Project report

Autonomous Traffic Analysis System

CONTRIBUTORS

Name	Branch	Reg. no.
Priyansh Lohiya	ECE	20215109
Aayush Verma	ECE	20215056
Priyanshu Maurya	EE	20212021
Rishi Mishra	ECE	20215096

MENTORS

1. Anurag gupta - ECE - 20195168
2. Kandukuri Yaswanth - CIVIL -20201057

Introduction

If we need to count the number of cars, bikes, buses & trucks passing a road and finding the busiest hours manually is a time-consuming and cumbersome task. So, our idea is to make this process easy by introducing a traffic analysis system that will detect them and classify them into their categories.
So, we have to build an autonomous system that collects the traffic data and provides us with traffic volume studies and spot speed analysis.

Description

Autonomous Traffic Analysis System is a software program that will take real-time vehicle data from the camera and convert the data into interactive charts and calculate required parameters like percentile speed and other important parameters.

The data collected for traffic volume studies and spot speed analysis which facilitates in determining the :

1. Magnitudes, classifications and the time and directional split of vehicular flows.
2. Proportions of vehicles in the traffic stream.
3. Hourly, daily, yearly and seasonal variation of vehicular flows.
4. Flow fluctuation on different approaches at a junction or different parts of a road network system.
5. The structural and geometric design of pavements, bridges and other highway facilities.
6. Intersection design.
7. Improvement of roadway operating conditions.
8. Traffic signal design.
9. Economic feasibility.
10. Design speed
11. Geometric design
12. Accidental analysis
13. Traffic control planning
14. Classification of roads as freeways, highways, arterials, collectors and local streets
15. Speed trends
16. Safety applications
17. Determination of existing traffic operations, evaluation of traffic control devices, and measurement of the effectiveness of traffic control devices, etc.

Tech Stack and Libraries

- Python
- OpenCV
- YOLOv8

- Haar cascade
- Jupyter notebook
- Python libraries such as Pandas, Matplotlib, Numpy, Supervision etc.
- Tkinter (for making GUI)
- Byte tracker Algorithm library.

The Steps Involved

Learning Basic Requirements:

Learning python was the first task since all the work is done using python libraries hence good understanding of python is required. We also have to set up the jupyter notebook.
After python, we need to learn its basic libraries that are used in our project and that include Numpy, OpenCV, Matplotlib, Pandas.

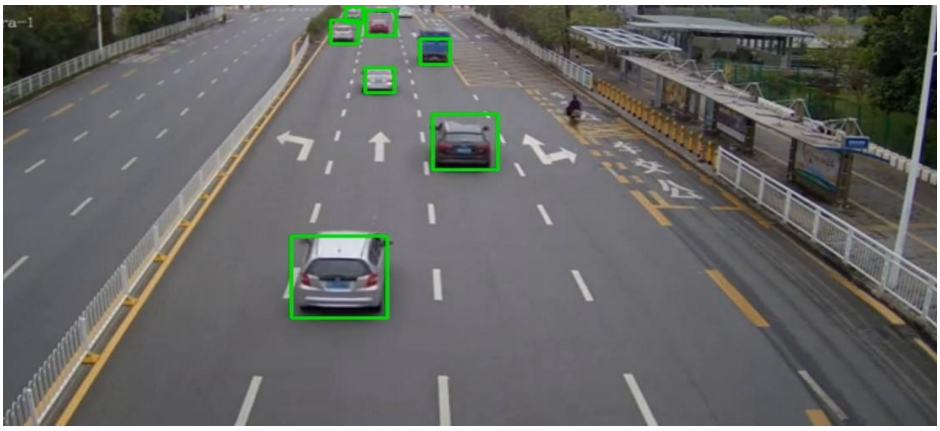
1. Selecting the Model:

Since, there are multiple methods and models to detect the objects so selecting the most appropriate model is an important task for our project. We have tried different methods and models but the most appropriate is Yolov8. It is the most accurate model available to us. Haar Cascade is also helpful but the good dataset for the Haar Cascade is very difficult to find. Some datasets are paid for Haar Cascade.

2. Detection of Required objects:

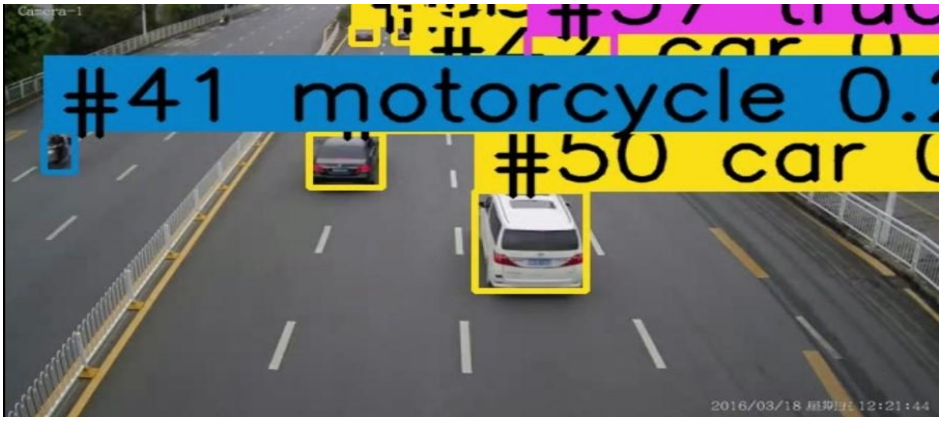
For our project, we need to detect the vehicles into 4 categories:
Cars, Buses, Trucks, Bikes. We also have to detect the pedestrian for our task.
We are using Ultralytics' YOLOv8 object detection model for detecting vehicles and a custom implementation of the BYTE Tracker algorithm for tracking the detected vehicles. The video is read frame by frame using the supervision library, and each frame is processed by the detection and tracking algorithms.

a) Vehicles detection:



Detected vehicles are enclosed in a bounding box.

b) Differentiating the different vehicles:



Detected vehicles are given ID's and their type is also detected and shown over the bounding box.

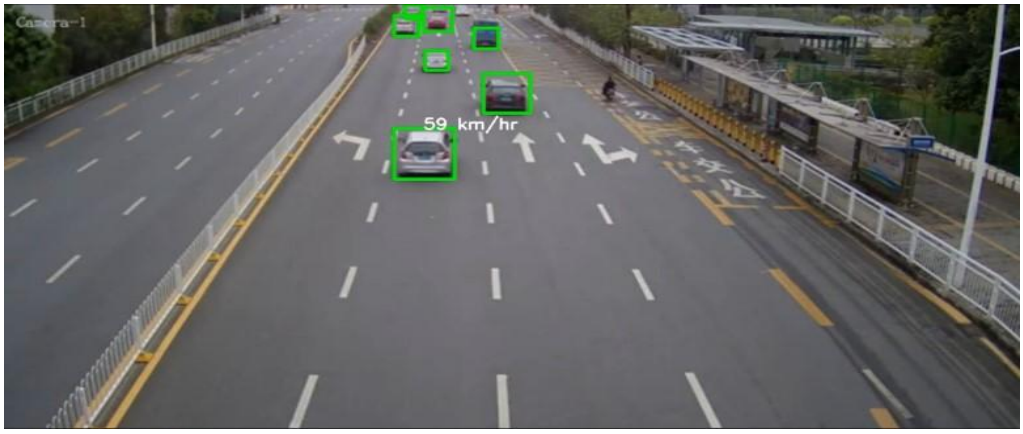
c) Categorizing the Vehicles:

Detecting and differentiating whether the vehicle detected is a car, bike, bus or a truck.

3. Speed detection:

For spot speed analysis we have to detect the speed of the vehicles. For speed detection, we use the Haar Cascade method to detect the vehicles and then we are measuring the time taken by the vehicle between any two points on the road. Since we already know the distance between the two points so speed=distance/time. This algorithm reads a video file of a traffic scene, detects and tracks vehicles using a Haar cascade classifier and a correlation tracker, and estimates the speed of the vehicles based on their movement between consecutive frames.

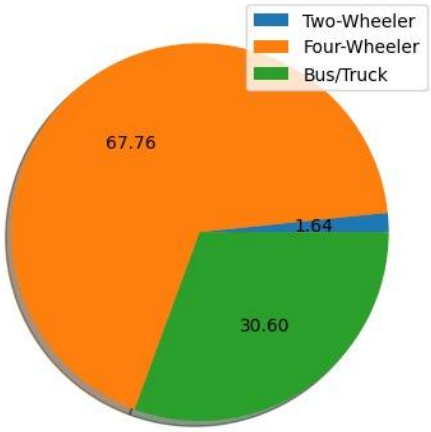
Selecting the data set for Haar Cascade is the most important task. So we need to find the most accurate dataset available.



4. Volume Analysis:

Traffic Volume is defined as the number of vehicles passing a section of a lane or roadway during a given time interval. Traffic volume studies are conducted to determine the number, movements, and classifications of roadway vehicles at a given location.

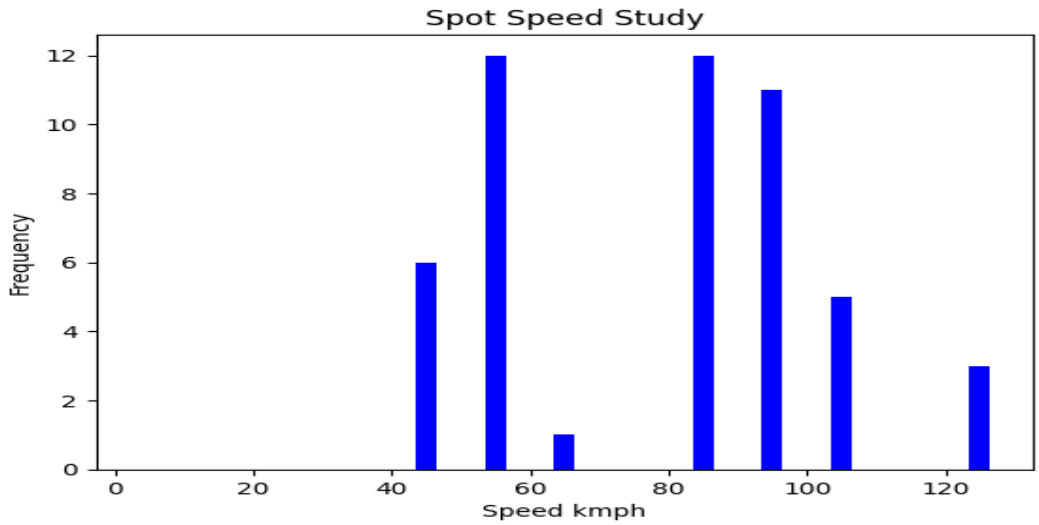
We count the number of vehicles in a given time interval and then convert them into their respective PCU (Passenger Car Units) which are traffic variables (such as headway, speed, and density) compared to a single standard passenger car and calculate the volume and peak hourly factor and the data can be presented and analyzed by plotting graphs



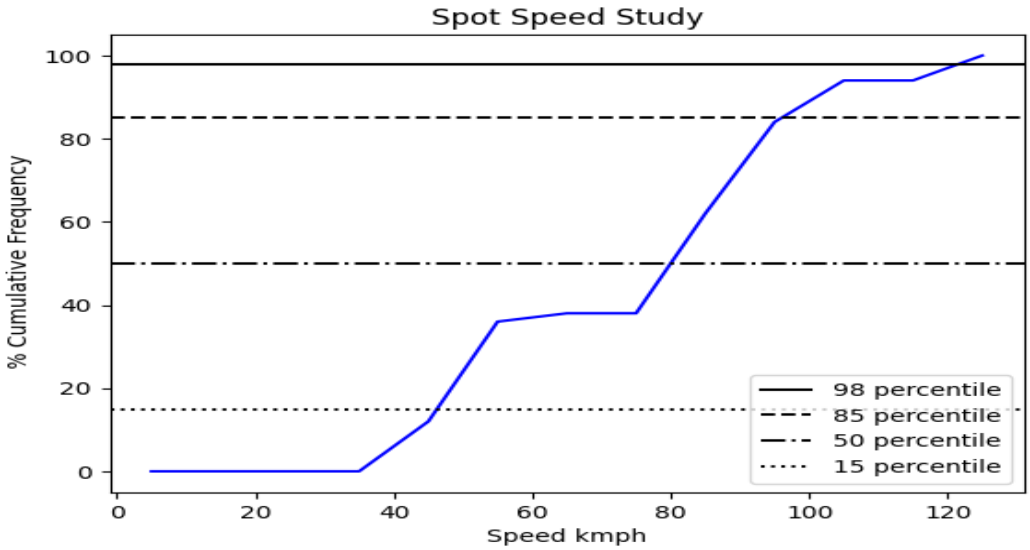
5. Spot Speed Analysis:

This is a statistical analysis of data we collected from speed detection. In speed detection, we collected the vehicle's number and their speed in an Excel file, now the spot speed Algo. will plot related graphs of the given data. For spot speed analysis we used the matplotlib library of Python.

Graph 1: Speed vs Frequency.



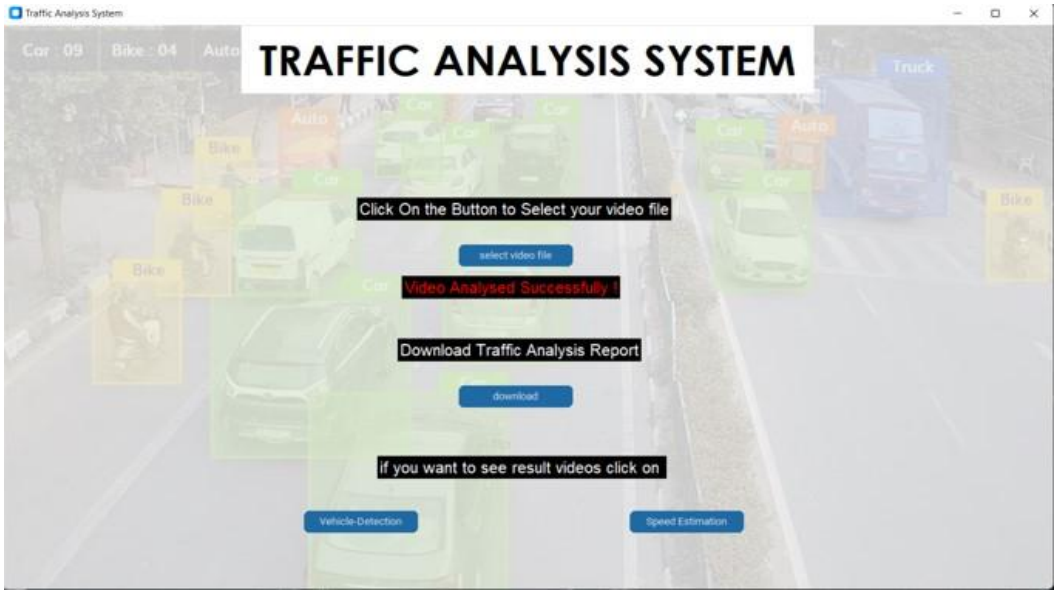
Graph 2: Speed vs Cumulative Frequency.



This analysis will give values like Mean Speed, Median Speed, Mode Speed, and standard deviation of speeds of vehicles.

6. GUI:

Now all above steps will finally be executed in Graphical User Interface.



Our GUI has Following features:

1. An upload button to upload the video we want to analyze.
2. After uploading the video download button to download the result pdf of the volume study and spot speed analysis.
3. And lastly, two buttons to see the result videos. One for vehicle detection video and the second for speed detection.

Problems Faced

1. Firstly we tried detection with Haar Cascade but with this model we detected vehicles but detection was less efficient.
2. Then we switched to Yolo V8 as this was a trusted model worldwide and unlike cascade detection, we didn't need to collect a dataset as it is a pre-trained model.
3. There was also a problem with yoloV8 as it wasn't working properly due to an unstable version of Python. So we tried changing versions of Python from python 3.11 to Python 3.9, Due to this we have to downgrade all the other library versions.
4. We used tracker ID to uniquely identify the vehicles as a single vehicle is detected multiple times.

5. As there are different parameters in different videos like orientation for some videos there is a change in the code parameters in order to get the correct speed.
6. The effectiveness of the detection will be better for high-resolution video

Source Code

Github:https://github.com/roboclub-mnnit/Autonomous_traffic_analysis_system-2022-23-Project

Video:

Resources

Official Python Documentation:
https://www.python.org/doc/

OpenCV modules:
https://docs.opencv.org/4.x/

YOLOv8:
https://github.com/ifzhang/ByteTrack
https://github.com/ultralytics

Haar cascade:
https://docs.opencv.org/3.4/db/d28/tutorial_cascade_classifier.html

Jupyter notebook:
https://jupyter.org/

Pandas:
https://pandas.pydata.org/

Matplotlib:
https://matplotlib.org/stable/index.html

Numpy:

https://numpy.org/doc/stable/

Tkinter:
https://docs.python.org/3/library/tk.html

Real-life Applications

The project finds a large spectrum of real-life areas of application.

1. To study the type of traffic passing a particular road, its volume studies and spot speed analysis which facilitates in determining the majority of traffic passing the road, to determine the busiest hours of the road and its traffic density.
2. The speed detection of vehicles can help in maintaining traffic rules and reduce accidents on roads.
3. This can also be used as a traffic management system as on busy hours the traffic can be diverted to reduce rush on road.

Thank you,

Team Autonomous Traffic Analysis