Real Time Vehicle-density based Traffic Signal Scheduling System

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Abstract - *The Exponential increase rate of vehicles running in the city necessitated change in current traffic management system. The need of digitalized traffic congestion control system is must. Conventional systems [1] use fixed pattern for deciding green signal timings or RIGHT TO PASS. These systems take only static behavior of the system into account. However, the negligence towards dynamic factors such as diversity in traffic at run-time, time to time changing circumstances such as peak hours, type of vehicle passing. There may be times when there is no one present at the intersection. Therefore, it is necessary to control traffic system such that the green light allocation pattern is adaptive to continuously changing traffic conditions.*

The proposed algorithm presented in this paper, consider all of the dynamic changing factors mentioned above [2] and digitally allocates the green light timings to available intersection. The advantages of proposed system would be reduced average waiting time at signals and it would ensure the safe and proper execution of the traffic lanes avoiding possible conflicting movements. The hidden advantage of the system after adapting this algorithm is alleviating traffic efficiently and reducing the ill effects on environment triggered due to pollutants generated.

Key Words: Algorithm, congestion, traffic cycle, phase, cycle length, saturation flow rate, dynamic, peak hours, average waiting time.

1. INTRODUCTION

Confusion! Confusion! and Confusion! And, this prevails no solution. With the current growth in population, and the desires of people to make their lives more comfortable, there are a lot of amenities humans use to satisfy the said desires. Vehicles are one of these amenities.

Considering the statistics the average number of vehicles owned by a family on a national scale has gone from 3 in 2007 to 6 in 2017. Taking into account the constant rate of growth of population, this rise in number of vehicles is never going to decrease. Since this number is escalating day by day, the amount of time we put in travelling each day is increasing day by day due to the increasing number of vehicles on the road.

After recognizing this problem, there are some common systems adopted to get over this, like multilane concept and various traffic scheduling algorithms.

Aside from the well-known reasons known for growth in traffic levels such as increase in the number of vehicles or cars, urbanization, let's look at some of the less obvious reasons; Although, the main offices of most businesses are in big cities, most people prefer living in the outskirts of these cities, to avoid the stress of urban life.

For instance, in Pune, India, everybody rushing to work in the morning and back in the evening has made driving a nightmare. A possible solution would be to build overflies/over bridge roads to the suburbs. This solution however, isn't feasible in that the number of resources and space is far too limited. Therefore, ultimately there is no working around the need for traffic congestion control [9].

An efficient workable algorithm can be used in order to achieve this. A problem specific to Indian cities is lane management. We would definitely assume that in order to accomplish traffic management, individual lanes have to be better managed, into slow lanes and fast lanes. But the primary problem overlooked is the dynamic growth of the vehicles i.e. the accumulation of these vehicles at various cross roads and junctions. There are a very few algorithms which use dynamic vehicle monitoring to handle traffic in theory, and even less number of algorithms which handle dynamic routing in practical.

Another problem faced in developing cities is the amount of green signal time given to the empty streets, this signal time can be easily divided among the streets having vehicles and traffic density can be decreased.

Taking statistics to support our argument here it is seen that a normal person waits for around 300 hours in a year waiting in the queue staring at a red signal stuck in traffic. If this figure is boiled down to a single day it is calculated to be one hour a day. Understanding this statistic [3], it says that we waste 1 hour of our 24-hour a day schedule only waiting at a junction stuck in traffic, this definitely needs to be mitigated.

The algorithm presented later in this paper aims at scheduling the vehicles at a junction by calculating the number of vehicles on each road and using various parameters to disperse this traffic so as to decrease the waiting time of individuals drastically., traffic is an important part of our lives. Traffic has an impact on our transportation time and urban environment also. For example, the combustion of gasoline in petrol engine produces 2.4 kg of

CO_2 per 1 liter of gasoline (diesel engines produce about 0.3 kg more) [4]. Regarding the up-surging traffic density in cities, the environmental impact is of greater consequence there. This is the reason why in the smart cities of the future, the traffic control algorithm should not focus on the traffic objectives only, but they should be made to see the problem from a higher view-point covering the environmental impacts as well.

2. ALGORITHM

The proposed algorithm is set to utilize the resources present for the traffic management and time allocation in efficient manner. The first thing to be consider is nonetheless, for any combination of vehicles present at the junction [10], every car has to cross the junction. So, there always be a minimal time requirement the traffic to move. We cannot reduce this minimal amount of time, but we can minimize the wastage of time or to say, we can effectively utilize the time, to reduce the delays in current traffic management scenarios.

Initially, we need to understand certain terms. A Phase is a set of such roads which can be opened at a same instance without any disturbance to other open roads. A simplest example to be considered is all three roads from same direction. One will proceed to left, other to the right and remaining will go straight to opposite direction, without disturbing or creating situations of conflict at same moment. For each phase, one of the road will have maximum traffic volume per lane and this volume is termed as Critical Lane Volume. The sum of all Critical Lane Volume at a junction is Critical Volume. A Cycle is the time between the two successive green signals to a road. All roads present will be opened exactly once in a cycle.

There are few parameters considered in the algorithm for defining and allocation of green signal time to each road.

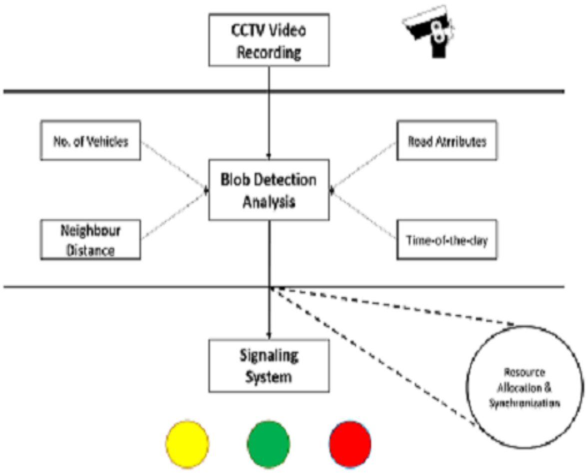

Fig.-1: Flow-Chart of Dynamic System.

Before that, one thing needed for the algorithm is the number of vehicles waiting on each road. This can be achieved by imposing various vehicle/blob detection techniques available on the video feed from CCTV at the junction. This will provide us number of vehicles with less deviation.

There are two major parts of the algorithm. First to decide the arrangement of roads in phases for a cycle. This arrangement is crucial part in the efficiency of the algorithm. Since, the well and better phases according to the number of vehicles lead to the better efficiency and optimality of the algorithm. Consider the whole traffic scenario as a task. Now partitioning this task into different phases should be coarse-grained partitioning. The bigger the size of the phase or more number of roads involve in phase will certainly devote to the more parallelism in using the resources and time. Also, keeping less number of roads in a phase will lead to more number of phases in cycle. In such fine-grained partitioning, the increased number of transfers among the phases will lead to wastage of time and irritation in vehicle drivers.

The major motivation behind this algorithm is the allocation of green time to the traffic in optimized fashion. There are specific situations which may occur in every traffic scenario. Discrete time interval taken by vehicles to cross the junction is one of them. It is always noticeable that, first few vehicles at the initial point of traffic cross the junction slower than the remaining vehicles following them. This difference in the vehicle speed results in loss of green time, which is termed as Lost Time. In some cases, a road can be narrow one, giving lesser vehicle per second value. This also affects the green time.

As a matter of fact, traffic at a junction doesn't remain almost similar throughout the day. Traffic at a junction can go to the peak at morning, and will be barely noticeable in afternoon time at the same junction. According to the locality, such as residential area, industrial area, etc. the traffic moment needs to be understood. For such cases, timing of the day also provides impact on the traffic routing. Traffic should be routed to the most prior direction according to the time of the day, and hence the rode should be allocated more green time. The number of vehicles passed through the junction in an hour is termed as Saturation Flow. Now deciding this Time-dependent factor should not be defined for a larger interval, since chances of change in traffic scenario during this interval may affect the management. Hence defining such factor for smaller interval of 15 minutes can provide better results. Peak Hour Factor is the ratio of the volume of vehicles in the 15 minutes at the junction to the volume of vehicles in the 60 minutes.

Algorithm : Green Time Computing

```
procedure GreenTimeCalc
    WHILE Vehicles_At_Junction
        Calculate CriticalVolume
        Calculate CycleLength
        Decide Phases

        FOR EACH phase
            Define PHF, LostTime,
                SaturationFlow,
            Compute GreenTime
        END FOR

    END WHILE

  END procedure
```

Fig-2: Pseudo-code for Green Time Calculation

Overall, this algorithm is built on the basis of various real-time scenarios and traffic defining factors. Calculation of these variable leads to better allocation of green time signal for roads participating in the junction. Such dynamic and real-time approach for traffic controlling will surely be more effective than manual management of the vehicular traffic.

3. EXPERIMENTAL RESULTS

The dynamic nature of the algorithm results in efficient management of traffic resources and hence providing with timely flow of vehicles through the junction. As it has been already discussed, Since the volume of the vehicles crossing junction at same moment remains definite, it is much likely to result in same time at which the last vehicle passes the junction, irrespective of the direction, in both the algorithm. So, whenever a new signal opens in dynamic algorithm, the vehicles benefits at the cost of extra time for vehicles at the previous signal. Though there exists a correlation between the timing for vehicles at different side of the junction, we can manipulate the relation such that, the waiting time can be reduced without a drastic effect on timing for other vehicles. The one thing need to be remembered is to maintain the correlation, so that other vehicles should not pay the bigger price, than what we are achieving

The graph in Chart-1, represents the waiting time for 12 vehicles in a traffic scenario i.e., first, middle and last vehicle of a route from each of the four directions at a junction, respectively. Orange colored line represents the Manual management of traffic, the static behavior of the process implies linear increase in the waiting time of the vehicles. Now, the line colored blue shows the changes in the waiting time of different vehicles due to dynamic management of the resources and signal allocation.

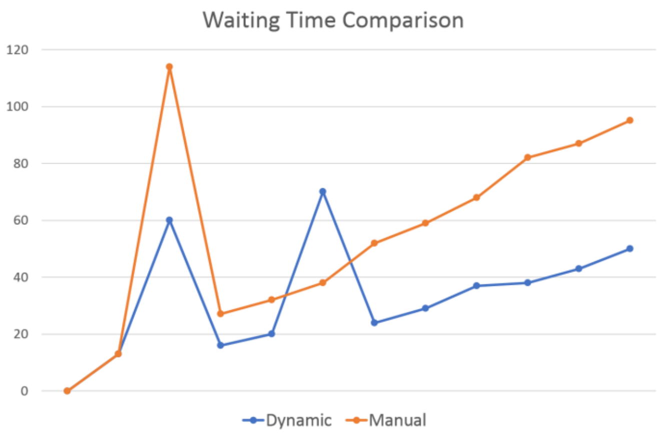

Chart-1: Waiting Time Comparison

As the comparative graph implies, for 1 coordinates i.e., one vehicle set among all 12 has lesser waiting time than manual management when traffic dealt with the dynamic algorithm. For initial 2 set of vehicles having same waiting time, leaving the remaining 9 sets with higher waiting time than manual one. Calculating the mean of these waiting time values, the manual one produces value of 55.58 whereas the dynamic algorithm results in the 33.33 seconds of average waiting time for the traffic scenario considered for both algorithms. Though for fewer vehicles the waiting time increases, for the whole scenario and the broader perspective, the dynamic algorithm provides efficient and optimized results for traffic management.

4. ADVANTAGES

Reduction in waiting time for a driver in Traffic
Such effective and real-time allocation of green time for roads at junction results in reduction of time spent by a vehicle at a traffic junction.

Reduction in total journey time
Implementing such algorithm in every possible or multiple junctions will compound the reduction in waiting time, resulting in reduction of total journey time to the beneficiary.

Lesser emission of Carbon gases from vehicles
Given that, vehicles need to spend lesser time at junction waiting for green signal with running engine, it leads to the lesser emission of green gases.

No need of Manual interference

Once installed and implemented, the management authority will need negligible human intervention in traffic routing and in managing the system.

Can be implemented with lesser architecture additions

For the working of the system, only CCTV installation is a hardware requirement at the minimal and sufficient.

5. CONCLUSION

The algorithm considers various real-life scenario problems and small interval of time involved in scheduling signal timings like saturation flow rate, maximum phase saturation. This method is better than the static algorithm used for scheduling which involves giving 15 to 20 seconds to each road regardless of the number of vehicles on that road. The simplistic nature of algorithm ensures that it can be implemented on low-end devices.

6. FUTURE SCOPE

The algorithm can further be totally automated by dynamically gathering and calculating signal controls without stopping the loop which might even be realized on the streets of countries like India or streets of another country by altering the number of phases. The blob detection can be altered to detect vehicles of varying sizes like huge trucks carrying cars and even bicycles. The peak hour factor can be precisely set depending on the locality of the street or junction at which is applied. Machine learning techniques that use previous and subsequent traffic signal data can also be used to enhance the dynamics of the current system. The system can be combined with navigation systems to improve signaling systems by bettering the accuracy of green signal times, based on data collected from this system.

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