Secure lab access using facial recognition system

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CSCI 575 FINAL GROUP PROJECT

Outline

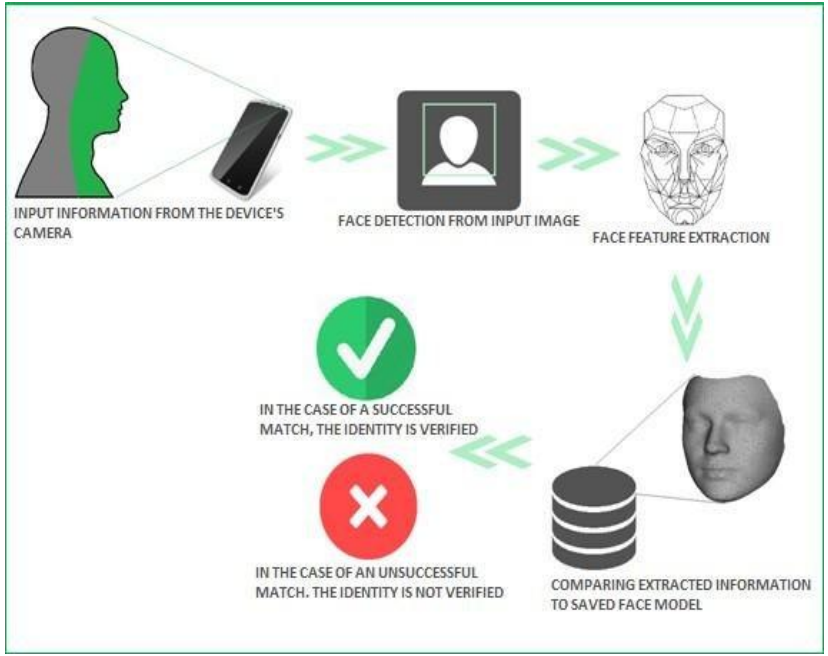
1. Problem Statement
2. Solution
3. Demo
4. Assumption, Constraints & Implications
5. Workflow
6. Summary

Problem Statement

- Face recognition systems associates with following problems:
  - Can’t find face
  - Insufficient information
  - Illumination
  - Face body
- Build face recognition system which allows identify a person using webcam and provide access to the lab
- Benefit to stakeholders: providing a fast and convenient product of authentication

Solution

- Webcam – capture the face image
- Machine Learning performs three tasks:
  - Face Detection
  - Facial Features
  - Recognition and Identification
- Approve/Deny the lab access



Data

Source: **FEI face database** is a Brazilian face database

- 14 Images for each of 204 individuals, a total of 2856 images.
- Colorful images with white homogeneous background, each image is 640 x 480
- Profile rotation of up to 180 degrees
- Age between 19 and 40 years old with distance appearance, hairstyle and adorns
- Number of male and female are exactly the same, equal to 100

Table 1. Some example of image variations from the FEI face database

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ML algorithm - Decision Tree

Use Decision Tree algorithm to classify 20 persons' images (280 images)

Training image - 196

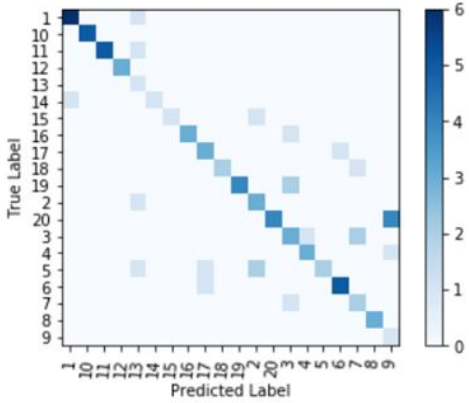
Testing image - 84

Accuracy - 71.43%

Reason to not use this algorithm:

Lesser accuracy

Confusion Matrix:



Classifier Metrics:

	precision	recall	f1-score	support
1	0.86	0.86	0.86	7
10	1.00	1.00	1.00	5
11	1.00	0.83	0.91	6
12	1.00	1.00	1.00	3
13	0.20	1.00	0.33	1
14	1.00	0.50	0.67	2
15	1.00	0.50	0.67	2
16	1.00	0.75	0.86	4
17	0.60	0.75	0.67	4
18	1.00	0.67	0.80	3
19	1.00	0.67	0.80	6
2	0.50	0.75	0.60	4
20	1.00	0.50	0.67	8
3	0.43	0.50	0.46	6
4	0.75	0.75	0.75	4
5	1.00	0.33	0.50	6
6	0.83	0.83	0.83	6
7	0.40	0.67	0.50	3
8	1.00	1.00	1.00	3
9	0.17	1.00	0.29	1
micro avg	0.71	0.71	0.71	84
macro avg	0.79	0.74	0.71	84
weighted avg	0.84	0.71	0.74	84

Accuracy: 71.43%

ML algorithm - CNN

Use CNN algorithm to classify

Train the model over 10 epochs

Train accuracy: 0.98

Test accuracy:0.54

Reason to not use this algorithm:

Lesser accuracy

Layer (type)	Output Shape	Param #
conv2d_5 (Conv2D)	(None, 123, 123, 32)	3488
max_pooling2d_5 (MaxPooling2	(None, 61, 61, 32)	0
conv2d_6 (Conv2D)	(None, 56, 56, 32)	36896
max_pooling2d_6 (MaxPooling2	(None, 28, 28, 32)	0
flatten_3 (Flatten)	(None, 25088)	0
dense_3 (Dense)	(None, 200)	5017800

Total params: 5,058,184
Trainable params: 5,058,184
Non-trainable params: 0

ML algorithm - Random Forest

Used Random Forest model to train and predict the Dataset.

n_estimators=200, random_state=0

Test accuracy : 0.8

accuracy			0.80	700
macro avg	0.81	0.82	0.78	700
weighted avg	0.86	0.80	0.80	700

Reason to not use this algorithm:

Lesser accuracy and was not used in the class.

ML algorithm - XgBoost

Used XgBoost model to train and predict the Dataset.

n_estimators=200,learning_rate=0.01

Test accuracy : 0.88

accuracy			0.58	700
macro avg	0.60	0.60	0.55	700
weighted avg	0.67	0.58	0.58	700

Reason to not use this algorithm:

Too slow in training, was not used in the class and lesser accuracy.

ML algorithm - MLP

Used MLP classifier to train and predict the Dataset.

hidden_layer_sizes=(2048,)

Test accuracy : 0.88

accuracy			0.88	700
macro avg	0.90	0.89	0.87	700
weighted avg	0.92	0.88	0.88	700

Reason to not use this algorithm:

Comparatively slow in predicting the input image.

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ML algorithm - PCA-SVM

PCA: $\min_{U,V} ||X - UV^T||_F^2$,

$s.t.\ U^T U = I.$

pca_components = 150

Training image: 2100

Testing image: 700

Results: Weighted F1-score = 0.86

Eigenfaces: 1:100:5

ML algorithm – FaceNet-SVM

- FaceNet:

  Input: 160*160 color image

  Output: 128-dim vector

  # Layers: 22

- SVM Results:

  Weighted F1-score = 0.81

layer	size-in	size-out	kernel	param	FLPS
conv1	220×220×3	110×110×64	7×7×3, 2	9K	115M
pool1	110×110×64	55×55×64	3×3×64, 2	0	
rnorm1	55×55×64	55×55×64		0	
conv2a	55×55×64	55×55×64	1×1×64, 1	4K	13M
conv2	55×55×64	55×55×192	3×3×64, 1	111K	335M
rnorm2	55×55×192	55×55×192		0	
pool2	55×55×192	28×28×192	3×3×192, 2	0	
conv3a	28×28×192	28×28×192	1×1×192, 1	37K	29M
conv3	28×28×192	28×28×384	3×3×192, 1	664K	521M
pool3	28×28×384	14×14×384	3×3×384, 2	0	
conv4a	14×14×384	14×14×384	1×1×384, 1	148K	29M
conv4	14×14×384	14×14×256	3×3×384, 1	885K	173M
conv5a	14×14×256	14×14×256	1×1×256, 1	66K	13M
conv5	14×14×256	14×14×256	3×3×256, 1	590K	116M
conv6a	14×14×256	14×14×256	1×1×256, 1	66K	13M
conv6	14×14×256	14×14×256	3×3×256, 1	590K	116M
pool4	14×14×256	7×7×256	3×3×256, 2	0	
concat	7×7×256	7×7×256		0	
fc1	7×7×256	1×32×128	maxout p=2	103M	103M
fc2	1×32×128	1×32×128	maxout p=2	34M	34M
fc7128	1×32×128	1×1×128		524K	0.5M
L2	1×1×128	1×1×128		0	
total				140M	1.6B

Schroff et al., 2015

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ML algorithm – FaceNet-NN

- FaceNet:

  Extract 128-dim vector

- Neural Network:

  Input -> Flatten -> Dense -> Softmax

  Tried between 1~3 Dense layers, results are similar.

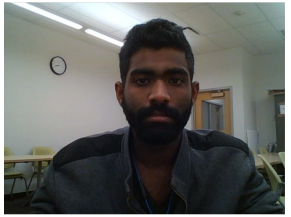
  After 50 epochs, accuracy is 79.4%.

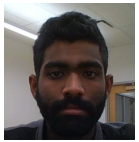
Layer (type)	Output Shape	Param #
input_1 (InputLayer)	[(None, 128)]	0
flatten (Flatten)	(None, 128)	0
dense (Dense)	(None, 512)	66048
dense_1 (Dense)	(None, 204)	104652

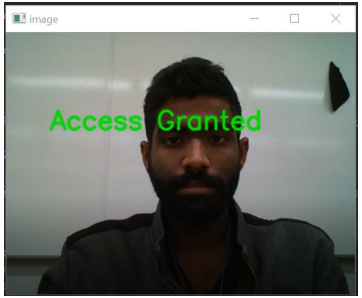
Total params: 170,700
Trainable params: 170,700
Non-trainable params: 0

Computer Vision processing

- Used videocapture function from OpenCV to capture frames from the webcam.
- Used facecascade function to extract the face out of a frame.
- Cropped the faces to a squared image and sent the same to
- the classifier to predict.
-
- Finally used puttext function to display the result in the opencv window.

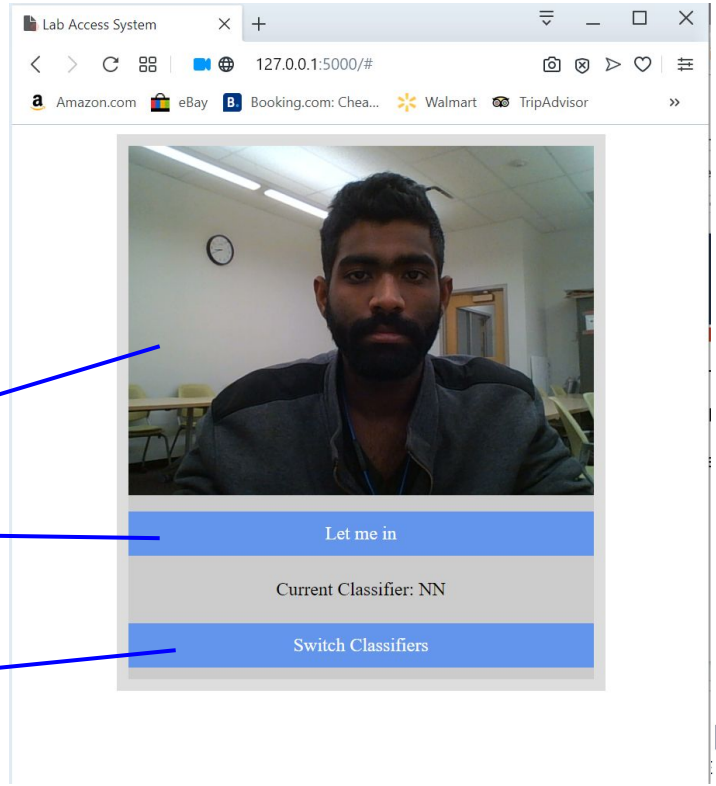






Product

- Our product is a web-based application.
- Deployed using HTML, CSS, JS and Flask
- Flask takes care of server side scripting

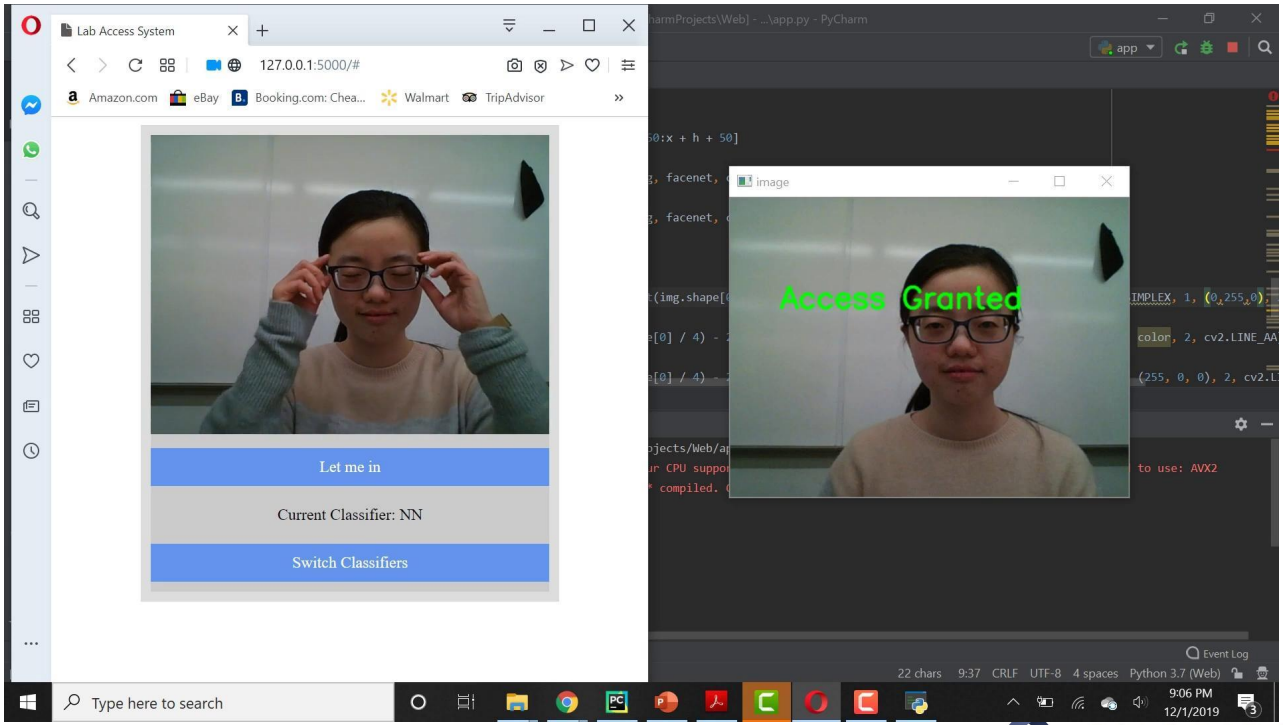


Display real-time webcam video

Request authentication

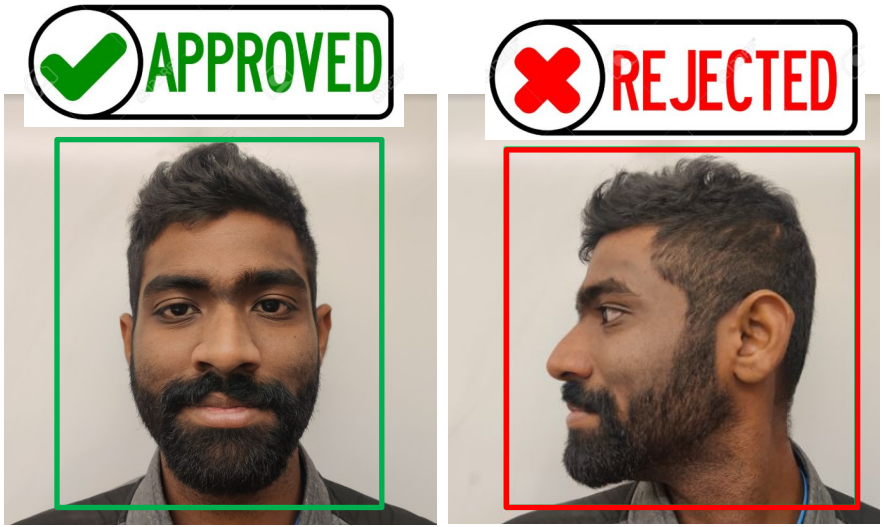
Supports two classifiers: FaceNet+SVM, FaceNet+NN

DEMO


Lab Access System
127.0.0.1:5000/#
Amazon.com
eBay
Booking.com: Chea...
Walmart
TripAdvisor
Let me in
Current Classifier: NN
Switch Classifiers
image
Access Granted
Type here to search
9:06 PM
12/1/2019

Constraints

- Recognize the face with complex datasets and accessories:
  - With/without spectacles
  - Make-up
- Product's interface
- Images with low light
- Eyes visibility (head position)



Summary

- Using face recognition method in lab security system provides high level security.
- Applied methods are designed to solve current face recognition problems
- FaceNet+SVM and FaceNet+NN algorithms are selected as very efficient (~0.8 accuracy)
- Faces issues such as different facial expressions might be interested for follow-up study.


THANK YOU FOR
YOUR ATTENTION
ANY QUESTIONS,
ASK GOOGLE

Reference

1. Schroff, F., Kalenichenko, D., & Philbin, J. (2015). Facenet: A unified embedding for face recognition and clustering. In *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 815-823).