Facial and Object Recognition Using CV2 & CVLIB

Scott Hameed

Springboard Capstone 2

Data Science Artist

Contents:

- Summary (TL;DR)
- Business Problem
- Scope, Approach, Process, and Libraries
- Solution Overview - Face Detection
- Solution Overview - Object Detection
- Key Challenges & Learnings For Future
- Future Enhancements & Optimizations
- Project Resources

Summary (TL;DR)

- This project leverages Deep Learning libraries to recognize and detect human faces and objects using live video
- One of the key inspirations for this project came from my idea that school shooters can be recognized in some cases based on:
    - If they are not existing school students
    - Carrying objects such as large bags or guns
- Future considerations for improving this Neural Network include:
    - Combining the identified person and objects in a single window
        - Currently, the face recognition and object/person recognition codes are separate
    - Identifying objects that indicate risk:
        - Large bags
        - Guns
- I am passionate about intelligent systems that can improve the life quality for people
- This project serves as a foundation for an ongoing project to build various computer vision and natural language processing functions that can then be used to create a risk assessment and security solution to secure school perimeters
- The goal is to help schools in USA and the world, better manage and address security risks

Business Problem

- Campus security that primarily involves security guards is:
  - Expensive
  - Complex: schools are generally speaking fairly large open spaces
  - In the post COVID world, hiring is a key issue
  - Personnel are not well trained to monitor threats
- Threat identification is a key component of averting disastrous scenarios
- There are two mainstream offerings to manage school campus security in addition to other use cases, however, there is a need for more specialized solution tailored for schools [1]
- This project is a first step in the direction of creating specialized AI based solutions for schools

[1] Actuate and Scylla

Scope, Approach, Process, and Libraries

Scope:

- Define vision and approach
- Systems setup
- Model training (Facial Recognition only)
- Coding
- Report and presentation

Approach:

- Identify the best libraries for the applications
- Setup of systems
- Data collection and setup
- Troubleshooting and solution validation

Process:

- Systems setup:
  - Ubuntu Linux
  - Apache MyPHP
  - Apache MySQL
  - Webcam setup
- Installing the key libraries (See below)
- Data collection and setup
- Training
- Coding
- Validation

Libraries

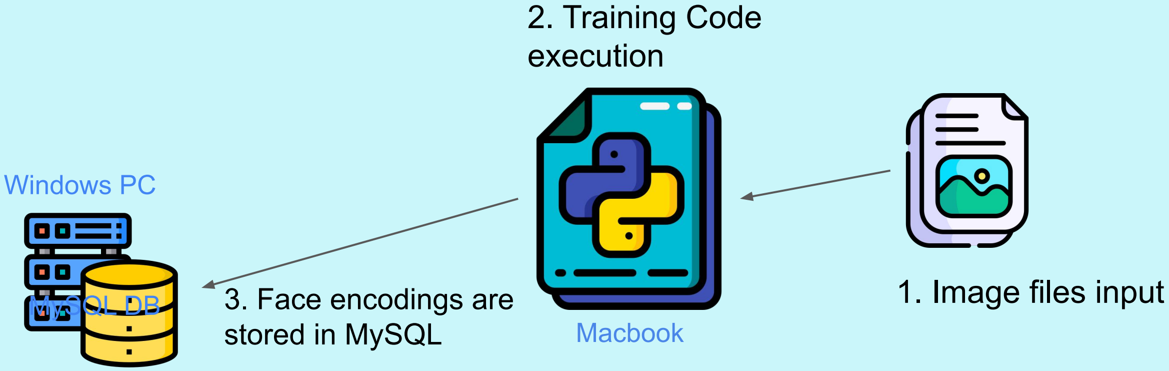
- Face Recognition (Dlib): It's a face recognition library that has a 99.38% accuracy and is built on top of the dlib library (Link)
  - Dlib: DLib is a high performance C++ toolkit which includes many Deep Learning, image processing, and (Link)
- OpenCV (CV2): The larger computer vision library (Link 1, Link 2)
- Numpy: library for arrays and mathematical functions (Link)
- CVLIB: person and object detection library powered by OpenCV (Link)
  - This leverages YOLOv4 model trained on COCO dataset capable of detecting 80 common objects in context

Solution Overview - Facial Recognition (1 of 5)

- The key components of the face identification solution consist of:
  - MySQL database
  - Photos with person names as labels
  - Webcam
  - Training code
  - Live video facial identification
- Below are the details of the training solution:
  - MyPHP and MySQL servers were installed on a windows machine
  - The code development and image files are worked on from a Macbook
  - 100+ images of celebs that were downloaded from the internet
    - One of the photos is of me (Author of this presentation: Scott Hameed)
  - Majority of these images were accepted by the algorithm but some generate errors and were removed
    - Usually the errors are due to the frontal face not being clearly visible
  - The code then generates face encodings for the photos
  - The face encodings are then saved in the MySQL database in the windows machine
- Below are the details of the live video solution face detection solution:
  - The code enables the webcam
  - The code looks for human face(s) in the live video stream generated from the webcam
  - It then computes the face encodings for any faces in the live video stream
  - It then makes a call into the MySQL server to compare the face encodings from the live video stream
  - If it finds a match, it labels it with the name of the file matched with (which in this case is the first and last name of the person matched)
  - I then test the code by running and the code and verifying that it recognizes my face and labels it
    - Also, that it does not recognize other people whose face encodings are not in the DB

Solution Overview - Facial Recognition (2 of 5)

TRAINING CODE



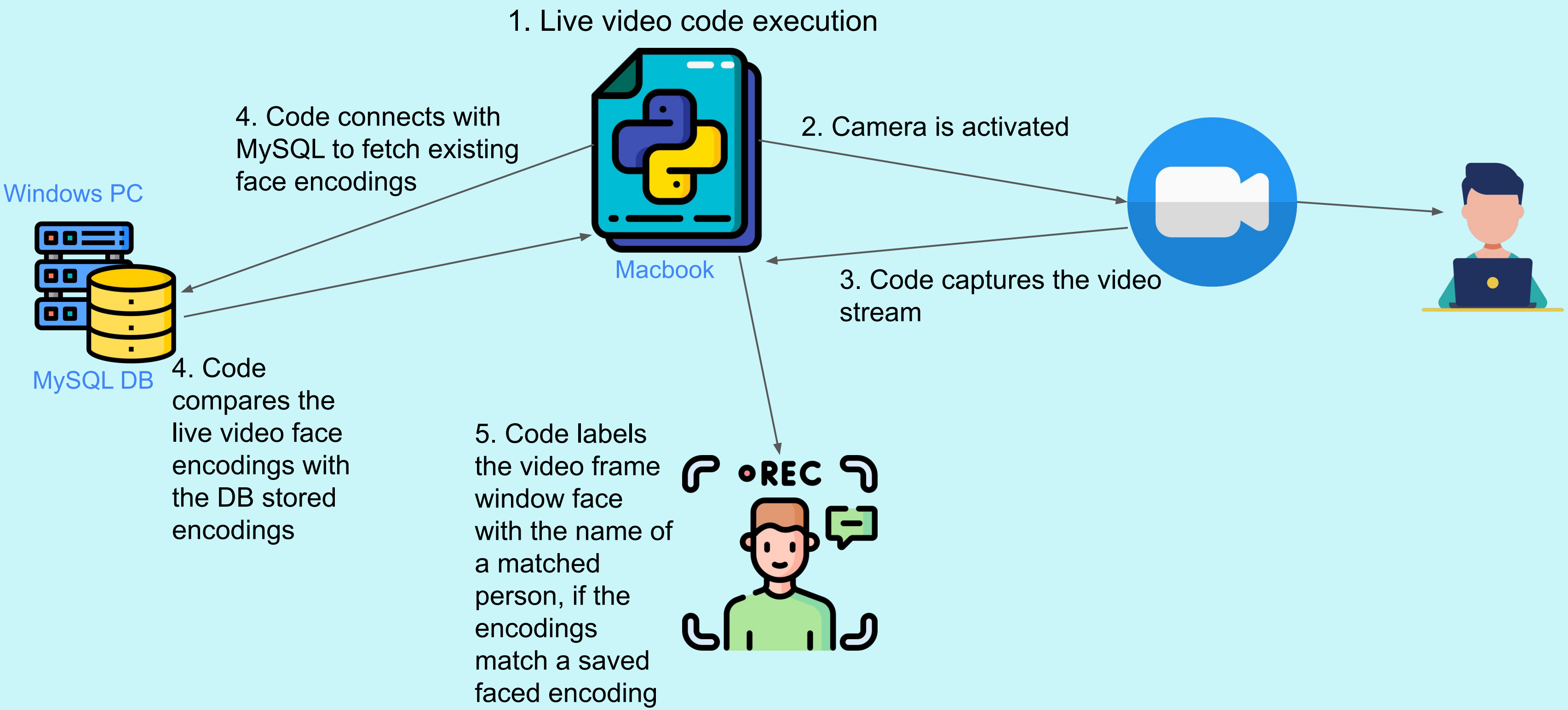
2. Training Code execution

3. Face encodings are stored in MySQL

1. Image files input

Solution Overview - Facial Recognition (3 of 5)

LIVE VIDEO FACIAL RECOGNITION CODE



1. Live video code execution

2. Camera is activated

3. Code captures the video stream

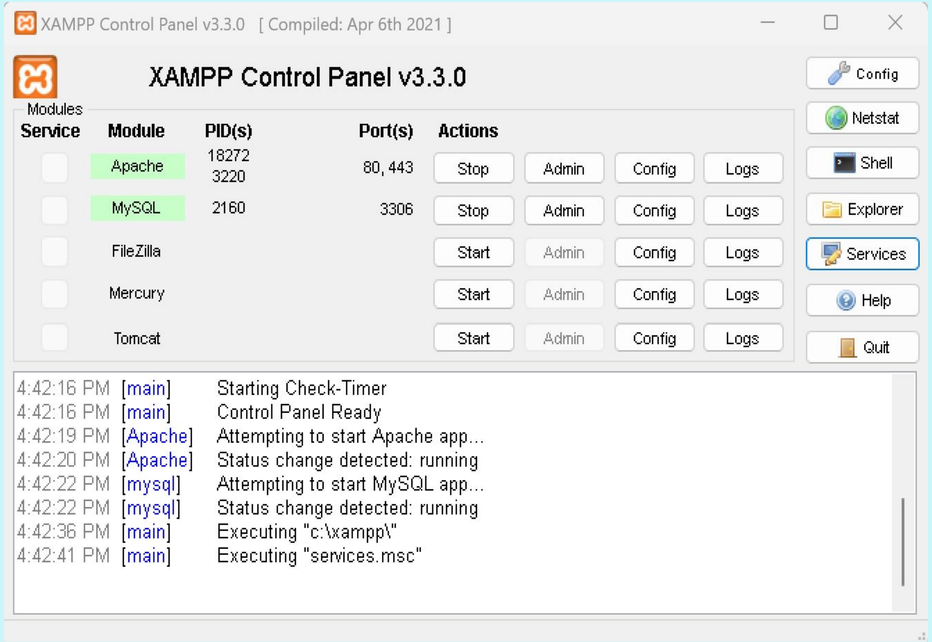
4. Code connects with MySQL to fetch existing face encodings

4. Code compares the live video face encodings with the DB stored encodings

5. Code labels the video frame window face with the name of a matched person, if the encodings match a saved faced encoding

Solution Overview - Facial Recognition (4 of 5)

XAMPP Control Panel for Apache & MySQL Servers

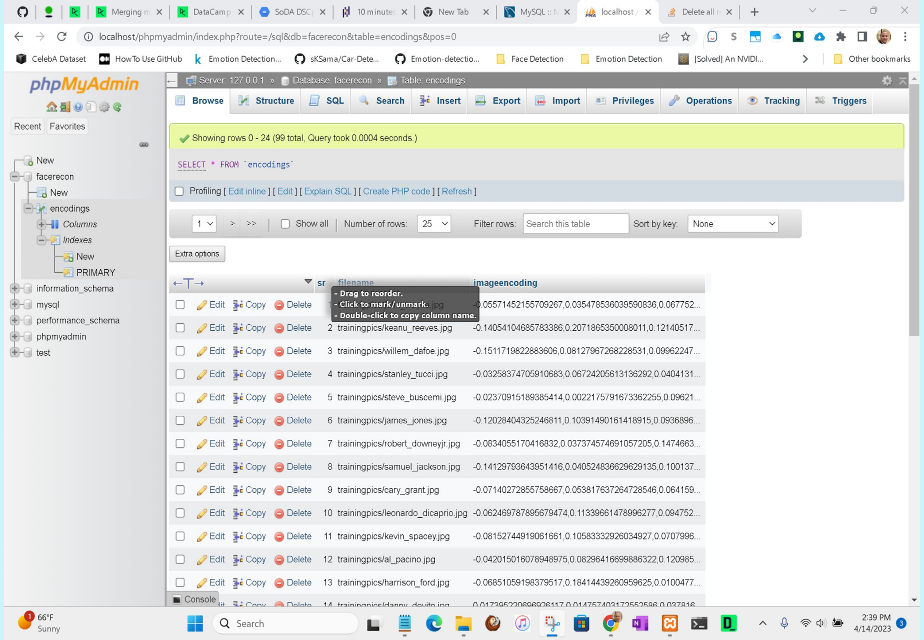

XAMPP Control Panel v3.3.0 [Compiled: Apr 6th 2021]
XAMPP Control Panel v3.3.0
Config
Netstat
Shell
Explorer
Services
Help
Quit

Modules

Service	Module	PID(s)	Port(s)	Actions			
□	Apache	18272 3220	80, 443	Stop	Admin	Config	Logs
□	MySQL	2160	3306	Stop	Admin	Config	Logs
□	FileZilla			Start	Admin	Config	Logs
□	Mercury			Start	Admin	Config	Logs
□	Tomcat			Start	Admin	Config	Logs

```
4:42:16 PM  [main]     Starting Check-Timer
4:42:16 PM  [main]     Control Panel Ready
4:42:19 PM  [Apache]   Attempting to start Apache app...
4:42:20 PM  [Apache]   Status change detected: running
4:42:22 PM  [mysql]    Attempting to start MySQL app...
4:42:22 PM  [mysql]    Status change detected: running
4:42:36 PM  [main]     Executing "c:\xampp\"
4:42:41 PM  [main]     Executing "services.msc"
```

Face Encodings MySQL Table



localhost/phpmyadmin/index.php?route=/sql&db=facerecon&table=encodings&pos=0

Server: 127.0.0.1 » Database: facerecon » Table: encodings

✓ Showing rows 0 - 24 (99 total, Query took 0.0004 seconds.)

```
SELECT * FROM `encodings`
```

□ Profiling [Edit inline] [Edit] [Explain SQL] [Create PHP code] [Refresh]

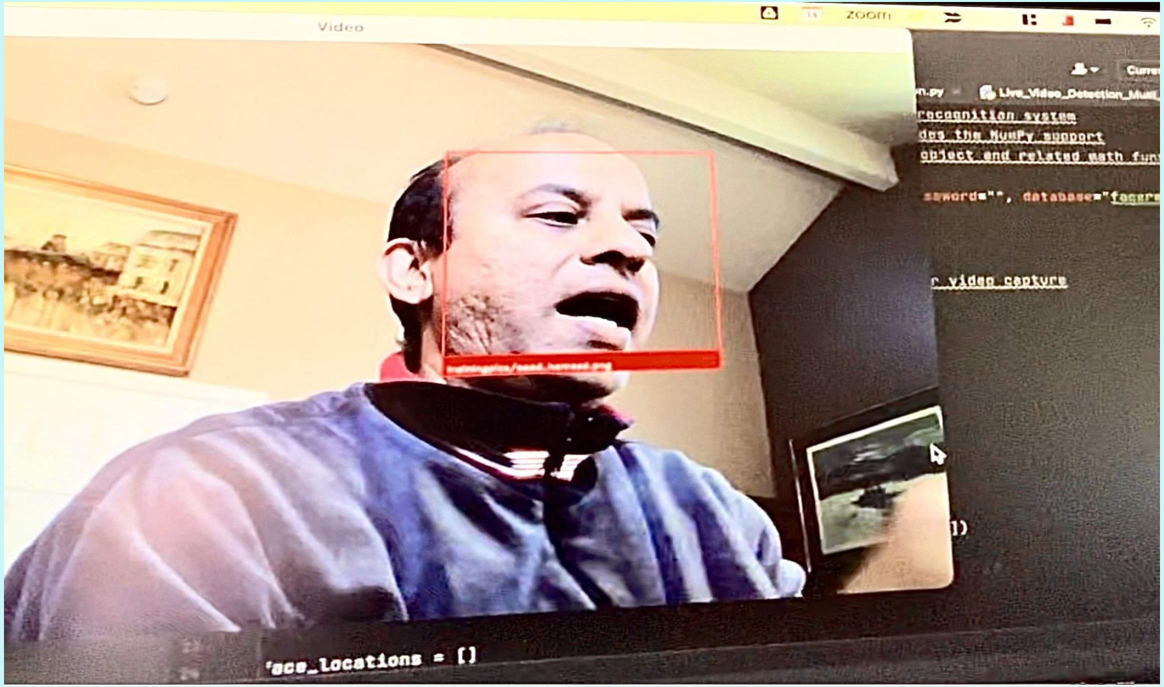
1 > >> □ Show all | Number of rows: 25 Filter rows: Search this table Sort by key: None

- Drag to reorder.
- Click to mark/unmark.
- Double-click to copy column name.

				sr	filename	imageencoding
□	Edit	Copy	Delete	1	[illegible].jpg	-0.055714521557092 67,0.035478536039590836,0.067752...
□	Edit	Copy	Delete	2	trainingpics/keanu_reeves.jpg	-0.14054104685783386,0.2071865350008011,0.12140517...
□	Edit	Copy	Delete	3	trainingpics/willem_dafoe.jpg	-0.1511719822883606,0.08127967268228531,0.09962247...
□	Edit	Copy	Delete	4	trainingpics/stanley_tucci.jpg	-0.03258374705910683,0.06724205613136292,0.0404131...
□	Edit	Copy	Delete	5	trainingpics/steve_buscemi.jpg	-0.02370915189385414,0.0022175791673362255,0.09621...
□	Edit	Copy	Delete	6	trainingpics/james_jones.jpg	-0.12028404325246811,0.10391490161418915,0.0936896...
□	Edit	Copy	Delete	7	trainingpics/robert_downeyjr.jpg	-0.0834055170416832,0.037374574691057205,0.1474663...
□	Edit	Copy	Delete	8	trainingpics/samuel_jackson.jpg	-0.1412979364395141 6,0.040524836629629135,0.100137...
□	Edit	Copy	Delete	9	trainingpics/cary_grant.jpg	-0.07140272855758667,0.05381763726472854 6,0.064159...
□	Edit	Copy	Delete	10	trainingpics/leonardo_dicaprio.jpg	-0.06246978789567947 4,0.11339661478996277,0.094752...
□	Edit	Copy	Delete	11	trainingpics/kevin_spacey.jpg	-0.08152744919061661,0.10583332926034927,0.0707996...
□	Edit	Copy	Delete	12	trainingpics/al_pacino.jpg	-0.04201501607894897 5,0.08296416699886322,0.120985...
□	Edit	Copy	Delete	13	trainingpics/harrison_ford.jpg	-0.06851059198379517,0.18414439260959625,0.0100477...
	Edit	Copy	Delete	14	trainingpics/danny_devito.jpg	0.017395220696926117,0.014757403172552586,0.037816...

Solution Overview - Facial Recognition (5 of 5)

Project Demo Video (Link)



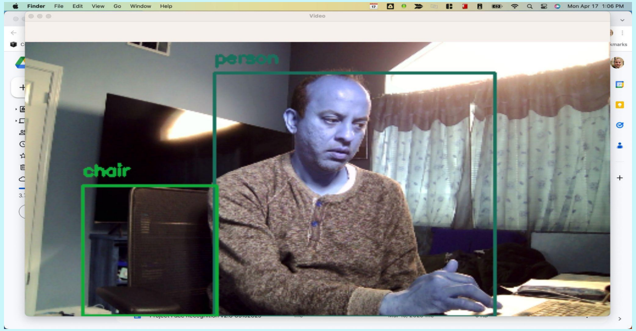
```
recognition system
des the NumPy support
object and related math fun

ssword="", database="facere

r video capture

1)
face_locations = []
```

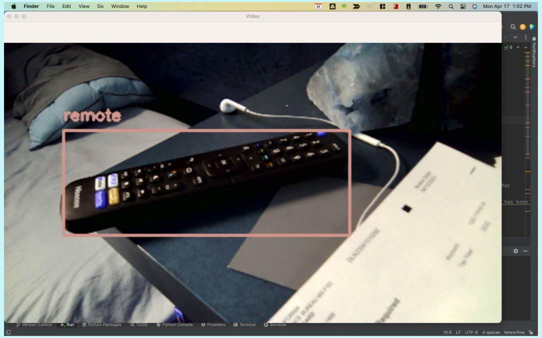
Solution Overview - Object/Entity Recognition (1 of 2)

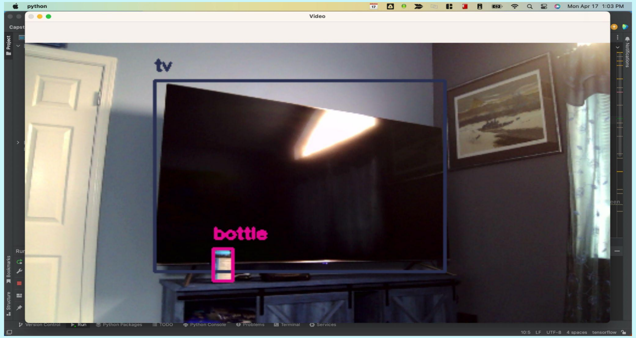
- The key components of the face identification solution consist of:
    - Webcam
    - Live video object identification
- Below are the details of the Live Video solution:
    - The code enables the webcam
    - The code looks for human and other objects(s) in the live video stream generated from the webcam based on a pre-compiled model that has encodings for a person and specific objects
    - If it finds a match, it labels it with the name of the entity (for example: person, cell phone, mouse, keyboard, tv, bottle, etc.)
        - See next slide for examples from a a code execution on April 17, 2023
    - I then test the code by running and the code and verifying that it recognizes my person and other objects by labels them

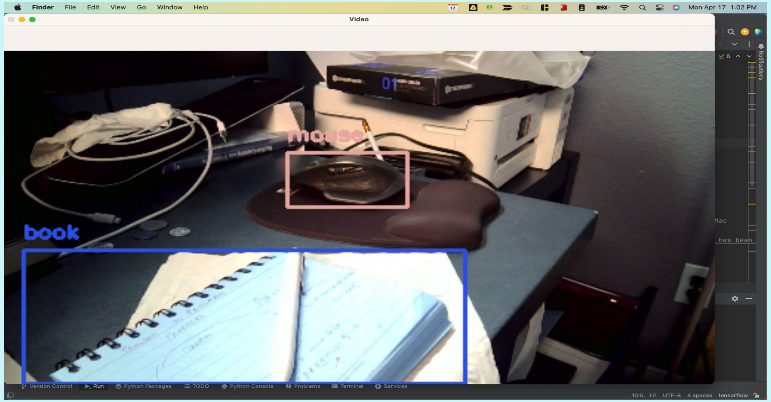
Solution Overview - Object/Entity Recognition (2 of 2)

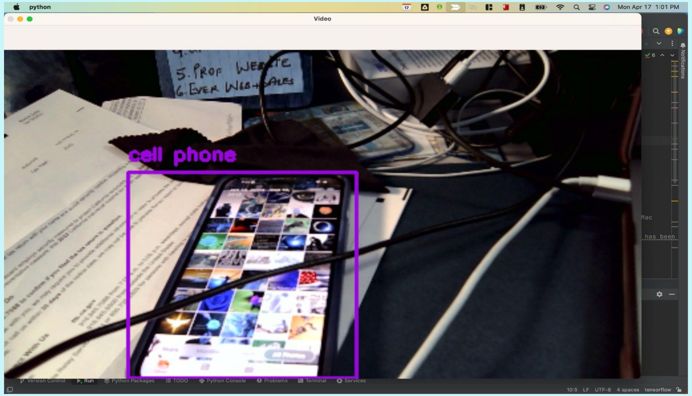
Project Demo Video (Link)











Key Challenges & Learnings For Future

Key Challenges:

- Dlib library installation ran into several issues; below is the sequence of the events:
    - Installation on Macbook failed
    - I then installed a VM using UTM and also Parallels but both had issues with installation of Dlib
    - I then changed to a new Ubuntu Linux system but the same issue kept coming up
    - I was able to resolve this issue through a set of other app installs and then using Conda for package management

Key Learnings For Future :

- It’s critical to not continue investing time into a systems problem that continues to worsen over time (cut losses)
- Always be willing to change an OS/system in sticky situations including using online compute (Colab et al)

Future Enhancements & Optimizations

- Combining the code sets of known person identification with entity/object identification
  - This will ensure we can create a solution where the system recognizes unknown persons for example a person who is not a student of a school
- Update object/entity identification code from CVLib library to Ultralytics YOLOv8 library
  - This will result in improved performance and also identification of larger set of objects
  - The v8 model is able to recognize backpacks (link)
- Leverage YOLOv8 to identify guns or create a new neural network to identify guns as this ensures we can create a school security and risk identification solution
- Create programmatic solution which identifies variations in sizes of bags to identify risks
- Leverage larger datasets for facial detection training

DATA SCIENCE ARTIST

Project Resources

Project Resources

- Github repository homepage (Link)
- Project demo video for Facial Recognition (Link)
- Project demo video for Object/Entity Recognition (Link)
- Google doc version of Python source code for Facial and Object/Entity Detection (Link)
- Python code file (Link)
- Project report (Link)