cross the track, the number of tracks available and the maximum number of lanes available. The formula uses a series of calculations to determine the time required for each lane and then adds up the results to provide the total time for the task. The predicted time obtained from this formula can be used as an estimate to plan and allocate resources effectively for completing the task within the given timeframe.

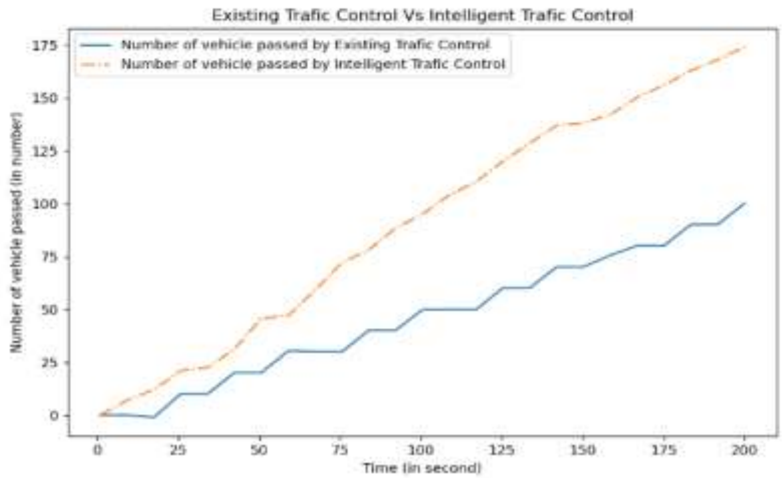


**Figure 4: Comparison with Existing and Proposed System**

Figure 4 shows the graph of traffic flow time of existing traffic control and intelligent traffic control. The graph is plotted with the number of vehicles passed with the fixed duration of time in existing system where as time given to signal depends on the weight of each lane in proposed ITS system.

To validate this further, we have developed a simulator with the model being integrated into it. The traffic intersection simulator's incorporation of AI-based traffic control has enormous potential for improving road navigation and reducing traffic. The simulator offers a thorough platform for research and development in traffic management by faithfully simulating real-world traffic scenarios and assessing the efficacy of AI algorithms. The advantages and ramifications of this simulator will be further examined in this part, with each benefit and consequence being elaborated upon to deepen the discussion.

Improved traffic flow is one of the main advantages of the AI-based traffic control system built into the simulator. The technology efficiently reduces congestion and increases traffic flow efficiency by dynamically adjusting signal timings based on real-time traffic data. As a result, commuter travel times are shortened and traffic flow is managed better overall. The simulator represents the complexity of traffic interactions by simulating several vehicle types, including motorcycles, cars, buses, and trucks. This enables a more accurate evaluation of traffic flow optimization tactics.

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**Figure 5: Animated Simulation Showing Traffic Junction**

Figure 5 shows the implementation of the traffic simulator in action. This simulator is designed to run a predetermined amount of time and give us the count of crossed vehicles.

The traffic control precision is much improved by the AI techniques used in the simulator. These algorithms enable efficient coordination between various lanes, reducing conflicts and enhancing intersection capacity by offering precise predictions for the ideal duration of green light phases. This accuracy guarantees that the simulator faithfully replicates actual traffic circumstances, enabling trustworthy assessments of AI-based traffic control systems. These insights can be used by researchers and transportation authorities to guide their decisions for implementation in the real world. The existing simulator [9] used as a platform for this project had impressive capabilities; however, it lacked support for AI integration and a counting feature. To address this limitation, we added these functionalities to the simulator, enabling us to run and test the AI model effectively.

The integration of the A.I. model resulted in a notable increase in the total number of vehicles crossed within the simulator. This enhancement allowed for more comprehensive evaluation and analysis of the traffic control strategies implemented by the AI system. Another essential feature of the AI-based traffic control system in the simulator is real-time adaptation. Realistic testing conditions are created by the capacity to adjust to shifting traffic patterns and unforeseen incidents. Based on the data supplied, the simulator may alter the timing of the signals in a timely manner, improving traffic flow in real-time. When dealing with variable traffic situations, such as peak hours, accidents, or road construction, when conventional fixed-timing methods could prove ineffective, this feature is especially helpful. The simulator's flexibility guarantees that the tested AI-based traffic control solutions are reliable and efficient in a variety of situations. The user-centric approach of AI-controlled traffic management, as seen in the simulator, is a key benefit. During peak hours, commuters stand to gain from fewer delays, greater predictability, and improved convenience.

Figure 6.5 shows a simulator working in comparison with an existing type simulator. This is designed to show the benefits of ITS.

The simulator is the perfect setting for testing and assessing how well the AI-based traffic control model performs in practical situations. Its capacity to generate automobiles dynamically and in ad hoc successions, closely resembling the actual traffic environment, is one of its main advantages. This feature is essential for evaluating the model's performance and comprehending how it affects traffic flow.

The simulator provides a realistic testing environment to see how the AI system interacts with various traffic patterns because it generates automobiles in real-time. The simulator's dynamic nature

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makes it possible to assess how well the model responds to shifting traffic conditions, such as shifting vehicle densities, abrupt spikes in traffic flow, or unexpected events. This ability guarantees that the model's performance corresponds to actual traffic.


**Figure 6.5: Simulation Based on Real Time Vehicle Detection**

Additionally, the simulator's random car generation allows for a thorough evaluation of the AI-based traffic control system's performance. The unpredictable nature of vehicle arrivals and their behavior makes the simulation more complex and closely captures the difficulties in managing traffic in real life. Researchers can learn important things about the model's flexibility, robustness, and overall performance by putting it under these various scenarios.

The assessment of the model's influence on traffic flow is made easier by the real-time and random vehicle generation aspects of the simulator. To assess the efficacy and efficiency of the system, researchers can monitor and quantify a variety of measures, including traffic throughput, typical trip times, and congestion levels. The effectiveness and possible advantages of the model may be evaluated by comparing these indicators to baseline scenarios or other traffic management techniques.

Additionally, the simulator enables scenario testing, giving researchers the opportunity to mimic certain traffic events or assess the efficacy of the model in various scenarios. This adaptability improves comprehension of how the AI system functions in varied circumstances, enabling optimization and fine-tuning.

The simulator's capacity to randomly and dynamically produce cars makes it a very useful testing environment for the AI-based traffic control model. Researchers can assess the system's responsiveness, flexibility, and influence on traffic flow thanks to the simulator's real-time nature and random car production. The simulator enables a greater understanding of the model's performance and possible real-life implications through thorough analysis and scenario testing, ultimately assisting in the creation of more effective and intelligent traffic management systems.

In conclusion, the creation of an AI-based traffic control traffic intersection simulator represents a significant progress in the improvement of road navigation and the reduction of traffic. The simulator offers a useful platform for research and development in traffic management since it can faithfully simulate real-world traffic scenarios and assess the efficacy of AI algorithms. The incorporation of AI-driven decision-making increases the effectiveness of traffic flow, decreases travel times, and enhances the commuter experience as a whole. The simulator's advantages include better accuracy, improved traffic flow, real-time adaptation, and a user-centric design. Traffic authorities and academics may make wise choices to build a more effective, sustainable, and user-centric transportation network by utilizing the insights obtained through this simulator.

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## V CONCLUSION AND FUTURE ENCHANCEMENT

Intelligent Traffic Signal (ITS) refers to the application of advanced technologies and communication system to transport infrastructure and vehicles. This sector is currently experiencing rapid growth and advances. ITS represent the next step in the evolution of a nation's entire transportation system. Traffic congestions, rate of road accidents, wastage of fuels are decreased to a large extend. Transportation has become a safer and efficient mode. Hence with much more interest and advanced research in the field of ITS, it can be implemented in our country and can prove to be the solution of the traffic problems including traffic congestion, air pollution and traffic accidents. This system will give a high progress in the development of our country. Intelligent Transportation Systems provide a set of strategies for addressing the challenges of assured safety and reducing congestion, while accommodating the growth in transit ridership and freight movement. ITS improve transportation safety and mobility, and enhance productivity through the use of advanced communications, sensors and information processing technologies.

### 5.1 Future Enhancement

Heavy traffic and road congestion are a new normal these days. Traffic congestion on road networks means slower speeds, longer travel times, and more vehicles queuing. Cities are expanding beyond their carrying capacities and adding new roads and related infrastructure is beyond the scope of these sprawling cities. Although traffic congestion can never be completely eliminated, it can be managed to reduce delays, maintain speeds, and improve travel time reliability. In such a situation, technology plays a pivotal role in managing road and traffic system with optimum resources available which makes our life smooth. On the other hand, to alleviate traffic congestion on the roads, a combination of information and communication technologies is used to manage traffic. Also we can add this method for pedestrian crossing by detecting and counting people.

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