Vehicle Detection and Counting Interface for Traffic Analytics

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Introduction

Nowadays, many places are equipped with surveillance systems that combine AI with cameras. These technologies are utilised by government organizations to various private facilities.

These AI-based cameras helps in many ways, and one of the main features is to count the number of vehicles. It can be used to count the number of vehicles passing by or entering any particular place. This project can be used in many areas like crowd counting, traffic management, vehicle number plate, sports, and many more.

Motivation

The thought of automated smart energy systems, electrical grids, one-touch access ports – it’s an enthralling concept! One of the core components of a smart city is automated traffic management.

If we could integrate a vehicle detection system in a traffic light camera, you could easily track a number of useful things simultaneously.

Literature Survey

s.no	Title	Authors	Description
1	Vehicle Detection and Classification using Image processing	R.Roopa Chandrika; N.S.G. Ganesh; A. Mummoorthy; K. M. Karthick (2020)	The paper presents a way to detect, count and classify vehicles using image processing techniques. The task of vehicle detection and counting is broken down into six steps.
2	Vision-based vehicle detection and counting system using deep learning in highway scenes	Huansheng Song; Haoxiang Liang; Huaiyu Li; Zhe Dai; Xu Yun (2019)	This paper proposes a vision-based vehicle detection and counting system. A new high definition highway vehicle dataset is published in this study.
3	Research on visual vehicle detection and tracking based on deep learning	Yaoming Zhang; Xiaoli Song; Mengen Wang; Tian Guan (2020)	The main work of this paper is divided into two parts: we should complete visual vehicle detection based on deep learning and vehicle tracking based on similarity measurement and association algorithm.

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4	Vehicle detection and counting under mixed traffic conditions in Vietnam using YOLOV4	Vuong Xuan Can; Phan Xuan Vu; Mou Rui-fang; Vu Trong Thuat (2021)	This paper, provides a method using YOLOv4 for the vehicle detection and counting of mixed traffic flow in the context of Vietnam's transport.
5	Detection and classification of vehicles for traffic video analytics	Ahmad Arinaldi; Jaka Arya Pradana; Arlan A.Gurusinga (2018)	This paper presents a system for automatic traffic video analysis. This system can automatically count the number of vehicles, classify the vehicles by type, estimate the speed.
6	Research on the Cascade Vehicle Detection Method Based on CNN	Jianjun Hu; Yuqi Sun; Songsong Xiong (2021)	This paper introduces an adaptive method for detecting front vehicles under complex weather conditions.

Problem Statement

To develop a vehicle detection system using opencv and tensorflow object counting API which can also extract relevant data like speed,color and size of the vehicle.

Objectives

- To detect and classify vehicles (car, truck, bicycle, motorcycle, bus) along with direction of travel and their approximate color.
- To develop vehicle counting systems capable of performing speed estimation and traffic flow estimation along with vehicle detection, tracking, counting, classification (into light medium and heavy).
- The focus is on development of vehicle counting system and it's comparative analysis on datasets.

Datasets

Dataset	Dataset link	files
Davis king`s dib library	http://dlib.net/files/data/dlib_front_and_rear_vehicles_v1.tar	Training.xml, testing.xml

- Each image element in the file includes the file path along with a number of bounding box objects. For each image, all visible front and rear views of vehicles are labeled as such.
- For color detection training dataset was used to classify White, Black, Red, Green, Blue, Orange, Yellow and Violet and further to get R,G, B color histogram.

Methodology

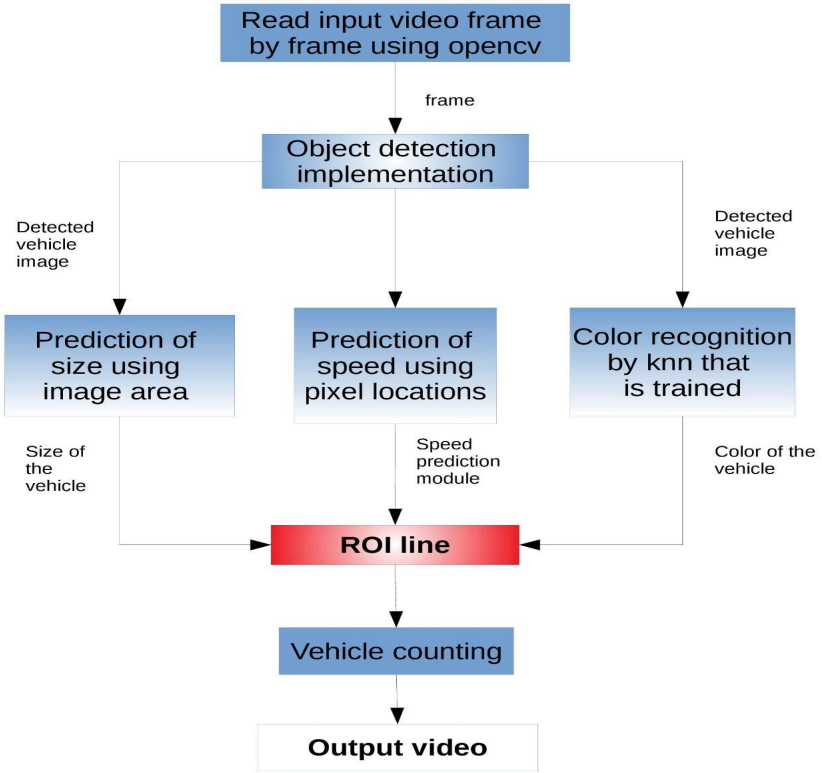


Fig 1: System Flow Diagram

Methodology

OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library.

- Source video is read frame by frame with OpenCV. Each frame is processed by SSD with Mobilenet model which is developed on tensorflow. This is a loop that continues working till reaching the end of the video.The model will detect multiple detection from the video frames.
- **For size/type of the vehicle:** The detected vehicle image is used to predict the size using image area, this is generally a size prediction module in order to detect the size of the vehicle.
- **For color of the vehicle:** The detected vehicle image also is used to color recognition by KNN is trained with color histogram, this module is to distinguish color in detected vehicle image frames

Model Training

In order to train the SSD model via transfer learning, following are the steps:

1. Download the pre-trained SSD model so we can fine-tune the network. And also need to set up the Tensorflow Object Detection API configuration file for training.
2. For Tensorflow object detection API, data points for object detection are needed. To achieve this, raw image dataset will be converted into tensorflow format dataset with corresponding class label files. After that, it can be used to train Tensorflow object detection API.
3. After this using transfer learning , set up Tensorflow Object Detection API configuration file for training.
4. Now use Tensorflow Object detection API to train the model.

Methodology

Vehicle Color Prediction

There are 3 main steps to understand basic workflow used for color classifting:

Feature Extraction: Its simple explanation is, how to represent the interesting points we found to compare them with other interesting points (features) in the image. Here Perform feature extraction for getting the R, G, B Color Histogram values of training images.

Training K-Nearest Neighbors Classifier: K nearest neighbors is a simple algorithm that stores all available cases and classifies new cases based on a similarity measure (e.g., distance functions).Train KNN classifier by R, G, B Color Histogram values here.

Classifying by Trained KNN: Read Web Cam frame by frame, perform feature extraction on each frame and then classify the mean color of it by trained KNN classifier.

Methodology

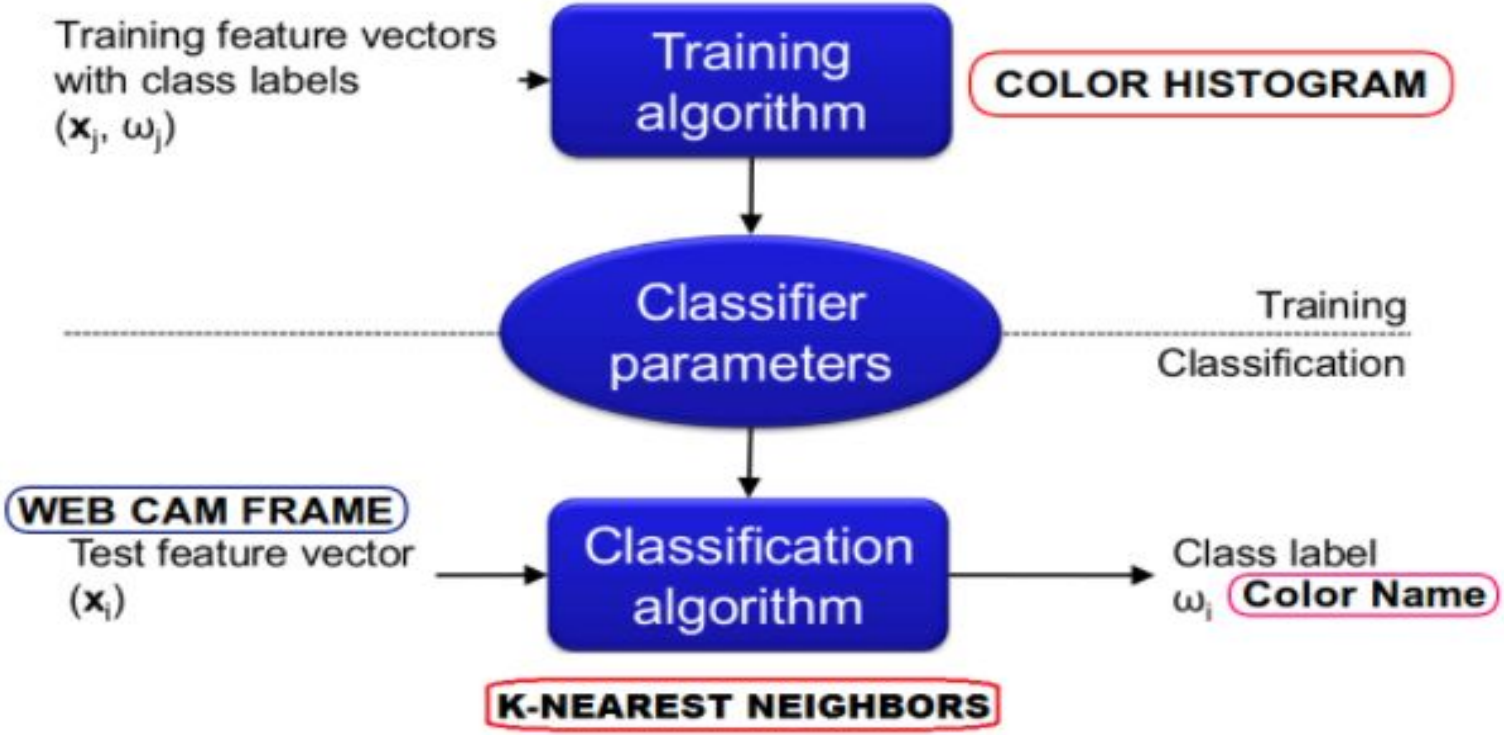


Fig 2: general workflow for color classification.

Methodology

Vehicle speed and direction module:

The detected vehicle image is used to predict the size using the image area, there is generally a size prediction module in order to detect the size of the vehicle. Computer vision system is designed to collect timestamps of cars to measure speed (with a known distance).

Vehicle counting:

After all detection passthrough the vehicle image will be detected in counting detected vehicles after the vehicle drives through the region of interest line.

Lastly the video will be output with extracted data. And The code for the project is in the following repository: “https://github.com/YashParakh5/CV_Project”.

Requirements

- OpenCV
- Scikit-image
- NumPy, SciPy
- TensorFlow 2.0:
  - Tensorflow Object Detection API
- Python 3.x
- SSD mobilenet

Results and Analysis

Evaluation metrics:

IoU(Intersection over Union) threshold values are used to measure the performance of this project.

$$IoU = \frac{Intersection}{Union} = \frac{\#TP}{\#TP + \#FP + \#FN}$$

- The mAP (precision) of a model alone does not directly show how tight the bounding boxes of your model are.
- The IoU threshold specifies whether a given bounding box prediction can be counted as a true positive or not.

Results and Analysis

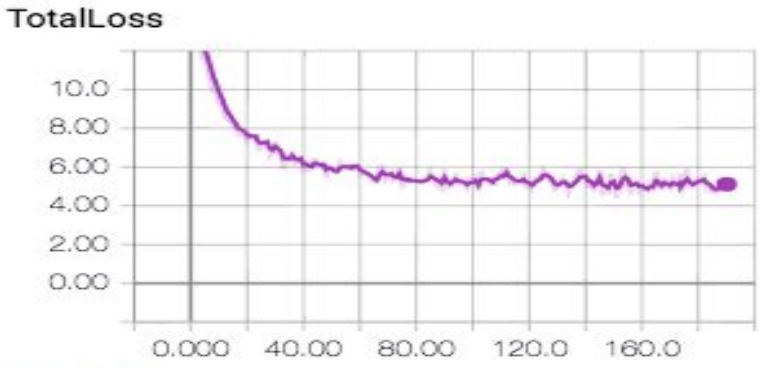


Fig 3: Tensorboard loss plot

Across scales	Small	Medium	Large
mAP	0.058	0.21	0.56
AR@100	0.11	0.29	0.648

Table 1:mAP and AR across scales like small,medium and large.

Results and Analysis

IoU (intersection over union)	Average Precision (mAP)
0.5	0.652
0.75	0.416
0.5:0.95	0.39

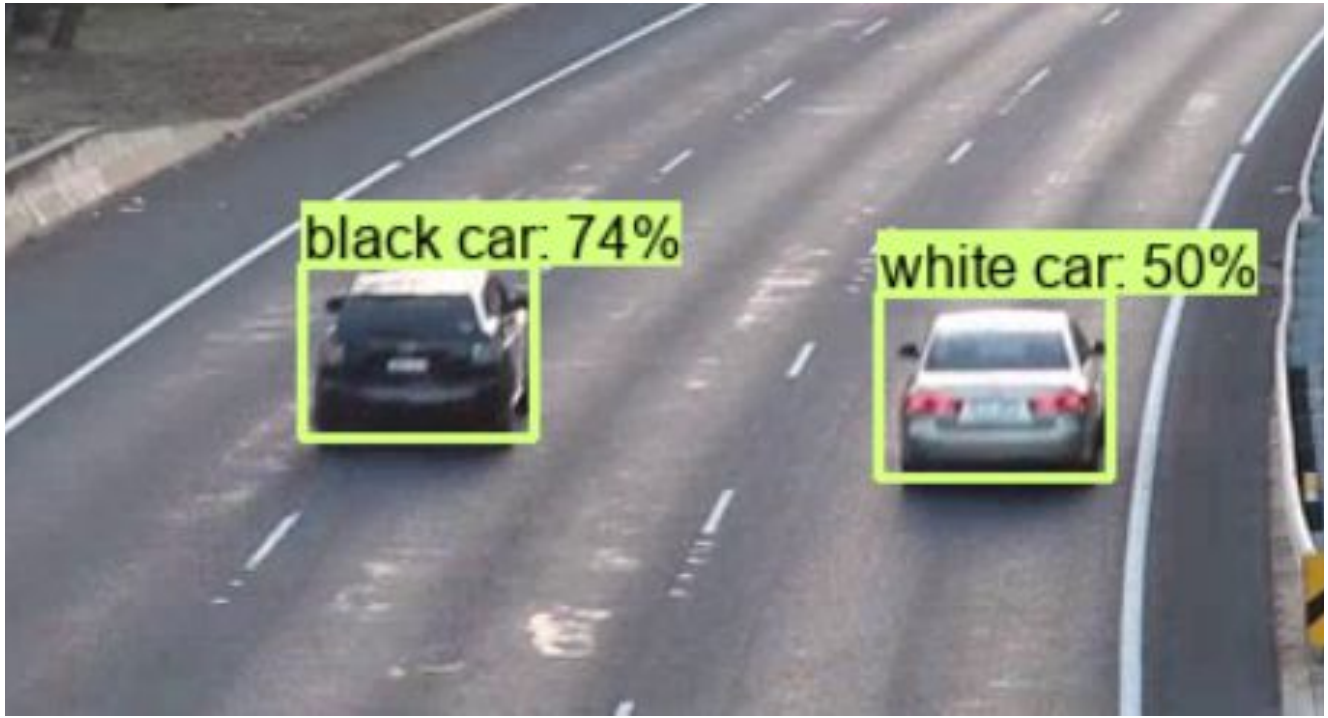
Table 2:Precision evaluation of the model.

As we can see, the SSD model achieves 65.71% mAP @ 0.5 IoU.

Results and Analysis

Img2: Vehicle Counting Passing through ROI Line

Results and Analysis



Img3: Color Prediction with Score

Innovation

- For vehicle counting and classification part, approach is based on detecting multiple detection from the video frames then the shadows are also dealt with. It uses various technologies and provides a system to detect, track and count the vehicles in the camera's view.
- Trained SSD on the Davis King’s vehicles dataset to differentiate the front and rear views of the vehicles.
- Predict the vehicle's size using the image area and vehicle's speed and direction using pixel locations.

References

[1] Vision-based vehicle detection and counting system using deep learning in highway scenes by Huansheng Song; Haoxiang Liang; Huaiyu Li; Zhe Dai; Xu Yun:

[2] Vehicle Detection and Classification using Image processing by R.Roopa Chandrika; N.S.G. Ganesh;A. Mummoorthy; K. M. Karthick:

[3] Research on visual vehicle detection and tracking based on deep learning by Yaoming Zhang; Xiaoli Song; Mengen Wang; Tian Guan:

[4] Vehicle detection and counting under mixed traffic conditions in Vietnam using YOLOV4 by Vuong Xuan Can; Phan Xuan Vu; Mou Rui-fang; Vu Trong Thuat:

[5] Detection and classification of vehicles for traffic video analytics by Ahmad Arinaldi; Jaka Arya Pradana; Arlan A.Gurusinga:

[6] Research on the Cascade Vehicle Detection Method Based on CNN by Jianjun Hu; Yuqi Sun; Songsong Xiong: