Automatic Vehicle Speed Detection System Using Image Processing

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Abstract:The project's aim is to create an automatic speed detection device that can identify vehicle speeds and directions. If over speeding is observed, a camera takes a picture of the vehicle automatically, and Digital Image Processing (DIP) techniques are used to map the vehicle's speed. The results are focused on tests of video recordings collected with various vehicles, driving styles, and vehicle positions at the time of filming. A new speed detection camera system that can be used instead of radar. In either online or offline mode, the speed detection camera system (SDCS) employs a variety of image processing techniques on video streams recorded from a single camera, SDCS is now capable of measuring the speed of moving objects without the need for conventional radar. SDCS is a low-cost alternative to conventional radars that has the same or better accuracy.
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Keywords: **Image processing, speed detection camera, radar, object detection, co-ordinates, framing.**

I. INTRODUCTION

The field of image processing has grown considerably during the past decade. This has been driven by 1) the increased utilization of imagery in myriad applications, coupled with 2) improvements in the size, speed and cost effectiveness of digital computers and related signal processing technologies Science, manufacturing, space, and government applications have all benefited from image processing. Many systems nowadays can be replaced by image processing alternate systems that perform better than the former systems. One of these systems that can replace traditional radars is an SDCS system. An SDCS system can be used as a replacement for current radar systems. This system is more cost-effective than current ones. It has the same, if not better, accuracy as traditional radars. The use of radar systems is becoming increasingly important. This is applicable not only to military but also to civilian applications. This includes (but is not limited to) monitoring vehicle speeds on highways, sporting events, aeroplanes, and so on [1-12]. The high cost of radar systems, as well as the increasing demands on the accuracy of the outputs, have had a negative impact on the widespread use of radar systems. This prompted researchers to look into alternative technologies that would provide greater accuracy while also being less expensive.

A. Problem Definition

Radars are incredibly costly nowadays. Nonetheless, they fall short of many possible applications in terms of precision. As a result, they must be replaced by automated systems in order to achieve greater accuracy, lower costs, and eliminate the human element from the system. There are two types of radars that are widely used in Egypt

•Radars for high-speed highways are highly costly (between 200,000 and 300,000 LE). They use cameras to measure the speed of moving vehicles and capture still images of vehicles that reach the speed limit..

• Radars for the inner city: these radars are less expensive (about 70,000 LE). They only use sensors to measure the speed of moving vehicles, and an operator is required to capture images of vehicles exceeding the speed limit.

• To prevent detection by conventional radars, other technologies are being used, such as:

• Laser and radar detectors are devices that detect when a vehicle's speed is being monitored and alert the driver (these may be illegal in some areas).

•Laser and radar jammers "jam" the laser and radar by sending back a scrambled signal that the speeding camera can't process (these may be illegal in some areas). As a result, the need for a new system to replace traditional radars has become a necessity due to their drawbacks.

B.SYSTEM DESIGN, RESEARCH AND IMPLEMENTATION

SPEED DETECTION CAMERA

1 Gatso

Police forces and local authorities in the UK are currently using over 4,000 fixed Gatso speed cameras [11]. The cost of installing a Gatso speed camera is approximately £20,000, but cost can go as high as £40,000 if located in a rural location, as the system requires a 240v power supply.

The Gatso camera is a fixed camera that can take up to 400 images. Gatso speed cameras can differentiate between cars, buses, and heavy trucks.

2 Truvelo

In the road, the Truvelo device is used to obtain vehicle speed and uses an infrared flash light instead of a visible flash light.

3 SPECS

The SPECS average speed camera systems use a cutting-edge video system with digital technology for Automatic Number Plate Reading (ANPR). A minimum of two cameras, each with an infrared illuminator, are mounted on gantries above the lane.

OBJECT DETECTION

Detecting moving objects in video streams is a well-known and challenging research issue. Apart from the obvious benefit of being able to separate video streams into moving and background elements, identifying moving blobs provides a focal point for detection, classification, and behaviour analysis, making these processes more effective because only “moving” pixels must be considered.

OBJECT TRACKING

Object tracking is the process of establishing a relationship between objects or parts of objects in a series of frames. It also aims to extract temporal data from objects like trajectory, posture, speed, and direction. It is a significant and difficult task to monitor detected objects frame by frame in video. It's an essential component of smart surveillance systems. This is because the device will be unable to extract coherent temporal knowledge about objects without object tracking. Higher-level behaviour analysis steps will be unlikely in such situations. Inaccurate foreground object segmentation caused by shadows, reflectance, and occlusions, on the other hand, makes tracking a difficult research issue.

SPEED CALCULATION

Since the performance of the object detection process is extremely accurate, it can handle abrupt lighting changes and shadows.. Therefore, the foreground image is ready for segmentation, labelling and tracking The object's speeds can also be determined by detecting the first frame at which the object entered the scene (Fr0) and tracking the object before it leaves the scene. This is done while ignoring other less relevant things, such as pedestrians crossing the road..

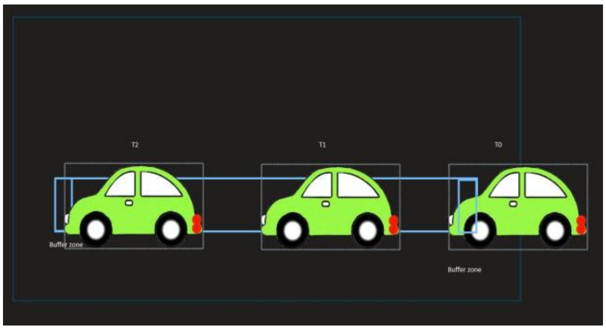
Raspberry Pi 3 Model B

Raspberry Pi users the B+ will be that little bit better for a wide range of tasks: from a media center able to play a wider range of video, due to the B+'s better performance and recent support for hardware-assisted decoding of HDCP-encrypted 1080p H**.** It has a 1.2GHz quad-core Arm Cortex-A53 CPU, 1GB RAM, 802.11n wireless LAN, and Bluetooth 4.1 built in.

II.PROGRAM OVERVIEW

The program's basic concept is to detect moving objects within a given frame. We don't detect movement across the entire image; rather, we detect movement in a given area where we know traffic will pass. We want this area to be as long as possible in terms of vehicle motion orientation, i.e. a large area. The height is less significant, but you want to make sure it can detect the vehicles' lights. We save the Pi time and resources by limiting the region that detects motion. We also reduce the risk of false detections, such as from birds in the sky. If it detects more than one item, it chooses the largest. Two green vertical bars represent the left and right extents of the tracked region in the picture below. I've made the monitored area very large in order to catch more frames while still being able to see the vehicle enter and exit the monitored area.

The feet per pixel at the distance the road is from the camera can be calculated using the Pi camera's field of view angle (Pi camera 2 is 62.2 degrees) and the distance between the road and the camera, as well as some trigonometry. OpenCV creates a sequence of frames with bounding boxes around objects it "sees" as moving as the vehicle moves across the image.

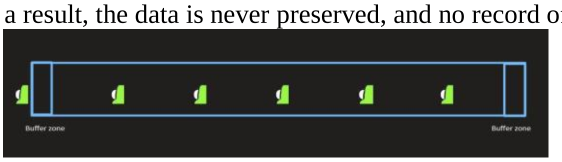


The code calculates the largest box and assumes it is the vehicle that will be registered. We get the x coordinate of each box's left-hand side. The x coordinate for a vehicle travelling right to left is at the front of the vehicle; for a vehicle travelling left to right, the x coordinate is the back of the bounding box, which usually corresponds to the back of the vehicle, but not if the vehicle has just reached the controlled area because the rear portion of the vehicle is still outside of the area. We can calculate the distance travelled by the vehicle between each frame by calculating the movement in the box's coordinates in pixels. The software also keeps track of the time between each frame, allowing us to calculate the vehicle's speed.

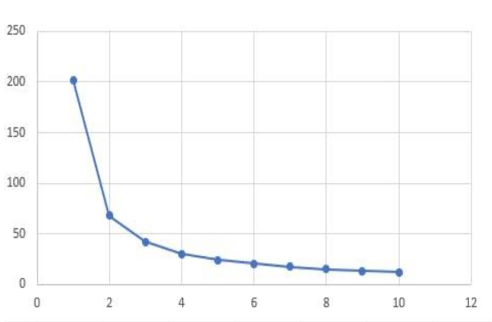
Modifications for Night Vision

The key to calculating speed at night is to follow the vehicle's front lights. You'll need to change the "minimum area" parameter since this is a smaller object than what you'd be monitoring during the day. This specifies the smallest box that OpenCV can draw around an entity. During the day, you want it to be very big to prevent picking up birds and other small animals. However, little else is visible at night (assuming there is no street lighting), so you can reduce the minimum area to the size of a headlight. The "threshold" parameter was the other one to play with. This is a number that OpenCV uses to detect an object based on pixel luminance differences. As a result, a low threshold detects more artefacts, whereas a high threshold detects less. We just want to identify the bright lights of a headlight on a car that has a strong contrast against black at night, so we'll set a high threshold. We'd like a value that senses front white light rather than red rear lights, but I discovered that there's too much difference in vehicle lights and weather conditions to do so.

When a vehicle approaches the sensor, the front lights are detected first, followed by the rear lights as it passes. If the rear lights tend to be larger than the receding front lights until the front lights leave the tracked region for either frame, the software shifts to monitoring the rear lights rather than the front lights. When this happens, the frame's speed measurement becomes negative; it's as if the car abruptly stopped and reversed in a fraction of a second. So, if we see a series of regular speed values followed by a negative value, we know it's picked up the tail lights. When this occurs, the software stops monitoring, disregards the most recent negative pace, and records whatever has been logged up to that point. As the light fades, the camera must extend the time the sensor is exposed to light for each image. This is to ensure that enough light is captured to create a picture. Despite the lack of a physical shutter, the Pi camera is essentially an electronic shutter that only switches on the sensor for a short period of time. In low-light conditions, exposure times lengthen, resulting in fewer frames being taken in the time it takes a vehicle to drive by. The moving box around the vehicle lights has the potential to cross the buffer zone strip between frames in the dark, particularly if the vehicle is moving quickly. As a result, the data is never preserved, and no record of this vehicle exists.



Increase the width of the strips at each end of the controlled region as a solution. The method used was to take a light metre reading every minute and then convert that reading into values for the buffer zone distance, threshold, and minimum area. Better results can be achieved by using a reciprocal function curve for the save buffer, a square root curve for the minimum field, and a simple stepped value for the threshold.

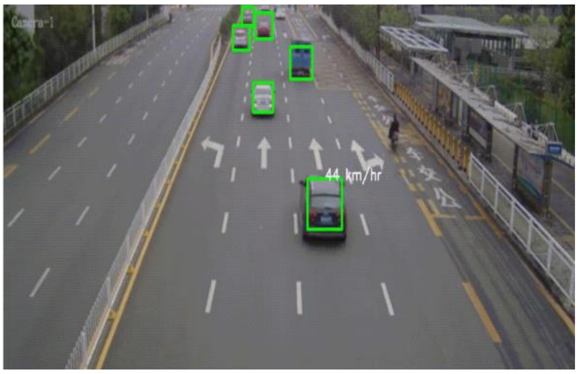


When a vehicle approaches the controlled area from the left, the front of the vehicle is the first to enter, but the entire vehicle is not normally entirely within the area, so the bounding box would not be along the entire length of the vehicle. For each frame, the Programme calculated the change in x coordinate as follows::

$$abs\_chg = x + w - \text{in}\,itial\_x$$

The left-hand corner of the bounding box of the first frame is "original." This is not the front of the car, but rather a position halfway between the front and back.

$$abs\_chg = (x+w) - (\text{in}\,itial\_x + \text{in}\,itial\_w)$$



Thus the figure 1 shows the speed of the passing vehicle across the camera.

III. CONCLUSION

The data is written to a local CSV file each time a vehicle is detected and its speed measured. It also sends it to another Pi running a MQTT server. Through various other steps it then end up with the data on a network share where it can open it in Excel. saving local files backed up in the cloud is so safer.

The SDCS framework is a software package that is explicitly designed to control a vehicle's traffic and offers a range of advantages.:

• SDCS is a cheap alternative system to the traditional radar system.

• SDCS is known as a valuable method for a number of complicated image processing algorithms and theories (Object Motion Detection, Shadow Removal, and Object Tracking).

• SDCS does not necessitate the use of professionals because it has a user-friendly interface and attractive nature.

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