TEKNOFEST

AEROSPACE AND TECHNOLOGY FESTIVAL

EDUCATIONAL TECHNOLOGY COMPETITION

PROJECT DETAIL REPORT

PROJECT NAME: Real Time DSU Attendance System Using Facial Recognition

TEAM NAME: Eyes on AI

TEAM ID: T3-14635-190

TEAM LEVEL: University-undergraduate

TEAM MEMBERS: Ammara Shaikh
Aireen Amir Jalal
Muhammad Moiz Hassan

ADVISOR NAME: Engr. Muhammad Owais
Engr. Anas Bin Iftikhar (Co-Advisor)

Project Detail Report

1. Project Summary:

Facial recognition is one of the widely encountered applications of pattern recognition these days. Over the past few decades, interest in theories and algorithms for face recognition has been growing rapidly. Video surveillance, criminal identification, building access control, and unmanned and autonomous vehicles are just a few examples of concrete applications that are gaining attraction among industries.

There are two parts to facial recognition problem with first being the task to detect a human face from an image by discarding all non-facial parts from the image (not scope of our project) and the second task being the challenge to identify whose face do we have by using different kind of classifiers or based on our prior information (supervised training) in the form of an image database or the training set.

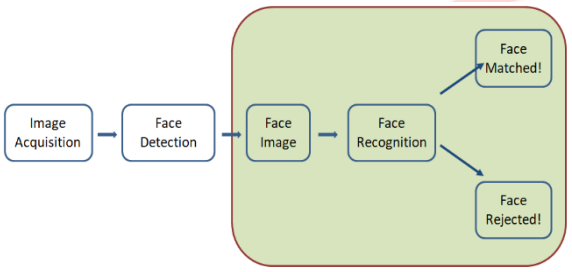


Figure 1 Scope of Project

Figure 2 Face Recognition Usage

The idea of this project is to mark attendance automatically. It is known that marking attendance has always been considered a ritual which is followed by almost every institute or organization. Therefore, it needs to be developed or updated accordingly with the latest technologies. The driving force of this development is the desire to automate, facilitate, speed up, save time and efforts; thus, reducing the manual errors and time.

Our system uses two different algorithms that is Principal Component Analysis (PCA) using Eigen face approach and Convolution Neural Network (CNN) algorithm based on Triplet Loss Function. Three varying datasets are used in this work with first containing facial images from that AT&T [1] or the Olivetti Research Laboratory facial database while second set has been generated locally at DHA Suffa University (DSU) and the third dataset is our OWN generated dataset.

The proposed project after implementing on MATLAB and Python will be executed on Raspberry pi.

2. Problem/ Issue:

DHA Suffa University (DSU) attendance System is managed manually which may be considered as a time-consuming process. It has become a tedious job for teachers like calling out students' names, waiting for their response and then marking the attendance. Roll calling alone takes approximately 10 mins from a total of 50 mins (For class strength of around 40 students).

The management of DSU locks the attendance marking system after every one week. In any case if any student's attendance is missed, the faculty needs to go to the administration department and requests to open the attendance marking system again. Considering this

current situation of DHA Suffa University (DSU), it is necessary to come up with a prototype or a solution which can replace the manual attendance system with an automatic attendance system in order to save both time and efforts for management/faculty to handle/deal with it.

3. Solution:

Since the traditional way of taking attendance takes time, providing a solution of automatic attendance system at real time makes it more efficient. Thus, reducing the time.

Considering the current situation of our university faculty members who give their almost 10 mins marking the attendance manually, the group members implements the real time attendance system in order to save teacher's time by focusing more on lecture.

This problem is solved by taking two algoithms into conideration i.e. Principal Component Analysis (PCA) and Convolution Neural Network (CNN) which helps us to achieve our goal.

Our system uses facial recognition technology to record the attendance automatically by acquiring images through a high-resolution digital camera. The defined algorithm then recognizes faces by comparing the test images with the face images stored in faces/training database. Once the test face matches a stored image, attendance is marked **(Refer Fig 3).**

Figure 3 A General Prototype of Project

Considering the above problems discussed and their provided solutions, the project has a remarkable contribution in Educational technology by marking the attendance of student's automatically by the use of simple and accurate algorithms.

4. Method

Principle Component Analysis or PCA is a machine learning algorithm, that works on the principle of extracting features and patterns in a human face known as Principle Eigenfaces (PCA) [2]. The Eigen faces which are the eigenvectors of the covariance matrix, represent the extracted features. Once the Eigen faces (Ghostly images) are created, the significant Eigen vectors are chosen corresponding to high Eigen values. The Eigen vectors are heuristically chosen according to the dataset created. The contribution of each Eigen face representing the image is shown by the weight vectors. Once the weight vectors are formed,Euclidean distance based classifier has been utilized which compares the Euclidean distance between the test image and the face images in the training set to ascertain the class to which the test image should belong.

Since PCA has certain limitations (**Refer Fig 7)** i.e. the Recognition is done under slight pose/viewpoint variations therefore, we have switched to CNN as it provides accurate recognition by overcoming these limitations.

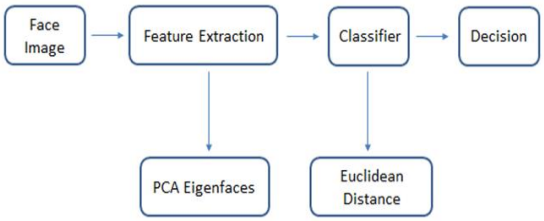


Figure 4 Approach 1: PCA

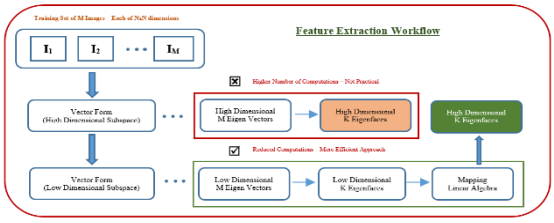


Figure 5 Feature Extraction Using PCA

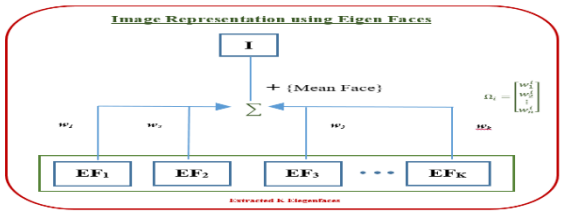


Figure 6 Image Representation Using PCA

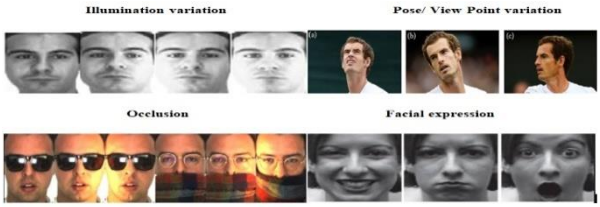


Figure 7 Limitations of PCA

Convolutional neural network a deep learning algorithm that uses a triplet loss function to create 128-d embedding's i.e. 128 dimension feature vectors of each image in the training dataset. The triplet loss function requires three images [3]: Two images from the same person and a third one from a different person. The first picture is called the anchor image, the second is the positive image and the last is the negative. The task of the loss function is to make the distance between the anchor and the positive images small and the distance between the anchor and the negative big **(Refer Figure 9).**

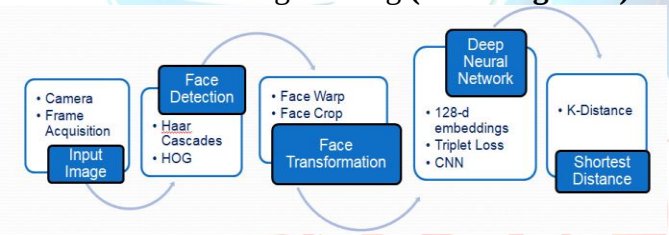


Figure 8 Approach 2:CNN

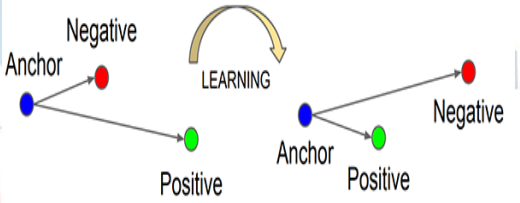


Figure 9 Triplet Loss Function

Experimental Results for PCA

The experimental results are obtained with the developed PCA algorithm on both the datasets i.e. the locally generated dataset which we termed as DSU Dataset and the dataset available online by the AT&T laboratory UK.

The ORL Database (400 images of 40 persons with 10 images per person).
70 % for training – 280 Images 30 % for testing – 120 Images
During the training phase, the mean face and the eigenfaces are generated by the algorithm for the two hundred and eighty (280) training images. Fig. 11 shows the mean face for the selected ORL database while Fig. 12 represents few significant generated ghostly eigenfaces.

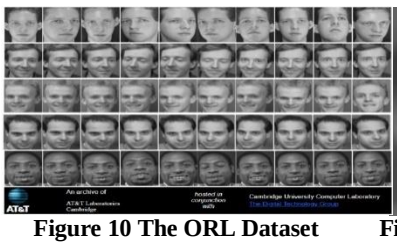


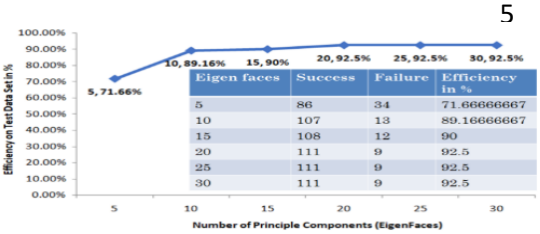
Figure 10 The ORL Dataset

Figure 11 Mean Face

Figure 12 Major Eigenfaces for the ORL Database

Figure 13 Sample Recognition Results (K=20)

Figure 14 Sample Recognition Results (K=10)



Eigen faces	Success	Failure	Efficiency in %
5	86	34	71.66666667
10	107	13	89.16666667
15	108	12	90
20	111	9	92.5
25	111	9	92.5
30	111	9	92.5

Figure 15 Effect of Increasing the number of Eigen faces on the ORL Dataset

Increasing the number of Eigenfaces after a certain number does not affect the efficiency on the test dataset. Only few principal components i.e. K =20 were sufficient enough to represent images in the face space for recognition **(Refer Fig 15).**

The DSU Database (100 images of 10 persons with 10 images per person).
70 % for training - 70 Images 30 % for testing - 30 Images
During the training phase, the mean face and the eigenfaces are generated by the algorithm for the seventy (700) training images. Fig. 17 shows the mean face for the selected DSU database while Fig. 18 represents few significant generated ghostly eigenfaces.

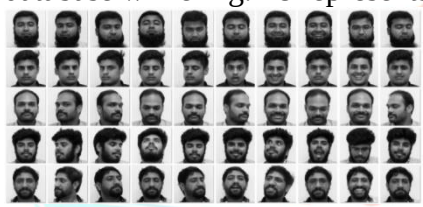


Figure 16 The DSU Dataset

Figure 17 Mean Face

Figure 18 Major Eigenfaces for the DSU Database

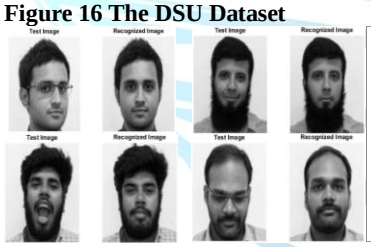


Figure 19 Successful Recognition with and without glasses

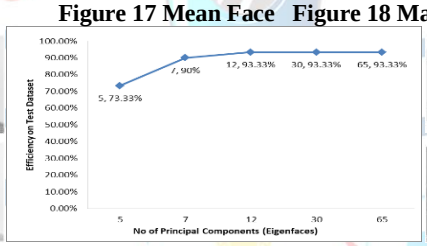


Figure 20 Effect of Increasing the number of Eigen faces on the DSU Dataset

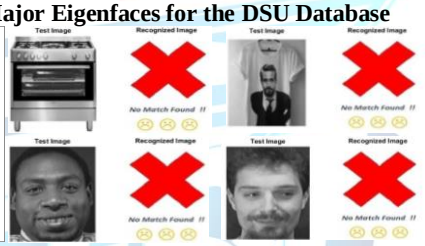


Figure 21 Successful Rejection using Thresholding

Thresholding or Match Pruning allows the possibility of rejecting images not belonging to face space. Very high values of threshold increases the counts of **false positives** (incorrect matches) while a very low value results in a large number of **false negatives** (incorrect rejections).It is thus crucial to select the optimum value of threshold in order to lower the count of false positives and false negatives **(Refer Fig 21).**

Experimental Results for CNN

The algorithm is trained using the locally generated Own dataset, comprising of 5 people and 100 images per person. A sample of the our face recognition i.e. OWN dataset (**figure 22**).

Figure 22 Training Images for OWN Data Set

Figure 23: Successful Recognition for Individual Test images

The experimetal results are generated for both individual persons as well as for group photos of the persons and their recognition results **(Refer Fig.23 and Fig.24 respectively).**

Figure 24: Successful Recognition for Group Test Images

Each face in this system is encoded and the output feature vector is represented as a list of 128 real valued numbers. By default, faces are considered a match if the Euclidean distance between the face vectors is 0.6 or less. You can control how strict the comparison is through compare_faces() function:**results=face_recognition.compare_faces(known_face_encodings, face_encoding_to_check, tolerance=0.5)**[4]. By applying different tolerance values on the group photos we achieve a higher efficiency on tolerance value 0.4 **(Refer Fig 25)** while for the individual test images we achieved higher efficiency on tolerance value 0.5 **(Refer Fig 26).** Lower the tolerance values the more strict recognition will be.

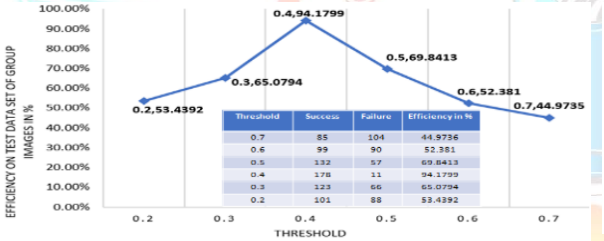


Figure:25 Effect of increasing the number of tolerance values on the Group Photos

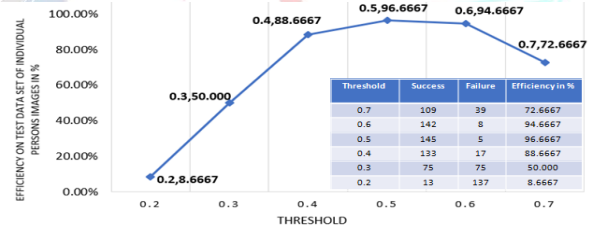


Figure:26 Effect of increasing the number of Tolerance values on Single Test Images

5. Innovative Aspect

Our project "Real time attendance system using facial recognition" ensures the physical presence of each candidate in a class using their distinct biometrics. The project demonstrates a robust algorithm that is invariant to scale, rotation, transformation, occlusion etc, making it more innovative. The speed obtained for the advanced implementations is achieved by integrating the algorihm with embedded system differentiating it from similar projects.

The project is innovative in a way that it is implemented on Raspberry pi, a low-cost device having a clock speed of 1.2 Ghz and dedicated dsp hardware called NEON which enables images to be processed with greater speed in real time i.e. the FPS of our pipeline is increased dramatically. Also the algorithm being implemented on raspberry pi allows one time training of the dataset. Once the dataset is trained, a model file is generated and is saved on the disk, which contains the weights and biases of each image (128-d embeddings). Thus, whenever a new image is inferred for test, the process of training the dataset is avoided. This saves time. The project hardware implementation is shown in Figure 27.

One of the challenges in implementing a facial recognition algorithm is to distinguish unknown people from the test images. PCA algorithm performs recognition by means of Euclidean distance-based classifier, which means that it is bound to get a match for every face

detected in a test image. To overcome this challenge, we have introduced the concept of MATCH PRUNING algorithm also known as thresholding. Threshold value is selected heuristically and the problem is overcome. The same problem arises when CNN is implemented. Here we varied the tolerance value while comparing face embeddings in similar manner to overcome the challenge. The concept of MATCH PRUNING ALGORITHM is introduced in the research paper we published "Human Face Recognition using PCA Eigenfaces" in an international IEEE conference held in Malaysia in 2019 [5].

6. Applicability

The system architecture for the project implementation is shown in figure 27. The Frame acquisition block acquires the pictures from the camera and passes it on as a frame to face recognition pipeline. The Face recognition pipeline involves the algorithms (PCA, CNN) which will be run on Raspberry pi. The Recognition results will be passed to a network stack which contains email or csvfile

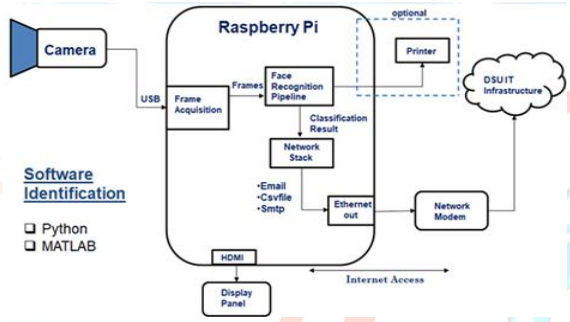


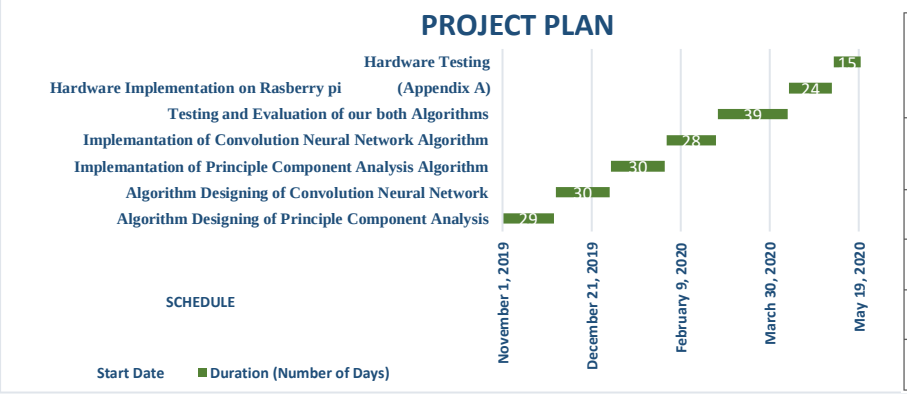
Figure: 27 System Architecture

to ensure that a student is marked present or absent for a record. The results are then transferred to Ethernet cable which is connected to DSU network mode (DSU IT structure).

Yes, the project can be easily converted into a commercial product by introducing a device which contains the algorithm based embedded system and can be easily installed in various educational institutions as well as in industries. There are currently no risks in the applicability.

7. Estimated cost and Project Scheduling

Appendix A:



Item Name	Price ($)
Raspberry Pi 4 (4 GB RAM) + Raspberry Pi Case	75+3
Web Camera 20 MP	63
Supply 5V 24A	3
Type 'C' Data Cable	2
Total in ($)	**$146**

8. Target Group of the Project Idea (Users):

At the moment, our target group of the project idea is from academia (DHA Suffa University) including professors and students. However, considering the growth in the popularity of facial recognition technology, our project has numerous applications in the industrial sector which includes security, surveillance etc.

9. Risks

Since the project has been designed on a small scale, there are no such risks associated with our project. But during the implementation of the project, there are few **limitations** which we would like to address:

- Insufficient training images for CNN algorithm can lead to poor approximation and can therefore effect the effeciency results.
- Hardware implementation of the CNN algorithm to figure out the optimal processing speed by testing of the setup in real time i.e. in a class environment was affected due to lockdown situation.
- A challenge to choose the optimum value of tolerance when the CNN algorithm was tested on different group photos or single test images.

10. Project Team

Name Surname	Mission In The Project	School
Engr. Muhammad Owais	Overall academic supervision and project administration with focused guidance on development and implementation of PCA based Algorithms.	Assistant Professor, DHA Suffa University.
Engr. Anas bin Iftikhar	Guidance on implementing Deep Learning Algorithms	Lab Engineer, DHA Suffa University.
Ammara Shaikh	Development of PCA algorithm. Identifying the value of tolerance for CNN algorithm. Testing CNN algorithm for group photos.	Final Year Student, DHA Suffa University
Aireen Amir Jalal	Development of Deep learning algorithm. Testing CNN algorithm for individual photos. Testing PCA algorithm for locally generated OWN dataset.	Final Year Student, DHA Suffa University
Mohammad Moiz Hassan	Testing of PCA algorithm for ORL dataset. Integration of CNN Algorithm on raspberry pi. Installation of suitable libraries for implementation. Preparing a quantitative analysis of the results generated during testing by other group members in the form of graphs.	Final Year Student, DHA Suffa University

As Final Year students of Electrical Engineering Department, we as a team are highly motivated to work on projects which are a current demand of the market. The members of the team are keen to learn new skills and are competent enough to become familiar about the latest technologies and industry news.

11. Resources

[1] The ORL database, AT&T Cambridge Laboratory formerly Olivetti Research Laboratory, United Kingdom.

[2] M. Turk, A. Pentland, “Face Recognition using Eigenfaces”, Computer Vision and Pattern Recognition, 1991. Proceedings CVPR'91, IEEE Computer Society Conference on. IEEE, 1991.

[3] ADRIAN ROSEBROCK *pyimagesearch* [online] United States [viewed 1 November 2019] Available from:https://www.pyimagesearch.com/2018/06/18/face-recognition-with-opencv-python-and-deep-learning/

[4] ADAM GEITGEY *Github* [online] [viewed 20 May 2020] Available from: https://github.com/ageitgey/face_recognition/wiki/Face-Recognition-Accuracy-Problems

[5] Muhammad Owais, Ammara Shaikh, Aireen Amir Jalal, Muhammad Moiz Hassan, “Human Face Recognition using PCA Eigenfaces”, 2019 6th IEEE International Conference on Engineering Technologies and Applied Sciences (ICETAS).