RealTime Traffic Management System Using Object Detection based Signal Logic

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Abstract

According to PRB (Population Reference Bureau), road traffic accidents are the third-leading leading cause of death by injury and the tenth-leading cause of all deaths globally. Delay due to traffic congestion at the junctions is causing the people to exceed speed limits leading to increased road accidents that demands for effective traffic management.

Traffic management is a critical issue in densely populated cities. Currently a fixed quantum of green time is allocated in all the directions irrespective of traffic density leading to unnecessary waiting. Automated object detection and counting technologies can provide benefits to develop the next-generation of AI-supported real-time traffic management systems. In this paper, we present a novel green time estimation algorithm that provides the green signal time in each direction (North, West, South and East) based on the traffic density and use AI and ML techniques for predicting the green time in a short interval. Directional loads were estimated using Linear, Quadratic, Exponential, Logarithmic Regression and time series ARIMA models. Among all, Linear Regression model proved to be best. Inputs include: number of directions, maximum green time for a direction, maximum green cycle time, and departure rates in various directions. Two dictionaries are maintained to store vehicle counts and green time is provided in all the directions. A signal logic scheme is detailed that uses directional threads to get vehicle counts every second by implementing Yolo algorithm for object detection. The cycle starts with North followed by West, South and East. We conclude by providing a case study of our object-detection based signal logic scheme using real world data sets in the Kakinada Smart City test bed.

INTRODUCTION

A city is a complex system which consists of many interdependent subsystems where a traffic system is one of its important subsystems. A study says; it is the cornerstone of the world's economy. Moreover, it is also declared as one of the major dimensions of the smart city. With the rapid growth of the population of the world, the number of vehicles on roadways is increasing consequently, the rate of traffic jams is also increasing in the same manner. Traffic jams are not just wasting time but, in some cases, it is witnessed that criminal activities like mobile snatching at traffic signals also happen in metropolitan cities. On the other hand, it is not only affecting the ecosystem badly but the efficiency of industries is also being affected. It is, therefore, identified that active traffic management is a necessity. In majority countries, traffic is managed through fixed time signals whereas, in large cities of some developed countries, traffic is managed through centrally controlled systems. To the best of our knowledge, it is identified that till date the current traffic management systems are centralized. In addition, there is less focus on fluctuations in traffic flow. Therefore, the proposed system manages the traffic on local and centralized servers by exploiting the concept of Artificial Intelligence. The representation of traffic data in statistical form can also be helpful to authorities for real-time controlling and managing traffic. Moreover, it may also be helpful for future planning. An effective traffic management system helps reduce congestion on the roads of the city. This proposed system overcomes the disadvantages of the previous traffic management systems. A web application which displays the city map with marked junctions of the city, the user when clicked on the junction can view the amount of green time allotted per lane at that instant. It takes the real time live data from the affixed cameras and is given as input to the object detection model to get the actual count of vehicles of each category serviced through the signal. The green time to be split for the signals is predicted and distributed considering the density of the traffic of the previous cycle. This effective way of estimating the green time to be allotted will significantly improve the traffic management to a greater extent which reduces the congestion on the roads and also leads to decreased frustration levels of the commuters.

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MOTIVATION

In, traffic majority countries is managed through fixed time signals whereas, in large cities of some developed countries, traffic is managed through centrally controlled systems. To the best of our knowledge, it is identified that till date the current traffic management systems are centralized. In addition, there is less focus on fluctuations in traffic flow. Therefore, the proposed system manages the traffic on local and centralized servers by exploiting the concept of Artificial Intelligence. The representation of traffic data in statistical form can also be helpful to authorities for real-time controlling and managing traffic.

PROBLEM STATEMENT

Traffic congestion has become an important issue in sprawling cities. Lesser the congestion at the junctions will lead to a better operating city. One of the major causes for the congestion is lack of efficient signal timing. In majority of the cities, the traffic is either manually controlled by the traffic police randomly or the signals are given in a cyclic manner by the police operating the signals. This cannot promise an effective way of dealing with the traffic. Thus, an online traffic management system in cities with automated signaling will reduce the congestion to a greater extent. The green signal will be given to the lane with the maximum density so that the passengers in that lane need not wait long. The cycle length will be decided by the density of all the lanes.

LITERATURE SURVEY

As per ref [1] Mr. Thavaseelan., et. Al proposed a system to evade issues caused during floods and traffic jams caused because of them. It planned an structure which will screen the traffic system, emergency and burglary vehicles less complex by using cloud information database. It is used IoT internetworking devices like sensors actuators, PLC's for information exchange. In this paper, the proposed system introduced on a self-administering 2-level system which will help in the conspicuous confirmation of emergency vehicles or some other needed vehicle. But this system doesn't give high accurate results and are not cost effective due to use of sensors.

As per ref [2] Ninad Lanke, et. Al developed a system for better traffic management and to effectively manage the traffic congestion problem. The existing systems like video data analysis, infrared sensors etc. are cost incurred and of high maintenance which makes it a difficult option to choose in case of long term instalments and cost-effective. The paper proposed a new system using Radio Frequency Identification (RFID) combined with the signalling system that acts as a smart traffic management system in real-time. This method requires less time for installation and also cost-effective. Although, the main problem with using RFID is lack of privacy, data warehousing and also skilled RFID-professionals that makes this system less reliable.

Sabeen Javaid, et. Al tackles problems related to traffic management using Internet of Things(IoT). There is a hybrid approach (mix of centralized and decentralized) is utilized to advance traffic flow on streets and an algorithm is formulated to oversee different traffic circumstances productively. Another algorithm dependent on Artificial Intelligence is utilized to foresee the traffic density for future to limit the congestion and RFIDs are likewise used to organize the emergency vehicles like ambulances and fire brigades. To exhibit the adequacy of the proposed system, a model is created which improves the progression of traffic as well as interfaces nearby rescue departments with a centralized server. As this system is also using RFID, it has the same issues as stated before.

Mr. Prashant Jadhav, et Al proposed "Smart Traffic Control System Using Image Processing". The principle purpose for the present traffic issue is the procedures that are utilized for traffic management. The present traffic has no accentuation on live traffic situation, which prompts to inefficient traffic management. This paper has been implemented by utilizing the Mat lab programming. A web camera is put in a traffic lane that will capture pictures of the street on which we need to control traffic. At that point these pictures are proficiently prepared to know the traffic density. As per the handled information from Mat lab, the controller will send the commands to the traffic LEDs to show specific time on the sign to manage traffic. The use of webcams in the system counts the number of vehicles but not the type of vehicles as that is also an important parameter to determine the traffic density.

Aditi Anekar, et. Al proposed "Automatic Traffic Signal Management System". It proposed a traffic surveillance system for vehicle tallying as vehicle flow identification is a significance part of surveillance system. The proposed algorithm is made out of five stages background subtraction, blob detection, blob analysis, blob tracking and vehicle counting. Tracking moving targets is achieved by comparing the extracted features and measuring the minimal distance between consecutive frame. The results show that the proposed framework gives a constant and useful data for traffic surveillance. The main issue in this paper is vehicle counting or vehicle identification method. It doesn't give accurate vehicle density. A better approach of this is to use object detection algorithm like YOLO to identify the objects.

Bilal Ghazal et. Al proposed a traffic control system to control the flow of vehicles at the intersections of numerous streets that are intended for smooth movement of vehicles in transportation routes. The conventional or existing systems do not handle with variable traffic flow at the junctions and pedestrian crossing, passage of emergency vehicles are not included. It proposed a system on PIC microcontroller that assesses the traffic density utilizing IR sensors and achieves dynamic timings slots with various levels. Additionally, a portable controller gadget is intended to tackle the issue of crisis vehicles stuck in the overcrowded streets. Even though it controls the variable flow of traffic, it is. not fully automated system without the need of any manpower.

Therefore, due to the discrepancies in the existing papers, we decided to develop a new system that uses YOLO algorithm for object detection and vehicle density as per vehicle type. Further, an automated system that allows the traffic department to use less man power and more effective way to control traffic.

METHODOLOGY

You only look once (YOLO) is a state-of-the-art, real-time object detection system. We have trained the model to detect auto rickshaws also, which are common on Indian roads along with Cars, Buses, Bikes, Trucks.

Object detection algorithm is used to retrieve the vehicle count, every second, from the camera feed in all the four directions simultaneously. Different vehicles types detected will be converted to PCU's (Passenger Car Units) for uniformity as per the below table.

Vehicle Type	PCU
Car	1
Motorcycle	0.75
Bicycle	0.5
Bus	3
Truck/ Tractor	4.5
Auto Rickshaw	1

Green Time Estimation

Green time calculation and assignment starts from North followed by West, South, East assuming there are 4 directions at the junction.

Phase is defined as the flow of traffic stream from one direction.

Single phase approach is one where traffic flow from only one direction is allowed at any given point of time. Maximum green time in each direction was initially confined to 30 seconds.

We follow single phase approach where traffic flows from one direction only at any given point of time.
A single cycle is one complete rotation through all of the directions provided.

Cycle length is the sum of green time in seconds allotted in each of the direction. Cycle length was initially limited to 120 seconds.

Departure rate for any direction is the number of PCU's transferred per second.

Buffer time is a correction factor applied in computation of green time split. This is the average error between actual and estimated green time calculated based on past data.

As the cycle begins with North, green time t_n was computed based on vehicle count/ traffic density at that instance. At the same instance in the other directions (West, South, East) the green time was estimated using regression techniques (Linear, Quadratic, Exponential, ARIMA) as follows:

- green time t_w to be provided to the West after t_n seconds
- green time t_s to be provided to the South after (t_n+t_w) seconds
- green time t_e to be provided to the East after $(t_n+t_w+t_s)$ seconds

After calculation of required green time, buffer time correction factor was applied in all the directions.

Green time allotment

Actual green time was allocated in proportion to the above estimated green times (including buffer time correction), subject to a cap of maximum cycle green time.

Once final list of estimated green time is available, allotment happens as follows based on different cases

1) Sum of estimated green time in all directions is less than 120 seconds and in any direction if estimated green time is less than 5 seconds then alloted green time in that directionwill be 5 seconds

2) Sum of estimated green time in all directions is less than 120 seconds and in one or more directions estimated green time exceeds the maximum green time (30 seconds) then allotted green time is equal to the estimated green time

3) Sum of estimated green time in all directions is more than 120 seconds and in one or more directions estimated green time exceeds the maximum green time (30 seconds) then the following procedure is followed for actual green time calculation

- the difference between estimated green time and maximum green time was computed in those directions where estimated green time is less than maximum green time

- then sum of the above differences was computed

- The computed sum was distributed to all directions where estimated green time exceeds maximum green time(30 seconds)

4) If estimated green time in all the directions is more than 30 seconds, then green time in all the directions will be set to 30 seconds.

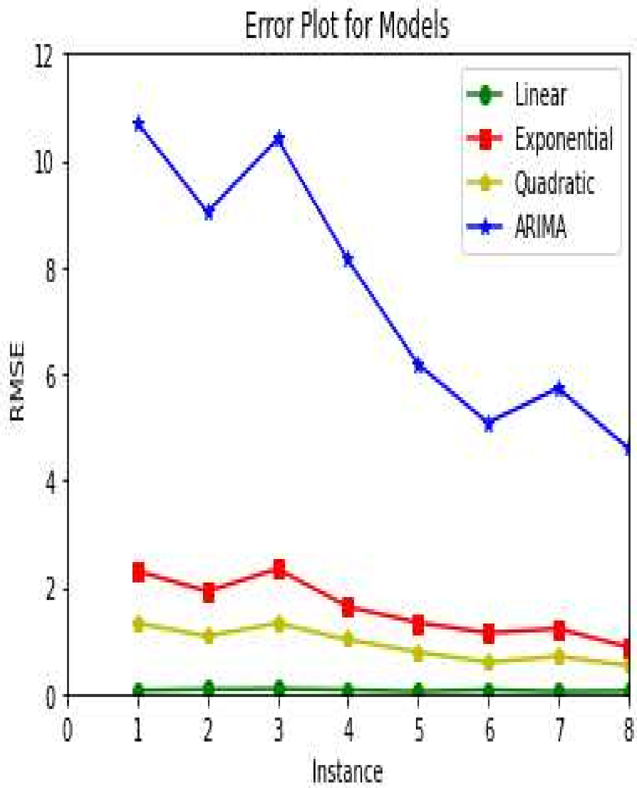
5) In the last direction of the cycle if required extra green time can be provided up to a maximum of 10% of the cycle length.

Cycle Process

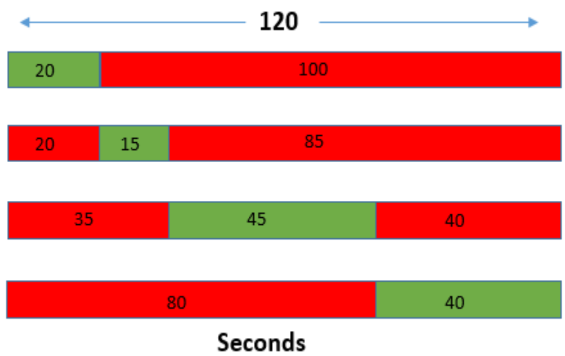
Green time assigned in the current direction is say n seconds green time will be re-estimated and adjusted accordingly at the following junctures

- At (n-3) seconds all the directional loads are re-estimated and green time allotted is readjusted if n is less than 30 seconds.
- If n is greater than 30 seconds, the green times are estimated and readjusted at 27th seconds and every 2 seconds there after

After the assigned green time is completed in the existing direction, estimate and recalculation process continues in the remaining directions. Once cycle is completed all the details will be written to a log file for further analysis.



Directional loads were estimated using Linear, Quadratic, Exponential, Logarithmic regression and time series ARIMA models. Among all, Linear regression model proved to be best, with minimum RMSE value of 0.06 and ARIMA models showed maximum error with RMSE value of 10.3425



FUTURE WORK

- The traffic load will depend on the following parameters
- The parameters that influence the traffic in any day are: temperature, humidity, rain, time of day, day type (holiday, fair/ festival, Saturday, Sunday)

• In order to forecast traffic density during specific hours, the data over a longer period can be accumulated.

• Then the traffic can be forecasted using multivariate models like Poisson regression, linear regression, ARIMA models etc.

• During peak traffic times, to avoid congestion, alternative routes will be suggested using shortest-path algorithms based on real-time traffic density estimation.

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