Automated Traffic Light Control And Violation Detection System

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***Abstract*—With the advent of computational technology, the growth of electronic systems as well as methods is great. With this being said, old problems which can be solved and have been now need to be optimised. This computational energy can be applied to modern transportation system management especially in the road transport sector, which can be made better with the use of image recognition and machine learning algorithms.**

The existing systems are first compared and analysed for their drawbacks and advantages in the implementation of that system. A documented list of existing methods to control and manage the road transport sector is made. The problems in the current systems are identified and are noted down as modules. We then analyse the given component in road traffic management and try to optimise it.

In this paper, the analysis is performed and a possible solution to a few of those modules are explored and implemented. The exploration takes place in road traffic light and signal management and the solution follows along the lines of calculating density of vehicles to control the light signal. The second part of the project tries to detect violations of traffic rules without the requirement of an active person trying to monitor it. All of the above mentioned problems have been automated. The whole point of this project is to optimise so the necessity being that we reduce workload on human resources and increase efficiency.

I. Introduction

The density of vehicles on roads is rapidly increasing which has given rise to problems like accidents, traffic and bottlenecks. As we all know, traffic lights can only be controlled by advanced technologies as it requires a lot of surveillance and monitoring to control the traffic. Due to the large number of these traffic signals it is impossible to monitor all of them. Hence we need to make an automated traffic light system that enables the flow of traffic as and when required by it. Road safety is a major concern by traffic as many rides fail to maintain all the traffic rules and they continue to violate them. Due to this the policeman is facing various problems as they cannot monitor every single violation.
To help solve this problem, we need an automated system which can at the very least help the policeman and the government to curb this problem. We propose to build a system which can monitor and report potential violations. People travel to their workplace, go to school and also for some other events daily which gives rise to the increase in traffic on a daily basis. For this reason, Many emergency vehicles get delayed and are made to wait for a long time on roads. In many metropolitan cities, the increase in traffic is a major concern these days. Most of the traffic light control systems are operating on a timing mechanism i.e. for a given duration of time which controls the lights and changes it for every fixed duration.

The present day traffic system is in a loop system where all the traffic lights are pre timed. Hence to solve these problems it is better to build a new traffic control system i.e. an automated and intelligent control system.As we all know that the traffic is increasing rapidly. For this reason people must always wait for longer durations in peak hours to reach their destinations. Because of this, people are getting impatient and violating the traffic signals.
Some People due to their negligence not wearing their helmets, which can cost their lives. So there is a need for a proper system to detect these traffic rule violators and bring them to justice.

The basic methodology of our project is that we use image processing techniques for all the image recognition and measurement, the density of vehicles, speed of vehicles can be computed. Capturing images of moving vehicles can also be done.

Our proposed system aims to achieve the following features, To automate and control the traffic-lights system by setting a timer.

- To allocate time for each signal based on density.
- To follow a specific scheduling order for traffic lights.
- Detection of helmet when violation occurs.
- To detect the vehicles whenever they cross the line.
- To detect the number plate when a potential violation is incurred

II. FUNCTIONAL REQUIREMENTS

- Image Recognition: Taking the camera feed as input and splitting it into frames in order to recognize objects based on a few parameters. The output is the object frame.
- Feature Extraction: The frames received are fed as input and matched to the respective attribute and those attributes are sent as features for further processing.
- Density Calculation: The features extracted are counted and density is calculated based on the count and sent to the next phase.
- Controlling traffic lights based on density: The received density is compared with a forecasting model to determine the status of the light and the new status is sent to the light.
- Violation detection: The features extracted are taken as the input given by the feature extraction module and checks if a violation has occurred and returns a boolean value.
- Number Plate Extraction: In case of violation signal sent by the violation detection module, the image is received and OCR is used to recognise the number plate and the image and the number is sent for further action

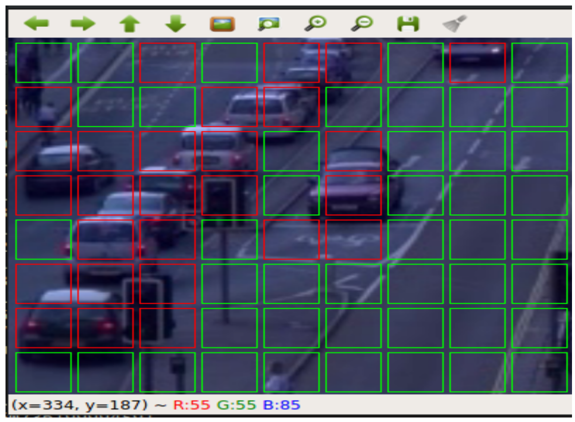
III. METHODOLOGY

3.1. TRAFFIC LIGHT AUTOMATION

We attempt to design an architecture which will try to automate the traffic lights without manual control. This proposed system is a 5 step methodology as follows :-

1. **Image Cleaning**
   The training images are obtained from a CCTV camera or a camera present at an intersection or a junction. These images are the result of the frames generated by the video stream. From each of these training images, we extract the Region of Interest (ROI) which holds the object we are interested in. We select the ROI in such a way that all the unwanted parts are weeded out and only the object of interest is included.

2. **Feature Extraction**
   The ROI that we extracted in the earlier step is now divided into a grid of XxY pixels within each cell. The number of cells vary based on the ROI which varies based on different lanes and intersections.
3. **Training the model**
   Each of the cells extracted is fed into Prewitt's Edge Detection algorithm and then, the features are sent to the SVM model to predict if the cell has the object of interest or it does not have. The model is trained and saved.
4. **Density Estimation**
   For the traffic density prediction, we take the live images that are captured from the cameras at the junction and then, extract the ROI and create a grid with each cell of dimensions X x Y pixels. Then we pass each of these cells to the trained SVM model as a test set and obtain the predictions. The SVM predicts if it contains traffic or empty roads for each of the cells. With this method, we classify the whole grid and can estimate the traffic density by getting the number of cells having traffic divided by the total number of cells expressed as a percentage.

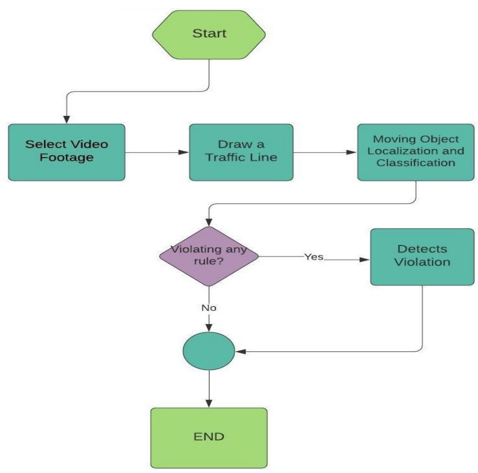


5. **Traffic Light Signalling**
   After obtaining the density, the density across all the signals are compared and ranked. Based on the rank, we allocate the time to the signal. The time allocation is done as follows based on a ARIMA forecasting model. The forecasted density is then taken and a decision is made based on the following.

Density(%)	Green Light Duration(sec)
0-30	15
30-50	20
50--70	30
70--90	45
90--100	60

The scheduling of the traffic lights is done in a Round-Robin fashion. After each round, the forecast is done again and the process is repeated. Each signal, after allowing a green light, shall not be allowed to get another green signal until it is time for its turn.

3.2 TRAFFIC LINE VIOLATION



3.2.1. Vehicle Classification

Using the CCTV camera or camera present at a junction, all the vehicles are being detected. With the help of an object detection model i.e., called YOLO (You Look Only Once) algorithm, all the vehicles and the bounding boxes will be put into their own corresponding classes. This algorithm has a better accuracy than many other existing algorithms and it is also helpful in detection of objects.

3.2.2. Features:

1. **Bounding Box Predictions:**

Using the YOLOv3 algorithm, we need to classify all the bounding boxes and all the calculations must be done as a single network so that everything is classified into a complete detection. This YOLOv3 algorithm works similar to logistic regression in such a way that all the calculations are 1, then all the bounding boxes will become an overlap over the object. This model predicts it as 1, bounding box before for each ground truth object and if there's any kind of error in this will occur for both classification loss and detection loss as well..

2. **Class Prediction:**

Independent logistic classifiers are used in YOLOv3 algorithm where it is being used for separate classes. All these processes are must for this to make a multi-label classification. Using this multi-label classification, each and every box will predict all the classes of the corresponding bounding box.

3. **Predictions across scales:**

To support detection at varying scales YOLOv3 predicts boxes at 3 different scales. For the predictions across scales, all the features will be extracted from each and every scale using the features of pyramid networks. Using the YOLOv3 algorithm, we can use the feature of predicting across scales in a much better manner. Using the dimension clustors, all the bounding boxes are being divided to 3 scales. These scales are then being counted as 3 bounding boxes per scale which in the end makes a total of 9 bounding boxes

4. **Feature Extractor:**

YOLOv3 uses a new network- Darknet-53. Darknet-53 has 53 convolutional layers. This YOLO algorithm is a better performer and more powerful than many traditional approaches. The most important feature i.e. feature extraction is easier and convenient in this algorithm.

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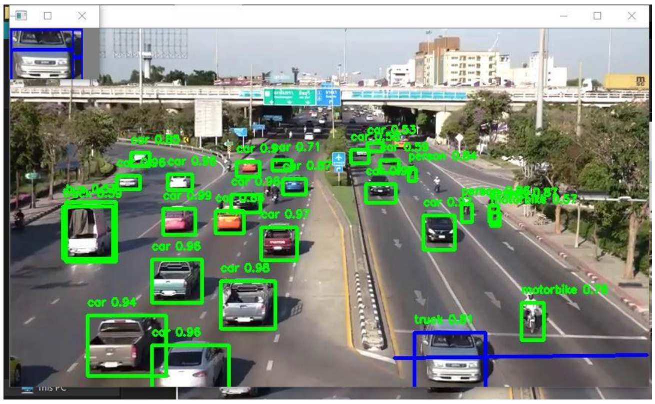

3.2.3. Violation Detection

The vehicles are detected using the YOLOv3 model. After the detection of all the vehicles, they moved to license plate recognition so that everyone is caught and details are sent to the traffic police. A straight line called the traffic violation line is drawn on the road near the signal in the CCTV footage or the camera footage from the junction. The crossing of this line during red traffic lights is treated as a violation. So if anyone crosses that line, all the vehicles that cross will be treated as violated and all these images of violated vehicles will be sent for license plate recognition. For the violation to occur, vehicles need to cross the line drawn. Whenever a vehicle crosses that line it is considered a violation and a red bounding box is drawn onto each vehicle. Other vehicles will be marked a s green i.e. not violated.

3.3. HELMET DETECTION

Technology used :- YOLOv3
Libraries used :- numpy , argparse , glob , OpenCv , sys , os
drawPred function is used to predict bounding boxes on the given frame.
Post Process Function is a one that will remove all the corresponding bounding boxes that are having a value of confidence level as low and this is done using a method called non- maxima suppression.

Detection of non-helmet riders using YOLO algorithm :

Finally we are having the iterator through input images feed where we have to identify the persons who are not wearing helmets.
In that we are creating a blob frame sending the input feed to the network. By Calling Post Process function we are Removing the bounding boxes with low confidence and retaining the bounding boxes which have high confidence.
The result of calling post process function which classifies the images into two parts like the person wearing a helmet and the person not wearing a helmet.
For Future reference purposes we are storing the both types of classified images. The person who is not wearing a helmet will be treated as a violation and these types of image frames are stored in the violation folder .
Then we execute ANPR on the particular violation folder to find the license plate of the violated vehicle

3.4. LICENSE PLATE RECOGNITION

Methodology in steps:

1. **Install and import dependencies:**

   Here we import easyocr,imutils dependencies

2. **Read in Image, Grayscale and Blur**

   Initially the image is loaded using imread, next we use cvtColor to recolor the image and convert it into a grey image that is done by passing the color code. So here we change the image color which is initially in BGR to GREY.

3. **Apply filter and find edges for localization**

   Here we are applying filtering to remove noise from the image and edge detection to find the edges in the image. For filtering we use a bilateral filter method so that we pass the image and pass the properties which allow us to specify how intensely we want the noise reduction.

   Then from that we use a canny algorithm to perform edge detection which has a set of parameters which can be tuned to get the ideal edges.

4. **Find Contours and Apply Mask**

   We do contour detection that is detecting the polygons within the lines. Ideally the shapes in the images. In our case we identify rectangles as our number plate is in that shape.

   First step we do is to find contours by using the method findContours to which we pass the edge image. And here we are approximating the required contour value by using cv2.CHAIN_APPROX_SIMPLE. And then we store the contours by using the function grab_contours and we sort the top 10 contours on the basis of contour area.

   Next we loop through these contours and find whether they are rectangle or square shaped. And by doing that we get the coordinates to the number plate. Next we mask and isolate the section of the number plate using the coordinates.

   Here first we masked the entire grey image. And next we highlight only the number plate using the drawContours function where it is given the location of the number plate as parameter to it. And in the final step we bitwise_and to put up the number plate on to the masked image.

   Next we isolate the segment which contains the number plate by cropping that part. So here we find the coordinates of every section where our image is in black and crop the image.

5. **Using Easy OCR To Read Text:**

   In this step we use easy ocr to read the text from the image.

6. **Rendering the result:**

   In this part we take our number plate and overlay our detection on the original image.

CONCLUSION

In order to overcome all the problems faced by the traffic policemen and public regarding the everlasting traffic, we have come up with a better solution that uses image processing techniques which is possibly better than many other existing systems. We also built a system that detects potential traffic violations so that policemen can conclusively render all the information of people violating the traffic rules. By using all the actual real-time videos as input, this proposed solution is consistent in its own way of vehicle detection.

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