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Automatic Traffic Rules Violation Detection and Number Plate Recognition System for Bangladesh

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***Abstract*— The traffic controlling system in Bangladesh has not been updated enough with respect to fast improving technology. As a result, traffic rules violation detection and identification of the vehicle has become more difficult as the number of vehicles is increasing day by day. Moreover, controlling traffic is still manual. To solve this problem, the traffic controlling system can be digitalized by a system that consists of two major parts which are traffic rules violation detection and number plate recognition. In this research, these processes are done automatically which is based on machine learning, deep learning, and computer vision technology. Before starting this process, an object on the road is identified through the YOLOv3 algorithm. By using the OpenCV algorithm, traffic rules violation is detected and the vehicle that violated these rules is identified. To recognize the number plate of the vehicle, image acquisition, edge detection, segmentation of characters is done sequentially by using Convolution Neural Network (CNN) in MATLAB background. Among the traffic rules, the following traffic signal is implemented in this research.**

***Index Terms*— YOLOv3, Darknet, OpenCV, Object detection, Traffic rule, Violation detection, ANPR.**

I. INTRODUCTION

TRAFFIC controlling and navigation system was adopted when the transportation system was occupied by the engine-driven vehicle. Several traffic laws were also made to decrease the number of road accidents, traffic jams and so on. The first manually controlled electric traffic lights were installed in Piccadilly, London, in 1925 [1]. The system is controlled by the traffic controlling agency. The first vehicle register plate using law was passed in New York in Apr. 25, 1901 [2]. The vehicle number plate contains information about the vehicle owner's district, metropolitan, type of the car. For manual traffic controlling, when a vehicle violates traffic rules the traffic police check the vehicle's number by the manual process. As the traffic controlling process evolved, the manual process replaced by an automated checking and imposing fine which is adopted by a few first world countries. An automated system like image recognition and processing technology is used there. In a developing country like Bangladesh, the number of vehicles is increasing in recent time but the traffic controlling process is not updated [3]. From some of the previous research, it is seen that Vehicle Number Plate Recognition (VNPR) in traffic monitoring systems is controlling traffic volume, generating tickets for the vehicle with no human control, vehicle tracking and vehicle policing and vehicle security [4]. From further research, vehicle tracking using a number plate recognition system is found. It is necessary to capture the number plate of the vehicle and use this captured number to track the path of the vehicle. To track they used to extract numbers from the captured image, using JAVA, Optical Character Recognition (OCR) or MATLAB libraries. Some of them used python or C++ along with OpenCV. There is seen that the algorithm of number plate recognition was almost the same [5]. But Automated Number Plate Recognition (ANPR) is not entirely implemented, human hand used to stop the violated vehicle and send the plate number to the processing unit. Researchers are still now working on it. Among the algorithms, Python and OpenCV are the best options to automate this system. Dubai's Roads and Transport Authority (RTA) launch a smart traffic controlling system where a radar including camera, sensors, transmitter-receiver, data server and few electronic devices have been used to recognize number plate, detect speed and wrong U-turn, unauthorized vehicle, and after generating fine with an attached violated picture. This research was almost similar to the part of the available technology where two cameras were used, one was at a high angle to detect the violation and another one was at eye angle to capture an image of a vehicle. The difference, however, was that this was not made in real-time. So, the future plane is to make it possible [6].

The main objective of this research is to recognize the number plate of a violated vehicle by following some steps, like edge detection, symmetry detection, binarization,

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projection, moving average filters, extreme detection, and OCR in the ANPR system. In computer vision and image processing edge detection method is widely used. Among the aims of edge detection, the main target is to detect and extract the feature. Identifying of edges in an image has many processes which are shown in the publication. A 3-edged detection algorithm is used like Horizontal edge, Vertical edge, and Canny edge detection in this preferred action [7]. Image binarization is the process of converting a black and white image to a 256 gray level [8]. Before the OCR binarization is widely used as pre-processing. The simplest way to convert a grayscale image to a binary image is to specify the full border value, classify all pixels like white and classify the rest of pixels with values like higher than black [9]. Symmetry is an important feature of artificial products. Most of the vehicles are symmetrical along the vertical axis at the rear or front. This property is used to identify the vehicles from an image and this is one of the main parts of the operation of number plate identification. Gray leveling is not functional for symmetrical patterns. This is because of the same area and strong redistribution can have a higher level of symmetry. These powerful reapplications create deformity in symmetry of vehicles, during a similar field and the patterns of framework introduce the most interconnected symmetry [10]. Moving average filter is familiar as playback average. This is used to facilitate multiple datasets, decreasing the impact of unsystematic changes in the data. Its primary target is to eliminate high-frequency elements and short term oscillations from the data set. A moving average is usually applied as a lower passage in digital signal processing [11]. The first process of text recognition is to check the text of the document and convert the characters into code that is used to process the data. OCR is sometimes referred to as text recognition [12]. The behavior of the processing unit or neuron is particularly dependent on activation operations. Activation operations can be expressed in 3 categories such as linear, threshold, and segment. To get maximum efficiency value in this research YOLOv3 network model is used and this is the improved version of the YOLO network [13]. In this research, object detection is going to detect through the YOLOv3 algorithm. To detect the traffic rules violation and number plate recognition, OpenCV is being used in this research.

II. Architecture Of the System

A. *System Block Diagram*

Surveillance through the camera is not new to the recent trend of the world but applying different algorithms for different recognition is new as a real-time recognition system is applying on real-time video monitoring surveillance cameras. This system will create the easiest solution to detect every vehicle. Figure 1, shows the process of the proposed method. In the detection process, software YOLOv3 is used to analyze the data from the given dataset.

At first, the videos have been collected and converted into images frame by frame. Then the frame of images from the real-time video feed will be matched to the dataset [14]. The whole system was implemented using the Python programming language. For object detection, YOLOv3 was used and OpenCV was used for violation detection and character recognition. To recognize vehicles on the road object detection system was implemented using the YOLOv3 algorithm. For this purpose, the Linux operating system was chosen since it has its default trained data to detect various object including vehicles.

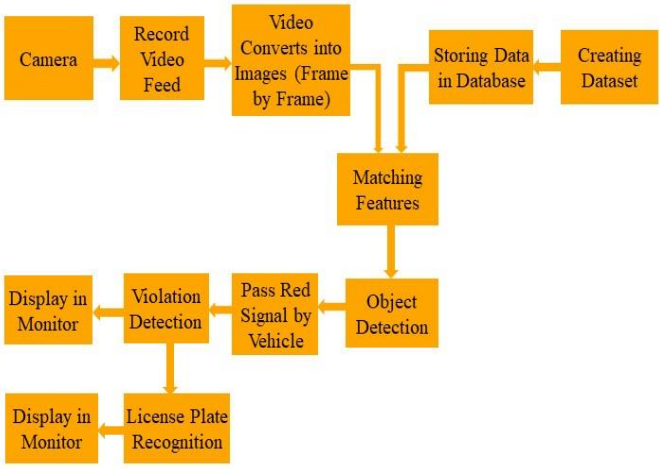

Fig. 1. Block diagram of the system

B. *Flow Chart for overall system*

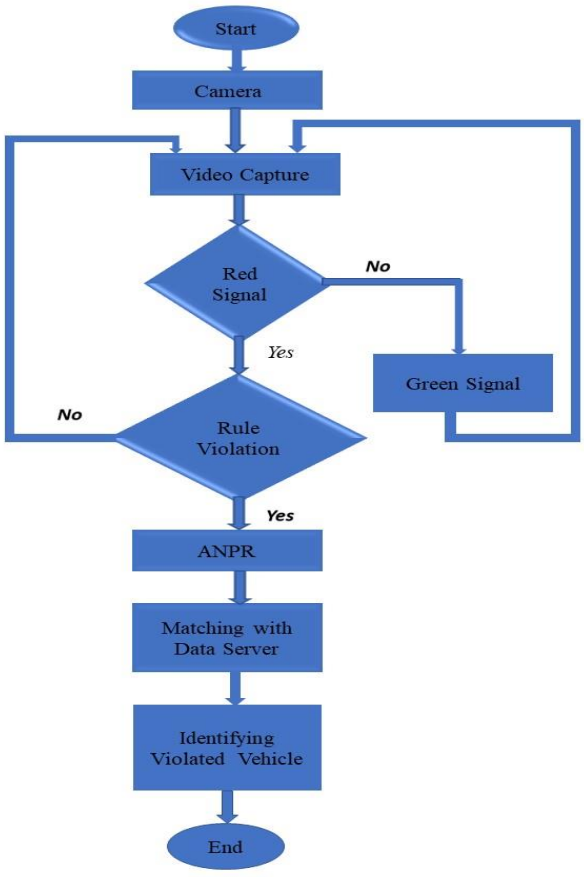

Fig. 2. System Flow Chart for the overall system

In figure 2, the flow chart of the overall system is shown. The systematizing of automatic traffic rule violation detection and number plate recognition system capitally has two main parts (i) Traffic rules violation detection (ii) Number plate recognition. The first video of vehicles is captured through a zoom lens camera at a perfect place. After that, Red and Green lines are drawn on the video frame by using the code of python platform where these are indicated as red and green lights respectively. So, when a vehicle passes the red line, it is under the forbidden condition and that is how the violation detection process is going to be worked. But if a vehicle passes the green line, no step will be taken and the Video Capturing process will start again. After the Violation Detection process, an image of a violated vehicle is captured from the exact video frame. Selected Image data is processed by using many steps which are gray scaling, thresholding, canny edge detection and Contouring. By following the image processing steps, number plate of the vehicle will be found. If not found, the whole process is started from the step of the Capture Frame. When the plate region is found, that is extracted and prepared for the next step. After segmentation, predicted data is found as the recognized character.

C. System Flow Chart for Violation Detection

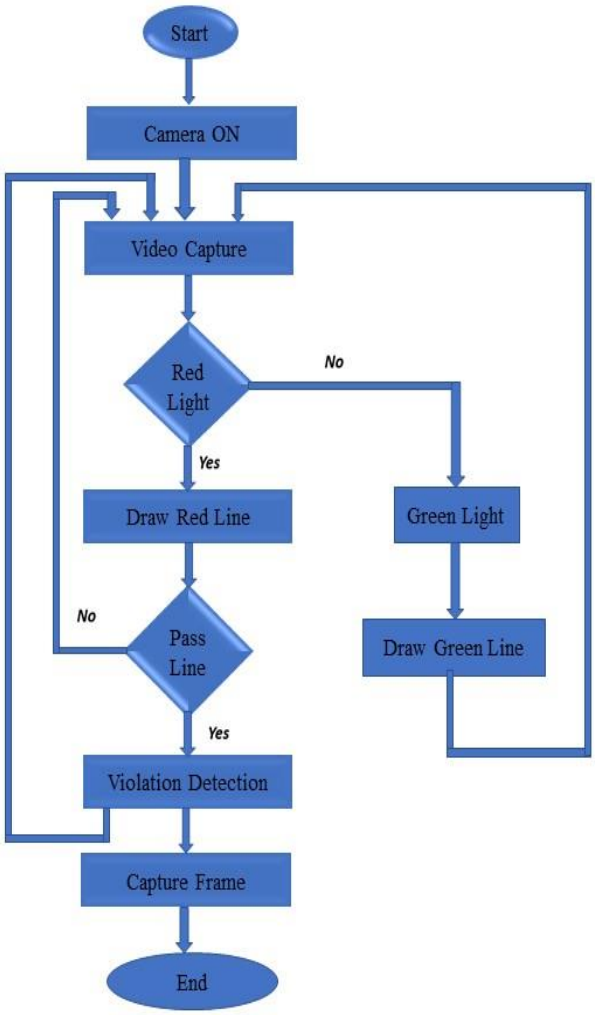

Fig. 3. System Flow Chart for Violation Detection

Automatic violation detection system flow chart is shown in figure 3. This system includes capturing video, traffic signal, traffic signal violation detection and capture frame of the violated vehicle. Firstly, a video is captured on a road, while the red light/line of the traffic signal is ON. In the meantime, if any vehicle crosses the red light/line, it is detected as a violation of traffic rule. Finally, a frame is captured of this violated vehicle. The System was used two cameras, one was at a high angle to detect the violation and another one was at eye angle to capture the image. The eye angled camera was received command from the high angled camera to capture an image of a vehicle after the violation.

D. System Flow Chart for ANPR

In figure 4, the flow chart of the ANPR system is shown. This system includes video data collection, frame capturing, image processing, number plate region finding, plate extraction and character recognition. The very important step is to find the plate region by the steps of image proposing, when, the character of number plate recognition is conformed to the data set of character.

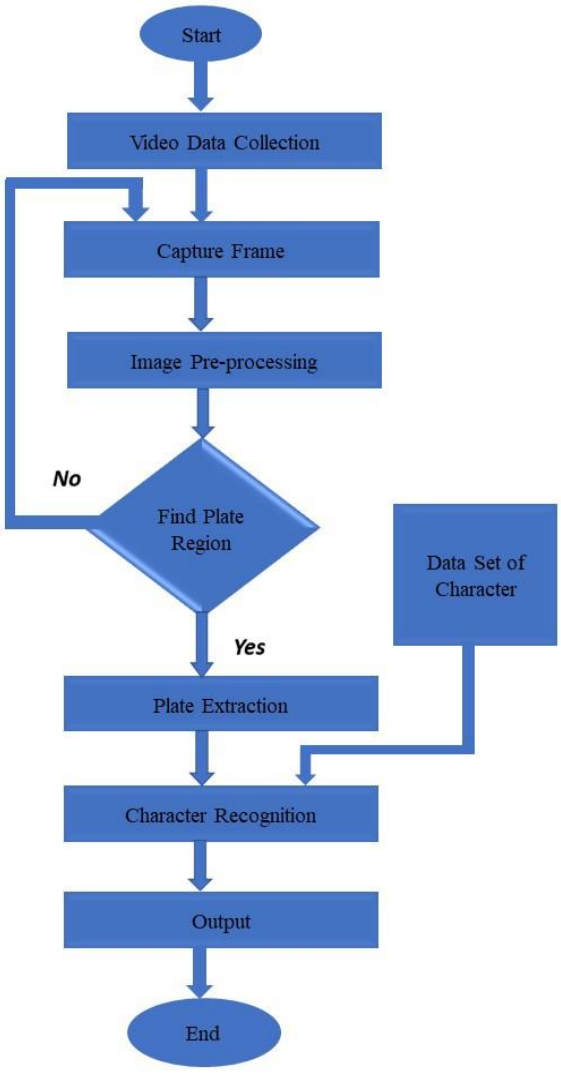

Fig. 4. System Flow Chart for Automatic Number Plate Recognition

In the end, the final output results are showing. The code is designed enough smart to find the number plate from any position from wherever it is.

III. Implementation Of The Project

A. *Object detection*

The whole system was implemented using the Python programming language. YOLOv3, OpenCV and MATLAB were used for object detection, traffic rules violation detection

Fig. 5. Sample image for object detection (day)

Fig. 6. Sample image for object detection (night)

and number plate recognition respectively. To recognize vehicles on the road object detection system was implemented using the YOLOv3 algorithm. For this purpose, the Linux operating system was chosen. YOLOv3 has its default trained data to detect various object including vehicles.

B. *Red light violation detection*

To detect red light violation video was captured by placing a camera right position of the road. After capturing video, a line was drawn by using the OpenCV library on the road indicating traffic signals where vehicles are supposed to be stopped when the red light of the traffic signal is ON.

Fig. 7. Sample image for traffic Signal violation detection (day)

When a vehicle disobeyed the traffic signal bypassing the red line it was detected as the violated vehicle (car). To represent the green light of the traffic signal, the green line was drawn on the video. When a vehicle disobeyed the traffic signal bypassing the red line it was detected as the violated car. To represent the green light of the traffic signal, the green line was drawn on the video.

Fig. 8. Sample image for traffic Signal violation detection (Night)

C. *ANPR system*

The image was captured from the front of a vehicle of the higher elevation during traffic rule violation by a car and considering the camera was at a higher altitude and mounted on top of the traffic light. With the help of OpenCV certain

processes were followed to detect the number plate. At first, the original image was converted into grayscale and then thresholding was done. By applying canny edge detection, the noise of the processed image was reduced by contouring twice. By following these algorithms, the region of interest of the number plate was found. After recognition of the number plate, characters of number plate were found using MATLAB. The system used OpenCV and MATLAB both. These functionalities were achieved by using "matlab.engine" in python platform to call MATLAB code.

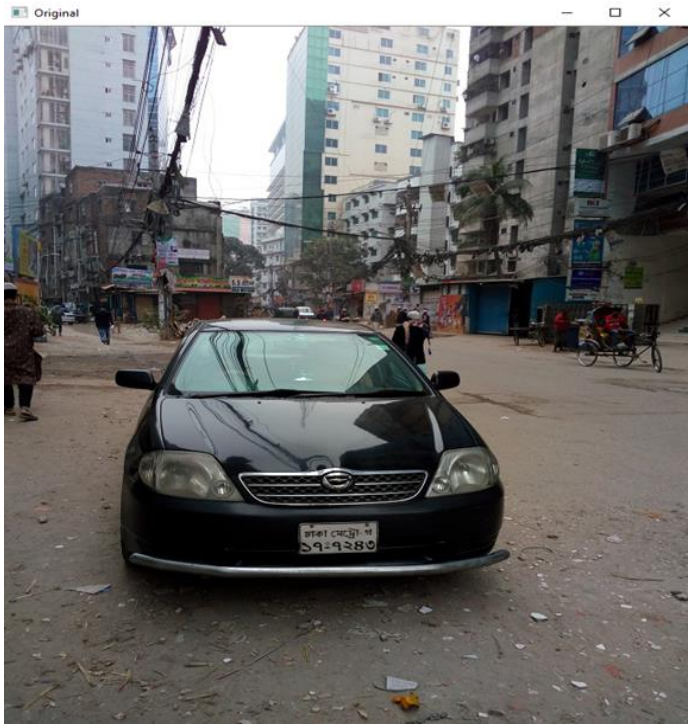

Fig. 9. Captured Image of a violated car (Day)

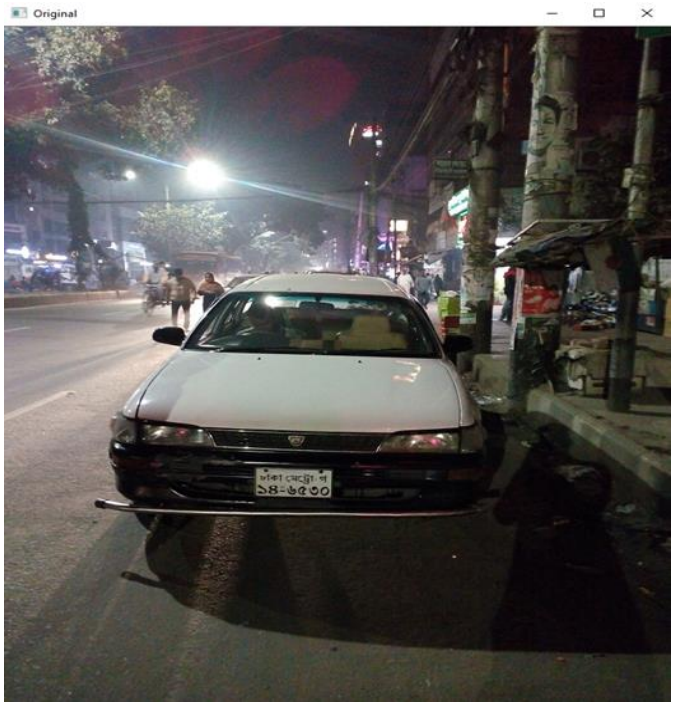

Fig. 10. Captured Image of a violated car (Night)

IV. Output Detection

A. Object detection

For real-time situation, the camera price was very expensive, that's why pre-recorded video was used for object detection where frame rate was 30 fps and the video duration was 11 seconds. YOLO v3 algorithm was applied in the Linux platform. Using the default data set of YOLOv3 various objects were detected including vehicles and humans on the road. The percentage of successful detection rate for cars is 80-99%, for motorbike 66-89%, for bus 94-100%, bicycle 67-89% and for person 60-88%. The total processing time is 83 seconds. When the distance between the objects and the camera is decreased, the percentage rate will be increased.

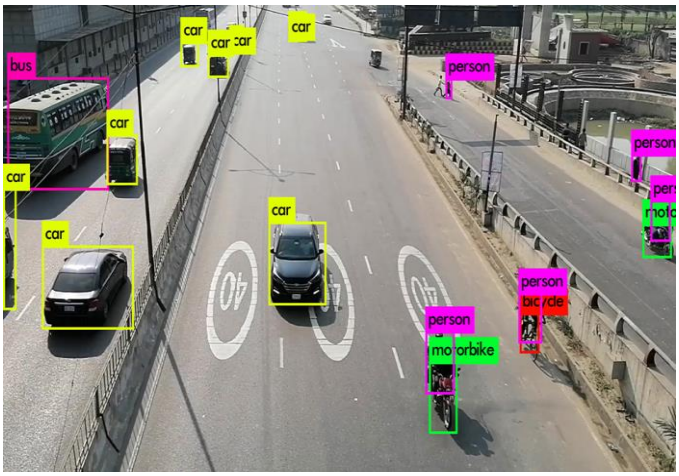

Fig. 11. Object detection using YOLOv3 (Day)

Three individual videos were taken at night time, to analyze the system's reliability at that time. The achieved result was outstanding. Though the system took a long time to detect which was average 69.92 seconds, the accuracy was very good. The range of accuracy for the bus is 82-92%, for the car is 81.20-93.83%, for truck the range of accuracy is 80-87%.

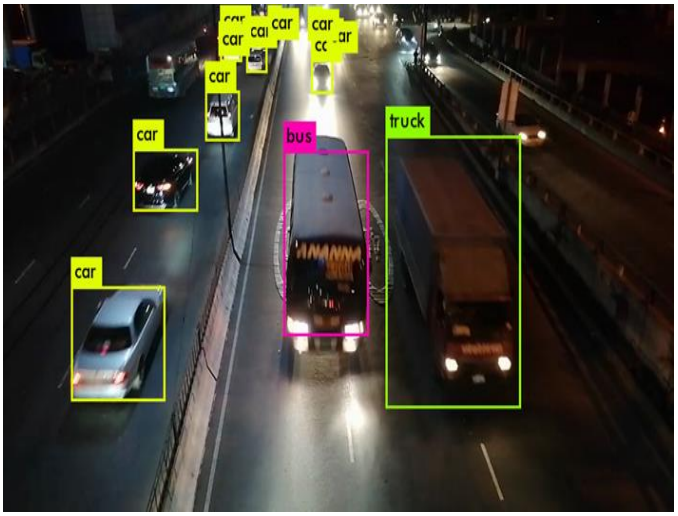

Fig. 12. Object detection using YOLOv3 (Night)

B. Red light violation

OpenCV libraries were used for violation detection purposes. A line was drawn using OpenCV when a car passed the line it was detected as the violated car. The video duration was 58

seconds and the frame rate was 30 fps. Because of the price, higher resolution camera was not used for which frame rate can be affected. The detection time is 2.84 seconds where accuracy is over 90%. On the other hand, accuracy at night time is almost 85%, due to low light intensity.

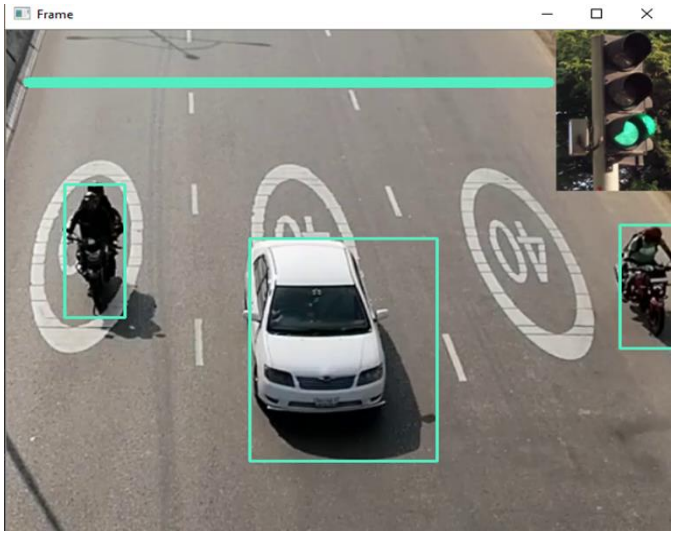

Fig. 13. When the green signal was drawn (Day)

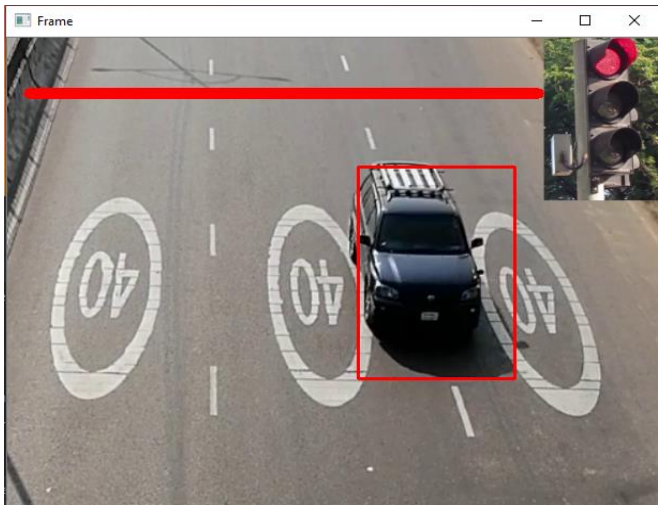

Fig. 14. Red light violation (Day)

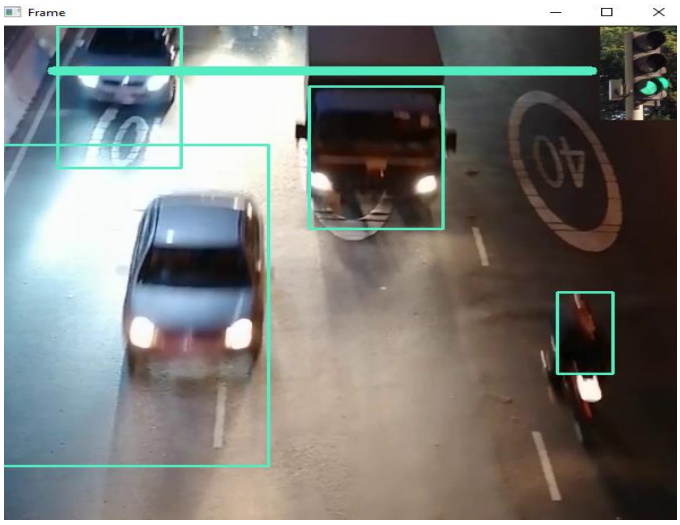

Fig. 15. When the green signal was drawn (Night)

Fig. 16. Red light violation (Night)

C. ANPR

After detecting a violation, an image was captured for number plate recognition which dimension was 640 × 480. The total processing time was 3.85 seconds. The percentage of successful recognition is 98%. The best result was found when the vehicle was 3.5 meters away from the camera horizontally. The camera was set 1.7 meters above from the ground.

Fig. 17. Gray scaling of the captured image (Day)

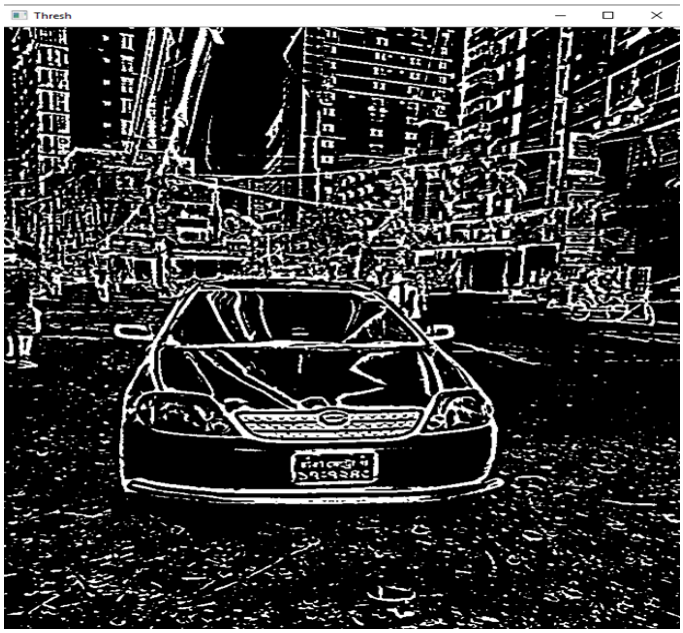

Fig. 18. Thresholding image of the captured image (Day)

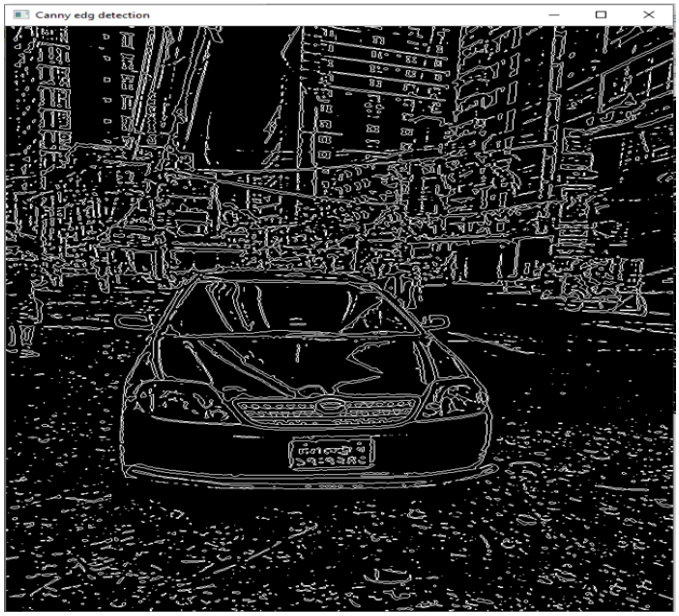

Fig. 19. Canny edge detection of the captured image (Day)

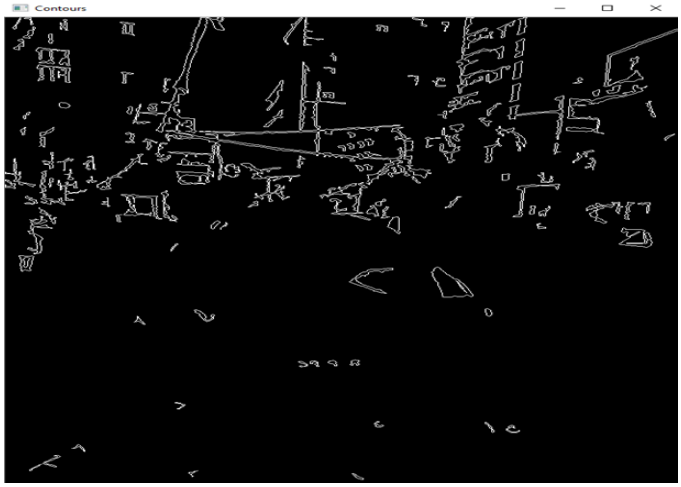

Fig. 20. Contouring to reduce the noise of captured image (Day)

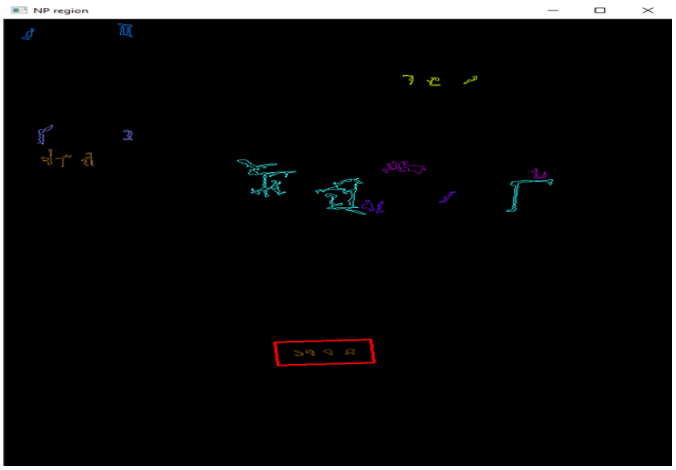

Fig. 21. Identifying the character region of the captured image (Day)

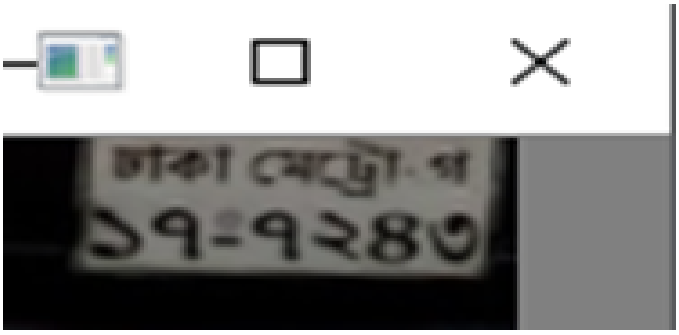

Fig. 22. Possible number plate extraction of the captured image (Day)

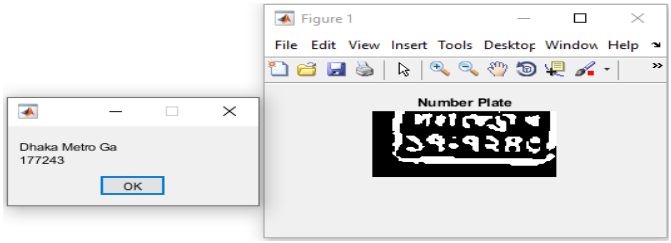

Fig. 23. Character recognition (Day)

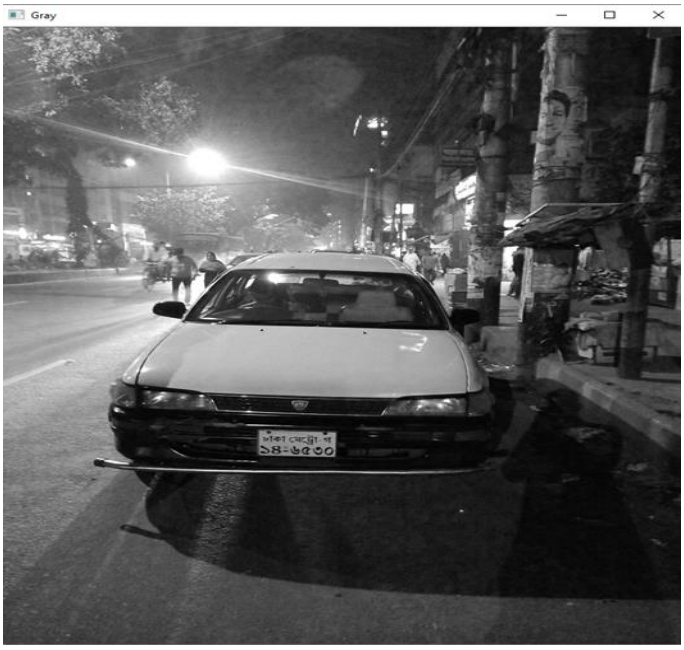

Fig. 24. Gray scaling of the captured image (Night)

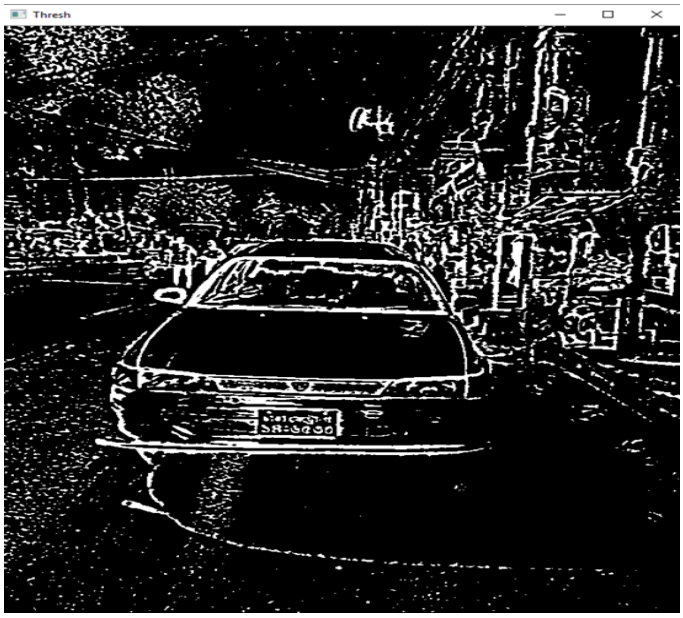

Fig. 25. Thresholding image of the captured image (Night)

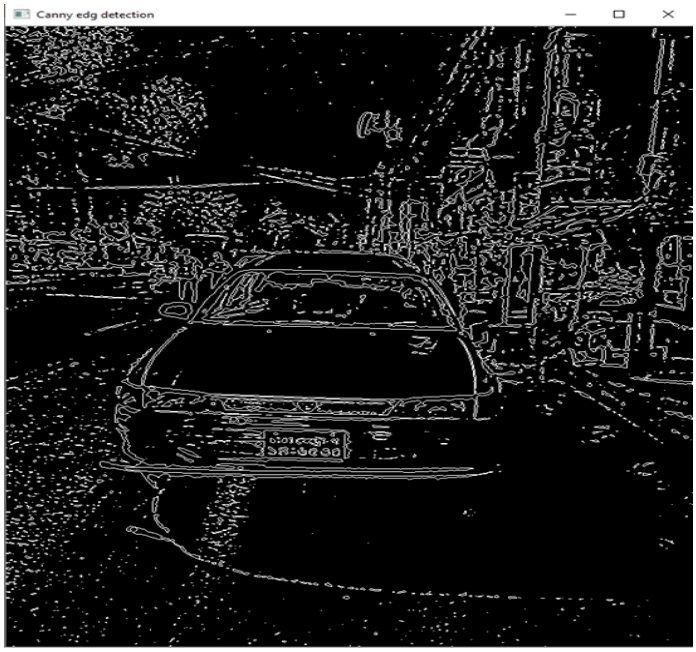

Fig. 26. Canny edge detection of the captured image (Night)

Fig. 27. Contouring to reduce the noise of captured image (Night)

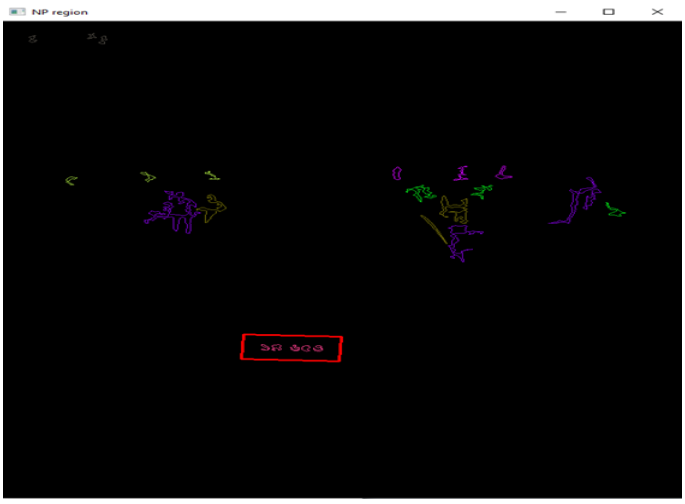

Fig. 28. Identifying the character region of the captured image (Night)

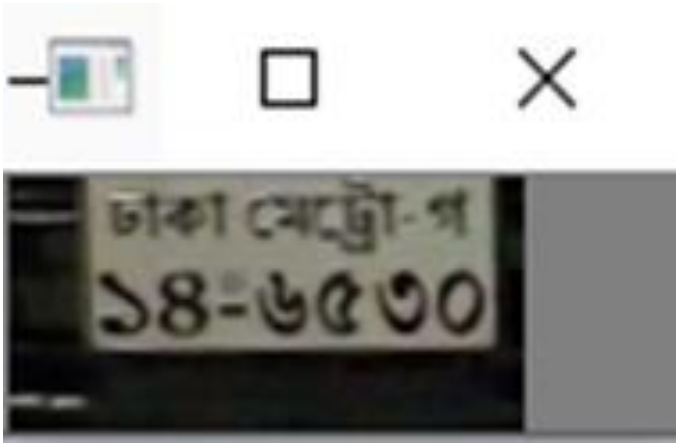

Fig. 29. Possible number plate extraction of the captured image (Night)

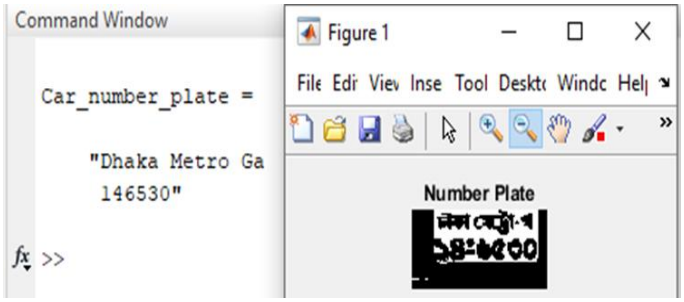

Fig. 30. Character recognition from number plate (Night)

V. Result Analysis

After training those video footages the ratio of the confidence value may vary from time to time. But the highest confidence value is assured by training & giving proper acquisition of time. Sometimes information of the identified may overlap with others. But proper information that is provided in the database is retrieved at the end. From the captured video by using the YOLO algorithm, 5 samples were taken based on distance from the camera to objects on the road. A total of 5 samples were analyzed and it was found that sample 4 provided the best result. Based on the highest accuracy, sample 4 was best because the objects were near to the camera and daylight was sufficient. The highest accuracy of detection for bus 99%, for a person 81%, for car 94%, for

motorbike 69%, and bicycle 61%. If the large data set of motorbike and bicycle could be used, the accuracy was up to the mark.

Table I
Percentage of Object Detection data (Day)

Sample	Bus	Person	Car	Motorbike	Bicycle
Sample 1	91.66%	67.25%	94%	59%	59%
Sample 2	91.66%	81%	83.36%	69%	59%
Sample 3	99%	64.33%	87.57%	69%	58%
Sample 4	99%	72.50%	80.40%	69%	61%
Sample 5	93%	60%	75%	69%	61%

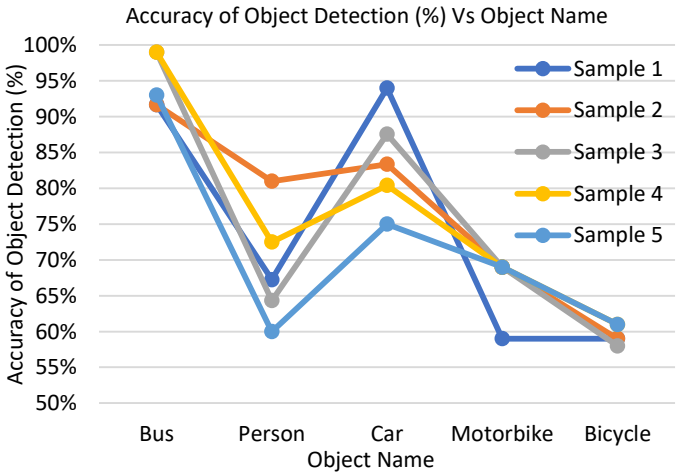

Fig. 31. Accuracy of Object Detection (%) Vs Object Name (Day)

Table II
Best Percentage of Object Detection data (Day)

Sample	Bus	Person	Car	Motorbike	Bicycle
Sample 4	99%	72.50%	80.40%	69%	61%

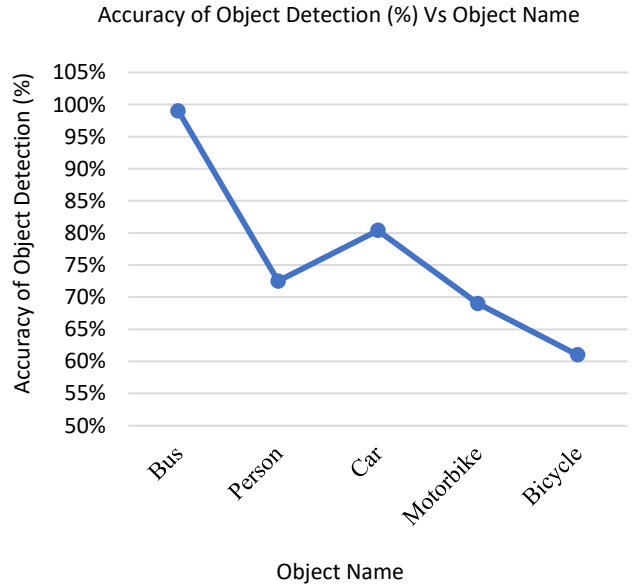

Fig. 32. Best Object Detection Data (Day)

From the captured video by using the YOLO algorithm, 3 samples were taken based at night on distance from the camera to objects on the road. A total of 3 samples were analyzed and it was found that sample 1 provided the best result.

Table III
Percentage of Object Detection data (Night)

Sample	Bus	Truck	Car
Sample 1	98%	80%	93.83%
Sample 2	82%	81.2%	81.20%
Sample 3	82%	80%	83.93%

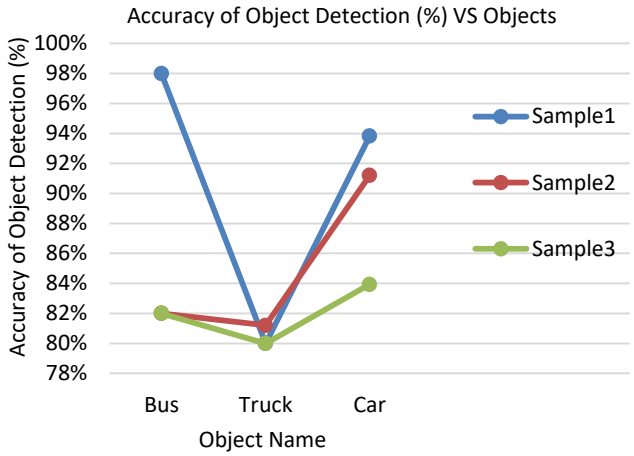

Fig. 33. Accuracy of object detection over different vehicles (Night)

Based on the highest accuracy, sample 1 was the best because the objects were near to the camera and for enough intensity of street light at night. The highest accuracy of detection for bus 98%, for truck 80% and car 93.83%.

Table IV
Best Percentage of Object Detection Data (Night)

Sample	Bus	Truck	Car
Sample 1	98%	80%	93.83%

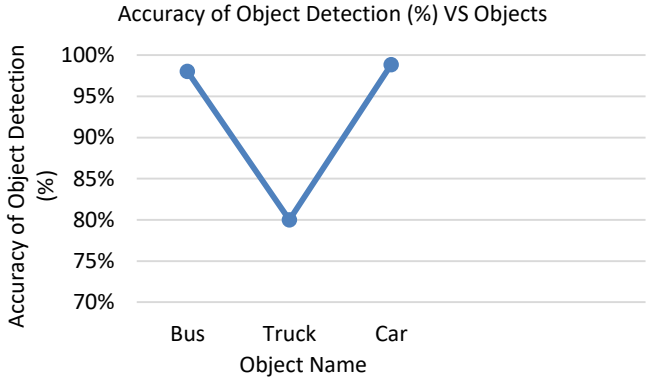

Fig.34. Accuracy of best object detection over different vehicles (Night)

Few figures and graphs are helping to analysis the outcome of the research. These data are gathered in two different times

like, day and night. Among these, the data of day is clearer and more perfect with respect to night due to light intensity. However, the situation can be solved either by setting up enough street light with high intensity or using a high-resolution night vision camera and this thing will be worked at fogy or a rainy day too.

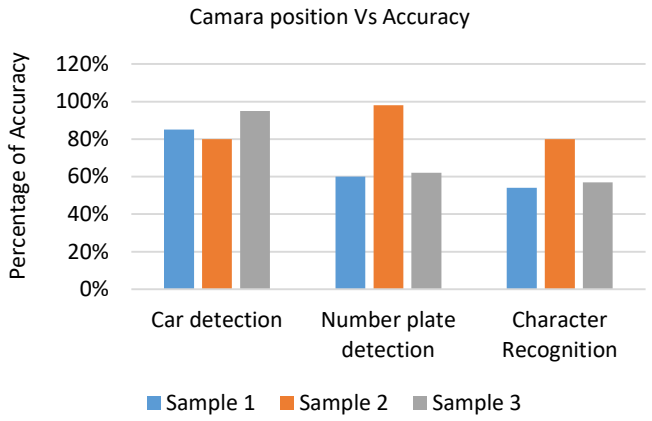

Fig. 35. Camera Position vs Accuracy (Day)

Figure 35, shows the accuracy of operations based on samples that were taken from a different angle of camera position. Here sample1, sample2 and sample3 were sequentially represented low angle, eye angle and high angle. Accuracy of Car detection, Number plate detection and character recognition of eye angle was 95%, 98% and 80% respectively in the day time. Result of Road object detection and violation detection was taken from the high angle and number plate recognition was done from the eye angle. From the data between day and night, data of day were shown the good accuracy because of sufficient light intensity.

Table VI
Result analysis

Event	Detection Accuracy (Day)	Detection Accuracy (Night)	Total Process Time Required (sec)	Camera Position
Road Object Detection	99%	90.61%	74.51	High Angle
Violated Car Detection	95%	85%	2.84	High Angle
Number Plate Detection	98%	80%	3.85	Eye Angle
Character Recognition	80%	75%	3.50	-

Available technology what is existed actually based on machine learning and little more sensors. Now, technology is advancing and turning on fully machine learning and IoT based and this research was actually focused on this advanced technology and no sensor was used only processing device, cameras, and python programming. Another good thing in this research was image processing time where red light violation and automatic number plate recognition (ANPR) were taken 2.84 sec and 3.85 sec respectively, that was enough processing speed to complete this process and if consider the accuracy which was also quite well around 80 to 90 per cent. The image processing speed and accuracy can be improved, what if a good processing unit is used and large data set can be generated respectively.

VI. Conclusion

In this research, Automatic traffic rules violation detection and number plate recognition system is presented. Image processing techniques are used to develop this system. YOLOv3 was used here to detect the object on the road. Using OpenCV the traffic rules violation was detected. MATLAB was used to recognize the characters of the number plate. Where object detection, violation detection and number plate reorganization were done sequentially for day 99%, 95%, 80% and also sequentially for night 90.61%, 85%, 75%. The results were evaluated on light intensity and camera position. The accuracy of the system was more accurate in day time due to higher light intensity than night time. The system is highly sensitive to the position of the camera. The smaller the distance between the camera and the vehicles the higher the detection accuracy. At an optimum angle, the accuracy was highest. This visibility problem like different weather condition such as rain, storm, and bad visibility due to dust or dusty number plate can be solved through a higher resolution camera and thousands of data of number plate.

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