SPEED DETECTION USING BACK-TRACKING ALGORITHM

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***Abstract* — Higher speed increases the likelihood of an accident and speeding is a major cause in approximately a one-third of all traffic fatalities. Not only does speeding cause crashes but it can also make accidents worse when they do happen. The idea is to develop a vehicle speed detection system using video streaming. This system requires a video scene which consists of components like vehicles which are in state of motion, starting point and ending point. The system is designed to detect and track the vehicles to calculate the speed of each vehicle. The idea is to develop a Speed Detection System (SDS) which can be used as an alternative for radar and other existing system. SDS uses several image processing techniques on video stream captured from camera, which makes SDS capable of calculating the speed of moving objects avoiding the traditional radar problems. SDS process is divided into three phases; first phase is the object detection followed by the object tracking in which the detected vehicle having assigned ID is tracked over frames. From distance and traveled time of detected vehicle, speed of that vehicle is determined.**

Keywords = Image processing, Camera, Object Recognition, Object tracking.

1.Introduction

Speed control on highways and accident-prone areas has been a challenging conundrum for the government on a global scale. According to RTO reports [1], a total of around 4,80,652 crashes happen all over the world each year, leading to 1,50,785 deaths. The number suggests that at least 413 people died every day in 1,317 road accidents [13]. A majority of them caused by over speeding of vehicles and It will be impossible to control accident but we can reduce them by reducing the speed and proper monitoring over the road which comes under the accident-prone areas. Using radar technology for speed detection is not enough and the current scenario demands a better alternative. Though radar technology is found to be giving promising results, several drawbacks exist. Many systems nowadays can be replaced by image processing for accurate predictions and better results. This is a better cost-effective system than current ones. It has proven to give more reliable results with lesser costs and efforts. A system is required that will easily detect over-speeding vehicles.

2. Related Works

A. Radar-speed gun:

A Radar-speed gun is a device used to measure the speed of moving objects. 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, athletes and tennis serves. Speed guns, like other types of radar devices, consist of a radio transmitter and receiver.

They send out a radio signal in a narrow beam, then receive the same signal back after it bounces off the target object. Due to Doppler effect, if the object is moving toward or away from the gun, the frequency of the reflected radio waves when they come back is different from the transmitted waves. When the object is approaching the radar, the frequency of the received wave is higher than the transmitted waves; when the object is moving away, the frequency is lower.

B. Lidar Device:

Lidar has a narrow beam, and easily targets an individual vehicle, thereby eliminating the need for visual estimation, and some models can record an image of the license plate at the same instant as recording the speed violation [6]. Speed estimation takes less than half a second, which, together with the narrow, targeted beam, results in offending vehicles having little warning even when using an evasion device [6]

Heavy weather may reduce the range of the device and in particular heavy fog will render it unusable. When used within a moving vehicle, the device measures the relative speed of the police and target vehicle. Sweeping the device while taking a reading so that (particularly at long range where angular separation between targets is slight) returning pulses from more than one target creates a false reading.

3. SYSTEM ARCHITECTURE AND METHODS USED

Initially the camera is positioned in such a way that all the vehicles can be easily captured through the window irrespective of the vehicles going in the set direction. Two lines will be drawn on the frame itself which will act as the starting line and the ending line for all the vehicles appearing in the frame where the distance between the two lines would always be different depending on the stream acquired by the camera set at different angles.

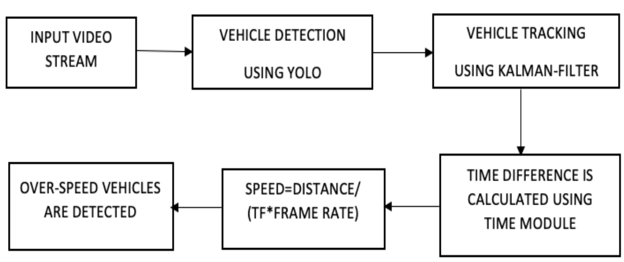

Fig 3.1 Block Diagram of SDS

There is a huge possibility that the stream received from the camera may not be crystal clear and the sharpness of the image matters a lot. The whole module is divided into three phases; The object detection phase, Object tracking phase and the Speed calculation phase wherein all the frames captured are passed on to the object detection algorithm (**YOLO**) [8] which is based on the concept of convolutional neural networks (CNN). The main objective of this algorithm is to predict the bounding boxes for the objects present in the frame. A bounding box describes the rectangle that encloses an object which shows the detection of object in that frame.

Fig 3.2 Object Detection using YOLO

Object tracking is the problem of estimating the positions and other relevant information of moving objects in image sequence. A back tracking is an algorithmic technique for solving problems recursively by trying to build the solution one step at a time.

After detecting the object **Kalman filter** which is a back-tracking algorithm is used to track the objects. Kalman filter estimates a process by using a form of feedback control i.e. the filter estimates the process state at some time and then obtains feedback in the form of measurements. [9].

They are ideal for systems which are continuously changing and uses a prediction followed by a correction in order to determine the states of the filter. This is sometimes called prediction-update. Since Kalman Filter's algorithm demands previous data points to be stored for feedback purpose Python's Pandas library's Data Frame module is used wherein it stores the centroids of all the vehicles in a row-column format so extracting those values becomes easy.

In this image sequence with the help of dynamics of moving object the object can be predicted from the position of objects in the current image. Using Kalman Filter an ID can be assigned to all the vehicles present in the frame and with the help of this ID, distinguishing the objects and tracking the objects throughout the frame becomes easy.

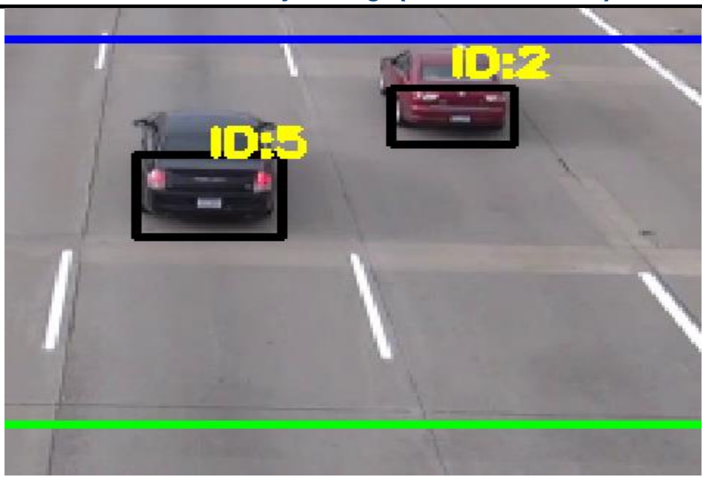

Fig 3.3 Object Tracking Using Kalman Filter

Now a specific area has to be decided in the frame where the two lines can be drawn. The distance between two lines is calculated using the Euclidean distance formula. Python's NumPy library provides in-built function which calculates the Euclidean distance.

In this case only the y- co-ordinates are taken into consideration keeping the x-co-ordinate values zero. To calculate the time frame which for this case, is the time the vehicle takes to reach from start line to the end line, time stamp has to be considered.

To capture the time-stamp of a specific vehicle some event is to be triggered. For each vehicle the centroid of that vehicle will act as a trigger event wherein as soon as the y-co-ordinate of the centroid (of vehicle) hits the start line, time-stamp is captured and when the vehicle hits the end line again time-stamp is captured. The time-stamp difference is calculated for every vehicle in frame. The centroids of all the vehicles are calculated using the Moments function which returns a list wherein only three parameters are considered i.e. the M00, M01 and the M10.

$$Cx = M10/M00 \text{ and } Cy = M01/M00$$

Considering the denominator of the formula which consists of time frame and frame rate, frame rate is calculated by using the API provided by OpenCV which is the **CAP_PROP_FPS** API where CAP stands for capture, PROP means properties and FPS stands for frames per second. Using this API frame rate can be found out with ease.

4.Experimental Results and Analysis

The experiment was conducted on raw video datasets where the system was tested on different videos wherein the format of these videos were of **mp4** and **mov** and the dimensions were of standard size i.e. 1280*720 pixels. The centroids are checked for all the vehicles passing in the frame and the centroid is denoted by red marker for all the vehicles.

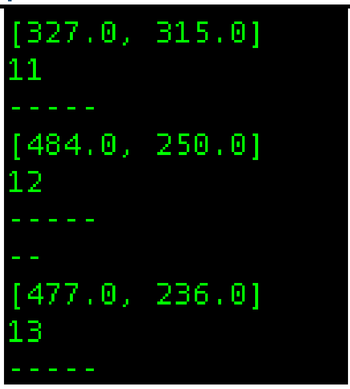

Fig 4.1 Centroids of vehicles at respective frames

The above snapshot is for a vehicle which shows that at 11^{th} frame the vehicle was at position (327.0, 315.0), followed by 12^{th} frame at (484.0, 250.0) and so on. Since raw videos are used the total number of frames can be found out using the **CAP_PROP_FRAME_COUNT** API of OPENCV.
The time at which the vehicle hits the first as well as second line can be found out using the formula

$$T = \text{FRAME AT THAT INSTANT} / \text{FRAMES PER SECOND}$$

The time frame is calculated as the the difference between T1 and T2. The below snapshot is the time the vehicle actually took to reach from the start to end line.

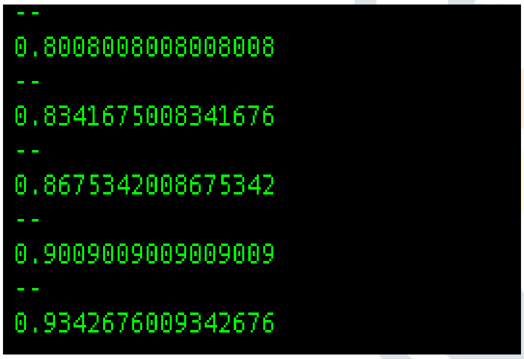

Fig 4.2 Time frame for vehicles

Finally, all the parameters which are required to find out the speed are found out and then the speed is then calculated using the formula

$$\text{Speed} = \text{Distance between two lines} / \text{Time Frame}$$

This speed is calculated for all the vehicles and works in real time as well. This method has good robustness and strong practicability but it. Exists some error as well. The issue faced is the moment when two or more than two vehicles hit the lines at the same time due to which it counts as a single entity. The entire system can be faster and time consuming and the effectiveness of the project is perfectly robust. Calculations are made and the speed in plotted onto image.

5. Conclusion

Speed detection system focuses to detect speed of every vehicle and can monitor as well as reduce the road accidents due to over-speeding with proper accuracy and efficiency, that provides number of benefits.

- As compared to the existing systems speed detection system is easy to handle with less physical effort.
- To operate speed detection system there is no need of any professional person as well as any special training to use it.

6. References

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