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TIME DIVISION ALGORITHM FOR DENSITY BASED TRAFFIC SYSTEM USING IMAGE PROCESSING

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1.ABSTRACT

An increase in population is increasing automobile usage. More vehicles imply more traffic and hence demand better traffic management. Advancements in automobile industry have reached heights that work is going on "self-learning automobiles" but the system which manages automobile movement i.e., traffic management system lacks advancements and still follows conventional approach. Time division methodology at traffic signals plays a very important role and is discussed in this paper.
Green signal time at each side is divided equally in current system but the question is that is it justified? The main difference between equality and justice is that the equality means having an equal position for everyone whereas justice means the quality of being just, righteous or fair in every aspect. This conventional method is not fair as density of vehicles may vary from side to side. Thus, to make this system fairer and time efficient we have designed an algorithm which can be followed at traffic signals using image processing. Green signal time will be allotted according to density at each side and result will be better traffic as well as time management.

Key Words:Density Based Traffic, Image Processing, Object Detection, green light time calculation.

2.INTRODUCTION

Word "Traffic" in dictionary means movement of people or goods from one place to another but from the perspective of common people it is equivalent to nightmare.

We all are aware of the increase in traffic congestion day by day. So, it's time for us to focus and develop an efficient method that would manage the congestion caused and will prevent useless time delay. To understand this better we should be aware of goals of the system that we want to improve.

Goals of traffic management system is smooth flow of traffic with minimum congestion and to achieve these goals we need to advance our system. Here in our proposed algorithm, we are focusing on time division methods which can potentially affect the performance of current traffic management system.

Time-division: This term refers to the division of time for green signal among different lanes.

Our proposed methodology is not only based on the count of vehicles but it also takes size of vehicle (two-wheeler, four-wheeler etc.) into consideration before dividing time to each lane.

We are going to use object detection and classification on processed image in our proposed solution for density calculation. This density calculations will further be used to calculate time for green signal at a particular lane.

The proposed system is simple and cost-effective as no sensors and microcontrollers are required. The basic need of the system is a high-resolution camera to capture the images periodically. Our major focus is on method of dividing time among all lanes of traffic signal.

Events that affect density at lanes:

1. The congestion at particular lane that happens daily at the same place, at the same time which is mainly during office hours. This can be called recurring traffic. This also happens because the number of vehicles at that particular time are more than the capacity of the road.

2. Change in count of vehicles due to special occasions like festivals, weather change etc.

3.Blockage of particular lane due to construction work / accidents or some special reasons like reserving lane for leaders / ministers incity.

4. The congestion happens randomly because of some unpleasant event which causes a sudden increase in traffic. This can be called non-recurring traffic. But it becomes difficult and vital to manage the non-recurring congestion as compared to recurring congestion with traditional methods. It also requires real-time analysis to manage thisproblem.

Most of the above factors can be classified as non-recurring traffic which needs more advancement and real time analysis.

Thus,wecansaythatdensityatanylaneisaprobabilisticeventandisdependentonmanyfactors.Thus,allottingsame time for each lane is not fair. Proposed method can help in situations like this to a largeextent.

Need of this system:

1. **Time efficient:** Efficient time division will improve the flow of traffic and fewer traffic jams will be encountered by the public which will result in smooth driving. Also, wastage of green signal timing will be prevented.

2. **Resource Utilization:** As it is observed that many people do not turn off their vehicles at traffic signal which result in fuel wastage which can be reduced if the waiting time is less.

3. **Reduce Mental Harassment and accidents:**

a) One of the main reasons behind rash driving is getting late to reach the destination. Proper time division will reduce overall time to travel and thus will prevent over speeding.

b) The smooth flow will affect people mentally and the amount of irritation one faces during driving will be less. A calm mind will result in focused driving.

4. **Utilize road capacity:** Congestion will be minimized which will result in better road usage.

5. **Pedestrian Flow:** This system can save time of pedestrians at lane with low density.

It is well said that "life is too short to be stuck at traffic". Thus, a well-structured system is needed which is introduced in our project.

3. LITERATURE REVIEW

There is a lot of research going on this topic as it provides a solution to one of the major problems encountered by people. The real motto of technology is to make life easier.
If we talk about the past and present methods of controlling the traffic, these are the methods that were or being used:

1. **Manual Controlling:** In this, the traffic policemen stand at the center of the signal. They carry sign lights or whistles to control the traffic. They keep on guiding continuously that which side will move and which all side will stay and wait until their turn. But this management becomes very hectic and cannot be considered as smart means of traffic. With the growing technologies, we can design a smart and efficient system that would reduce human effort as well as control traffic in a more manageable way.

2. **Automatic Controlling:** Timers play an important role in this mechanism. In this, a fixed time is given to each side for the green light. The lights automatically get ON and OFF depending on the timer value shifts. The side of the signal which has green light will move and the rest will wait until their side of the signal turns green. This happens either in a clockwise or anti-clockwise direction. Since this traffic light system remains helpless in reducing the congestion, a smart system is needed which divides time based on density rather than fixing the time for each side.

3. **Sensors for intelligent transportation:** In this method, there are two sensors installed on each lane that detect the vehicles. These sensors are also used to detect vehicles violating red signals.

We went through many research works done previously and below is the summary of the same:

Microcontrollers-based solution: This solution comes under the field of electronics and communications. In this approach, traffic is controlled at signal using infrared sensors with an embedded microcontroller chip. This approach is discussed in (*Udoakah&Okure, Design and implementation of a density-based traffic light control with surveillance system 2018*).
In one of the researches works as cited (Amaresh et al., *Density-Based Smart Traffic Control System for Congregating Traffic Information 2019*) priority-based scheduling is used in which time allocated depends on the density percentage. In this previous research, work density is equivalent to the count of vehicles.
Some authors focused widely on how to find density. One such method is to compare the original image to referenced image. The difference in the count of objects/vehicles gives the density percentage. Time allocation is based on the previous method as discussed above. This approach is discussed in (*Tahmid& Hossain, Density-based smart traffic control system using canny edge detection algorithm for congregating traffic information 2017*).
Technologies like Arduino uno, image processing with MATLAB, raspberry pi is widely used in density-based traffic system to connect software implementation with traffic lights. Few works are there which combine IR sensors with image processing to improve the accuracy of the system. Few authors also included emergency services like giving priority to an ambulance in their project. It is very significant work as waiting time for an ambulance will be reduced. In all the related work major focus is given on density calculation, in our project, we are more concerned with the time allocation algorithm. Research work studied by us generally used the approach of calculation of density of all sides at once before the beginning of the iteration.

4. METHODOLOGY

To design an efficient traffic management system, we need to focus on methods that consider real-time scenarios and then work on them accordingly. It is needed that fixed timers for green light must be replaced with a dynamic time allotment system to achieve the goals of a traffic management system. For this, we have come with an approach where we don't need to calculate time for all sides at once. The method is based on the approach that while one lane is having a green signal on, calculate the density of the rest of the three lanes (In a standard four lane system), and using these density values we can find green signal time for the next lane in a clockwise or anticlockwise direction.
Starting with the first lane when all the sides/lanes of traffic point complete their green signal timing once we call it one complete iteration or cycle. In the current system, there is a fixed total time for each iteration which is distributed equally among all the sides. For e.g total time be T and total sides be 4 so each side will have green signal time = T/4.
Our objective is to distribute this total time T among lanes fairly considering density.

Density Calculation: In our proposed system the time for the green signal is a function of the number of vehicles at that side.

Density: This term here not only refers to the count of vehicles but it refers to a function that takes count as input and returns formulated value of density.
For calculating density, first we need to keep a count of the number of vehicles on that side.

For this, we are using image processing using OpenCV in python. We will then detect vehicles with the help of yolo and label them as cars, motorcycles, and buses. For each kind of vehicle, we will have some weight based on the size and speed of the vehicle that will be multiplied by it.
The weights that we have taken in our algorithm are:

Type of vehicle	Weight associated
Motorcycle (two-wheelers)	0.75
cars (four-wheelers)	1
bus/truck	1.5

The final density will be calculated by the formula:
X = 0.75*Nm + 1*Nc + 1.5*Nb
where Nm, Nc, and Nb are the number of motorcycles, cars and buses respectively detected in an image.
In this way, we will get a value of density at any particular side.

Algorithm to find green signal time:

When the signal at one side is green, capture the image and calculate the density of each of the remaining sides.

Find the sum of densities of each side

sum = X1 + X2 + X3 + … + Xn-1

Here X1 , X2,… Xn-1 represent next i^{th} side for any side numbered i.

n is total number of sides (In + type intersection n=4).

Using above values calculate green signal time t for next lane:

t = [(density of next signal) / sum]*T

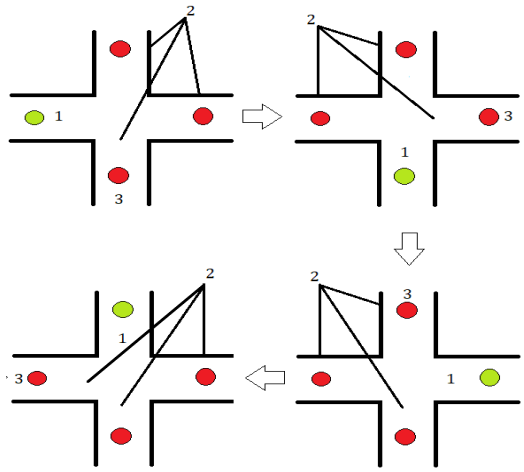
Where T is total time reserved for one complete iteration.

Thus, the amount of time any side gets is proportional to the density at that side. This process will run in the loop.

Initial conditions: For the first iteration, we can give one by nth part of total time to the first side and calculate next by using the above method.
One more possibility is that we can find time t for the first lane in the first iteration by simply using the formula:

t = [(density of the first lane)/sum of densities of all the sides]*T.

Illustrative diagram:
The working of this method can be understood from following diagram.



In this diagram, green denotes the side/lane with green signal on and red denotes the remaining sides with red signal on. Following diagram depicts the one complete iteration of traffic signal.
Numbers at each side represents steps to be taken in order:
1: It represent the side with green signal on.
2: Calculate density of remaining sides.
3: Using calculated density in step 2, find green signal time for next side dynamically.

Why this method?
In this method, density is not based on just the count of the number of vehicles but also on their size and speed.
We observed that if the number of buses on one side is equal to the number of motorcycles on another side, we need to give more time to the side having buses. This is the reason behind using this weighted approach.
So far, we have seen that in all related work, time was calculated at the beginning of iteration which can cause signal which just had the green light on to suffer as density for that side will always be less than others. To overcome this, we are calculating the green signal timing of the side dynamically when its previous side is having a green signal.
One more method could be of giving green signal time to the side with heavy density without following clockwise or anticlockwise turns which can result in starvation for other sides and confusion for common people as they will not know which side will get green signal next. Hence, we are following a clockwise or anticlockwise direction which is similar to the round-robin system in process scheduling.

6. CONCLUSION

To encounter modern congestion problems and to utilize time at signals properly it is very important to move from conventional methods of traffic controlling to density-based traffic management. Various approaches are used by many authors and in addition to that our project provides an efficient method for the division of green signal timing among four lanes at a traffic intersection point. This method removes some of the existing limitations and introduces a dynamic approach to tackle the problem stated. This density-based system has a wide scope and can be used to integrate all the signals of a city to provide a proper density flow overview on maps. This methodology can lead to many other

advancements in traffic management when combined with other technologies.

7. ACKNOWLEDGEMENT

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