Traffic Light Control System Using Image Processing

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Abstract - In present times traffic plays a huge role in people's busy lifestyle, this requires a more effective and efficient method to deal with today's consistent growth of traffic at big intersections. The paper proposes using Image Recognition to incorporate a smart traffic controller. This system detects the vehicle on the lane and based on detection it estimates the vehicle count. The vehicle count tells the traffic condition, is it high, low or normal on a lane.[3] If it is normal then basic traffic management will work or if it is low or high, then only on its basis certain type of traffic management will work. Not now, but in future the system will be going to work on some other functionalities like emergency vehicle detection to deliver the fast emergency to the one who need and the system will also estimate the traffic and its condition on the lane using database and predictive analytics to predict the traffic situation on the lanes that not only help system for its proper functionality but also help people to decide their movement. Based on the number of vehicles in either direction, it was customised to be used in the future to monitor the traffic light sign by allowing each sign ample time.[1]

Keywords – Traffic Light Control, Image Processing, Traffic management, Object detection, Vehicle count.

I. Introduction

In this modern era, the one of the most important need and want is quick mobility which in term related with transportation [1]. For transportation there is a medium called vehicle and with continuous growing population, the number of vehicles increases as well. With this modern transportation infrastructure, a management is needed to manage the traffic because nowadays traffic congestion become one of the most concerning issue. Traffic management manages this traffic congestion to avoid increasing accidents and hazardous.

The traffic management system that manages the current situation basically follows image processing. Image processing is a method of performing operation on the image to get an improved image or to extract the useful information from the image. In this method there is a technology named as object detection which deals with detecting object from any digital video or images. The current Traffic management system uses this object detection technology to detect vehicle. This system first detects the presence of vehicle on the routes using object detection algorithm and on the basis of vehicle count, it estimates the traffic. The traffic estimation tells the system that how it needs to manage the vehicle congestion on the lanes.

[4] There are different cases while managing the traffic that are based on vehicle density or vehicle count on any of the route. The first case is, if the vehicle count is normal or not exceeding the maximum count then the system manages the traffic with the concept followed by basic traffic management system where for every route, a green light timer is set for a specific time which is certain for every route. Another case is, if the vehicle counts crosses the maximum counts on any route then the timer for the route will increase to reduce the congestion and increase the mobility. The next case is, if the vehicle count on any route is zero then the timer will skip that route, so that time wastage will reduce. This system only motive is to manage the traffic efficiently so that increasing vehicle density will not affect the working life as well as social life hazardously.

Fig 1. Flowchart of the Algorithm.

II. EXISTING METHODS

[5] There are various existing methods which is used in object detection for traffic management system other than BackgroundSubtractorMOG, which is used in this project as an algorithm for object detection because of its appropriate process timing and working. But there are some flaws or problem that are found in these existing methods as a disadvantage for selecting them in the project and which are as follows.

1. R-CNN

The Region based convolutional network or R-CNN is a method for object detection which uses selective search algorithm where regions are extracted from the image as a region proposal which further will be feed into CNN to extract the feature for knowing the presence of an object within the region. This method is used to detect the presence of vehicle by segmenting the frame of a video into a set of regions.

This method has some problems while working as an object detector for real time. R-CNN method cannot be implemented on the real time videos as it takes around 4050 seconds to process a frame which is time consuming as well as a slow process for the live traffic video where foreground can be change after every frame. Due to its slow speed, the system will skip some of the vehicle detection which effects the car count value and an error will occur while estimating the traffic on the route, on the basis of car count.

2. FAST R-CNN

The fast Regional based convolutional network or fast RCNN is a method for object detection which uses same concept as R-CNN for detecting object but instead of feeding region proposal, an input image is directly feed to CNN further from there region proposals are identified to known the presence of an object in the region which is fast as compare to R-CNN.

This method is used to detect the vehicle for estimating the traffic or knowing about the route instead of having fast speed it is still not an appropriate method for real-time videos as it take around 2 seconds for each test frame which is still time consuming and slow for counting the vehicle on the route. This method results an error if it skips any vehicle which passes from the route and varies the vehicle count.

3. FASTER R-CNN

The faster Regional based convolutional network or fast RCNN is a method for object detection which is the solution of the problems faced by Fast R-CNN method i.e., slow speed. Instead of using Selective search algorithm, this method use object detection algorithm that lets the network predicts the region proposal by itself and further detect the object in the region.

This method reduces the complexity but for the real time traffic estimation the method requires many passes to extract the object or the car from the single frame as well as the there are many systems working one after other in the model so the performance of one depends upon the other which is indirectly time consuming.

4. YOLO

You only look once or YOLO is a method for object detection which split the image into s*s grid, where there in each grid there is no bounding boxes and further the bounding boxes are selected with class probability which is above the threshold value and are used to locate object in the image. The YOLO method is used to detect the cars using single convolutional network with the concept of bounding boxes and class probabilities of those boxes.

This method is fast and appropriate but as it follows grid cells concept i.e., if cell contains more than one car than the model will not be able to detect all of them correctly and the another case which is there is that if the car locates in more than one grid than it detects the car more than one time. This varies the car counts and results an error.

5. HOG

Histogram of oriented gradient or HOG is a method for object detection which split the image into small cells of squared shape and further evaluate the histogram of oriented gradient in each cell. Then the results are normalized and based on occurrence of gradient orientation, object are localized in the frame.

This method is used for traffic estimation because it is simple and easy to understand but the method can only handle the object i.e., vehicle which can only be observed from a single orientation, it means it need to be certain. The drawback of this method creates a problem when the camera for the traffic estimation changes its orientation from one route to another, the model get failed or stopped working for other routes.

III. PROPOSED SYSTEM

The proposed system is implemented in Python using OpenCV library with an objective to detect the number of vehicles on a particular lane in a given time period. The algorithm which is being used in the system in BackgroundSubtractorMOG.

As the name of the algorithm suggests, we actually detect the moving foreground from the static background in order to detect the vehicle on the intersections. Background Subtraction Algorithm is widely used for detection of moving objects in reference to a static background.

[1] Fundamental logic behind the detection of moving object is the difference between current frame and a reference frame, also called as “Background Image”. This method is also known as Frame Difference Method.

The System is divided into five major steps:

1. Image Acquisition

This is the first step in the process of digital image processing. In general, an image is considered a twodimensional function f (a, b) where a and b are spatial coordinates. The value of this function at any instantaneous point is known as intensity or grey level of the image. The values of a and b must be converted [13] into finite discrete values in order to form a digital version of the image which could be processed through a digital computer machine. Each digital image is made up of pixels which are finite elements. A prerecorded video is used for processing and frames are extracted to obtain images.

2. RBG to Grey Conversion

All the colour images are in RGB (Red Green Blue) Format. We convert these colour images into greyscale images because in greyscale image each pixel is represented using 8 bits and the pixel values are represented using 256 different levels ranging from 0 to 255. The greyscale values are obtained as a weighted average of the individual values of R, G and B component of a colour image as 0.3R + 0.59G + 0.11B

3. Morphological Transformations - Dilation

Morphological Transformations are basis operations done on the image shape. It is performed on binary images. We give two inputs; one is the original image and second is the structuring element/kernel which decides the nature of operation.
We perform the dilation operation [10] on our greyscale image, it increases the white region in the image, and thus the size of foreground object increases. It is done in order to join the broken parts of the object in greyscale image.

4. Contour Detection

Contours is basically a curve joining all the continuous points along the boundary having same color or intensity. It works best with binary images. It is very helpful in our system because it helps us in finding white objects from black background.

This is a simple and effective method to categorize an image into foreground and background. It helps to isolate the object from the background

5. Foreground Detection

It uses for Pixel Identification that cannot be explained by the background model and gives output them as a binary foreground mask. It compares the input video frame with the background model and identifies foreground pixels from input frame. Approach is to check significant pixels from the corresponding background.

IV. IMPLEMENTATION

The main parts required for this system are pre-recorded videos of lanes on the intersections and a well-built software module for calculating the vehicle density on a particular lane and perform the traffic operations accordingly.

Pre-Recorded Videos: A pre-recorded video of the aerial view of the lanes present on intersections. The duration of this video would be exactly similar to the time duration in which a traffic signal on that particular lane goes from green to red. This pre-recorded video will be an input for our software where all the processing is to be done. We can also replace the prerecorded videos with the live video feed using CCTV cameras[6] [8]and other video capturing devices to make this system more real-world oriented. We have discussed about this in the future works of our project.

Software Module: Python 3.6 along with OpenCV is used to develop a robust algorithm which identifies the vehicles and count them on the lanes within a stimulated time period. We use this data of vehicle density on individual lanes of the intersection to perform the stimulated traffic-based operations like extending the traffic signal timers and reducing the traffic signal timers, on very high traffic conditions and on very low traffic conditions respectively.

The Vehicle Counting System built is made up of three main components

1. Detector

Main function of the detector is to identify vehicles in a frame of the video and return the corresponding list of bounding boxes around the vehicles to the tracker.

2. Tracker

Main function of the tracker is to use the bounding boxes send by the detector to track the vehicles in the subsequent frames. Also, the detector, updates [9] the tracker periodically to ensure that they are still tracking the vehicles correctly and accurately.

3. Counter

Main function of the counter is to count the vehicles whenever they leave the frame or pass on the counting line drawn across the road.

The steps in which our vehicle detection software works

I. Start the program.
II. Give the pre-recorded videos of the lanes and intersections as input.
III. Algorithm processes the video by dividing it into multiple image frames.
IV. Algorithms processes the individual image frames and count the vehicles.
V. The data of vehicle count is stored in the database with timestamp.
VI. The processed vehicle data is used to stimulate the traffic conditions.
VII. The traffic modules process the vehicle count.
VIII. Traffic modules process the data generate the stimulated [14] output.
IX. The output generated is basically the time for which the traffic signal must operate.

X. According to the vehicle count, green light timings are generated and displayed.

V. EXPERIMENTAL RESULTS

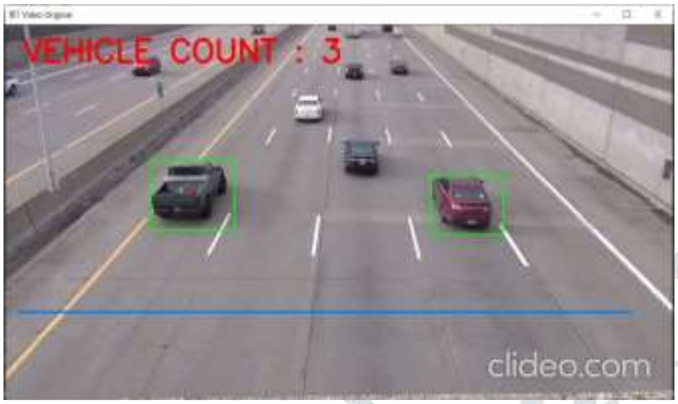

Fig 2. Real-Time Vehicle Counting using BackgroundSubtractorMOG Algorithm.

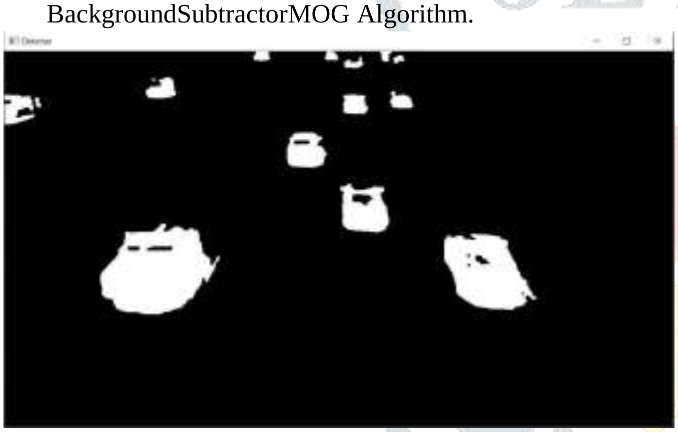

Fig 3. Real-Time Morphological Dilation and Contour Detection.

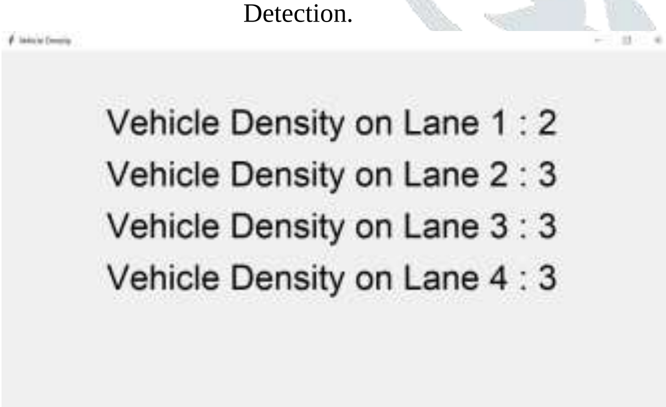

Fig 4. GUI Based output generated for vehicle count on the intersection.

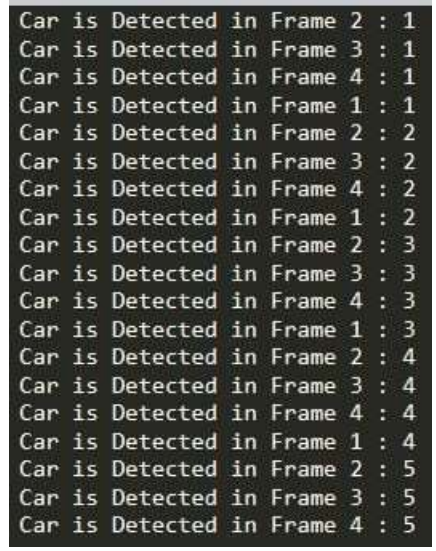

Fig 5. Real-time vehicle detection performed on every frame generated from the video.

Fig 6. Database Schema for the project where the vehicle count will be stored.

VI. SUMMARY AND FUTURE WORK

To summarise, we would like to say that a technology like image recognition can be very helpful in solving the problems not only related to traffic management but in many other sectors as well. As you may have already concluded, a vehicle counting system is a system that counts vehicles on the road. Why would you want one to be built? Why would you like the cars on the road to be counted?

Here are few explanations

- Management and planning of traffic
- Traffic control
- Parking Management
- Advertising

And why the video?

[3] From manual counts to pneumatic tubes to piezoelectric sensors, there are a handful of ways to count cars on the lane. Why did you use the video? Why are they preferred? It is possible to use[11] sensor data (video footage) to check the effects of the system, which makes it simpler and quicker to test and develop the system. The footage can also be used for other uses, such as tracking, automated identification of plate numbers, identification of vehicle type and detection of vehicle speed, to name a few. Compared to other schemes, it's comparatively cheaper to incorporate and scale as a permanent

vehicle counting scheme. It will detect and count several vehicles travelling over several lanes in various directions.

Future Work

A) Counting Cars via Zebra Crossing

This future Implementation has two very necessary purposes

1. Cross-checking of the car count created by our algorithm for image recognition only to ensure that we deal with the right number of cars.

2. As we have not considered the weather conditions as of now, the car count can be created by the zebra[10] crossing when the vehicles cannot be spotted by our cameras for image recognition, such as heavy rain, thick fog, thick smog, etc. Since this module is built on hardware, we can use IR sensors and Motion Tracking Sensors for surveillance over a Zebra Crossing Network The number of vehicles in this concept passing a given lane or intersection. In order to locate the traffic jam on a particular Lane, we can further use this info.

B) Emergency Vehicle Pass Functionality

This is also a hardware-based module in which we can use a sound sensor that senses emergency vehicle sound at various frequencies so that it will be easy to differentiate them from other vehicle sounds. In turn, this will activate an emergency vehicle algorithm [15] that will direct the vehicles on that specific lane and set the lane signal as green and stop all the other lanes.

C) Traffic Forecasting

This future initiative includes the excessive use of knowledge collection, where[12] we take data obtained from one intersection and estimate what the traffic patterns will be at the next intersection after analysing the data.

D) Traffic Learning

We will use databases[13] in this potential implementation to gather data from multiple intersections and then identify patterns, so that our algorithm will learn how and when to work when the pattern repeats itself.

For example: We know that there is a Hanuman Temple on Intersection 3 lane 1. Now our algorithm will reconfirm a trend of weekly increase in vehicles on lane 1, particularly on Tuesday. So, if the trend is known, our algorithm will be able to distribute time on Lane 1, 2, 3 as it knows that the number of vehicles on lane 1 will increase.

E) Vehicle path prediction

Our algorithm will be able to detect the indicator signal provided by a vehicle using finer equipment and coding [12] ,which in turn will help the algorithm find out in which direction the vehicle will turn at an intersection and change the traffic in the lane ahead as needed at the moment.

F) Traffic Time by Calculating Vehicle Ratio

We will be presented with an approximate ratio of vehicles entering the traffic[7] to the vehicles exiting the traffic in this module, so, we can determine an estimated time for traffic clearing.

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