Carnegie Mellon University

Computer Vision for Traffic Density Estimation

24-678: Computer Vision for Engineers

LA PRIMA +

Aditya Ramakrishnan
Badal Pardhi
Parth Malpathak
Rupanjali Kukal

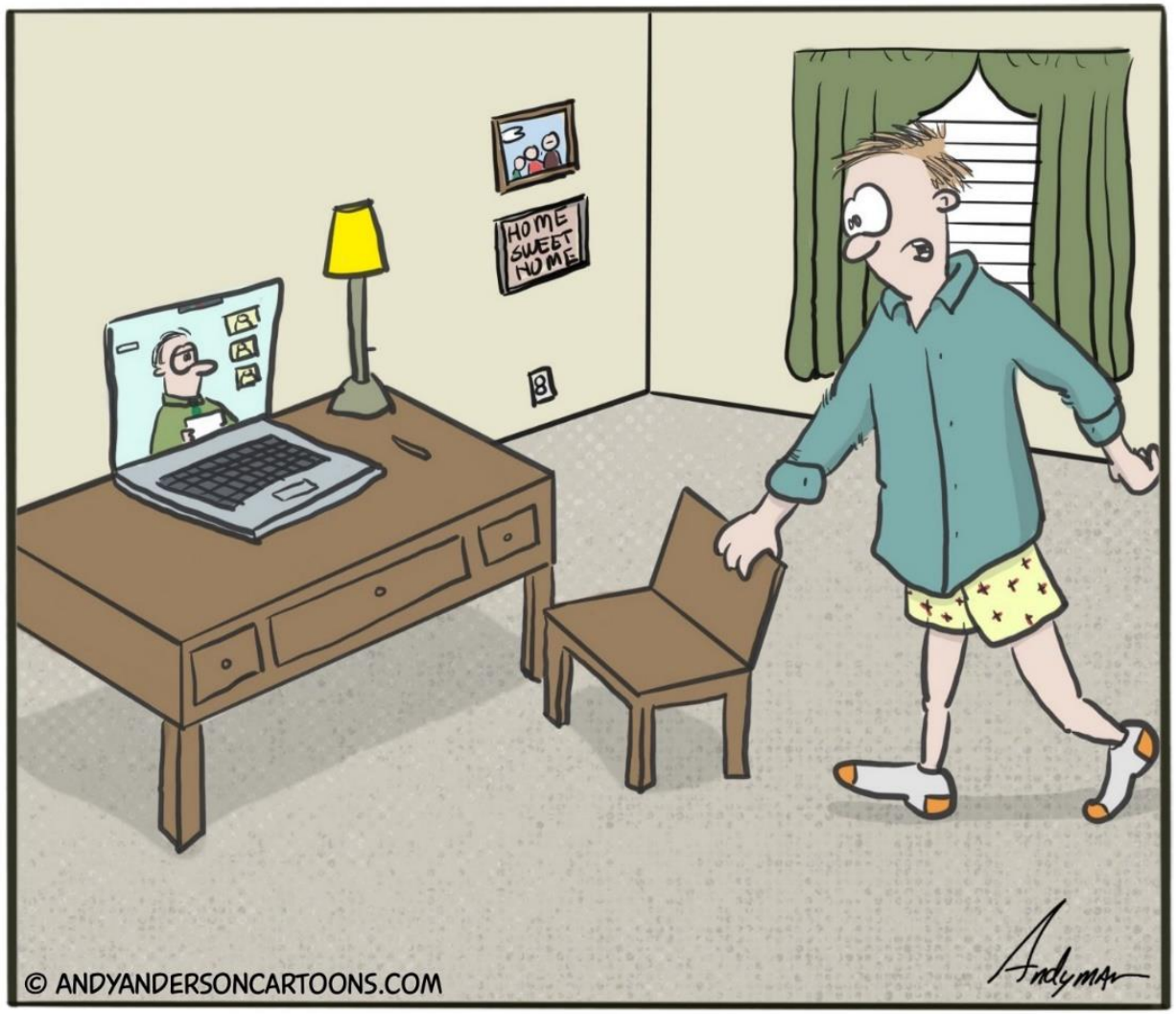
Overview

- Web-based map services like Google Maps are widely used by everyday users to identify the transit time throughout the day.
- These Map-services actively tracks the number of people connected to the server in real time.
- It calculates the velocity of every individual user's mobile device to predict the traffic density by applying thresholding algorithms.
- In this way, these services can suggest the quickest way to reach the destination by understanding traffic density on the roads.

State of Art

Web based mapping platforms can be unreliable!

- **Estimated Time of Arrival (ETA)** is never accurate!
  - Bluetooth & GPS services need to be enabled.
- Heavy reliance on the **applications ability to track location accurately.**
  - Primary dependency for traffic density algorithms
- **Current solutions are not as robust**
  - User-server connectivity is a must for accurate traffic prediction and navigation planning.



SORRY I'M LATE FOR WORK. TRAFFIC ON THE STAIRS WAS BRUTAL.

⚠ Existing Gaps

What are the current Issues?

- Efficient use of resources – **at the cost of accuracy** ☹

  - Infrastructure to use map-based applications available at minimal cost (consumer's mobile device)

- **Urban development** presents a technical problem!

  - High-rise buildings and skyscrapers in urbanized areas tend to interfere with signal transmission making it harder to enhance the accuracy of location tracking services without a significant cost.

⚠ Existing Gaps

What are the current Issues?

- **Technological advancements** (5G) still have **hiccups**

  - Advances in technology have accelerated.
  - Heavy investments on antennae structures are required for improving signal bandwidth transmissions.
  - However, existing issues still remain unsolved.

- Inability to distinguish between **real and fake data-points.**

  - Results of the afore-mentioned inaccuracies lead to the production of fake data-points.

📌 Impact

User Groups & Pain Points

- **Professional workers** (Uber / Lyft / Delivery driver) :

  # Frequent navigation to different location

    - What are the shortest routes?
    - How can I get there in the quickest manner?

- **Local consumers** :

  # Looking for directions to travel locally

    - Navigation routes that adapt to real time traffic data

Product Opportunity

Where do we come in?

- Solution already exists!
- Augment the algorithm by providing reliable data points
- Account for real-time discrepancies

Goal

- Organize information and make it more useful
- Focus is on Customer Engagement
  - Revenue
  - Impact

Previous Work

- A Simple Method for **Calculating Vehicle Density in Traffic Images**.
- **Image Matching Using SIFT, SURF, BRIEF and ORB**: Performance Comparison for Distorted Images
- **Automatic traffic density estimation** using Single Shot Detection (SSD)
- **Optical Flow Based Moving Object Detection** and Tracking for Traffic Surveillance

Study shows how Google Maps can be tricked!

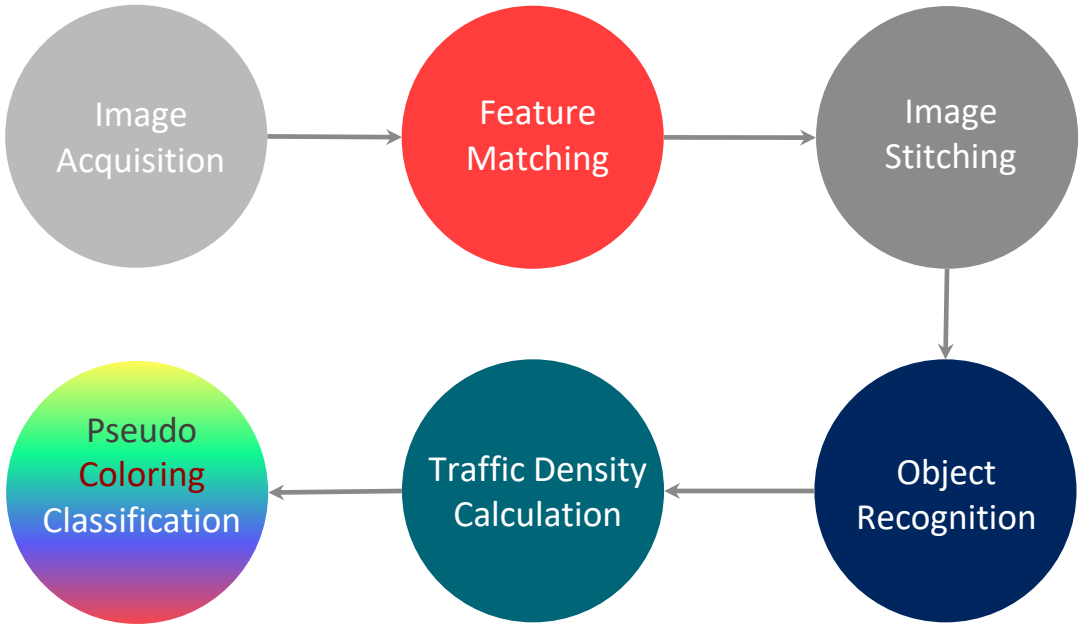
Source:

https://www.youtube.com/watch?v=HbJGTKQ2NII


PENNDOT
12:42:05
12:42
37%
3079-3001 PA-291
PA-291
1 min
14 min
1 min
5 min
Penrose Ave
& S 26th St
Recently viewed
14 min
Wawa
RevZilla
1 min (0.5 mi)
Fastest route now due to traffic conditions
Preview
Steps
Pin

Our Process

Flowchart for Traffic Density Estimation:



Our Process

- First, we acquire images, where images from stereo cameras are captured synchronously within set time frames.
- Then these images will then be feature detected and matched using appropriate computer vision algorithms (ORB).
- The two feature matched images will then be stitched together to form a single image that contains information about the road and vehicles present on it when the images were captured.
- The newly stitched image is fed to an object detection algorithm that differentiates the vehicles from their surroundings and returns their total count.
- Based on the total number of vehicles present in the images pertaining to a specific duration of time interval, a simple arithmetic calculation will provide us with an approximate density of traffic on the selected road.
- Since the density will be calculated in relative terms, the road (under observation) in any navigation application can now be pseudo-colored with respect to the corresponding traffic density.

Image Acquisition

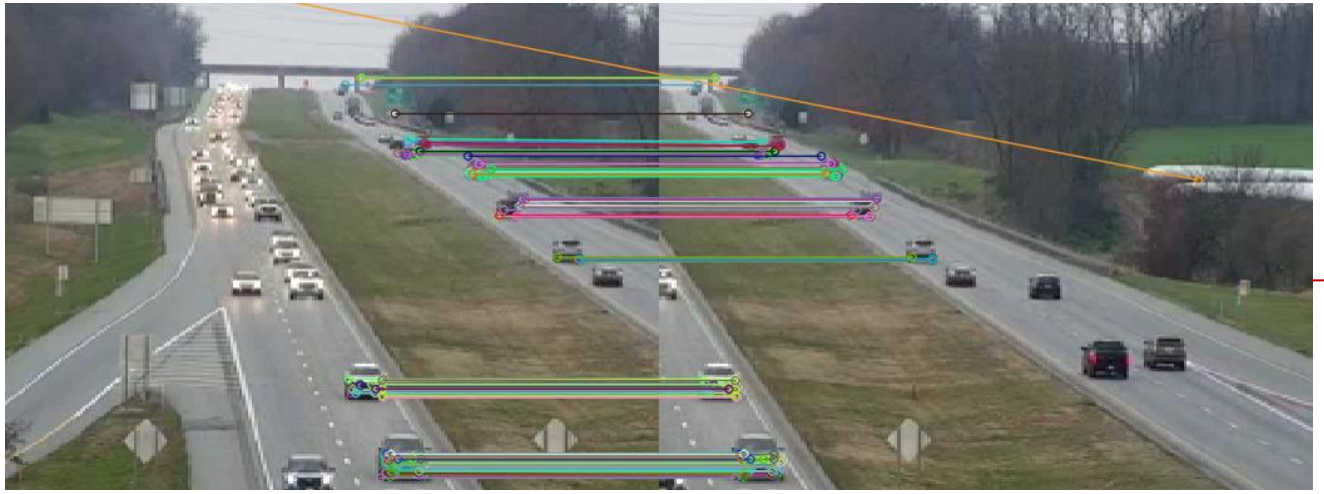
ORB Feature Matching

- **Compute Keypoints** : corner/edge/contour detection
- **Extract features** : Brute Force Matching & ORB
- **Compute distances** : between every descriptor pair

  Hamming Distance (ORB uses binary string based descriptors)
- **Select best matches**

ORB Feature Matching

Test Case 1



Test Case 2

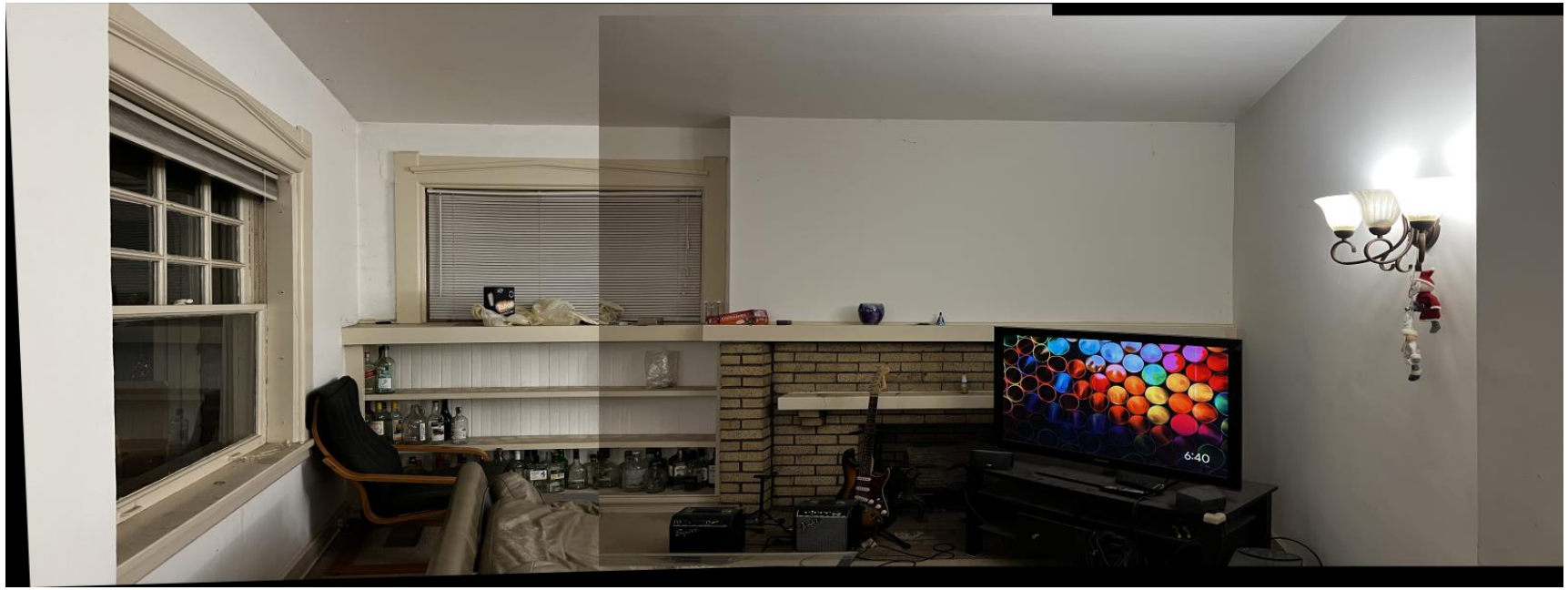
Image Stitching

- **Estimation of Homography Matrix**
- **Warp source images** : Realignment for stitching
- **Stitch wrapped Images** : about every descriptor pair

Image Stitching

Test Case 1

Test Case 2

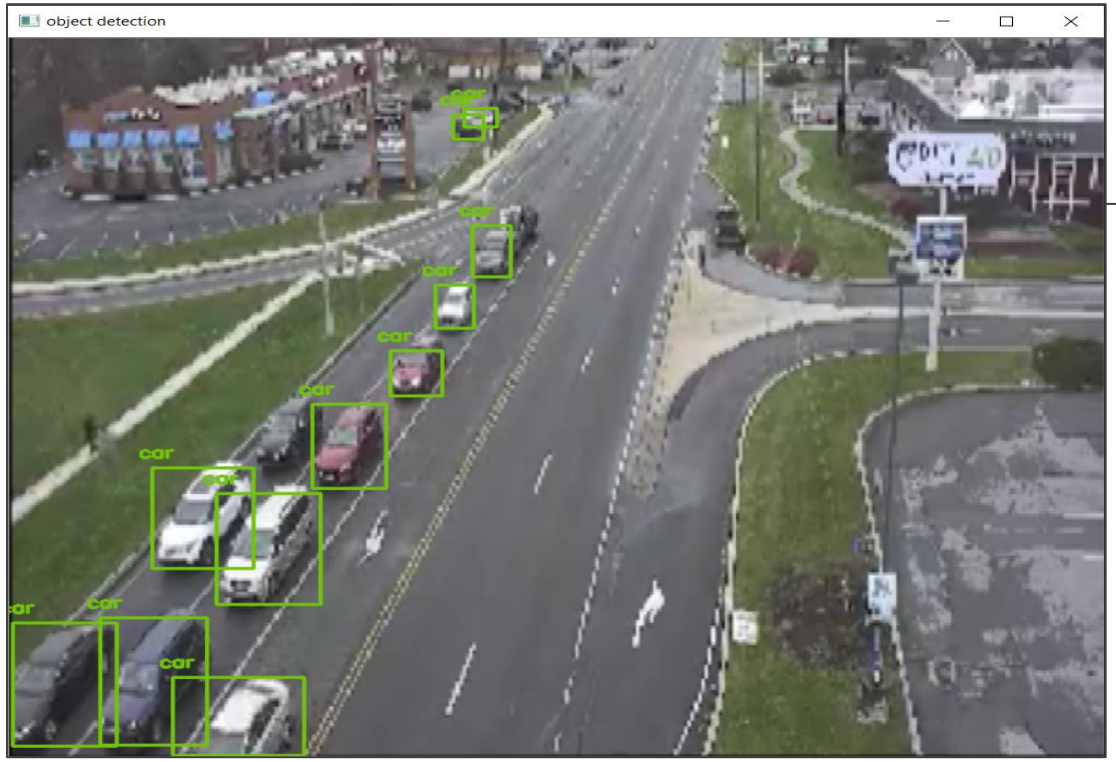


Fine-Tuning:

Code was tested on other test images to validate accuracy of stitching.

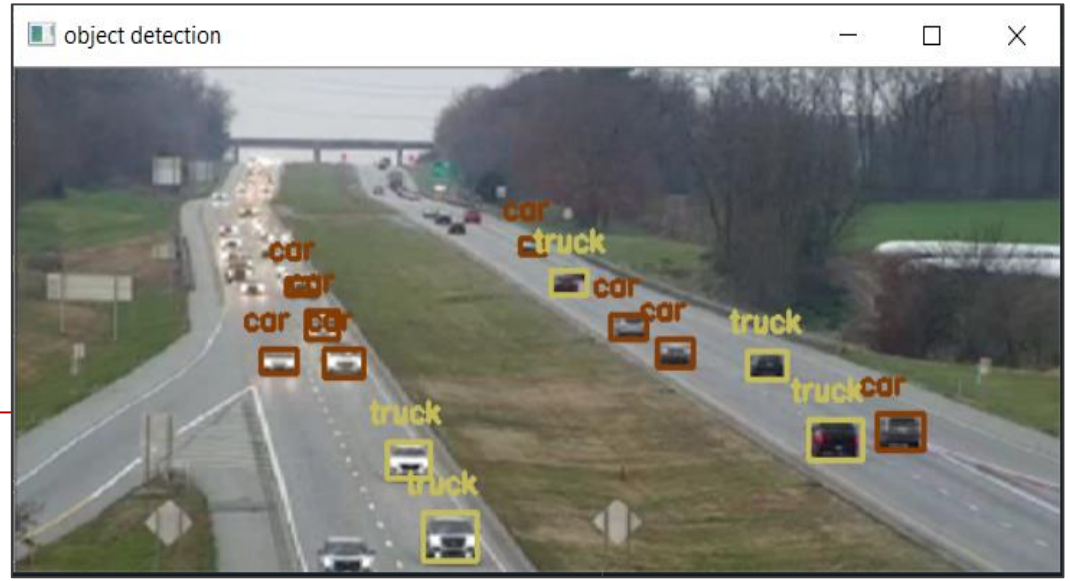
Object Recognition

- **YOLO** : Deep learning based Object detection algorithm.
- **Dataset** : Microsoft Common Objects in Context (COCO Dataset)
- **Train Algorithm** : to detect various vehicle classes in a given image
- **Classify and Store** : the number of vehicles found in the image



Test Case 1

Test Case 2



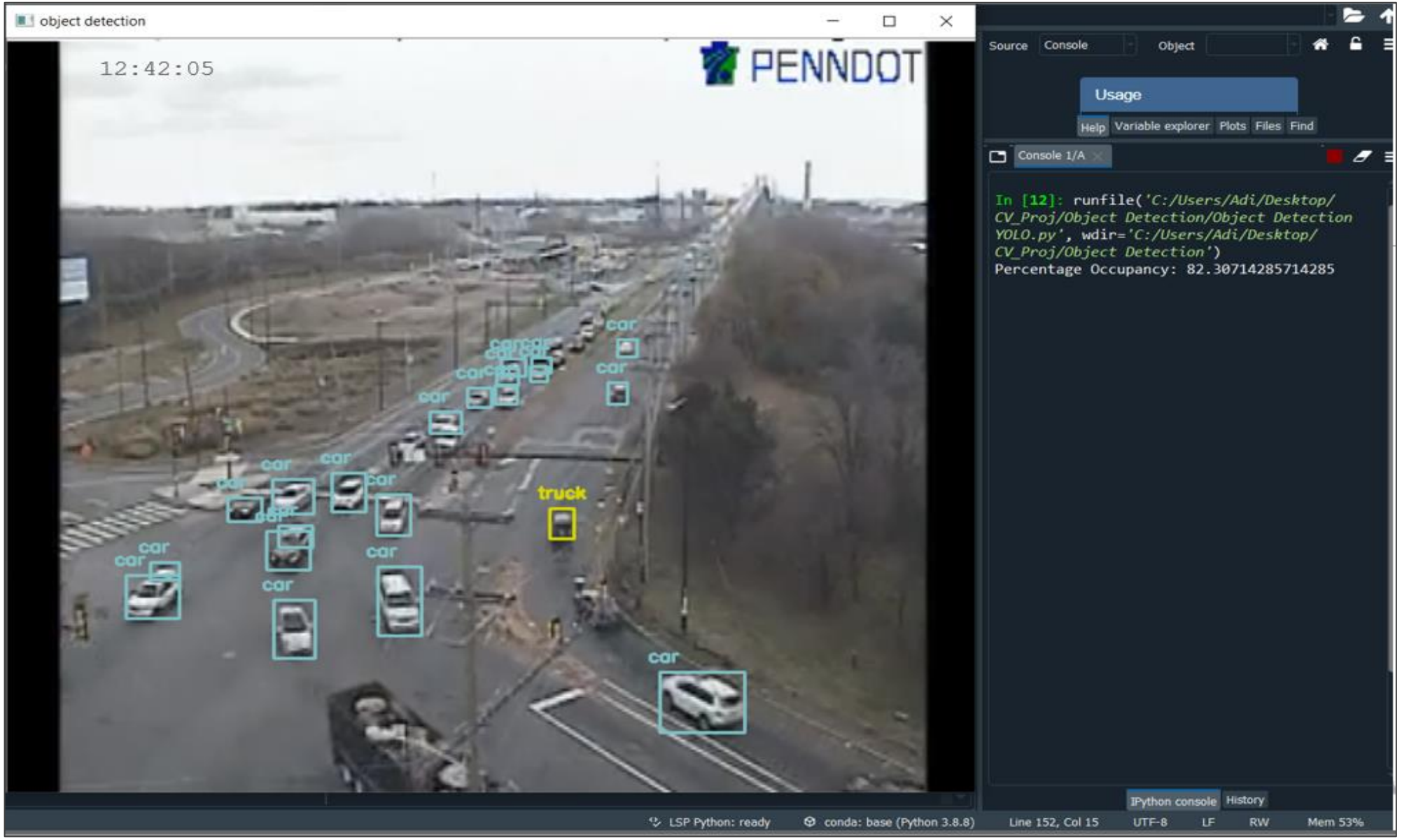
Test Case 3

Traffic Density Calculation

- **Calculate road_area :** the area of road with respect to the input image
- **Calculate Total_vehicle_area :** the sum of individual vehicle areas
- **Compute percentage occupancy:** by dividing the two areas

$$Road\ Percent\ Occupancy = \frac{Total\_vehicle\_area}{Road\ Area}$$

- Note: The Road area may differ based on the type of road (single lane, multi-lane, incoming, and outgoing traffic)


object detection
12:42:05
PENNDOT
car
truck
Source
Console
Object
Usage
Help
Variable explorer
Plots
Files
Find
Console 1/A
In [12]: runfile('C:/Users/Adi/Desktop/CV_Proj/Object Detection/Object Detection YOLO.py', wdir='C:/Users/Adi/Desktop/CV_Proj/Object Detection')
Percentage Occupancy: 82.30714285714285
IPython console
History
LSP Python: ready
conda: base (Python 3.8.8)
Line 152, Col 15
UTF-8
LF
RW
Mem 53%

Future Scope

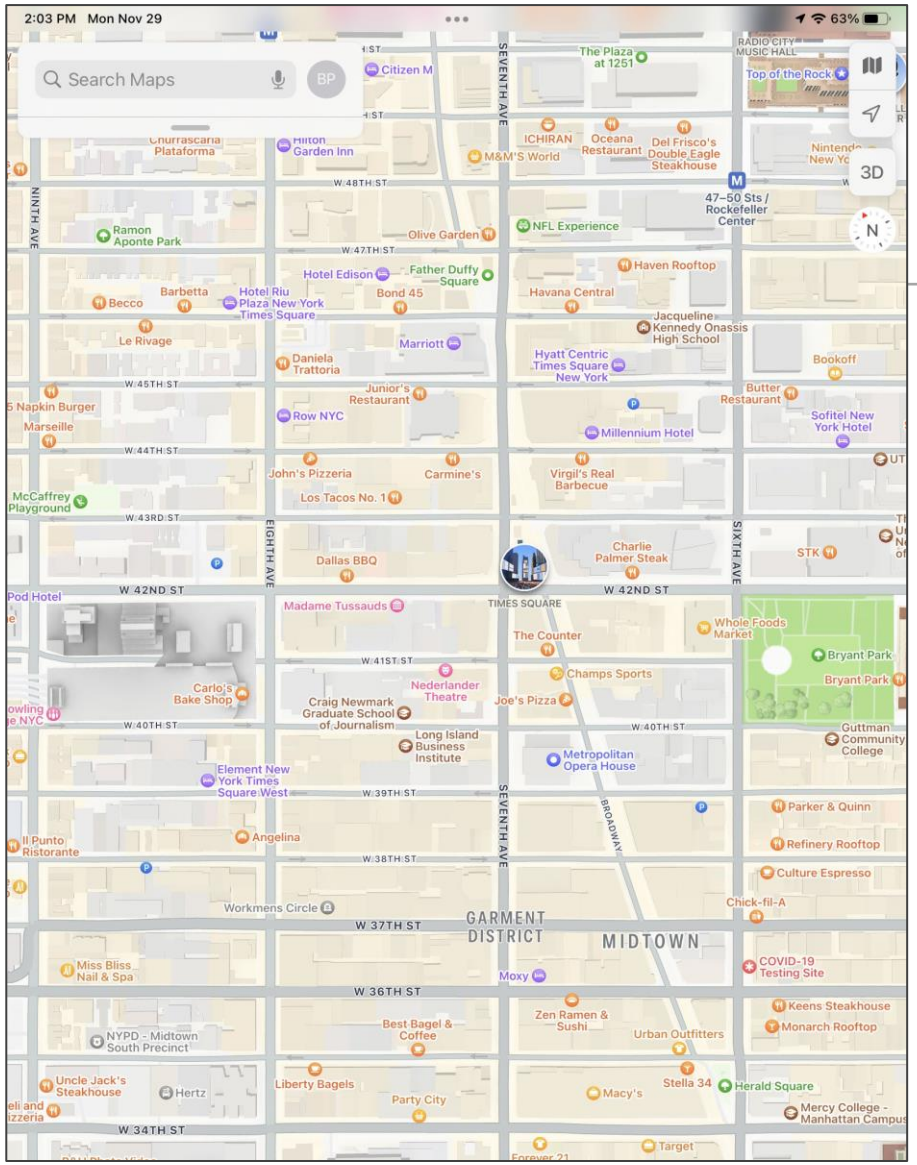
Pseudo-coloring (Mobility Heatmap)

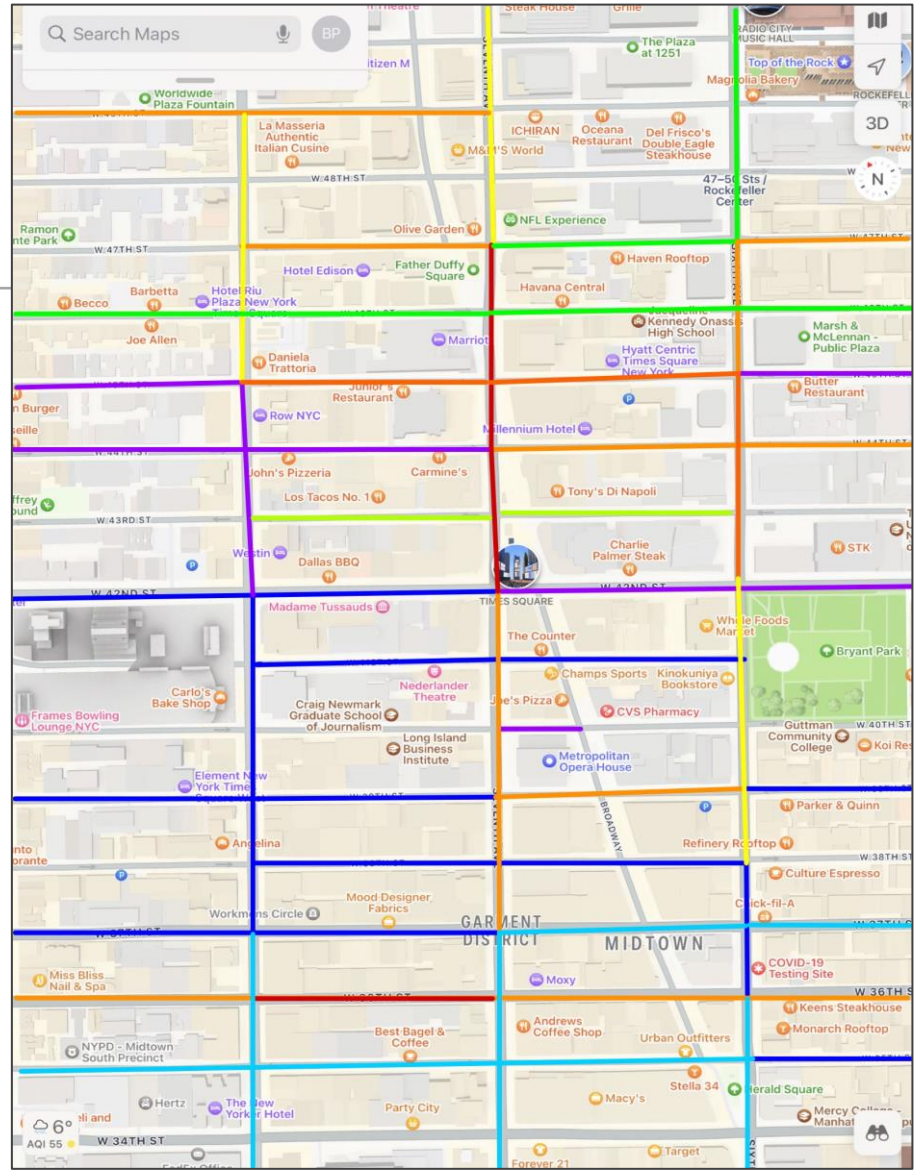
- Dataset showing the volume of traffic flow.
- Violet to Red spectrum applied with appropriate thresholding to pseudo-color map in conjunction with map API.

Data-driven city planning

- Dataset measuring street speeds of traffic using **Optical Flow**.
- This information would be vital to installation of traffic signals, traffic cameras and road infrastructure planning.
- Critical to road transportation safety.

Pseudo-Coloring





Motion Detection

Image 1

Substraction (1-2)

Image 3

Substraction (2-3)

Value proposition

Customers Satisfaction

- Reliable traffic density data
  - Enables our customers to plan their commute economically.
- Privacy protection (Big Brother data harvesting)
  - Growing concern over user data-privacy require a shift in data harvesting practices.

Economic Impact

- Increase in productivity and business revenue
  - Benefit for local consumers and professional workers

Value proposition

Urban Infrastructure Planning

- Highways, Parking Lots, Metro Lines, Malls ...

  - On a larger scale, our solution would be able to provide critical insights for urban infrastructure planning.

  - This data can aid governments in allocating resources towards development projects of highways, parking lots, metro lines and more to address issues arising from traffic congestion that contribute to lower productivity and it's associated economic implications.

Thank You!

- **Any Questions?**

  Please find us at LaPrimaPlus@gmail.com

- **Please don't forget to provide your scores and any feedback! ☺**