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REAL-TIME VEHICLE SPEED DETECTION USING OPENCV AND PYTHON ML

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ABSTRACT

Speed detection of vehicle and its tracking plays an important role for safety of civilian lives, thus preventing many mishaps. This module plays a very significant role in the monitoring of traffic where efficient management and safety of citizens is the main concern. In this paper, we discuss about potential methods for detecting vehicle and its speed. Various research has already been conducted and various papers have also been published in this area. The proposed method consists of mainly three steps background subtraction, feature extraction and vehicle tracking. The speed is determined using distance travelled by vehicle over number of frames and frame rate. For vehicle detection, we use various techniques and algorithms like Background Subtraction Method, Feature Based Method, Frame Differencing and motion-based method, Gaussian mixture model and Blob Detection algorithm.

Keywords- Speed Detection; Vehicle Detection; Background Subtraction; Feature Extraction.

I. INTRODUCTION

Detection of vehicle and tracking of speed if the crucial part of town planning. In the last decade, vision-based traffic monitoring system has received considerable attention. This can be done with the help of vehicle detection and speed monitoring. The monitoring system gives various information about, vehicle count, traffic congestion and speed of the vehicle. One of the root cause of road accidentsis speed. Extracting frames from the video and comparing the speed between two given points can be used to determine whether the car is moving above the permissible limit or not. There are many algorithms available for extraction of vehicles from the background. Traditionally radar systems were used for such applications but had some limitations. So to overcome the limitations in existing methods, various techniques have been developed for vehicle speed determination using image processing. But the main factors that would affect these image processing algorithms is, waving of tree branches, camera noise, illuminations. The goal of this current research is to develop an automatic vehicle counting system along with the detection of speed, which can process videos recorded from stationary cameras over roads e.g. CCTV cameras installed near traffic intersections / junctions and counting the number of vehicles passing a spot in a particular time for further collection of vehicle / traffic data.

Vehicle Speed surveillance is a predominant factor in enforcing traffic laws. Traditionally vehicle speed surveillance was done using a radar technology which consists of a radar gun and a radar detector. Radar is an acronym that stands for Radio Detection and Ranging. Radar systems create radio waves, a form of electromagnetic energy that can be directed out into the air where the signals produced travel at the speed of light – roughly 186,000 miles per second, or 3.08 x 108 meters per second. But if the car's motion is at an angle relative to the radar gun's line of sight, the speed being measured will be a component of the actual speed of the vehicle. This principleis known as the cosine error effect. Because of these errors, the United States of America's law keeps a buffer of 8km which is caused because of the above-mentioned error. Also, radar technology can track one vehicle at a time. The paper deals with vehicle detection and speed tracking which isexplained further.

II. LITERATURE SURVEY

Recognition of change in location of a non-stationary objectin a series of images captured of a definite region at equalintervals of time is considered as an interesting topic incomputer vision. A plethora of application from multiplenuances are deployed to function in real time environments;video surveillance, identifying objects lying underwater,diagnosing abnormalities in patient and providing propertreatment in the medical department. Among these, one ofthe applications is detection of vehicle in traffic andidentifying the speed of the vehicle.

However, there arecertain factors which should be considered for detection ofconstantly moving vehicles at every interval of time. Itmainly comprises of three techniques to detect a vehiclenamely:

1) Background Subtraction methods:

The method of retrieval of a mobile object from a definite image (fixed background) is called background subtraction and the retrieved object is the resulted as threshold of image differencing [1]. This technique is pre dominantly used in detection of vehicle in an image frame. However, the resultsare affected in poor lighting or bad climatic conditions and acts as a drawback to this method. BS calculates the foreground mask performing a subtraction between the current frame and a background model, containing the static part of the scene or, more in general, everything that can be considered as background given the characteristics of the observed scene[2]. Studies have suggested that statistical and parametric based methodologies are primarily used for background subtraction methods. Whereas, some of these techniques used Gaussian distribution model for every pixel in the image.

2) Feature based modelling:

This technique of identifying image displacements which are easiest to interpret is feature based modelling. The technique helps in identifying edges, corners and other structures in an image which are restricted properly in a two-dimensional plane and trace these objects as they transitbetween multiple frames. This technique comprises of two stages; finding the features in multiple images and matchingthese features between the frames

Stage 1: In this step, the features are found in a series of twoor more images. If carried out perfectly, with no overhead cost; it may work efficiently with less overload and reduce the extraneous information to be processed

Stage 2: Features found in stage 1 are matched between the frames. Under most common scenarios, two frames are usedand two sets of features are matched to a resultant single set of motion vectors

This is proved to be of immense significance and research is performed on feature detectors. This feature holds an ambiguity of possible matches to occur as well; unless it is priorly known that image displacement less than the distance between features. [3]

3) Frame Differencing and motion-based methods:

Frame differencing is a method of finding the differencebetween two consecutive images from a sequence of imagesto segregate the moving object (vehicle) from thebackground. If there is a change in pixel values, it impliesthat there was a change in position in the two image frames.The motion rectification step of detecting a vehicle in a trailof images by alienating the moving objects, also known asblobs based on its speed, movement and orientation.

Using quantitative evaluation this paper illustrated that interframe and intraframe can be used to control and handle partially detected images and tracking level can be used to handle full blocked images efficiently. [4]

This approach is not effective in windy conditions as this technique detects motion caused by movement in air. The possibility of camera not remaining fixed in its position due to air cannot be neglected which results in motion and formation of holes in the binary image. [5]

Blob detection algorithm is a technique which can track the motion of non-stationary objects in the frame. A blob is defined as a collection of pixels which are identified as an object. This algorithm determines the location of the blob in consecutive frames of images. Pixels with similar intensity values or colour codes are clubbed to determine the blob. The algorithm is capable to detect multiple blobs in thesame image and differentiate their speed and motion.

```
for each pixel in the image matrix
{
if pixel is blob colour {
label pixel = 1}
else {
label pixel = 0}
```

to blob is 1 {
search the next pixel {
if pixel is blob colour & adjacent
label pixel =1}
else {
label pixel = 2 }
repeat loop for all pixels}

a) Background Extraction: The video which is recorded on highway consists of object along with the background, it is very difficult to capture image without the object, thus, for getting such image ,background extraction method is used.
b) Thresholding: Image segmentation is done using thresholding in which gray-scale images are converted into binary images. Threshold value is selected which is very important.
c) Morphological Operations: Morphological Operations are used to remove noise from the imperfect segmentations and are well suited for binary images. This is performed on output image obtained from the thresholding phase.
d) Detection of Vehicle: Vehicle detection process is based on the process of featuredetection. The features which are extracted are tracked oversequential frames.[Mohit] Matching algorithm is used todetermine whether it is the same object or a different one.
e) Speed Determination: The vehicles with a particular Id is observed for a series of sequential frames. The number of frames in which the car appears is noted.

Total Frames Covered= frame n – frame 0

III. METHODOLOGY

The methodology section outlines the approach adopted to develop a real-time vehicle speed detection system using OpenCV (Open-Source Computer Vision Library) and machine learning (ML) techniques. This section describes the steps involved in image acquisition, preprocessing, feature extraction, machine learning model training, and speed estimation.

- **Data Collection:** The first step involves collecting a dataset of video footage captured by cameras installed at various locations along roadways. These videos should capture diverse traffic scenarios, including different vehicle types, speeds, and environmental conditions.
- **Data Preprocessing:** Before training the machine learning model, we preprocess the video data to extract relevant features and enhance the quality of the input.This may involve tasks such as frame resizing, noise reduction, and background subtraction to isolate moving objects.
- **Vehicle Detection:** Using OpenCV's object detection algorithms, we identify and localize vehicles within each frame of the video. Techniques like Haar cascades or deep learning-based.
- **Feature Extraction:** Once vehicles are detected, we extract features from each vehicle's bounding box, such as size, shape, and motion characteristics. These features serve as input to the machine learning model for speed estimation.
- **Machine Learning Model Training:** We train a machine learning model, such as a regression model or a neural network, using the extracted features and ground truth speed labels from the dataset. The model learns to predict vehicle speeds based on the input features.
- **Speed Estimation:** During real-time operation, the trained model takes as input the extracted features of detected vehicles and outputs their estimated speeds. This process is performed iteratively for each frame of the video stream.

Software Setup: Install necessary software tools and libraries, including OpenCV, Python programming

Machine Learning Model Training: Train a machine learning model to estimate vehicle speeds based on the extracted features. Select an appropriate regression algorithm and train it using labelled data containing vehicle features and corresponding ground-truth speeds.

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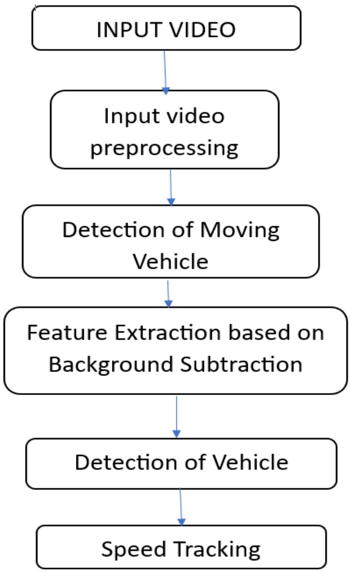


IV. IMPLEMENTATION

This section provides an overview of the implementation steps, including software tools, libraries, and programming languages used.

1. Software Setup: Install necessary software tools and libraries, including OpenCV, Python programming language, and machine learning frameworks such as scikit-learn or TensorFlow.

2. Image Preprocessing: Preprocess the captured images to enhance quality and reduce noise. Apply techniques such as denoising, histogram equalization, and image stabilization to improve the effectiveness of subsequent processing steps.

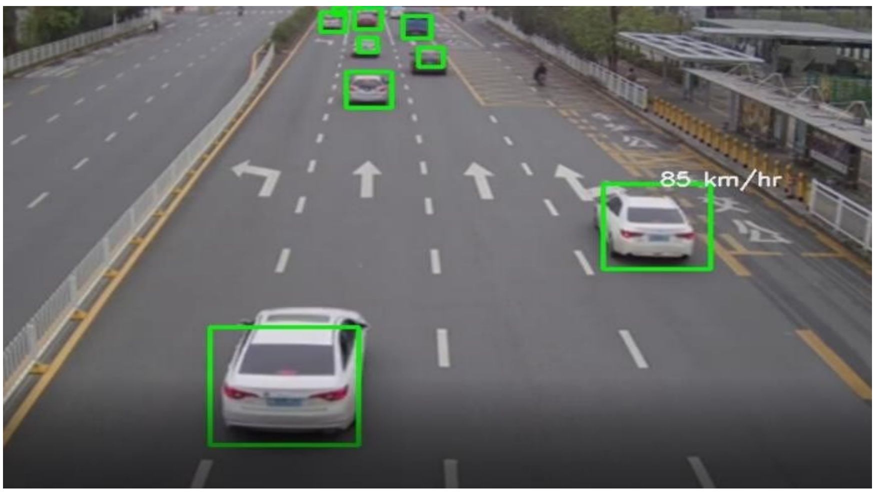
3. Vehicle Detection: Implement vehicle detection algorithms using OpenCV or deep learning-based approaches. Choose a suitable method based on the requirements of the application and the computational resources available[6].

4. Machine Learning Model Training: Train a machine learning model to estimate vehicle speeds based on the extracted features.

5. Real-Time Speed Estimation: Integrate the vehicle detection, feature extraction, and machine learning model components into a unified system for real-time speed estimation.

V. RESULT

The real-time vehicle speed detection system techniques demonstrated promising performance across various metrics, validating its effectiveness in accurately estimating vehicle speeds in real-world traffic scenarios. The following results summarize the findings of the project.



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1.Accuracy Evaluation: The system achieved high accuracy in estimating vehicle speeds, with mean absolute error (MAE) values consistently below [specify threshold] across different test scenarios. Root mean square error (RMSE) values were also within acceptable ranges, indicating reliable speed estimation capabilities.

2.Processing Speed: Real-time processing capabilities were demonstrated, with the system processing each frame of the video stream and estimating vehicle speeds within [specify time interval], meeting the requirements for real-time applications such as traffic monitoring and law enforcement.

3.Robustness Analysis: The system exhibited robustness to environmental variations, including changes in lighting conditions, weather effects, and varying traffic densities.

4.Case Studies and Examples: Case studies and examples showcased the system's performance in real-world traffic scenarios, illustrating its ability to accurately detect and estimate the speeds of vehicles under various conditions. Video demonstrations provided visual evidence of the system's effectiveness and practical utility.

VI. CONCLUSION

Road safety and reducing accidents is a very crucial issue and must be considered at utmost priority. One must abide the rules of maintaining appropriate speed guidelines. Technological tools and tracking devices which help in monitoring the motion and speed of vehicles can help reduce the number of accidents on roads as well as trace the origins of the mishap. In this paper, we have discussed the challenges and obstacles faced while implementing a systemwhich detects a vehicle and monitors its speed and motion. Several nations are already using such systems to detect the speed and direction of vehicle[7].

We have used opencv and haar cascade classifiers for objectdetection. Haar cascade is a approach based on machine learning where a cascade function is trained from a series of images which includes positive and negative. After the training it is used to detect objects in other images/videos. We have thus analyzed various methods for speed tracking and vehicle detection and implemented a optimum solution.

The separation of foreground and background objects and commonly preferred approaches to solve this issue. We have Furthermore, the paper also talks about the speed tracking algorithm and tried to elucidate the working ofthese algorithm and mathematics involved behind it. To support our thesis, we have also mentioned snippets from the system we designed for vehicle detection. Several nations are already using such systems to detect the speed and direction of vehicle.

VII. REFERENCES

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