International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 11 | Nov 2021 www.irjet.net p-ISSN: 2395-0072

A Review Study on Green Corridor Implementation and Real-Time Adaptive Traffic Regulation using Machine Learning and Image Processing

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Abstract - *Traditional traffic light control systems rely on fixed time intervals for the trafficlights. These traditional fixed traffic light controllers have limitations and are less efficient because they use hardware that functions according to a system that lacks the flexibility of real-time modification and adaptation. As a result of the fixed time intervals between green and red signals, there is excess and unnecessary waiting time on roads, and vehicles use more fuel the purpose of this project is to create a traffic system which is adaptive to the present traffic scenario in a lane. Usually, we have fixed average waiting time for all lanes. This project suggests changing the average waiting time by monitoring the number of vehicles in a lane. Additionally, a predictive model will be instituted which will take decisions based on the previous patterns of traffic, mainly at routinely congested intersections. Moreover, emergency vehicles will be identified and a convenient route will be deployed for them.*

Key Words: **Traffic congestion, real-time object detection, adaptive traffic regulation, smart green corridor formation, predictive analysis, vehicle density**

1.INTRODUCTION

India takes pride in being the second-biggest street organization on earth. The complete stretch of the Indian street systems is an astounding 5.4 million km! Traffic Signal lights indeed play an important role in controlling and regulating traffic on a daily basis. Presently, the traditional types of traffic lights used, such as the timed traffic lights wherein the timing for each signal is pre-determined is based on the previous study of traffic density in a particular area. Heavy traffic congestion has been undeniably increasing in major cities and is majorly been seen at the main junctions, especially during peak hours. Thus, it shapes a challenge for the Indian Government to give impeccable streets at each progression.

1.1 Major Causes of Traffic Congestion

A)Traditional Fixed Signal Timers:

The static timer approach has the disadvantage that even when there is less traffic on a road, a green signal is still assigned to the road until its timer value falls to 0, while traffic on another road, which has more traffic, faces a red signal at that time, causing even more congestion and time loss to commutators. The majority of current systems are not automated.

B)Routinely congested junctions:

The road junctions where there is traffic congestion during peak hours add up to the existing problems. These intersections are usually those near commercial complexes, the neighbourhoods of corporate office areas wherein the traffic aggravates during the office leaving or starting times and thus create a commotion on the roads. If the traffic patterns at these sections of the road traffic network are properly studied then smart predictions can be made, for dexterously handling the traffic in real-time.

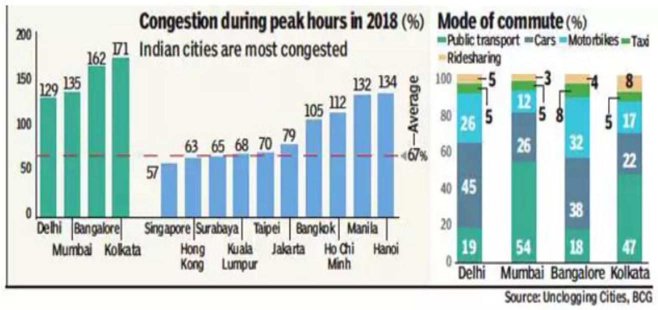

Fig-1: Congestion during peak hours in different Indian cities

[Source: Unclogging cities, BCG/Times Of India,

<https://timesofindia.indiatimes.com/india/traffic-congestion-costs-four-major-indian-cities-rs-1-5-lakh-crore-a-year/articleshow/63918040.cms>]

C) Conventional Method of Handling Emergency Vehicles:

The traditional method of transporting organs requires policemen aiding an ambulance. The ambulance then move around the traffic wherein a specific traffic lane is chosen and all signals on the route are changed to become green.

This approach is not smart and dynamic and thus proves to be inefficient in terms of speed.

1.2 Major Effects of Traffic Congestion

A)Inadequate Emergency Vehicle Handling:

In the past years, during organ transportation for transplantation several organs, have failed to reach the patients on time . Furthermore, because cadaver organs have a limited lifespan, transplants should be performed within a certain number of hours. As a result, a faster and smarter organ transportation handling system is required as the current method of handling these services is hardly efficient.

B) Noise and Air Pollution:

The community living along busy traffic lanes is constantly subjected to sound levels that exceed the allowable limits. This constant exposure to noise pollution is cause for concern even though it has a number of negative effects on human health. Traffic noise causes annoyance and irritability, as well as sleep disruption, cardiovascular disease, stroke risk, diabetes, hypertension, and hearing loss.

Sources of PM2.5 Pollutant	2016-17	2019-20
Transport	16%	30.5%
Industry & Power	36%	18%
Residential (cooking in households and slums, trash burning, cow dung burning, emission from street vendors, wood burning, etc.)	27%	15%
Wind Blown Dust	21%	15%
Other sources (municipal solid waste (MSW) plants, MSW open burning, crematories, aviation sector, incense sticks, brick kilns etc)	NA	21.5%

Fig-2 : Increase in air pollution due to transportation

[Source: System of Air quality Weather Forecasting and Research / GaonConnection,

<https://en.gaonconnection.com/air-pollution-mumbai-maharashtra-health-transport-vehicles-dust-safar/>]

PM 2.5 refers to **a category of particulate pollutant that is 2.5 microns or smaller in size**. Particles that are 2.5 microns or smaller are considered especially dangerous to human health because they bypass many of our body's defenses.

C) Time Delays:

Traffic signals have fixed timings and are not able to sense road density. It further causes the roads to run at the same speed regardless of vehicle density, resulting in longer wait times.

D)Fuel Wastage :

In a traffic congestion, a vehicle ingests more fuel, making travelling a costly affair. This is due to the idling vehicles at various traffic intersections that end up consuming more fuel as they maintain a constant speed waiting on the clogged streets.

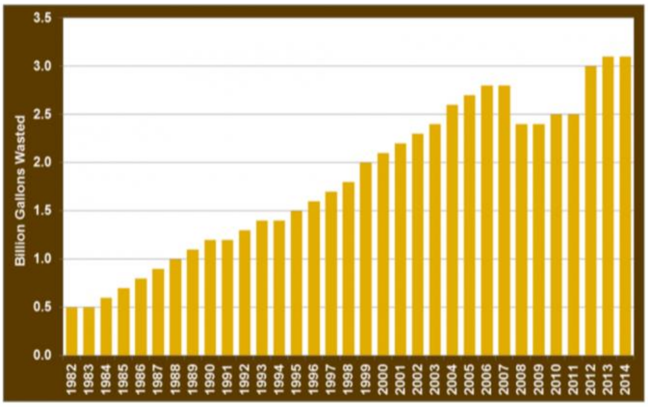

Fig-3: Total fuel wastage due to congestion from 1982-2014

[Source: ENERGY.GOV

<https://www.energy.gov/eere/vehicles/fact-897-november-2-2015-fuel-wasted-traffic-congestion>]

E) Environmental Effects:

Maintaining a consistent speed usually results in a constant amount of fuel being burned. The biggest factor is constant acceleration and braking, which usually results in more pollutants being pumped into the air. Climate change is exacerbated by carbon dioxide, and acid rain is caused by sulphur dioxide. Humans are at risk from high levels of nitrogen oxide.

F)Effect on Mental Health Of Humans:

Researchers discovered that populations living in high-traffic areas reported more depressive symptoms, which arose from the unpredictability of traffic and the sense of helplessness it instilled. It has also been discovered that traffic causes stress and anxiety, lowers tolerance thresholds, causes family squabbles, and intensifies exasperation and frustration. Traffic blockage can prompt drivers to get baffled and participate in street rage.

2. Literature Survey

Prashant Jadhav, Pratiksha Kelker, Kunal Patil, Snehal Thorat, in 2016 studied the "Smart traffic control system using image processing." under this study the method for estimating the traffic using image processing is presented and this method is done by using camera image captured from the highway and videos taken are converted to image sequences. This method uses the MATLAB software and it aims to prevent heavy traffic congestion by implementing this project using image processing technique.

Swapnil Manohar Shinde, in 2017, studied about "Adaptive traffic control light system", this paper talks about the improvement of traffic regulation and control in the cities and contends that it should be mainly dependent on using intelligent systems for monitoring and regulating the traffic. The proposed system makes the use of network of array of sensors for sensing the traffic. On categorizing this sensed traffic the timing intervals of red and green lights at each crossing of roads are intelligently decided and varied so as to keep the waiting time minimum.

Boris A. Alpatov, Pavel V. Babayan , Maksim D. Ershov, in 2018, studied the "Vehicle detection and counting system for real-time traffic surveillance" and the actual problems of the road congestion and the situation was analysed, the algorithms for processing video sequences were obtained by an optical sensor when observing the road sections. These algorithms perform a road marking detection, vehicle detection and counting, evaluate parameters of traffic flows.

Mohamad Belal Natafgi, Mohamad Osman, Asser Sleiman Haidar, Lama Hamandi, in 2018 studied "Smart Traffic light system using Machine learning", the performance of the proposed system was compared with the first proposed system and they defined the state of the environment using grid intersection decided into cells and the network fed the grid describing the environment. The output of the model will determine the optimal phase to set the traffic light .

K. Priyadarshan, S.K.Manikandan, in 2019, studied the " Automatic traffic control system based on the vehicular density", in which their proposed system works on the principle of changing time delays of traffic signals dynamically based on the number of vehicles passing through the concerned section of the road. They have realized this using infrared sensors and microcontroller environment.

Aditi Yadav, Vaishali More, Neha Shinde, Manjiri Nerurkar, Nitin Sakhare, in 2019, studied " Adaptive traffic management system using Iot and Machine Learning", in which their proposed system implements different algorithms like Min-Max fairness algorithm, Additive increase multiplicative decrease algorithm and principal component analysis to design an adaptive traffic management system.

Mamata Rath, in 2018, studied " Smart traffic management system for traffic control using automated mechanical and electronic devices" in which he has proposed a framework that makes use of traffic control system, includes designing a smart vehicle using VANET protocols and stresses on implementing an elaborate mechanism of using the smart vehicle and smart traffic control system in coordination.

Abbas Kiani , Guanxiong Liu, Hang Shi , Abdallah Khreishah , Nirwan Ansari , Jo Young Lee and Chengjun Liu, in 2018, studied, "A Two-Tier edge computing based model for advanced traffic detection", in which they have proposed a model in which they intend to solve the traffic problem by proposing a two-tier edge computing based model that takes into account the computing capability of the Traffic management control and the low bandwidth requirement of the cloudlets and hence have designed a two-tier edge computing model which is faster and efficient.

3. Proposed Design

A system that adapts to the variations of the traffic dynamically and updates the traffic signal phases accordingly. Additionally, a predictive traffic control system for routinely congested routes can be implemented using machine learning and tested using real data from the everyday traffic patterns of these routes.

A green corridor formation can be assisted by our project as it will help to create a route that will not be hampered by the ongoing traffic. The signals will change to a green colour one after the other depending on the real-time position and route of the ambulance and will return to their adaptive behaviour once the vehicle passes the signal.

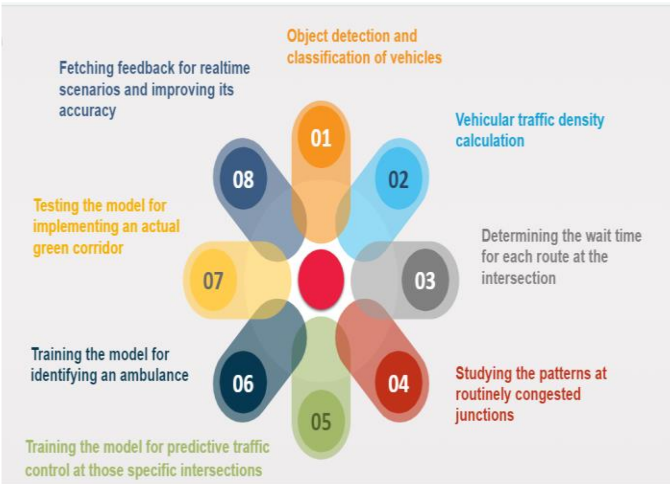

Fig-4: Steps involved in the proposed design

3.1 Methodology

1)Real-Time Traffic Regulation:

The proposed solution will use live images from traffic junction cameras to determine traffic density using object detection. The captured image will be sent to a central server having an algorithm that will have a preset threshold for the number of vehicles at the signal. If the threshold is crossed then the signals will change their status (either the wait time or the signal colour) based on the vehicle density. The colours of the signals can be modelled to change dynamically based on the comparative number of vehicles at each route.

2)Traffic Pattern Prediction Model:

The model will make use of datasets consisting of information on the traffic patterns of daily commute routes. This dataset will be used to build the machine learning model. Depending on the performance, the most accurate machine learning algorithm will be employed. A sufficient amount of data will be fed to train the model to make appropriate decisions for peak-time traffic. The trained model will then be tested for real-time decision making. It will then be implemented to function without human intervention. The model will keep improving and make decisions efficiently.

3)" Smart" Green Corridor Formation:

The route for the ambulance will be decided and fed into the system before the commencement of the journey. The camera modules on the signal junctions will keep track of vehicles passing under them. When the ambulance is detected by the camera, it will send the data to the server and also turn the signal green. The server will instruct the next signal on the route to turn green after a fixed amount of time or if it detects an ambulance, whichever happens, earlier. This will form a green corridor on a limited division of the route so that it will not obstruct the entire stretch of the route. The signals will return to their normal functioning behaviour for real-time traffic regulation once the ambulance passes that particular stretch.

3.2 System architecture and implementation

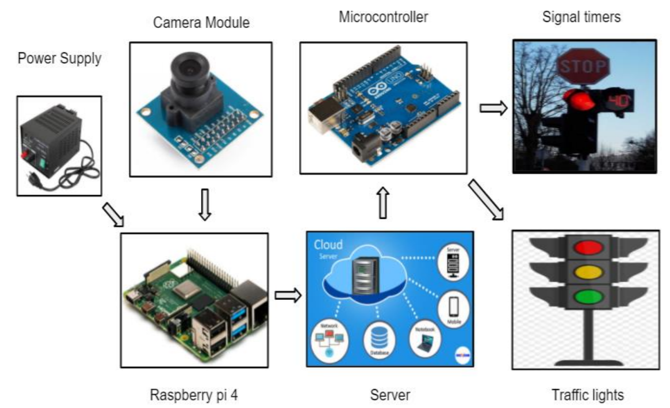

Fig-5 : Block Diagram of the complete system

1)Data collection:

The data input will be taken with the help of camera modules placed at specific clusters of the roads. The input will be in the form of a video feed which will eventually be disintegrated into image frames at the server where the data processing algorithms will be implemented.

2)Object detection::

The most efficient object detection algorithm will be used for detecting the number of vehicles on each street at the intersection and along with this, it will also distinctly identify the ambulances on any road. The algorithm adopted for this system is YOLO-v4, as it ensures a perfect balance between accuracy and speed as compared to all other states of the art models designed for object detection[1]. This can be proven with the help of the statistics mentioned in figure

3)Vehicle density calculation:

The density calculation is counting the number of vehicles in the region of interest. A code programmed in python language will be employed for calculating the number of vehicles in the video data that were taken as an input from the concerned road and this data will be given as an input to the waiting time calculation algorithm.

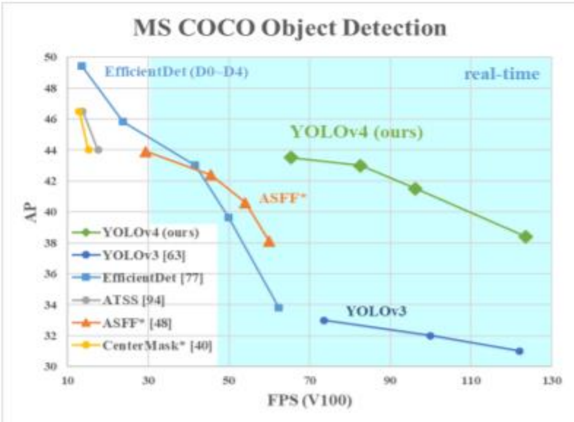

Fig-6: Comparison of various object detection algorithms[1]

4)Real-time timer initialization:

The timer will be assigned values based on the vehicle count. The most efficient waiting time will be ascribed to each road at the intersection by combining the results of vehicle density and the algorithm specifying the optimal waiting time. The timers will be set in such a way that none of the roads at the intersection faces starvation or heavy congestion.

5)Deploying the pre-trained ML model at routinely congested junctions:

The ML prediction model will be trained using the database consisting of the data of routinely congested traffic junctions in which the number of vehicles on a road and the signal timer assigned to it will be specified. This will be a supervised learning ML model. This model will be then used at such places for time-efficient decision making for lowering congestion.

6)Implementing the "smart" green corridor with the ML model:

The camera module on the raspberry pi atop the signal light will capture the image of the incoming ambulance and then send it to a simple secure server where that image/video will be run through the object detection algorithm. When the algorithm gets a match, the raspberry pi will command the microcontrollers on the calculated short stretch of the preferred area to turn the signal green. After the ambulance passes that signal, the raspberry pi will send a communication to that signal to return to its adaptive nature. This process will continue sequentially till the ambulance reaches its destination. This dynamic stretch creation will be more suitable than creating an entire green corridor at a given instant.

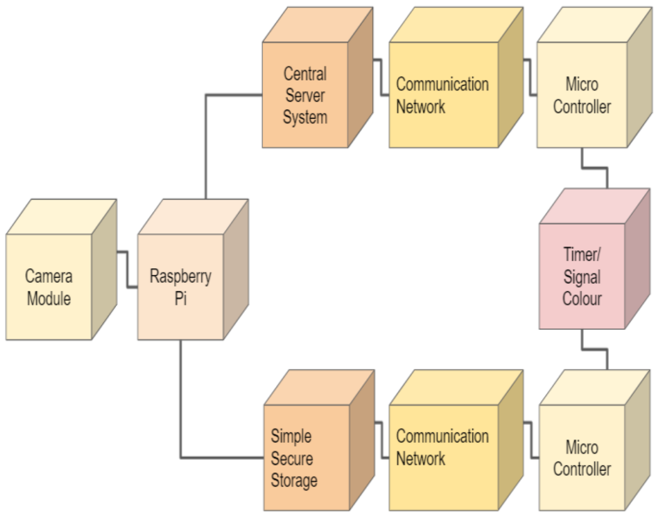

Fig-7: Hardware block diagram of the system

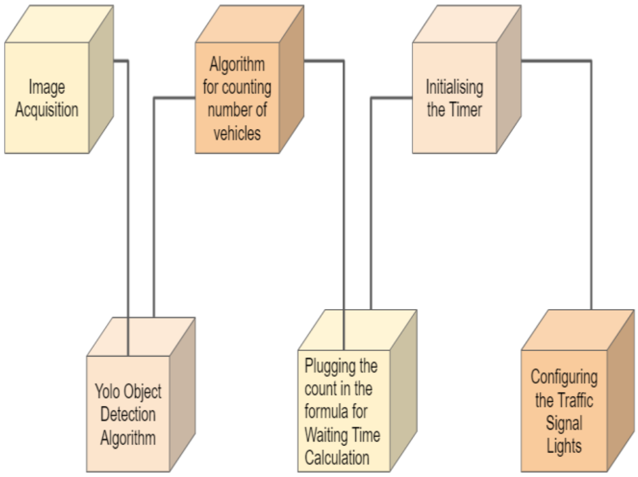

Fig-8: Software block diagram of the system

4. CONCLUSION

The automatic and smart nature of this project will help to reduce the burden on the already starved manual traffic handling system. The project will aid traffic policemen and help them to better utilize their resources and workforce efficiently. The mundane and repetitive work of managing the endless city traffic manually can be replaced with a smart traffic management system for a better and efficient transport system across the country. In addition to this, ambulances transporting organs for transplants, for example, should be allowed to pass through traffic signals more quickly. The model is trained to detect not just vehicles but also to identify an emergency vehicle and to adjust the timers so that the emergency evacuation is given priority and can cross the signal as quickly as possible.

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