Vehicle Speed Detection Using PI CAM

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Abstract

With the increase in automobile use, the traffic on roads have only surged. At the current rate of increasing automobiles, speed determination has become a major concern in avoiding fatal accidents. Radar technology is the current productive way used for speed detection. The speed of the vehicle is also identified using offline videos which is a time consuming process. In this project we have come up with another method of using image and video processing which can overcome the drawbacks of radar guns and offline calculation. It uses the live video stream from the pi cameras for calculating the speed of the vehicle. The speed of the vehicle will be identified with the help of raspberry Pi and image of the car will be taken by the pi camera. This project helps in finding Any violation in the speed laws, can be observed. This helps in keeping track of the speed violators and saves the effort of an officer holding a radar gun on the highways.

Keywords: Vehicle speed detection, background subtraction, object detection, OpenCV, Python

1. Introduction

Traffic control has been a challenging conundrum for the government on a global scale. According to reports, a total of around 1.3 million crashes happen all over the world each year; a majority of them caused by over speeding of vehicles on roads. It will be impossible to provide sufficient manual labour to control traffic at all the busy areas if the on-road vehicles keep increasing at the current rate. Using radar technology for speed detection is not enough and the current scenario demands a better alternative.

Radar guns run on the Doppler shift phenomenon; radio waves are incident on the object of which speed is to be determined and the frequency of the reflected radio waves varies depending on the rate at which the object is moving. This change in frequency of reflected waves can be used to calculate the speed of an object. Though radar technology is found to be giving promising results, several drawbacks exist in this technology as mentioned below.

While in use, if there are any devices that generate radio waves in the near vicinity, the results are influenced & Extremely expensive. Radar gun must be pointed towards the direct path of the incoming traffic which may cause human errors some time. All these drove the researchers to look for an alternative that is better in terms of both performance and cost. Image and video processing has proven to give more reliable results with lesser costs and efforts. [1]Vehicle speed detection using offline videos are done over a decade which is a time consuming process and needs lots of storage.

This project illustrates how we can use pi cameras to detect the speed of vehicles. The prototype developed is designed using open cv, python & Raspberry Pi OS for software and can process on Quad Core 1.2GHz Broadcom BCM2837 64bit **CPU** (raspberry pi). The following are the steps involved in the speed detection

of vehicles. First phase is Object Detection – Several background and foreground extraction algorithms exist, like the use of Gaussian distribution by Bailo et al .(2005), adaptive median by Shi et al. (2002), morphological background estimation by Assad and Syed(2009) etc., but keeping in view the complexity and reliability, adaptive background subtraction is used where the background is separated from the foreground (vehicles). Second phase is object and keeping track of the objects in each frame of the video. Third comes the phase for the speed calculation in which the final speed in km/hr is calculated.

2. Existing System

The vehicle speed can be detected widely using a Radar gun. Radar gun is a device used to detect the speed of the moving object. [2]It is used in law-enforcement to measure the speed of moving vehicles and is often used in professional spectator sport, for things such as the measurement of bowling speeds in cricket, speed of pitched baseballs, and speed of tennis serves.

A radar speed gun is a Doppler radar unit that may be hand-held, vehicle-mounted or static. It measures the speed of the objects at which it is pointed by detecting a change in frequency of the returned radar signal caused by the Doppler effect, whereby the frequency of the returned signal is increased in proportion to the object's speed of approach if the object is approaching, and lowered if the object is receding.

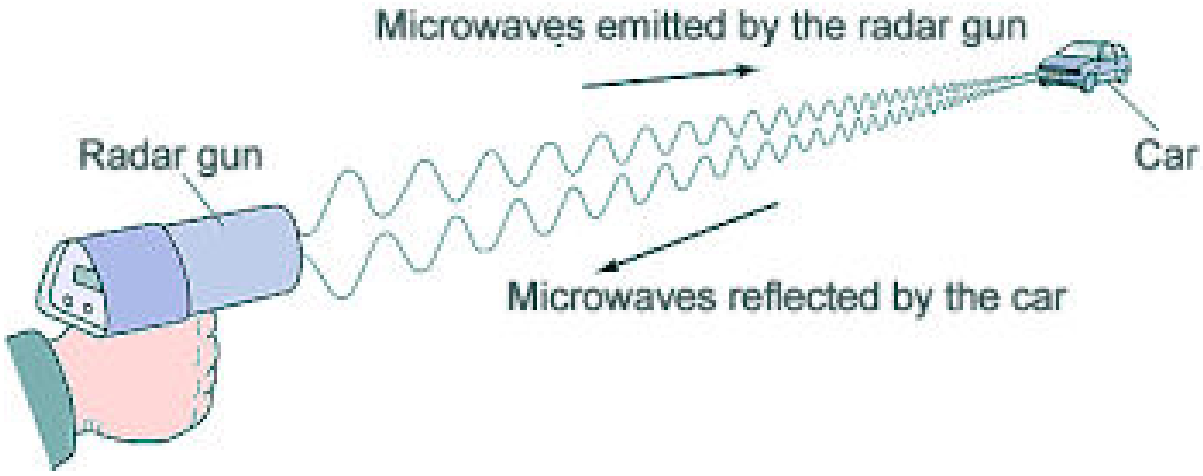
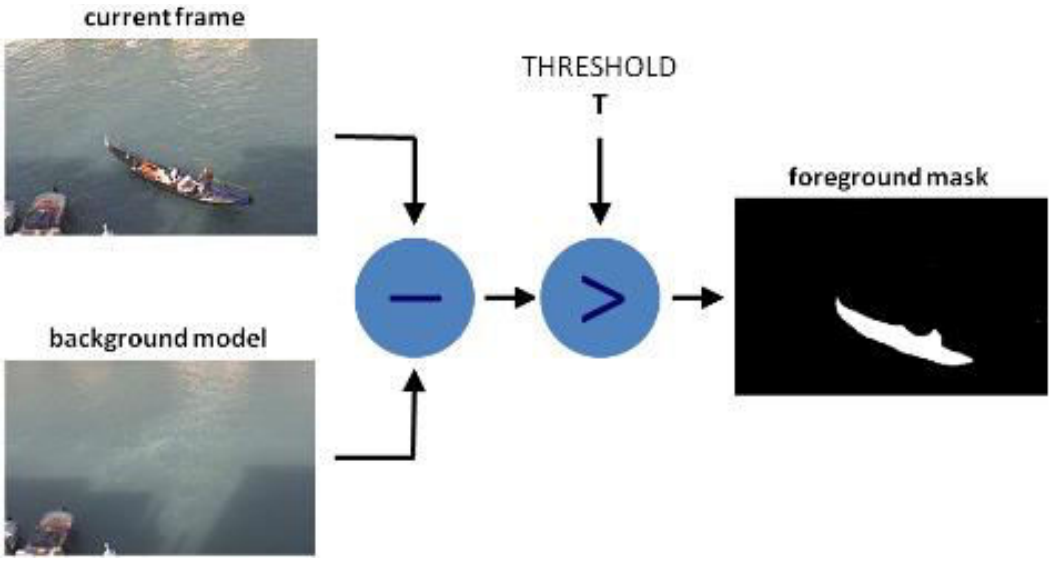


Figure (a) working of radar gun

3. Proposed System

As said before, the principle used behind object detection is background subtraction. Background subtraction is the process of separating out foreground objects from the background in the sequence of video frames. [4][5][6]Background at time t = B(x,y,t) & foreground image at time t = I(x,y,t). B(x,y,t) = I(x,y,t-1) **& Frame difference** is : $|I(x,y,t) - I(x,y,t-1)| > Threshold(th)$. When change in pixel value is found in frame difference threshold value becomes zero therefore detection of the object will be confirmed by segmentation & gray scale comparison.



Figure(b) shows the process behind background subtraction which will detect the moving object.

4. Experimental Setup

For object detection the Raspberry Pi will use the mounted Pi camera in it which has to be placed in a certain location from the travelling road of the vehicle. The field of view (FOV) of the Pi camera is about 53.5 degrees. [3]Let's say the road is about 49 feet (D) from our camera. The horizontal distance (C) covered by the image at a distance 49 feet from the lens would be:

Distance covered(**C**) = 2*49(tan (53.5 * 0.5))
= 98*tan(26.75)
= 98*0.50
= 49 feet

From figure (**c**) and the above equation we know the horizontal distance covered by the Pi camera's image is roughly equal to the distance between the road and len's. Of course, other cameras may have a different field of view and won't have this easy to determine correspondence.

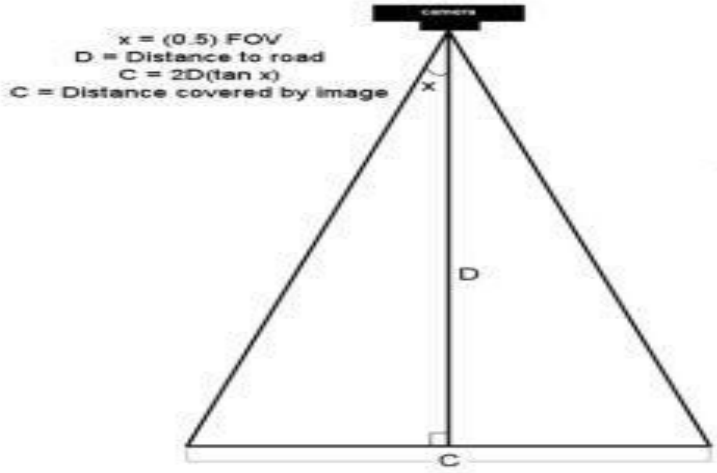


Figure (c) Camera Placement

6. Working methodology

When the camera is placed in a position vehicle detection will begin only after switching on the Raspberry pi and running the program. The total distance covered by the Pi Camera will be positioned under the name point A and point B. point A is where the vehicle enters the frame and point B is where the vehicle exits the frame.

When a vehicle is approaching the monitored lane [7][8][9][10]Raspberry Pi will Track the moving vehicle until it reaches the opposite side of the frame. Time taken for the vehicle to travel from point A to point B is noted by the Raspberry Pi.

Horizontal distance covered by the camera is known. [11]Dividing the horizontal distance by the number of pixels in the width of the frame gives the distance each pixel represents. The speed of the vehicle can be calculated from the time it takes for a vehicle to traverse the pixels.

- **Frame width** = □ × [□□□(□□□ × □. □) × □□□□□□□□]

  Frame width is the size of the frame covered by PI CAM
- **Feet per pixel** = $\left[\frac{\square\square\square\square\square\ \square\square\square\square h}{\square\square\square\square\square\ \square\square\square\square h}\right]$

  Feet per pixel gives the distance each pixel represents
- **Speed** = $\left[\frac{\square\square\square\square\square\square\ \square\square\ \square\square\square\square\square\square\ \square\square\ \square\square h\square\square\square\ \square\square\square h \times \square\square\square\square\ \square\square\square\ \square\square\square\square\square}{\square\square\square\square\ \square\square\square\square\square}\right]$

  Time taken is the amount of time taken for vehicle to travel from Point A to Point B

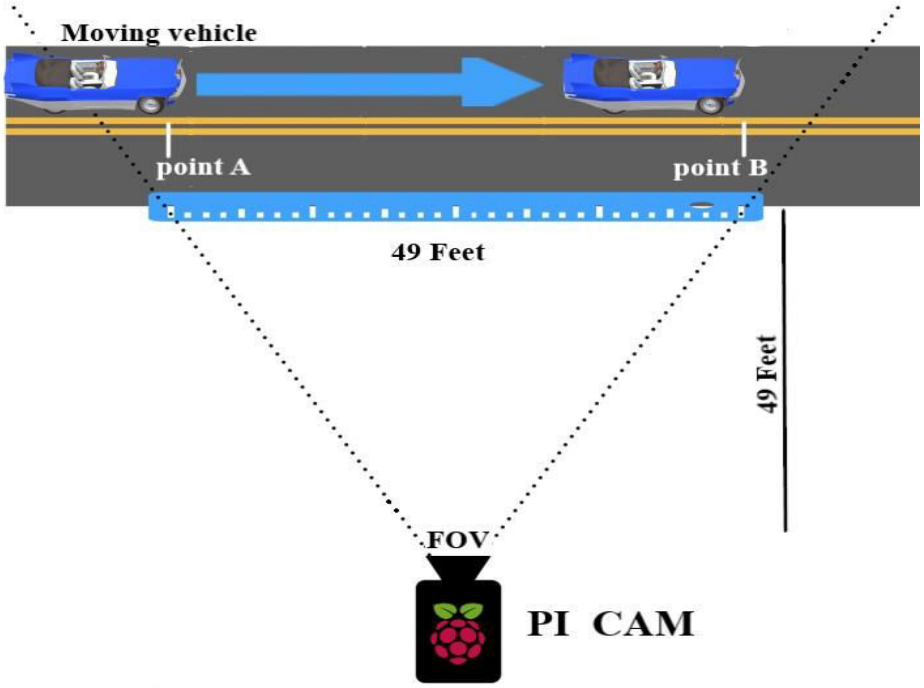


Figure (d) Speed Calculation

The figure (**d**) shows the model of calculating speed using a Pi camera. The Raspberry Pi will start detecting the object after running the program and a frame is drawn on the window to mention the vehicle lane to the Raspberry Pi. Once the vehicle speed is calculated the program will save the image of the vehicle along with the Speed information.

Figure (**e**) shows the flow chart of this project, after running the program Raspberry Pi will stream the real time video, then using background subtraction frame capturing will be processed to detect the vehicle and to track the moving vehicle. After tracking the vehicle path, feet per pixel is used to calculate the speed of the vehicle. The last image of the vehicle will be saved in Raspberry Pi along with speed information of the vehicle.

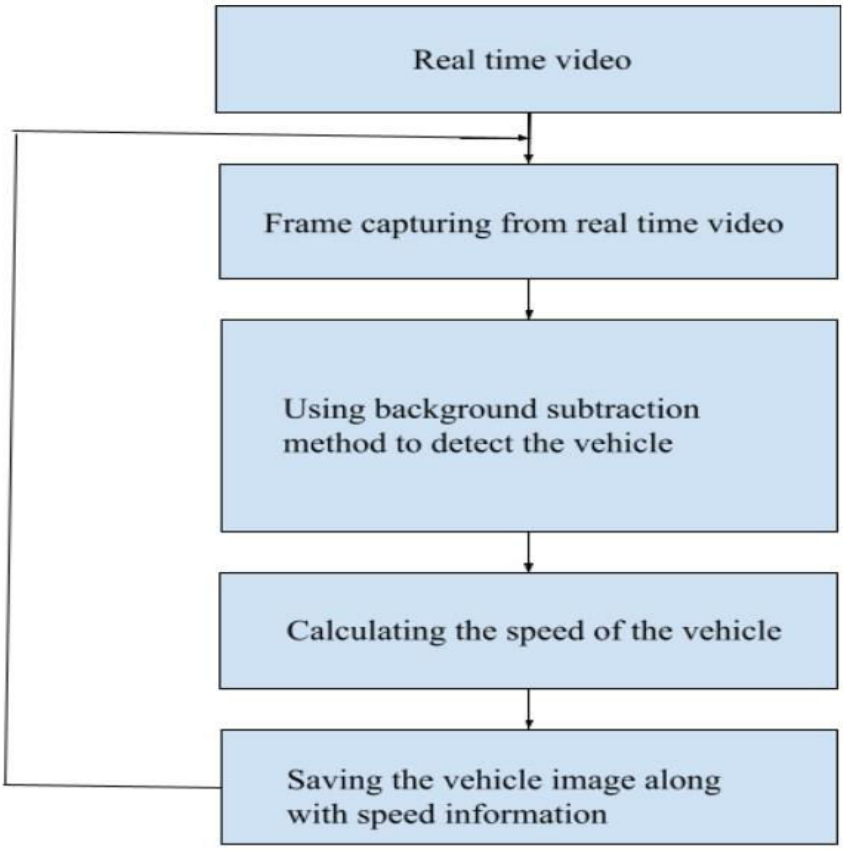


Figure (e) Flow Chart

7. Result and Output

The figure (**f**) is the experimental output which was taken by Raspberry pi with the help of Pi Camera by detecting the moving vehicle and tracking it for calculating the speed of the travelling vehicle. As shown the image of the moving vehicle is taken and saved in raspberry along with speed of the vehicle as well as date and time information.

The accuracy in speed measurement is tested by comparing the original travelling speed of the vehicle and speed which is measured by the Raspberry Pi shows original speed of the vehicle which is shown in speedometer is mostly accurate to the speed of the vehicle which is measured in Raspberry Pi.

When vehicle is travelling at the rate of 40 plus kph the accuracy may differ ± 1kph which can be overcome by using the latest version of Raspberry pi and also by improving the method for calculating the speed of the vehicle in python code.

Figure (f) Output

8. Conclusion

vehicle speed detection using the Pi Cam system was capable of continuously monitoring the speed of the approaching vehicle on road. In this system the Background subtraction worked very well to detect the moving vehicle as well as tracking the moving vehicle. The Pi camera worked well for the vehicle tracking at sunny weather. A minute change in accuracy occurred when the vehicle was travelling at the rate of 40 plus kph. The output was more accurate when there were no other moving objects in the surrounding.

The value of speed of each passing vehicle was stored in the Raspberry Pi along with the image of the vehicle. The proposed system has an accuracy of 93% - 95% on sunny days and 80% - 85% in dim weather due to change in lighting. By setting the speed limit in the program this system can be used for identifying the over speeding vehicles on road. Further improvements can be done in this system like using a high quality camera or by using the latest version of Raspberry Pi.

Accuracy can be improved by combining background subtraction algorithms along with superior object detection algorithms. Therefore the vehicle speed detection using Pi camera worked very well by detecting the moving vehicle speed in real time and also produced the expected result by saving the vehicle image along with the speed information without major compromise in accuracy.

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