“Vehicle Speed Estimation Using Object Detection and Tracking”

Minor Project Report

in partial fulfilment for the award of the degree

of

BACHELOR OF ENGINEERING

in

COMPUTER SCIENCE & ENGINEERING – Data Science

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

GYAN GANGA INSTITUTE OF TECHNOLOGY & SCIENCES

JABALPUR (M.P.)

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BHOPAL (M.P.)

April- 2022

CERTIFICATE

This is to certify that the Minor Project report entitled "**Vehicle Speed Estimation Using Object Detection and Tracking**" submitted by **Akshit Narang** has been conducted under my guidance & supervision. The project report is approved for submission towards partial fulfilment of the requirement for the award of degree of **BACHELOR OF ENGINEERING** in **COMPUTER SCIENCE & ENGINEERING** from **RAJIV GANDHI PROUDYOGIKI VISHWA-VIDYALAYA, BHOPAL (M.P).**

Mr. Vikas Dubey
Guide
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CERTIFICATE

This is to certify that the Minor Project report entitled "**Vehicle Speed Estimation Using Object Detection and Tracking**" submitted by **Akshit Narang** has been carried out under my guidance & supervision. The project report is approved for submission towards partial fulfilment of the requirement for the award of degree of **BACHELOR OF ENGINEERING** in **COMPUTER SCIENCE & ENGINEERING** from **RAJIV GANDHI PROUDYOGIKI VISHWA-VIDYALAYA, BHOPAL (M.P).**

Internal Examiner	External Examiner
Date:	Date:

DECLARATION

I hereby declare that the project entitled **“Vehicle Speed Estimation Using Object Detection and Tracking”** which is being submitted in partial fulfillment of the requirement for award of the Degree of Bachelor of Engineering in Computer Science and Engineering to **“RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL (M.P.)”** is an authentic record of my work done under the guidance of **Prof. Vikas Dubey, Department of Computer Science & Engineering, GYAN GANGA INSTITUTE OF TECHNOLOGY & SCIENCES, JABALPUR**.

The matter reported in this Project has not been submitted earlier for the award of any other degree.

Date:

Place: JABALPUR

ACKNOWLEDGEMENT

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I take this opportunity to express deep sense of gratitude to Dr. **Ashok Verma, Head of Department of Computer Science and Engineering** for his encouragement and kind approval. Also, I thank him in providing the computer lab facility. I would like to express our sincere regards to him for advice and counselling from time to time.

I owe sincere thanks to all the faculty members of Department of Computer Science and Engineering for their advice and counselling time to time.

Date:

Place: JABALPUR

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1. Introduction

Computer Vision, a field that wasn’t known to a vast group of people just a few years ago, is now something that everyone knows about. The application of Computer Vision is seen in many areas from medicine to security and from traffic flow analysis to self-driving cars.

This project makes use of Computer Vision to estimate the speed of vehicles and log their details into a csv file if it crosses a certain threshold value of speed. Further details about the project are discussed below.

1.1 Scope of the Work

This project is being built with the idea of it being implemented on a smaller scale rather than a full scale city-wide or state-wide deployment. It can be very helpful in identifying miscreants who violate traffic rules on a whim. But if we talk about the prospects for the project, it can be implemented on a city-wide basis especially dedicated to areas where it is hard for law-enforcement agencies to keep a constant watch.

1.2 Product Scenarios

The user of this project can be anyone who is facing problems in their localities where there are people who show no regard to the traffic rules and violate them whenever they desire. We can understand the product scenario better with a case study which is discussed below.

‘Mr. Sharma lives in Ambedkar Nagar colony with his family. Since there is no playground in the colony many a times his son plays with his friends on the road right outside his home. The colony has already made this clear that no vehicles should cross a speed limit of 20kmph within the colony to ensure the safety of the children, but it has been observed that they are not following this rule and endangering the well-being of the children. So, Mr. Sharma wants a system to be developed which is capable enough to identify such people so that they can be reported to the local authorities. Mr. Sharma isn’t very tech savvy, but he wants the system to be low cost and efficient.’

2 Requirement Analysis

2.1 Functional Requirements

- Reporting Requirements – These are the information and data that an individual must supply to government agencies in case of any ill practices or law violation is found.
- Historical Data Management – This includes how the log files will be handled, which includes the data of the vehicles passing by along with the time stamps.

2.2 Non-Functional Requirements

- Compatibility – Throughout the development of the project it must be made sure that the minimum hardware requirements and software versions are compatible.
- Maintainability – With changing surveillance environment how easy it is to maintain the system.
- Usability – The system should be easy for people to interact with as it might not be handled by people who are tech savvy.
- Performance – The performance aspect of the system is of utmost importance as the system would be deployed as a real-time solution and the response time and accuracy for detection and tracking would be ideal.

2.3 Use Case Scenarios

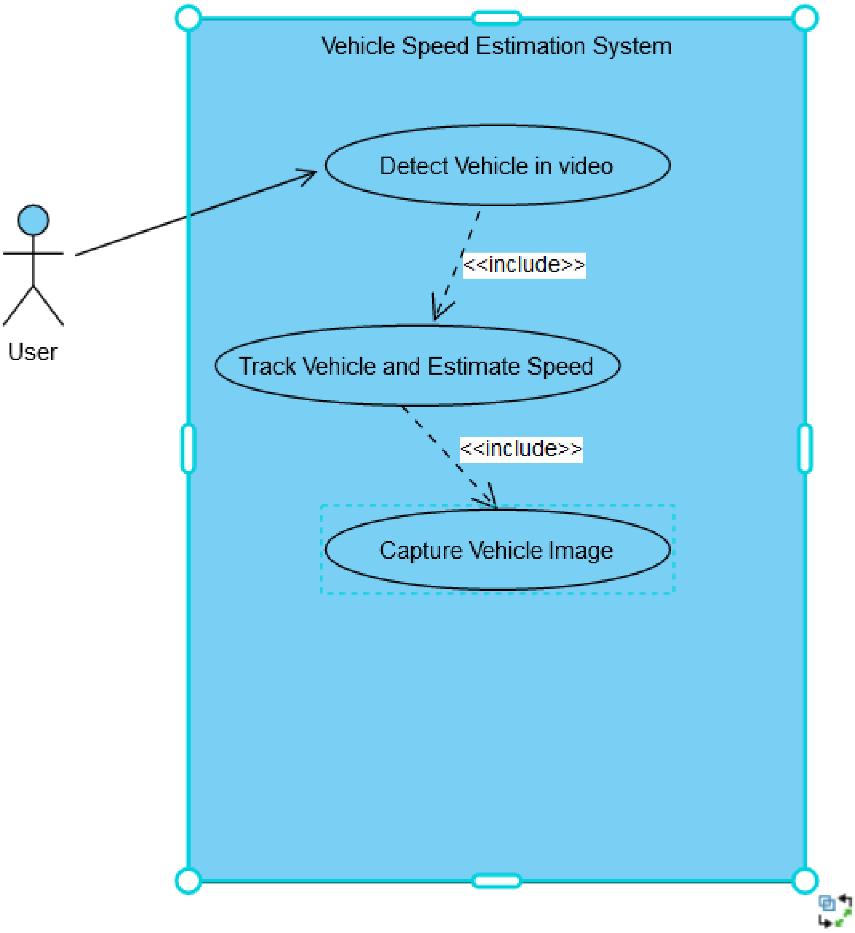


Fig 1. Use Case Diagram

- Users interact with the system through a video feed.
- The system first detects the cars in the video and once it is detected it proceeds to tracking them. Using two reference points the speed of the vehicle is estimated and a picture of the same is also captured for future reference.

2.4 Other Software Development Methodologies

- Incremental Model – The model that is being followed for the development of this project is an incremental model. With each new increment a new functionality is added to the project thereby the project will be completed in the stipulated time. Along with this the main reason for choosing this model is that the technology being used in the project is somewhat unfamiliar, so incremental model is the best choice model for this project.

2.5 RELEVANCE

- Speeding Cameras are present on many highways in order to catch speeding vehicles and improve safety on roads. Developed cities have more speed cameras and have more well monitored roads. Cameras today not only catch speed, but also register if a vehicle goes on the wrong lane or crosses a red light. If there are consequences to rash driving on roads (like road fines or license suspension), people would be more careful in following street rules. This in turn would reduce the number of accidents on the road.

3. System Design

3.1 Design Goals

Following are the design goals for the project:

- Usability – The system should be easy to use for different user groups.
- Compatibility - Throughout the development of the project it must be made sure that the minimum hardware requirements and software versions are compatible.
- Performance – The performance aspect of the system is of utmost importance as the system would be deployed as a real-time solution and the response time and accuracy for detection and tracking would be ideal.
- Efficiency – Reducing the number of resources consumed through design.
- Cost – Reducing the total cost of the project through efficient design.

3.2 System Architecture

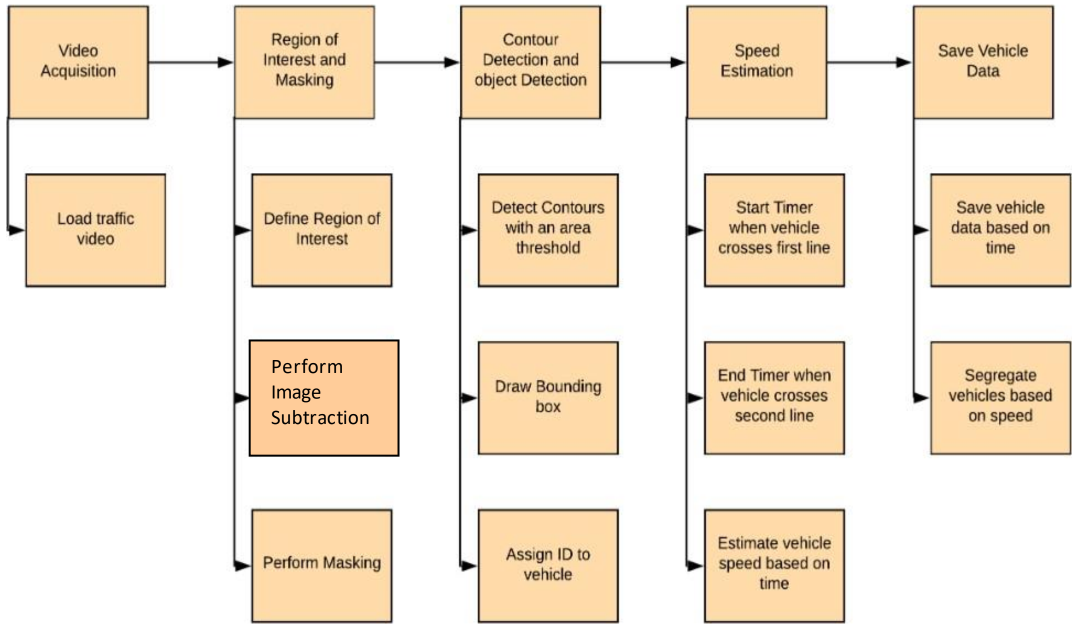

Video Acquisition
Region of Interest and Masking
Contour Detection and object Detection
Speed Estimation
Save Vehicle Data
Load traffic video
Define Region of Interest
Detect Contours with an area threshold
Start Timer when vehicle crosses first line
Save vehicle data based on time
Perform Image Subtraction
Draw Bounding box
End Timer when vehicle crosses second line
Segregate vehicles based on speed
Perform Masking
Assign ID to vehicle
Estimate vehicle speed based on time

Fig 2. Project Model

The system architecture is defined in the diagram above, first up we've Video Acquisition and Loading of the video. Next-up we identify our Region of Interest, once the region of interest is identified we perform image subtraction and masking to find the exact location of the object. Once it is done, we do the Object Detection where we draw a bounding box around the object and assign it a Vehicle ID. Next step in the process is to estimate the speed of the vehicle for which we define two reference lines, and we start the timer once the vehicle crosses the first line and stop the timer as soon as it crosses the second line. The speed of the vehicle is calculated using the metrics 'Distance travelled' divided by the 'Elapsed Time'. Once the speed is calculated t\an image of the vehicle is also captured to feed it to a different module that can extract the license plate number of the vehicles captured using the previous module.

3.3 Detailed Design Methodologies

- Video Acquisition - The video used in this project is a street view in Abu Dhabi. The number plates of the vehicles in the video are however not clearly visible.

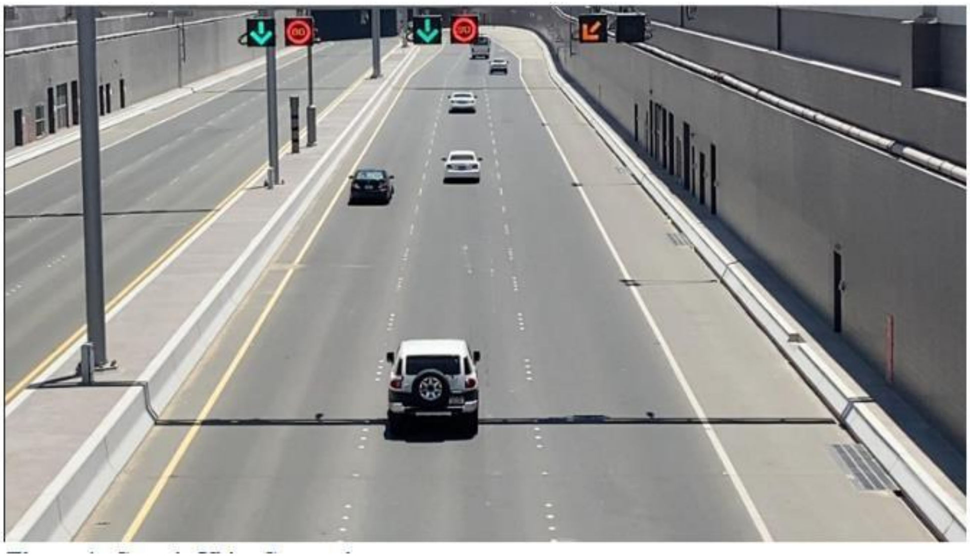


Fig 3. Traffic Feed

- Region of Interest and Masking - Region of Interest (ROI) takes a smaller portion of the original video. On this ROI, Image subtraction is performed to detect a moving vehicle. (Image Subtraction helps find the difference between two frames). Masking is performed to make the moving vehicles appear white and the rest of the image black.

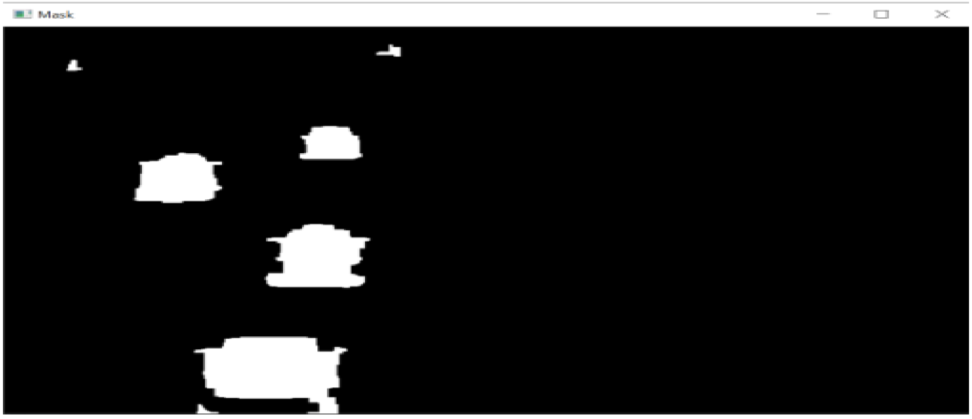


Fig 4. Masking the frames

- Contour Detection and Object Tracking - Based on the area threshold of number of pixels, the contours are detected. The threshold is used to avoid detecting contours of smaller moving objects that are not vehicles. The object is tracked based on the distance between two contours between frames. An ID is assigned to each contour

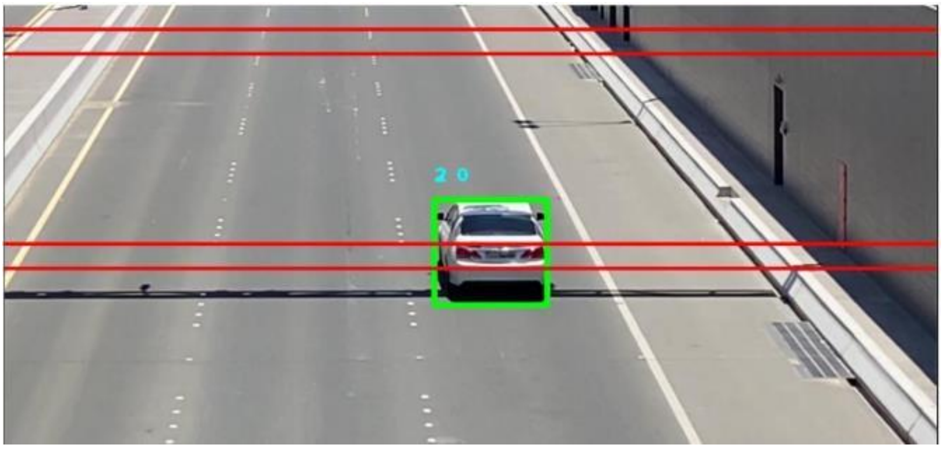


Fig 5. Detection of Vehicle

- Speed Estimation - Time difference between the position of a vehicle is calculated and the speed is estimated based on a formula. The timer starts when the vehicle crosses the first line, and the timer ends when the vehicle crosses the second line. The speed is displayed on top of the bounding box only when the vehicle crosses both the lines.

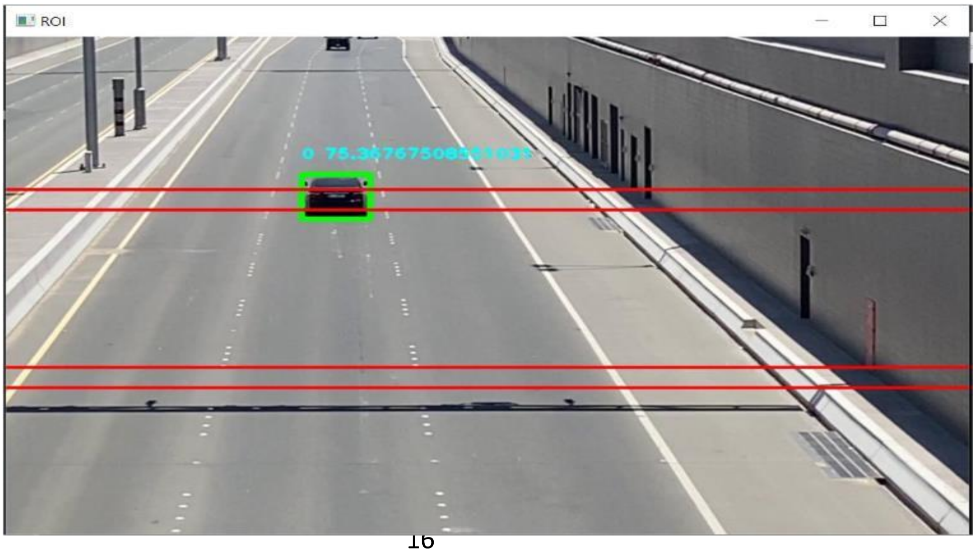


Fig 6. Speed Estimation

- Save Vehicle Data - The picture of the bounding box (the vehicle) is saved into a file along with the speed. Vehicles crossing the speed limit are segregated into a separate folder.

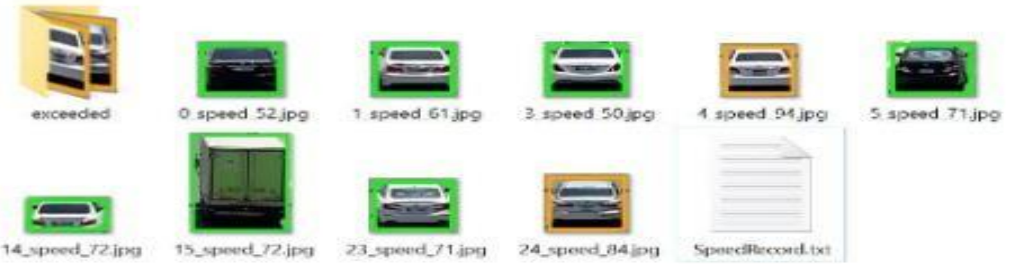
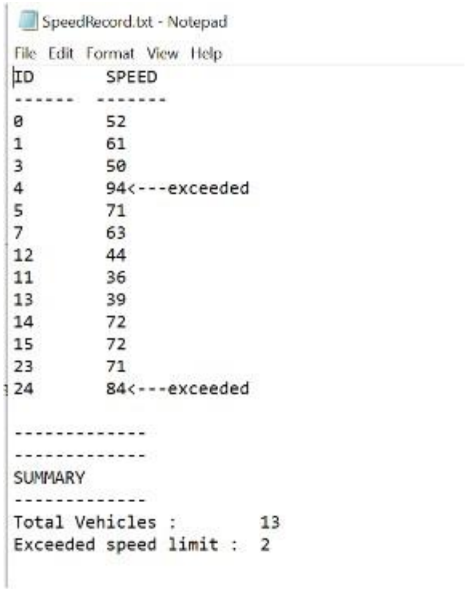


Fig 7. Captured Images

- Create Summary - The vehicle data is saved in a text file. The vehicles that exceeded the speed limit are pointed. A summary of the number of vehicles and the speed violators are displayed.



```
ID        SPEED
------   -------
0         52
1         61
3         50
4         94<---exceeded
5         71
7         63
12        44
11        36
13        39
14        72
15        72
23        71
24        84<---exceeded

-------------
-------------
SUMMARY
-------------
Total Vehicles :        13
Exceeded speed limit :  2
```

Fig 8. Saved Summary

7. Using Tesseract for License Plate recognition – Further the images saved are to be processed using tesseract to obtain the license plate number of the vehicles.

4. Work Done

4.1 Development Environment

4.1.1 Software Requirements:

- Python version 3.7
- OpenCV
- Jupyter Notebook
- Google Colab

4.1.2 Hardware Requirements:

- Intel i5 10th Gen or above OR AMD Ryzen 3750H or above
- 16GB RAM or above
- Nvidia GTX 1660ti or above
- Camera recording at 30fps or above

4.2 Implementation

- Video Acquisition

```
cap = cv2.VideoCapture("traffic4.mp4")
f = 25
w = int(1000/(f-1))print(w)
```

- Region of Interest and Masking

```
kernalOp = np.ones((3,3),np.uint8)
kernalOp2 = np.ones((5,5),np.uint8)
kernalCl = np.ones((11,11),np.uint8)
fgbg=cv2.createBackgroundSubtractorMOG2(detectShadows=True)
kernal_e = np.ones((5,5),np.uint8)

while True:
ret,frame = cap.read()
frame = cv2.resize(frame, None, fx=0.5, fy=0.5)
height,width,_ = frame.shape
#print(height,width)
#540,960

#Extract ROI
roi = frame[50:540,200:960]

# #MASKING METHOD 1
# mask = object_detector.apply(roi)
# _, mask = cv2.threshold(mask, 250, 255, cv2.THRESH_BINARY)

#DIFFERENT MASKING METHOD 2 -> This is used
fgmask = fgbg.apply(roi)
ret, imBin = cv2.threshold(fgmask, 200, 255, cv2.THRESH_BINARY)
mask1 = cv2.morphologyEx(imBin, cv2.MORPH_OPEN, kernalOp)
mask2 = cv2.morphologyEx(mask1, cv2.MORPH_CLOSE, kernalCl)
e_img = cv2.erode(mask2, kernal_e)
```

- Contour Detection

```
contours,_ = cv2.findContours(e_img,cv2.RETR_TREE,cv2.CHAIN_APPROX_SIMPLE)
    detections = []

    for cnt in contours:
        area = cv2.contourArea(cnt)
        #THRESHOLD
        if area > 1000:
            x,y,w,h = cv2.boundingRect(cnt)
            cv2.rectangle(roi,(x,y),(x+w,y+h),(0,255,0),3)
            detections.append([x,y,w,h])
```

- Speed Estimation

```
    def getsp(self,id):
        if (self.s[0,id]!=0):
            s = 214.15 / self.s[0, id]
        else:
            s = 0

        return int(s)
```

- Drawing Rectangles and displaying on the screen

```
boxes_ids = tracker.update(detections)
    for box_id in boxes_ids:
        x,y,w,h,id = box_id



        if(tracker.getsp(id)<tracker.limit()):
            cv2.putText(roi,str(id)+" "+str(tracker.getsp(id)),(x,y-15),
cv2.FONT_HERSHEY_PLAIN,1,(255,255,0),2)
            cv2.rectangle(roi, (x, y), (x + w, y + h), (0, 255, 0), 3)
        else:
            cv2.putText(roi,str(id)+ " "+str(tracker.getsp(id)),(x, y-15),cv2.FONT_HERSHEY_PLAIN,
1,(0, 0, 255),2)
            cv2.rectangle(roi, (x, y), (x + w, y + h), (0, 165, 255), 3)

        s = tracker.getsp(id)
        if (tracker.f[id] == 1 and s != 0):
            tracker.capture(roi, x, y, h, w, s, id)
```

- Save Vehicle Images and speeds

```
#SAVE VEHICLE DATA
    def capture(self,img,x,y,h,w,sp,id):
        if(self.capf[id]==0):
            self.capf[id] = 1
            self.f[id]=0
            crop_img = img[y-5:y + h+5, x-5:x + w+5]
            n = str(id)+"_speed_"+str(sp)
            file = './TrafficRecord/' + n + '.jpg'
            cv2.imwrite(file, crop_img)
            self.count += 1
            filet = open("./SpeedRecord.txt", "a")
            if(sp>limit):
                file2 = './TrafficRecord/exceeded/' + n + '.jpg'
        cv2.imwrite(file2, crop_img)
        filet.write(str(id)+" \t "+str(sp)+"<---exceeded\n")
        self.exceeded+=1
    else:
        filet.write(str(id) + " \t " + str(sp) + "\n")
    filet.close()
```

- Create Summary

```
#TEXT FILE SUMMARY
    def end(self):
        file = open("./SpeedRecord.txt", "a")
        file.write("\n-------------\n")
        file.write("-------------\n")
        file.write("SUMMARY\n")
        file.write("-------------\n")
        file.write("Total Vehicles :\t"+str(self.count)+"\n")
        file.write("Exceeded speed limit :\t"+str(self.exceeded))
        file.close()
```

4.3 Results and Discussions

Currently the development that has been made so far is satisfactory with an object detector and tracker implemented. The system can identify vehicles passing on a road and track them at the same time along with giving each of the vehicles a unique id that helps in uniquely identifying a vehicle in consecutive frames. Multiple vehicles can be detected, and their speeds can be detected. However, if two vehicles are moving extremely close to each other, it may be detected as a single object. This project requires the camera to be as still as possible, as movement is used to distinguish vehicles from the background.

Along with this it is also able to estimate the speed of the vehicle given two reference points. A separate module for license plate recognition has also been set in place which can be used to find the license plate number of the cars.

5. Conclusion and Future Plans

The project is modelled around the field of Computer Vision and makes use video feed to detect the speed of a moving vehicle along with that the license plate number of the vehicle is also logged in case if it must be reported for traffic rule violation. All this is being achieved by making use of for object detection using image subtraction technique, for object tracking we are using a frame-based tracking approach and we track the object in every consecutive frame and OpenCV (for handling the video feed). As of now an object detector and a tracker have been implemented which are capable of tracking vehicles in consecutive frames and along with that it also assigns an ID to each detected object so that it can be uniquely identified.

The module built is also capable of detecting speed of the moving vehicles and logging their details in a separate text file along with their corresponding IDs and Speed. It also captures the images of the vehicles once it passes a reference line.

6. References

- Determining vehicle speed based on video using convolutional neural network

  https://www.sciencedirect.com/science/article/pii/S2352146520307705

- Detection of Vehicle Position and Speed using Camera Calibration and Image Projection Methods

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- Vehicle speed measurement model for video-based systems

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- An Efficient Approach for Detection and Speed Estimation of Moving Vehicles

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