

Detection and Management of Traffic Congestion using Artificial Intelligence

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ABSTRACT

Traffic congestion is a major problem in many cities of India along with other countries. Failure of signals, poor law enforcement and bad traffic management has led to traffic congestion. One of the major problems with Indian cities is that the existing infrastructure cannot be expanded more, and thus the only option available is better traffic management. Traffic congestion has a negative impact on the economy, the environment, and the overall quality of life. Hence it is high time to effectively manage the traffic congestion problem. There are various methods available for traffic management but the problem with these systems is that the installation time, and the cost incurred for the installation and maintenance of the system is very high. In any case, Firstly, the flow of vehicles depends on the time of the day where the peak hours are for the most part within the morning and the evening on the days of the week and times as occasions and summer. Furthermore, the current activity light framework is actualized with difficult coded delays where the light's transition time intervals are settled routinely and don't depend on flow of the vehicles. The third point is concerned with the state of one traffic light at a crossing point that impacts the traffic flow at adjoining crossing points.

Keywords : Traffic congestion, intersection, efficient flow.

1. INTRODUCTION

Traffic congestion on road networks is nothing but slower speeds, increased trip time and increased queuing of the vehicles. When the number of vehicles exceeds the capacity of the road, traffic congestion occurs. In the metropolitan cities of India traffic congestion is a major problem. Traffic congestion is caused when the demand exceeds the available road capacity. This is known as saturation ^[1]. Individual incidents such as accidents or sudden braking of a car in a smooth flow of heavy traffic have rippling effects and cause traffic jams ^[2]. There are even severe security problems in the traffic system due to anti-social elements which also leads to stagnation of traffic at one place. In a country like India, there is an annual loss of Rs 60,000 crores due to congestion (including fuel wastage). Congestion in India has also led to slow speeds of freight vehicles, and increased waiting time at checkpoints and toll plazas ^[3]. The average speed of

vehicles on key corridors like Mumbai-Chennai, Delhi-

Chennai are less than 20kmph, while it is merely 21.35km/h on Delhi-Mumbai stretch. As per the transport corporation of India and IIM, India's freight volume is increasing annually at a rate of 9.08% and that of vehicles at 10.76%, but that of roads is only 4.01%. This has resulted in reduced road space in accordance with the number of total vehicles ^[3]. The average fuel mileage in India is only 3.96kmpl. The major reason for this is traffic congestion ^[3]. India is the 2nd most populated country after China in Asia, thus with increase in population, the number of vehicles also increase ^[4]. The economic growth has certainly has had an impact on urban traffic. As the income rises, more and more people begin to go for cars rather than two wheelers ^[5]. Hence there is a need to manage traffic in a smart way as the management of traffic with the conventional way such as the signaling system is not having a major effect in curbing congestion of vehicular traffic.

2. EXISTING METHODOLOGY

2.1. Inductive Loop Detection

Inductive loop detection works on the principle that one or more turns of insulated wire are placed in a shallow cutout in the roadway, and a lead-in wire runs from the roadside pull box to the controller and to the electronic unit located in the controller cabinet. When a vehicle passes over the loop or stops, the induction of the wire is changed. Due to the change in induction, there is a change in the frequency. This change in the frequency causes the electronic unit to send a signal to the controller; indicating the presence of the vehicle ^[6]. Inductive loop detection is useful in knowing the vehicle presence, passage, occupancy, and even the number of vehicles passing through a particular area ^[6,7]. But there are few problems with this system. These include poor reliability due to improper connections made in the pull boxes and due to the application of sealant over the cutout of the road. If this system is implemented in poor pavement or where digging of the roads is frequent then the problem of reliability is aggravated.

2.2. Video Analysis

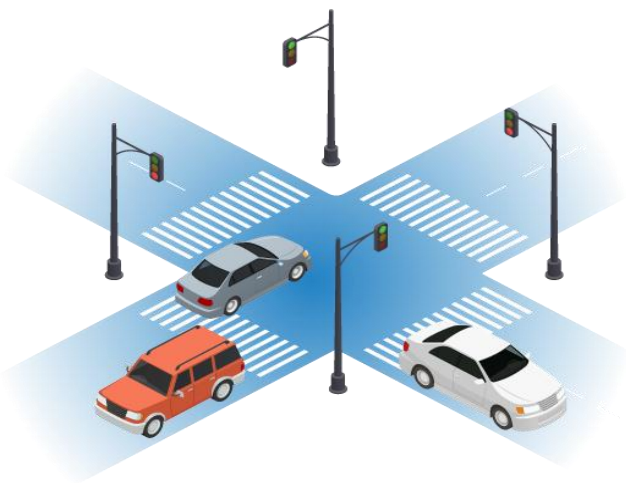
Video analysis consists of a smart camera placed which consists of sensors, a processing unit and a communication

unit ^[9]. The traffic is continuously monitored using a smart camera. The video captured is then compressed so as to reduce the transmission bandwidth. The video analysis abstracts scene description from the raw video data. This description is then used to compute traffic statistics. This statistic includes the frequency of the vehicles, the average speed of the vehicles as well as lane occupancy ^[9,10]. The problems associated with video analysis are – (a) the overall cost of the system is quite high (b) the system gets affected in case of heavy fog or rains (c) nighttime surveillance requires proper street lighting.

2.3 Infrared Sensors

These sensors are used to detect energy emitted from vehicles, road surfaces and other objects. The energy these infrared sensors capture is focused onto an infrared-sensitive material using an optical system that converts the energy into electrical signals. These signals are mounted overhead to view the traffic. Infrared sensors are used for signal control, detection of pedestrians in crosswalks and transmission of traffic information¹. The basic disadvantages of infrared sensors are that the operation of the system may be affected due to fog; also installation and maintenance of the system is tedious.

3. SMART TRAFFIC MANAGEMENT SYSTEM

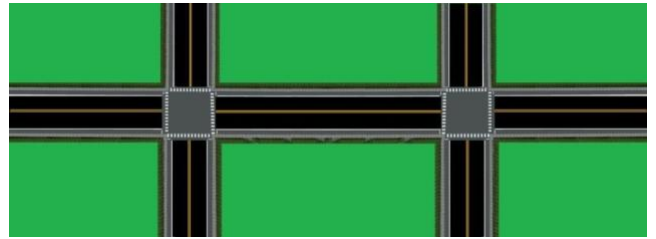


3.1. Background

Vehicles

This class contains various attributes and methods like vehicleClass: Represents the type of vehicle such as bus, car, truck etc. speed: Speed of motion of the vehicle. direction: 0 for right, 1 for down, 2 for left and so on x and y coordinates move() to control movements based on traffic lights All the above attributes when put together functions accordingly as needed for the simulation to take place.

Intersection



This represents a general idea of how intersections are implemented in real-life scenarios. Includes various diversions, turnings, etc.



3.2. System Overview

Traffic congestion happens due to demand-supply imbalance in the transportation network. Traffic flow slows down when the number of vehicles traveling on the road increases / the roadway capacity decreases due to various reasons. This has been a significant problem that challenges traffic flow on roads in many cities around the world. It is growing rapidly and has been becoming a more problem today as there are more and more vehicles on the road today, it would be really efficient if the traffic signals had an ability to know the traffic conditions and work in a way to save time on the road ahead will enable commuters to save fuel by reducing wait time.

3.3. Data Requirements

Traffic Dataset

The number of vehicles is detected and sent to the system so that it can assess the strength of the traffic flow. Adjusting the signal to green or red based on the traffic density, while giving more preference to the lanes with more number of vehicles to implement a smoother flow for most vehicles.

3.4. Proposed Methodology

3.4.1 Used Library

A set of Python modules called *Pygame* is cross-platform and made for creating video games. It provides music and graphics libraries created specifically for use with the Python programming language. On top of the excellent SDL library, Pygame adds capabilities. This enables users to develop multimedia applications and fully functional games in the Python language. Pygame may be used on almost any platform and operating system and is fairly portable. It is free and LGPL-licensed.

3.4.2 Relevant Algorithm

Input:

Max_red denotes the maximum time for which the signal can be red.

Max_green denotes the maximum time for which the signal can be green.

Min_freq_count denotes the minimum frequency of vehicles passing per second stored statically in controllers.

Act_freq_count denotes the actual frequency of the vehicles passing per second = $\sum \text{vehicles/second}$.

Timer denotes the actual timer count.

Algorithm:

1. When the signal turns green.

While (Timer < Max_green and Timer is

not 0) do If

(Act_freq_count > Min_freq_cou

nt)

Keep the signal green.

Decrement timer count

by 1.

Else if

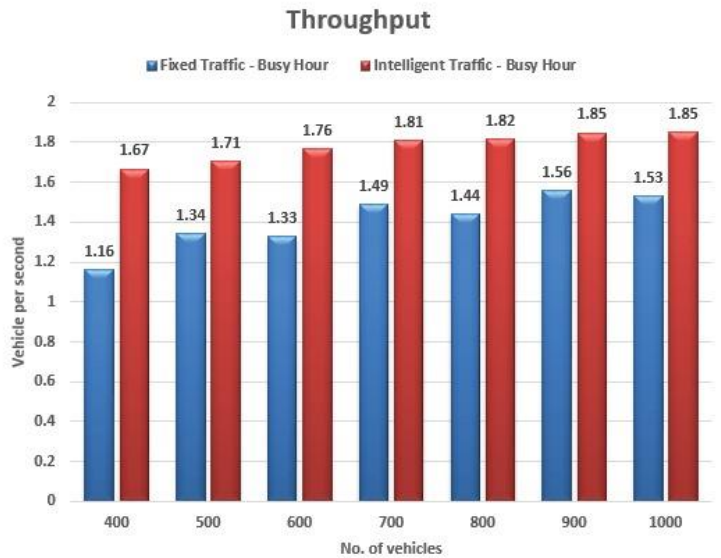
(Act_freq_count <= Min_fr

eq_count) Goto 2.

End

2. Make the signal red. Turn the adjacent signal green. Goto 1.

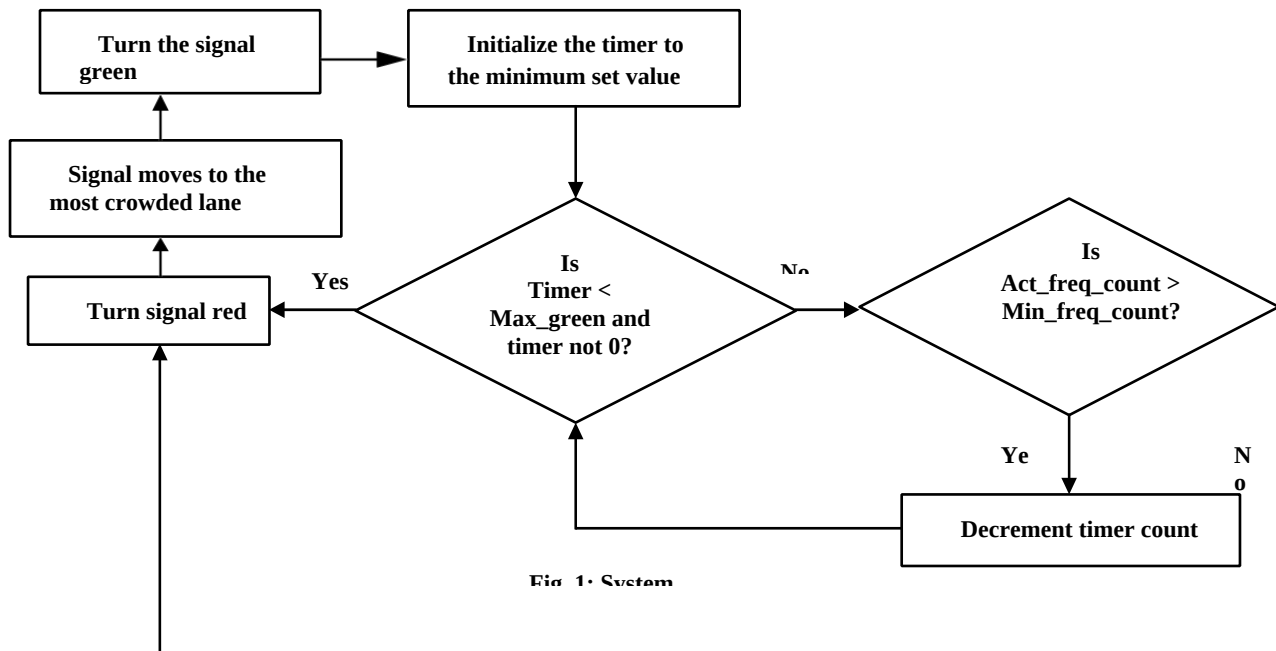
Desired Output: An effective congestion management



The above chart represents how efficiently the system works during a busy peak scenario.

TABLE. SIMULATION RESULTS OF CURRENT STATIC SYSTEM

No.	Distribution	Lane1	Lane 2	Lane 3	Lane 4	Total
1	[300,600,800,1000]	79	59	53	55	246
2	[500,700,900,1000]	111	49	48	31	239
3	[250,500,750,1000]	73	53	63	62	251
4	[300,500,800,1000]	74	43	65	71	253
5	[700,800,900,1000]	85	33	26	45	189
6	[500,900,950,1000]	95	71	15	14	195
7	[300,600,900,1000]	63	63	79	14	219
8	[200,700,750,1000]	50	94	15	62	221
9	[940,960,980,1000]	110	20	18	14	162
10	[400,500,900,1000]	84	31	90	40	245
11	[200,400,600,1000]	45	49	57	88	239
12	[250,500,950,1000]	41	55	96	24	216
13	[850,900,950,1000]	80	10	17	17	124
14	[350,500,850,1000]	49	46	69	50	214
15	[350,700,850,1000]	53	67	39	46	205



the maximum value of the timer is reached, then the congestion has occurred at that point. Once the congestion has been detected, the RFID controller can send a message to its preceding signal's controller notifying it to temporarily stop traffic along that stretch. After receiving the message from its successor signal the RFID controller will put ON the red signal for that stretch towards that congested crossing point for a predefined time period. When the congestion is released at the crossing, the respective signal's controller will send another message to its earlier controller indicating to resume the traffic flow again in that direction. Accepting this message the controller of the preceding signal put the red light OFF and green signal ON and restarts the signal cycle as before.

4. APPLICATIONS

4.1 Detection and Management of traffic Congestion

In addition to the earlier method of traffic congestion detection, one more method can be used. A server can be maintained to receive certain crucial data calculated by the Controller of the signals. The main aim is to implement a system that would trace the travel time of individual cars as they pass the roadside controllers and compute an average trip time using a rule-based system to decide whether the area is congested or not congested. If congestion is sensed then the system would control traffic signals / generate automatic rerouting messages to selected approaching vehicles.

4.2 Minimizing waiting time

As this system is put to work, it detects the amount of vehicles in each lane, based on which the AI makes the decision as to which lane must be given the green signal to pass and turns red immediately after all the vehicles have passed safely

4.3 Reduction in infrastructure construction cost

Many cities now see infrastructure expansion as a last resort. The effectiveness of providing new road capacity as a "solution" to congestion management is often undermined by new traffic demand. However, there are cases where the provision of new infrastructure is an effective policy - but for where it is nearly impossible, it is best to implement an algorithm using AI to at least sort the issue by a considerable margin

5. CONCLUSION AND FUTURE WORK

Considering the low rate of recycling of old vehicles compared to the production of new ones, where the government has also tried enacting new scrappage policies, there are significantly more vehicles on the road than the expected capacity with the increase in population, which is accompanied by a significant rise in automotive sales worldwide each year. This project offers a traffic congestion monitoring strategy that is AI-focused. Based on information gathered from parameters throughout time, the congestion management system will determine traffic patterns in a certain location. By using this model, the system will be able to recognize the local traffic flow and alert the signal as necessary.

Construction of new road infrastructure is often hampered by a lack of space in dense urban cores and is almost always an expensive undertaking even in outlying urban areas. An extensive study was conducted to determine the most cost-efficient, reliable, and practical vehicle movements. The reliability and effectiveness of the system depend on the AI system in different areas. The system can be further improved or used for various other functions for a complete traffic management system.

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