An Efficient Algorithm for Detecting Traffic Congestion and a Framework for Smart Traffic Control System


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Abstract—Since the number of vehicles is increasing day by day, traffic jams are becoming a common scenario in large cities like Dhaka. These frequent traffic jams at major junctions kill a lot of man hours. Thus it creates a need for an efficient traffic management system. This paper proposes to implement a smart traffic control system which is based on the measurement of traffic density using real time video processing technique. The video sequences from a camera are analyzed using object detection and counting methods to obtain the most effective way. The computed vehicle density is compared with other parts of the traffic in order to control the traffic signal brilliantly. The system has an advantage of using RFID sensors to ensure law enforcement. Therefore, any car or vehicle which breaks the traffic rules can be easily caught. Through this paper we tried to present a progress in the existing manual traffic control system.

Keywords—Intelligent Traffic Control, Object Detection, RFID, Sequential Timing Algorithm, Traffic Density, Video Processing

I. INTRODUCTION

Traffic light posts are positioned at road intersections and pedestrian crossings. Traffic light posts blink the light Signals after a certain time period which is not a complete systematic system [1] as it cannot solve the traffic problems fully. Thus traffic jams take place. Lack of trained traffic police officers [3] and old manual traffic light control system made this problem worse in many cities like Dhaka, Chittagong etc. Since the traffic vehicle pressure is not same at every road at the same time, Traffic lights should be controlled by an adaptive system which will detect the traffic conditions and use traffic light signals accordingly. Instead of using electronic sensors embedded in the road [2] our system is based on Video processing which is a form of signal processing and for which the input is a video frame; the output of video processing may be either an image or a set of characteristics or parameters related to the image. Our system will detect vehicles through video frames instead of using any other Mechanism. A camera will be installed alongside the traffic light. It will capture video sequences of traffic condition on road. This technique will analyse the videos from cameras and count the number of vehicles for each direction and also import to the controller. Then the controller estimates a period of time needed by each path to open and each traffic light to turn on or off based on the number of vehicles in a fixed sequence. It will also be used to monitor the traffic conditions. It can reduce the traffic congestion and avoid the time being wasted by a green light on an empty road. This system is more reliable to detect vehicle presence because it uses actual traffic condition images. This system is intended for country like Bangladesh where traffic policeman can take clever, critical decisions and handle emergencies but with the help of our automatic system they can use preset signal timings to control traffic at intersections because it provides more accurate information for signal decision making.

II. PROPOSED MODEL

In our proposed model, there will be four cameras in one intersection for a four way road. A CPU will be connected with these cameras which will be responsible for video processing. The RFID will be placed under the road for detection of the car. The hardware’s that we will be using are: HD Camera, CPU (For video processing), Microprocessor (For traffic light controlling) and RFID Reader (For vehicle detection) which will be beneath the road. According to Figure 1 a High definition camera placed on poles will observe the vehicular traffic flow continuously on a road. Then using frame by frame Real-time video analysis through our developed algorithm, we can detect how much cars are present on the road. Depending on the number of detected vehicles we have developed and implemented a sequential traffic timer system. Microcontroller will detect the signal from CPU and start the sequential traffic light. While the light phase goes from green to red, our microcontroller or arduino will send a signal to CPU and CPU will energize the RFID reader. RFID reader will detect the car which already has a RFID tag [7]. This information will be transmitted to CPU or the central database. Thus our system will detect the law breakers who move regardless of the red light. According to this automatic traffic system, the traffic light ON/OFF will depend on the number of vehicles on the road. The HD camera will be installed in the traffic light post at a height of 19-25 feet above the road which is illustrated in Figure 2. This camera will take the live video footage of the
road and send it to a computer where video analysis will be done. For a 4 way intersection, CPU will detect each and every car and will count the vehicle number in the road by using our developed algorithm. It will also do the same thing with other road by using another camera. CPU then compares vehicle number of both roads. The road which has more vehicles will get the preference and green light for that road will be on and red signal will be shown automatically to the other road. Traffic lights will be connected to the computer and intelligent system will control the traffic light system. Our project is divided into three parts:

A. Algorithm for Traffic Detection
B. Smart Traffic Light Management System
C. Law Enforcement by RFID Reader

A. Algorithm for Traffic Detection

Car detection by video processing is the most important process to implement our project. Video processing will be done by using OpenCV (OC) instead of MATLAB for its faster processing [4]. Installed camera will send the output to the main server computer that will analysis that video and give its after analyzing result to the microcontroller. The vehicles are detected with the help of OC and camera.

Here first the vehicles are detected by some car models in xml file. Figure 4 depicted the result of the code. By using Cascade Classifier we have created haar_cascade. It was trained in that xml file with some rickshaw model. Then we have subtracted the background and the shadow by Background Subtraction (BS) with the help of BGS library. Another technique that we have used is Blob detection for better detection. We have filtered the video frames by area, circularity, convexity and inertia. There can be limit of counting vehicles for a segment of road and that will be given by the user. When the given amount of vehicles are detected which are standing on a jam, it prompts a message to the user. Then it changes the camera and works in the same way for other segments of the road. Finally it makes decision after calculating the jam situation. 4 cameras will be installed in every lane in 4 lane intersection. All 4 cameras will send its data to the main computer and computer will send it to microcontroller. The microcontroller will follow some mechanism to decide which traffic light will be on/off in the road. The mechanism is described in later part of this paper.

Car detection procedures and steps are shown bellow in the flowchart.
B. **Smart Traffic Light Management System**

Smart traffic light system working procedure can be divided into two parts.

1) **Camera Placing Calculation**

3) **Traffic Light Controlling Mechanism**

1) **Camera Placing Calculation:** Car detection is the primary work of the system. For detecting car or any other vehicle, Camera placement is very important for better vehicle detection and accuracy. Perfect height and angle for camera yield high accuracy for car detection, by ensuring the most area coverage. The higher the camera coverage is, the better decision this system will make. According to proposed project, we will set up a camera in the Light post. The height has to be in a certain range so that the software could detect car and detect as many car as possible in a road. After taking samples from various heights, we calculated that when the camera’s height is in range between 19 feet to 25 it gives us the best result. So camera’s height should not exceed 25 feet otherwise there will be problem to detect car for the software. Any kind of obstacle must not come in front of camera so; it should be placed in such region where clear line of sight is available.

In Figure 4, the camera placing height and angle is perfectly illustrated. In our project we use camera at length of 25feet (7.62 meters).

Base Angle = 7° and Rise = 7.62

Base = \[
\frac{7.62}{\tan(7)}
\]

Top angle = (90° - 7°) = 83°

Diagonal = \[
\frac{7.62}{\sin(7)}
\]

Our goal is to get more than 40 cars in the frame. By this arrangement we can get coverage of 62.06 meter. Now we need to calculate how many cars could be possible to detect in that road within our coverage. Average length of a sedan car is approximately 4.5 meter; so,

\[
\frac{62.06}{4.5} \approx 14 \text{ Cars in one column on the road.}
\]

There are 3 or 4 columns of car can accommodate on the road. So assuming 3.5 columns of cars are there (for 4 lane road), then we will end up with 13.791111 × 3.5 = 48.2 cars (50 cars approx.)
3) Traffic light controlling mechanism: As we are working with a four way intersection, for the time being, we will break this down for just one road only. For each road we will check twice for traffic. We have shown before that we can cover almost 50 cars (48.2 cars to be exact) with our camera for a specific road. So we will put a threshold value of 48 cars, means if our video processor could detect 48 cars then the OC will send a specific string in our com port of arduino. Microcontroller will keep checking if there is the string or not. This will lead us to two situations. If arduino could detect the string in its com port it will consider the road is crowded which is situation 1. If arduino could not detect the string in its com port then that will be situation 2 which indicates the road is not so crowded. For situation 1 (Table 1) (When a road reaches its car threshold value) we will turn the green light on. This light will be turned on for 60 seconds. After passing the Assigned 60 second the OC will check again for the traffic. For situation 2 (When a road is not near its car threshold value) we will turn the green light as well, but for shorter period of time which is 30 seconds. After passing assigned 30 second the OC will check again for the traffic. This whole process will be repeated by the system for the same road again. So in total a road will get 90 (60+30) second at most and 30 second at least. Car threshold can be changed according to traffic conditions. Traffic situation is also not same all the time. Traffic pressure is very much high during rush hours or any other emergency period but it is much less at late night. So interval between lights and threshold car value will be changed according to time. Threshold value will be higher during traffic congestion and less during late night.

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<th>Red</th>
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<td>On/off Time(sec)</td>
<td>On/off Time(sec)</td>
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<td>5s</td>
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<td>0s</td>
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<td>30s</td>
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C. Law Enforcement by RFID Reader

This system will be built to detect and identify any vehicle which breaks law especially traffic signal law. RFID Tags are intelligent bar code that contains some information which can be read by using RFID reader. It exchanges the information by using electromagnetic field to transfer data for the purposes of automatically identifying and tracking tags attached to objects. The chip typically is capable of carrying 2,000 bytes of data or less [5]. A RFID reader has basically three parts. They are:

- Antenna.
- A transceiver with a decoder to interpret the data
- The RFID tag - that has been programmed with information.
- Computer which will show the information.

RFID (Radio Frequency Identification) tags are already installed in almost every vehicle's number plate in Dhaka this contains the basic information of the owner of the vehicle. For every car there will be a unique passive RFID. This passive RFID will be energized by the reader. In Fig. 6 we have tried to illustrate the system in a block diagram. According to this system a RFID reader will be placed in the joining point of the road junction where a car must stop when the traffic signal shows the Red signal. During the red signal this RFID reader will be active and other time it will be deactivated. During its active time if any car breaks the law and move despite red signal, those cars will have to cross the RFID reader which will be placed beneath the road and RFID [Fig. 7] will then detect the RFID tag of the car. It will read the stored information of the tag which will be used to detect the owner and penalized him according to law. RFID reader detection zone area radius should not exceed more than 1 meter otherwise it could detect legally parked car also. It will be better if the radius of the RFID detection zone is lengthwise. So according to these conditions of this project, it will be best if we use High frequency (HF) RFID. More than one RFID can be placed beneath the road for wide road.

III. CONCLUSIONS

From the beginning, the promise of the traffic system management has been to develop the current traffic controlling situation and make things happen smoothly without any blunders. Video detection technology became a new frontier in case of vehicle tracking because of its dependability. This type of traffic signaling is more structured however; we are far away from seeing widespread use of this type of traffic controlling by video detection. Each area needs to be exclusively programmed and the RFID equipping and maintenance is somewhat costly. Unlike any other system, our system confirms high accuracy and we are confident about its success and feasibility. However, further research and development in this management system could bring that extra edge. So far we’ve made this system to ease the traffic law enforcement agencies. There are still some cases where manual controlling is needed. Connecting all the individual intersection or node could be the next big step. Knowing about the traffic pressure of the adjacent node would make the system more artificially intelligent. Gathering data from adjacent nodes would give extra accuracy during traffic signaling. Taking live traffic feed from the node and putting it in a dedicated server for the mass people would be very promising. Drivers will check their destination route for any congestion from that server through a Smartphone application. Then the driver could choose the route that is free of congestion and can reroute their destination. As a result of that extra congestion would not occur.

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