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VEHICLE TRACKING AND SPEED ESTIMATION

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1. Abstract
People's lifestyles have drastically changed in recent years due to rising wages and falling car prices, which has resulted in an enormous increase in the number of cars on the road and increased traffic and bustle. The manual enforcement of traffic laws, such as the posted speed limit, is insufficient. Police and manpower are not available in sufficient numbers to monitor traffic and automobiles on the roads and inspect them for speeding. As a result, we need to install technologically superior speed calculators that can identify automobiles on the road and determine their speeds. To teach our system to detect the item, in this example the automobile, we may use open CV software, which employs the Haar cascade. We created a Haar cascade to identify automobiles on the road, and then calculated their velocities with a Python.

Key Words: automobiles, cars, cascade, management, manpower, people, pollution, traffic

2. Introduction
The ever-increasing number of cars on the road has put a strain on road capacity and infrastructure, making traffic management difficult and giving rise to issues such as congestion, crashes, and air pollution, among others. These issues have a huge influence on our everyday lives. To mitigate their impact, a strong and effective traffic management system is essential. Every day, a vast amount of traffic data is created. Traffic data comprises information on traffic flow, distribution, patterns, and collisions that may be utilised to solve a variety of traffic problems. Traffic volume and distribution may be utilised to create structural and geometric designs for road segments. Traffic collisions may be analysed to determine the relationship between traffic volume and the number and severity of collisions, which can aid in the investigation and assessment of collisions and dangers. RADAR (Radio Detection and Ranging) technologies are currently used in the majority of vehicle speed detection systems for traffic signal speed law enforcement [1]. This approach employs active gadgets, which are significantly more costly than static camera systems. At the same time, the RADAR-based system must interface with rapid and high-resolution imaging sensors to acquire images for vehicles. In addition to the RADAR approach, there are audio systems[2] and LIDAR (Laser Imaging Detection And Ranging)[3]. The Doppler shift phenomenon describes how the RADAR technology works [4]. We commonly encounter the Doppler shift phenomena in our daily lives. It occurs when sound is produced by a moving vehicle, resulting in a sonic boom.When the sound wave reflects back to the wave generator, the frequency of the sound changes, and the scientists use the frequency variation to determine the speed of the vehicle. However, the equipment required to utilise this procedure is expensive. Finding alternative equipment to cut costs is therefore required. Image processing technologies can help here.

3.System Requirement Analysis

3.1 Existing System

Doppler radar is one of the advancements used by our law enforcement office to determine the speed of a moving vehicle. It emits a radio wave at a vehicle and then estimates the vehicle's speed based on the change in reflected wave recurrence. It is a fixed or handheld device that works when a moving thing is in the field of view and no other moving items are nearby. If the firearm is not visible, the cosine error must be considered. Furthermore, radio interference, which causes errors in speed finding, must be considered. With the increase in metropolitan population in many cities, automobile measurements have also increased dramatically. In a new report over-speeding causedthe majority of the mishaps, trailed by tanked driving.Overspeeding on motorcycles and three-wheelers is one of the leading causes of accidents. To aid traffic the executives framework in our country, we need to create conservative traffic checking frameworks. Recently, image and video processing has been used to the field of traffic executives framework.

Disadvantages

1. *Range folding:* Doppler radar can cause range folding errors on the image projected on thescreen. The lines and the random little streaks in an image are generated by range folding.

2. *Difficult to measure round trip return:* Round trip return timing is very essential for theDoppler radar system. It is very difficult to determine the returns from the targets and otherobjects located in the same area.

3. *Limited range:* The radars are able to see target objects at a certain range with completeconfidence. Anything that is outside the normal range (unambiguous range) is unclear.

4. *Cannot detect wind independently:* Unless you have additional remote sensing, the Dopplerradar system can't detect wind independently.

5. *High maintenance:* The Doppler radar system require constant maintenance in order toprovide accurate information. This may turn out to be expensive.

6. *Prone to failure:* Due to its increased sensitivity, the radar is more prone to failure whenexposed to severe weather.

7. *Reliability*: The system cannot be entirely be relied upon. It lacks some forecasting principlesdue to certain limitations.

8. *Require expertise to analyze:* The measured data require a professional meteorologist toanalyze collected data and provide accurate information.

9. Inaccurate readings due to interference: Doppler radar can provide inaccurate speedreadings if there is interference from other sources such as weather conditions, nearby objects, orreflections. This can result in speed readings that are either too high or too low, leading toincorrect measurements.

10. *Limited accuracy at close range:* Doppler radar can have limited accuracy at close rangesdue to the small frequency shift in the radar signal caused by slow-moving objects. This canresult in inaccurate readings for vehicles that are traveling at low speeds or are in close proximityto the radar device

3.2. Proposed System

The manual attempts to prevent persons from breaking traffic rules, for example, as far as practicable. There isn't enough police and manpower to follow traffic and automobiles on the streets and truly look at them for speed regulation. As a result, we demand mechanically advanced speed addition devices to be created that can recognise cars on the road and determine their velocity. Two things are required to carry out the preceding idea. As a result, we may use Open CV programming, which employs the Haar course, to build our computer to recognise the item, in this case the automobile.

Advantages

1. *Accuracy:* Open CV can be used to accurately estimate vehicle speed by tracking themovement of vehicles in real-time. By analyzing the movement of vehicles overtime, Open CVcan calculate the speed of the vehicle with a high degree of accuracy.

2. *Real-time processing:* Open CV is designed to process video streams in real-time, making itan ideal tool for tracking the movement of vehicles on the road. This means that Open CV canprovide speed estimates for multiple vehicles simultaneously, without any lag or delay.

3. *Cost-effective:* Open CV is an open-source software library that can be downloaded and usedfor free, making it a cost-effective solution for vehicle speed estimation. This is particularlybeneficial for small businesses or organizations that may not have the resources to invest inexpensive hardware or software solutions.

4. *Easy integration:* Open CV can be easily integrated with other software and hardware systems,making it a flexible tool for vehicle speed estimation. This means that Open CV can be used withvariety of cameras, sensors, and other equipment to provide accurate speed estimates in avariety of settings.

5. *Customizable:* Open CV is highly customizable, which means that it can be tailored to meetthe specific needs of different applications. This allows users to modify the algorithms andsettings used for vehicle speed estimation, depending on the specific requirements of theirproject or application.

Software Requirements	
Coding Language	python
Operating system	Windows 10
Tool	PyCharm/Python IDLE

Hardware Requirements	
Hard Disk	512 GB
Monitor	15” LED

Input Devices	Keyboard, Mouse
System	Intel core i3
Ram	4 GB

4. Python Modules

4.1 Open CV Library

Open CV (Open Source Computer Vision Library) is a free and open source computer vision and machine learning software library. Open CV was created to offer a standard foundation for computer vision applications and to speed the adoption of machine perception in commercial goods. As an Apache 2 licenced product, Open CV makes it simple for enterprises to use and alter the code.

The collection contains over 2500 optimised algorithms, including both traditional and cutting-edge computer vision and machine learning techniques. These algorithms can detect and understand faces, detect objects, categorise human actions in videos, track camera movements, track objects as they move, extract 3D models of objects, produce 3D point clouds from stereo cameras, stitch images together to create high-resolution pictures of an entire scene, find similar images in an image database, remove red eyes from images taken with sparkle, follow eye movements, know scenery, and create markers to overlay.

The Open CV user community has over 47 thousand people, and the estimated number of installations exceeds 18 million. The library is widely utilised in businesses, research organisations and government agencies. It supports Windows, Linux, Android, and Mac OS and offers C++, Python, Java, and MATLAB interfaces. Open CV is primarily geared towards real-time vision applications, and it makes use of MMX and SSE instructions where they are available. Open CV is used to tackle a variety of applications, including face recognition. Automated inspection and monitoring, people counting (e.g., foot traffic in a mall), Vehicles relying on roads, as well as their speeds, Installations of interactive art, Detecting anomalies (defects) in the production process (the unusual damaged product), Image merging from a street view, Search and retrieval of video/images Navigation and control of robot and driverless cars, object recognition Image analysis in medicine, A three-dimensional structure from motion in movies Identify advertisements on TV channels.

4.2 Algorithm

Haar cascades are undoubtedly Open CV's most popular object identification approach, having been initially proposed by Viola and Jones in their landmark 2001 work, Rapid Object identification Using a Boosted Cascade of Simple Features. Not only can the Haar Cascade algorithm recognise faces, but it can also detect objects. The following are the general stages for utilising the Haar Cascade method to detect objects.

a. *Collect positive and negative images:* The first step is to collect a set of positive images that contain the object of interest and a set of negative images that do not contain the object. These images will be used to train the classifier.

b. *Train the classifier:* The algorithm uses a machine learning classifier, such as a Support Vector Machine (SVM), to learn the features that distinguish positive and negative images. This 30 involves extracting Haar-like features from the training images, which are essentially rectangular regions of the image with different intensities, and using them to train the classifier.

c. *Create the cascade:* The Haar Cascade algorithm uses a cascade of classifiers to improve detection speed and reduce false positives. The cascade consists of multiple stages, with each stage containing multiple weak classifiers. Each weak classifier applies a simple threshold to a Haar-like feature to determine whether it matches the object of interest.

d. *Detect objects:* Once the cascade is created, it can be applied to a new image or video frame to detect the object of interest. The algorithm slides a window of varying sizes over the image, and at each window position, it applies the cascade of classifiers to determine whether the object is present.

e.*Post-processing:* The algorithmapply post-processing techniques, such as non-maximum suppression, to filter out duplicate detections and improve the accuracy of the results.

f. *Output the detected objects:* The final output of the algorithm is a set of bounding boxes around the detected objects. Overall, the Haar Cascade algorithm can be a powerful tool for object detection, but it does require a significant amount of training data and can be sensitive to variations in lighting and background. Additionally, the algorithm is relatively slow compared to some other object detection algorithms, so it may not be suitable for real-time applications

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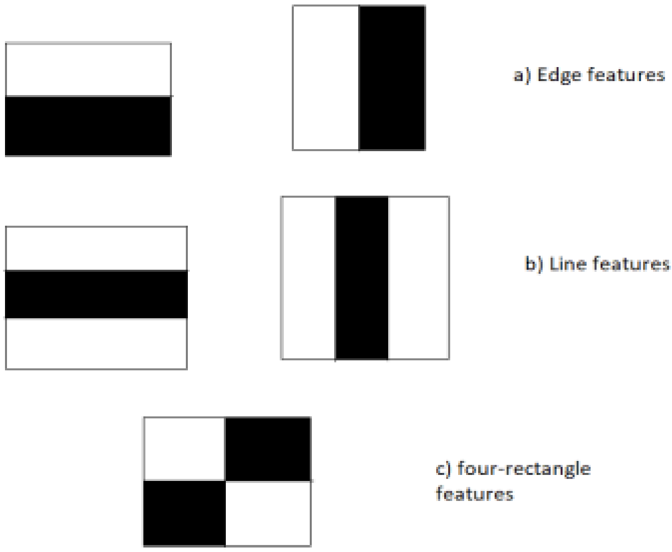

g.

4.3 Sample Code

Importing Modules

The initial action is to load the necessary archives, which include numpy, and Open CV (cv2). NumPy is used for computational tasks, time for time measurement, and Open CV for computer vision applications.

```
import numpy as np
import time
import cv2
```

Load Haar Cascade Classifier

The next phase is to use the cv2.CascadeClassifier() function to load the Haar Cascade Classifier XML file. This classifier is used to detect the presence of automobiles in video footage.

```
car_cascade = cv2.CascadeClassifier('hand.xml') #haarcascade
```

Open video file

```
cap = cv2.VideoCapture('car.mp4').
```

Initialize variables

Initialize some variables such as the width of the car, a flag variable, and start andEnd time variables.

```
wide=0.1 #depends upon size of car(~2.5)
flag=True
```

Read video frames

The read() function of the VideoCapture object may be used to read each frame of the video. This function returns two values: a boolean that indicates whether or not a frame was successfully read, and the frame itself.

```
while(cap.isOpened()):
ret, img = cap.read()
```

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```
height,width,chan=img.shape
print(height,width,chan)
```

Convert frame to grayscale:

Using the cv2.cvtColor() function, convert the coloured picture to grayscale. This is because grayscale photos are easier to work with for feature extraction and detection.

```
gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
cars = car_cascade.detectMultiScale(gray, 1.3, 5)
crp=gray[0:480,0:int(width/2)+10]
```

Detect cars

Using the cascade classifier's detectMultiScale() function, detect automobiles in the grayscale picture. This function takes as input a grayscale picture, a scaling factor, and a minimum number of neighbours and returns the coordinates of the recognised automobiles.

```
cars = car_cascade.detectMultiScale(gray, 1.3, 5)
crp=gray[0:480,0:int(width/2)+10]
```

Crop the frame

Crop the image using the coordinates of the detected car to get a region of interest (ROI).

```
while(cap.isOpened()):
ret, img = cap.read()
height,width,chan=img.shape
print(height,width,chan)
gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
cars = car_cascade.detectMultiScale(gray, 1.3, 5)
crp=gray[0:480,0:int(width/2)+10]
for(x,y,w,h) in cars:
cv2.rectangle(img, (x,y), (x+w,y+h), (0,255,0),2)
center_x=(2*x+w)/2
center_y=(2*y+h)/2
print(center_x,center_y)
```

Calculate distance and velocity and display information

Compute the distance that exists between the camera and the identified automobile using the width of the picture and the width of the detected car. Calculate the real distance between the camera and the automobile as well. Then, using the distance and time difference between the start and finish times, compute the car's velocity.

```
dist1=((wide*668.748634441)/w)
print("Distance from car:",round(dist1,2),"m")
roi_gray = gray[y:y+h,x:x+w]
roi_color = img[y:y+h,x:x+w]
dist0=((wide*668.748634441)/w)
actual_dist=dist0*(width/2)/668.748634441
print("Actual Distance:",actual_dist)
```

Display image

Display the image with the bounding box and the information using the cv2.imshow() method.

```
cv2.line(img,(int(width/2),0),(int(width/2),height),(255,0,0),2)
```

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cv2.imshow('frame',img)

Break loop
If the user presses the 'q' key, break the loop.
if cv2.waitKey(1) & 0xFF == ord('q')
Break;
Release video object and delete windows: Finally, use the release() method to release the VideoCapture object and the cv2.destroyAllWindows() function to destroy all Open CV windows.
cap.release()
cv2.destroyAllWindows().

Output:

In the above output, clearly we can observe that initially detecting the cars and then estimating it's speed at the bottom of the window.

4. Conclusion

By employing frame subtraction and masking techniques, moving vehicles are segmented out. Speed is calculated using the time taken between frames and corner detected object traversed in that frames. Finally frame masking is used to differentiate between one or more vehicles. With an average error of +/-2 km/h speed detection was achieved.

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