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Smart Traffic Light Switching and Traffic Density Calculation Model using Computer Vision

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***Abstract*. Different Traffic control systems have played a crucial part in traffic management around the globe, especially in densely populated major cities, but they are still not as efficient as they could be. Perhaps some changes can be made to better deal with the traffic in this ever-changing traffic density environment. Traffic congestion has consistently been a rage issue in numerous urban cities. The traditional way was to give each lane a specific predefined time with the green light and had to stop for the rest of the time. Even the lanes with no traffic got the same amount of time as the lane with huge traffic jams. These were promoting traffic congestion rather than solving the issue. Thus, the need for a better system has emerged for changing the current traffic handling setup to be smarter enough to meet this ever-changing demand. In this paper, the idea of traffic lights controlled by live video feed is explored with an enhanced traffic flow system to optimally benefit from the computer vision technology used.**

Keywords: Traffic light, Computer Vision,vehicle detection,image processing

I. INTRODUCTION

To manage traffic and to control the flow of vehicles in a disciplined way at every interaction we make use of traffic lights. There are three standard colors used in this i.e red, yellow, green. The present systems in India are inefficient due to the use of traditional systems of predefined specific times for each light. Although these systems have been fine-tuned to accommodate the traffic on a particular road these tunings are far from sufficient. The present traffic control framework in India is not that effective mainly due to unevenness of the number of vehicles flowing at that time frame of the day or week. The traffic signal timers are usually defined using data from over a year of traffic patterns on the road which might result in unproductive results as traffic density changes from moment to moment. As a result, the people have to suffer time loss even if the other lanes are clear and without traffic. In this paper we propose an idea in which we can manipulate the traffic light as per the live traffic vehicles count. Which will lead to better traffic flow and less wastage of time of the travelers. Traffic congestion leads to loss of productive time being wasted, traffic rage issues, delayed delivery, etc. Therefore, by solving this traffic problem we can better the living standards of society in general.

The proposed method in the paper gives us an alternate cheap and reliable system to tackle the problems mentioned above. The advancement in computer vision and processing systems has led us to explore the possibilities of better traffic systems in India.

II. RELATED WORK

In [1], The suggested system aims to provide a complete application to manage traffic signal systems dynamically based on the current vehicle count.

The authors have proposed a system in which the signal lights will be adjusted in accordance with the volume of traffic in that specific lane. A preference will be given to the lane with the most traffic. Although this technology has been used with sensors in the past, they are attempting to replace the entire system with video processing. Since no sensors need to be purchased, the substitute has cheap costs.

The proposed System consists of 6 steps: Image acquisition, Image Cropping, RGB to grayscale, Threshold, Contour, Calculate traffic density.

The author gets an accuracy of 83.33% for the detection of vehicles.

The author uses this hardware for implementation: 1) Power Supply, 2) Arduino, 3) Servo motor, 4) USB, 5) Camera, 6) Python 3, 7) Arduino IDE, 8) OpenCV, 9) Ubuntu 19.04.

The study demonstrated that video processing is a useful method for reducing traffic. Using actual traffic frames is also more reliable for detecting the presence of vehicles.

In [2], This study describes a new approach for regulating vehicle density by managing traffic signals with image processing. Vehicle density is calculated using specified classifiers from image processing. If the detected density exceeds the usual density (threshold value), a signal is sent to the traffic signal's microcontroller that controls the traffic light to display appropriate traffic lights. Software and hardware used for implementation are Library-OpenCV, IDE-Qt, Arduino Uno, Bluetooth, and LCD projector.

In this project, an Arduino Uno is utilized to transmit Bluetooth signals to and from interruptions like ambulances and fire departments. Because it is simple to use and because all of the design requirements, schematics, and software libraries are publicly available to all users on the open-source board, it is utilized in this project.

This system uses ANN and YOLO for vehicle detection and helmet detection

In [3], The author uses two virtual detection lines in this technique to only count a vehicle once (VDL). Only the region of the virtual detection line is computed by the classifier. Therefore, cars are only identified when they enter the area between virtual detection lines. Create four categories for the road's state after tallying the number of passing vehicles: 1) free), 2) moderate), 3) busy), and 4) heavy). They provide the vehicle-to-lane ratio. Without taking occlusion into account, the typical rate of detection is 97.8%. The typical rate of false positives is now 1.8%.

Additionally, the counting accuracy is acceptable.

The proposed approach offers 93.11% accuracy in counting. Although the findings are encouraging, the algorithm still requires modifications. because the method's accuracy suffers when there is a lot of traffic. Additionally, it produces an unsatisfactory outcome on routes where rickshaws are widely available. The obstruction of traffic is the cause.

In [4], in this methodology every 30 seconds (in green time), the densities will be compared, and there will be a 5-second wait in the middle of light changes (yellow time). At each check, the group of lanes with the most traffic will be given green time, while the other group will enter red time.

The first cache of frames used in background reduction comes from the camera's video input. They are implementing BS with a mixture of the Gaussian (MoG) model. By using this method, memory utilization is decreased and less powerful hardware may be used to accomplish it. The recommended approach only works effectively when there is little traffic and no cross paths.

III. Proposed Idea

A. Traditional lane management system:

To better accommodate the traffic flow, we first propose a different lane management system at the intersections.

As the traditional system dictates in fig 1. There are 4 lanes at the intersection as given in the diagram given below, the 1st and 3rd lane being part of one road and 2nd and 4th being the part of the other road. In a two-road intersection. Each lane is further divided into two parts

- Right and turn and straight movement of vehicles.
- Left hand turn movement of vehicles.

The left-hand turn is always on green as there are no obstacles for this directional flow.

Whereas the right and turn and straight movement of vehicles have to wait for their turn (until the light turns green) and move only in the time precalculated.

Thus, giving us 4 motions of vehicles one for each lane to be governed by the traffic light.

The traffic signals turn green in an anti-clockwise direction. Both the Right hand and the straight movement of vehicles is allowed during this time gap.

This method of lane management has stood the test of time, but better systems can be proposed for a smoother flow of the traffic.

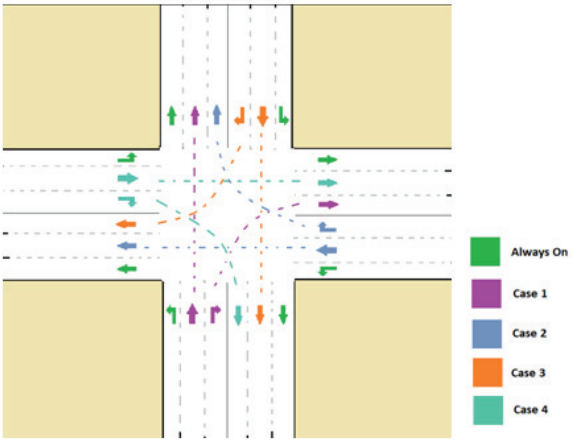


Fig. 1. Traditional lane management System and each case represented by a different color.

In is lane management system the flow of cases would be

Case 1 => Case 2 => Case 3 => Case 4 => Case 1. (Anti Clockwise Movement)

B. Proposed Lane management system:

We usually observe that on an intersection the right-hand turn vehicle is comparatively very less compared to those who want to go straight. This can usually be seen very clearly in a case where a main highway is intersected by smaller roads as tributaries.

In the proposed lane management system as shown in fig 2, we divide the movement of vehicles not based on the lanes but on the bases of direction the vehicles want to travel

Given in the below diagram we can see the different groups each lane is divided into.

The groups are as follows

- Straight movement of vehicles of a road
- Right hand movement of vehicles a road
- Left hand movement of vehicles on all roads

All the left-hand turns are always green, similar to the traditional system. Although only the straight movement or right-hand movement of vehicles is allowed at a time for a lane.

Thus, giving us 4 groups of vehicle movement 2 for each road to be governed by the traffic lights.

This system is better as it also helps managing the pedestrian movement relatively safely and efficiently. The pedestrians can walk when the parallel straight lanes are moving.

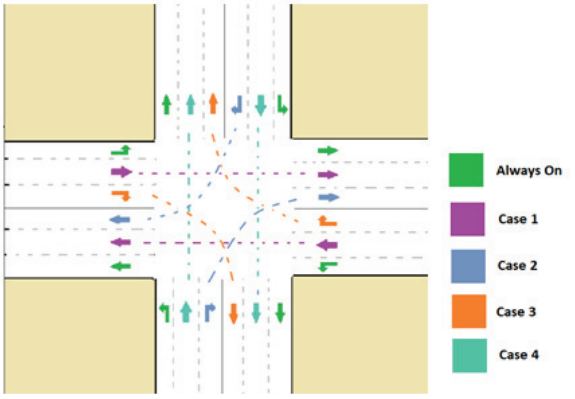


Fig. 2. Proposed lane management System and each case represented by a different color

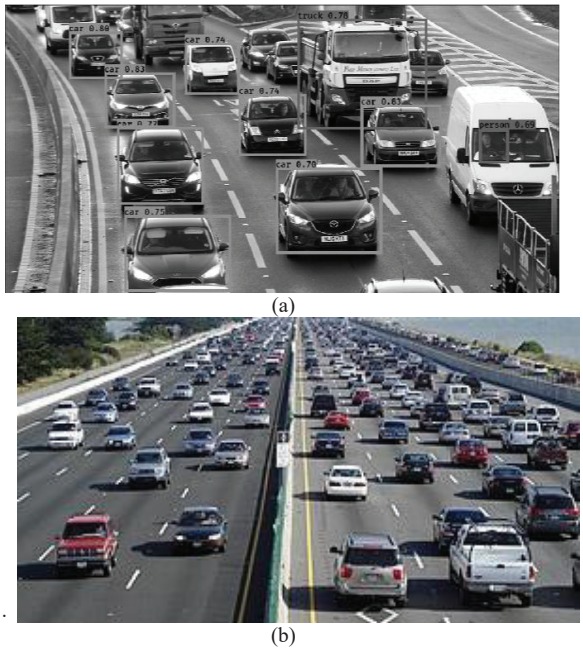
In is lane management system the flow of cases would be

Case 1 => Case 2 => Case 4 => Case 3 => Case 1.

C. Proposed traffic light switching algorithm:

1) Technical Setup

The system consists of Four cameras one facing each lane at the intersection. These cameras focus on the vehicles arriving grid, as seen in Figure 3. The idea is proposed to be carried out by a conventional PC, or a mini computation device running YOLO-3 like a raspberry pi.



(a)

(b)

Fig. 3. (a) Yolo vehicle recognition; (b) Traffic image capture

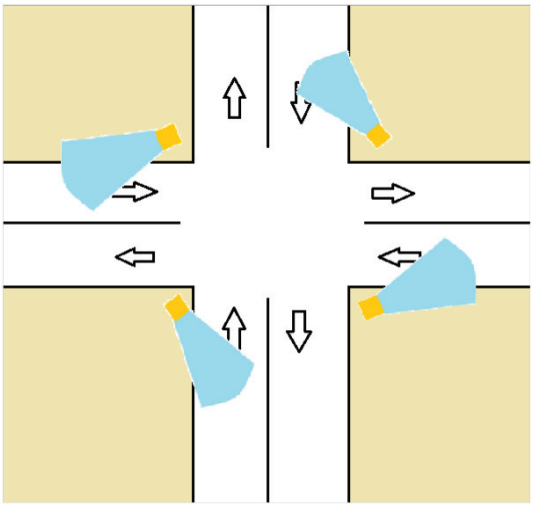


Fig. 4. Placement of the cameras.

Each camera is connected to the main processing unit. The cameras capture video with a resolution of 416 x 416 pixels, enough to distinguish the number of vehicles on the road.

Analysis of the situation is done using the YOLO-3 software on the processing unit and relative time for the green light to be switched on is provided

2) Calculations based on the observations

The images from the cameras are fed to the processing unit which uses YOLO-3 to recognize the number of vehicles in the lane into two categories. The vehicles which are in the straight movement lane and vehicles in the right-hand turn lane respectively, where n is the average of the traffic count of corresponding lanes. l is the number of lanes for vehicles to move. Mostly one for right hand turn, one for straight motion and one for left hand turn vehicles, although these can vary.

The length of the crossing of the intersection is pre-measured as S, and the average acceleration of vehicles is assumed to be 1 m/s2. The speed limit set for the vehicles on the specific road is assumed to be v (in km/hr).

TABLE I. CALCULATIONS BASED ON OBSERVATIONS

	Time green (T_g) in seconds	Time yellow (T_y) in seconds	Time red (T_r) in seconds
Opposite Straight road 1	$\sqrt{s}\cdot\frac{n}{l}+A_1$	$\frac{v_1}{4}\cdot(0.27)$	Rest of the wait time
Opposite Straight road 2	$\sqrt{s}\cdot\frac{n}{l}+A_1$	$\frac{v_2}{4}\cdot(0.27)$	Rest of the wait time
Right turn road 1	$\sqrt{s}\cdot\frac{n}{l}+A_2$	$\frac{v_1}{4}\cdot(0.27)$	Rest of the wait time
Right turn road 2	$\sqrt{s}\cdot\frac{n}{l}+A_2$	$\frac{v_2}{4}\cdot(0.27)$	Rest of the wait time
Pedestrian group 1	Same as OS1	-	Rest of the wait time
Pedestrian group 2	Same as OS2	-	Rest of the wait time

IV. FLOWCHART FOR PROPOSED TRAFFIC LIGHT SWITCHING:

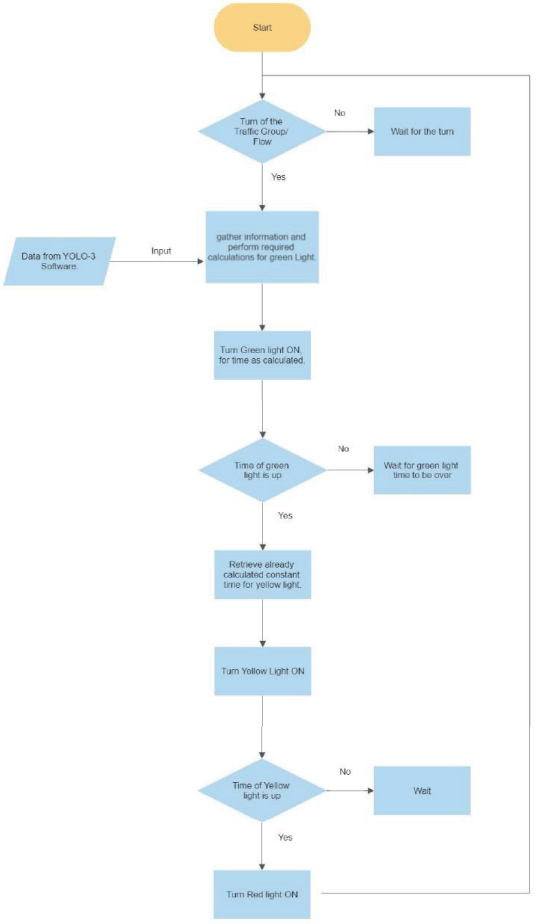


Fig. 5. Flowchart for proposed Traffic light switching

V. CONCLUSION:

Analyzing road footage to monitor traffic is an extremely difficult task. On congested roadways, it is more challenging. To better handle the traffic flow, we have suggested a better lane management system at the junctions and we have mentioned the technical setup for traffic light switching algorithm. We are investigating the potential for improved traffic systems in India as a result of the development in computer vision and processing systems.

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