EasyChair Preprint

№ 13473

Image Analysis for Face Recognition and Detection Using Machine Learning Algorithm

Admasu Teferi, Habitamu Kassahun and Ayodeji Salau

May 29, 2024

The Second National conference on Emerging Trends in Electrical, Electronics, Computing, Communication Control, Information Technologies, and Advanced Automation,
FDRE Technical and Vocational Training Institute, Addis Ababa, Ethiopia, 2024

Image Analysis for Face Recognition and Detection Using Machine Learning Algorithm

Admasu Yehule Teferi
Electrical and Computer Engineering
University of Gondar
Gondar, Ethiopia
admasuyehule@gmail.com

Habitamu Endalamaew Kassahun
Electrical and Computer Engineering
University of Gondar
Gondar, Ethiopia
habend100@gmail.com

Ayodeji Olalekan Salau Department of Electrical/Electronics and Computer Engineering,
Afe Babalola University,
Ado-Ekiti, Nigeria
ayodejisalau98@gmail.com

***Abstract*-Dominant method for security purposes and emerged as a public safety concern for modern society. In this regard, various algorithms such as Linear Discriminant Analysis (LDA), K-Nearest Neighbors (KNN), Principal Component Analysis (PCA), and Voila-Jone (VJ) have been implemented for face recognition and detection. Each of these applications has its own distinct advantages and disadvantages. For example, PCA is often regarded as a simpler and more appropriate approach for differentiating faces within a given image. On the other hand, the Voila-Jones algorithm excels in the face detection mechanism, offering superior capabilities for detecting faces in two-dimensional settings. While these applications have demonstrated successful results, they may encounter challenges in accurately representing faces due to various factors. In this study, we have made a comparative investigation of the performance, accuracy, and effectiveness of these algorithms in their application in face recognition and detection tasks. This study was conducted and tested based on well-known face datasets, such as ORL and Yale data sets. We divided these datasets into training and testing sets to prepare the data. We then proceeded to perform face recognition and classification, considering the selection of input data. Finally, we computed the system's accuracy. Moreover, this study focused on conducting face recognition and detection in 2-Dimenitional settings. For performance evaluation, we used various testing and traing images. In the testing phase with 45 images, PCA showed an accuracy of 97.78%, whereas Voila-Jones algorism achieved a detection accuracy of 100%. Furthermore, when testing with 40 images, LDA achieved an accuracy of 100%, however, KNN demonstrated an accuracy of 98.5%. However, the Viola-Jones algorithm achieved a slightly lower detection accuracy of 97.5%. Overall, our results showed that LDA outperformed the other methods and demonstrated better results.**

Keywords: Training Images, machine learning, VJ algorithm, Testing Sets.

1. Introduction

The most attractive field in modern day society is face recognition. Despite the vast number of individuals within human society, the human eye possesses remarkable capability in distinguishing one face from another [1]. Throughout their lifetime, people are able to remember and recognize thousands of faces, and can easily identify familiar faces with a single glance, regardless of the length of time that has passed. The ability of human eye is moderately effective, despite of the fact that there are modifications inside the remark of becoming old Person, expression and extrude of appears because of glasses, beards or in hair style [1].Areas like security purpose, master card, verification, criminal identifications took an attention for face recognition system. The identification of a face plays are a very important role. A small recognition of a specific person is going to be far better than not even recognizing the least bit. Although it is clear that people are good at face recognition, it is not obvious that a human brain can encode or decode for every face. Face recognition is the most interesting and grateful application of pattern recognition and image analysis. Developing an appropriate application, which can be used digitally in recognizing a face, can be a hard challenge, due to human faces place unit complex and place unit extraordinary from each other in every face [2]. In face identification, the starting step is extraction of the relevant feature from facial images. The planning at achieved through many researchers over the last few years shows that humans to select out faces utilize positive facial traits. PCA may be a historical device broadly used within technique for dimensional reduction and then performance. Extraction in maximum of the pattern recognition application. Face recognition in a extensive feel consists of related technology for making a face recognition system. It consists of face detection, face feature, identification popularity, image prepossessing and so on. Face detection is to hunt down out the body of reference of all faces in a single image. This will be the approach of scanning the whole photo to training session whether or not the candidate location can be a face. The output of the face location can be square, rectangular and so on. The face function is the coordinate function of the face feature inside the face detection coordinate system [1][3]

II. BAGROUND

In broad terms, the process of face recognition can be broken down into three primary stages: face detection, feature extraction, and classification. To achieve these steps, it requires a database system to give the desired output. The first stage involves verification of the presence of a face in a given database image which is followed by feature extraction that extracts unique and discriminative features from the face to create a representation that can be used for recognition. The next stage focuses on capturing key facial features, such as the shape of the eyes, nose, and mouth, as well as the placement of facial landmarks and texture patterns. In the last step, the system compares the extracted features of the detected face with the features stored in a

database or known faces. The goal is to determine if there is a match or similarity between the detected face and the reference faces. At this stage of face recognition, the performance rate which is called the recognition rate is typically calculated by comparing the number of correctly identified faces to the total number of faces in a given dataset or test scenario. Among the common method to calculate the recognition rate is known as accuracy (ACC), mathematically, this can be written as follows:

$$ACC(\%) = \left(\frac{W}{Q}\right) \times 100 = \left(\frac{\text{the Faces is Recognized Correctly}}{\text{Total numbers of testing set}}\right) \times 100$$

where W is the number of correctly recognized faces and Q is the total number of testing sets containing Q faces. The higher the value of accuracy or recognition rate the better the performance of the algorithm [4]. Many algorithms implanted this method in the face recognition stage of identification and verification because it provides a straightforward and easily interpretable measure of performance [4]. However, it is important to note that accuracy may not always capture the complete picture and the choice of evaluation metric should align with the specific requirements and objectives of the face recognition application.

III. RELATED WORKS

Navpreet Kaur in [5] It is proposed that one of the most significant areas of image processing study is face recognition, which finds extensive application in security, identity verification,and personal identification applications. Kohonen's tool modified into now not a realistic achievement, however, because of the need for precise alignment and normalization. The method like PCA, ICA and SVM are tested face recognition schemes based on edges, inter-feature distances, and different neural network approaches are implemented. However several methods are successful on small databases of aligned images, none successfully addressed the more realistic problem of large databases where the location and scale of the face is unknown.

Tomesh Verma in [6] Proposed that the extracted face image features are then related to belong with a class and separate faces to different classes. Features which are having high separability are continued for further processing and lower one is discarded. To reduce computational costs, face image data, generated after various linear or non-linear transformations, are represented in a lower dimensional space. Some successful appearance-based methods like PCA, LDA and ICAs, have been widely used to extract the abstract features of the face in facial analysis for face recognition is implemented. PCA gives class representations which are in an orthogonal linear space. However, LDA generates class discriminatory information in a linear separable space which is not necessarily orthogonal.

Qiong K. et.at in [7] proposed that the extract the first, second and third channels of each color image and use PCA and LDA to get a score of each channel, then we use a combine scheme to attain a final score and use this final score to classify test samples. PCA maximizes the variance of the samples with inside the projection subspace. LDA maximizes the between-scatter distance with inside the projection subspace. In order to test the overall performance in their approach, that put together experiments on GT colour face database, on the equal time, with inside the examine our approach with PCA and LDA, and test consequences display that our techniques take higher overall performance.

Sushma N. et.at in [8] proposed that face recognition is one of the maximum generally used biometric for individual recognition. It is used for real time offer regulation enforcement and statistics security. Feature extraction is one of the vital difficulties in face recognition. Amongst the diverse answers to the trouble maximum a hit are look primarily based totally techniques. In look primarily based totally approaches, PCA and Linear LDA are particularly used for dimensional reduction and feature extraction. However the extraction features and response time is much complex than ever before.

Seema S. et.at in [9] The study of facial recognition in the context of machine technology has been a prominent area of research for the past thirty years, with ongoing investigations being pursued. It mainly concentrates on physical appearance of a person, where the facial features such as eyes, ears, and nose plays the most important role in identification. In the proposed system, face is mainly used for identification.

Most of the journals that mention in this paper from [5]-[9] have the accuracy of ranging in modern ate value of 90%-95% .Among the above mention researcher from related work none of them are not doing in face detection and recognition in the same time but they do independently, and it only doing in at least one algorithm or at most two algorithm in comparison one to the others and then also compare the performance the used algorithm in order to see their performance separately by studying which one has more recognition rate from the given database.

IV. Methodology

This paper aims to explore various algorithms for face recognition and detection, with the primary goal of understanding the performance, accuracy, and effectiveness of algorithms. To achieve this goal, we followed the five most significant stages which are shown in Figure 1 below.

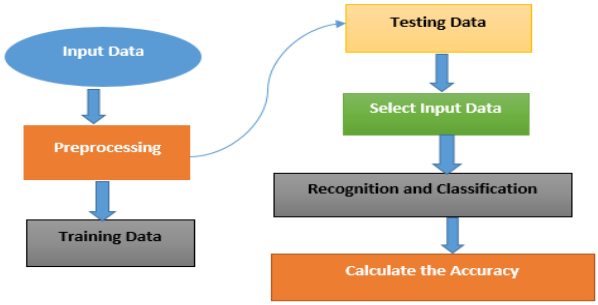

Figure 1 The Workflow of face recognition process.

The initial step involves obtaining the input image from the face database, which is then split or separated into train and test datasets. The choice of the specific database is important because they are necessary for most methods that need to be trained with a training set and face databases play a crucial role as they provide the necessary training data for various methods. A well-constructed face database can significantly image prove the performance of face detection methods, making them essential for testing and evaluation. It is worth noting that the detection rates of face detection methods can

vary when tested with different databases. This indicates that certain methods may be more effective with specific databases. With this in mind, we have selected the following databases for our evaluation

Yale Face Database

The Yale Face Database has 165 GIF-formatted grayscale photos of 15 different people. Each of the eleven subjects has a different face expression or configuration, such as happy, sad, sleeping, astonished, winking, normal, center light, w/glasses, and normal.

Figure 2 Sample of Yale Face Train

V. Methods of Face Recognition

A. Principal Component Analysis

PCA serves as the foundational algorithm for the implementation of the Eigen faces classifier. It is of great significance to explore the prior research conducted on this subject in order to establish a comprehensive understanding.. PCA is a data reduction tool used for multivariate data. When we defines , The process of Principal Component Analysis (PCA) involves transforming the original dataset, consisting of vector samples, into a fresh set of vector samples with adjusted dimensions. This method simplifies the task of compressing a larger dataset into a more concise format that retains essential elements for reducing dimensionality. It is important to note that PCA is an unsupervised method, indicating that it operates independently of class information. Unsupervised learning process extracts the statistical properties of the training image and group's similar vector into features. Features, or eigenvectors, are extracted from a covariance matrix a matrix that holds the covariance for each data element [10][11] and it is powerful statistical method and one of the most popular algorithms used in image processing for decreasing the number of values in images while keeping unique values needed to identify faces and is useful in reducing large datasets of images.

In these steps, it follows the following mathematical formulations [12]:

System Modeling of PCA: The equation to evaluate value for M training image as shown the equation as follows as. We elaborate that the training set of face images can represented in for an X training set of face images.

1) The first step is calculating the typical mean for M training image,

$X = [X_1, X_2, X_3 \dots \dots \dots \dots X_M]$

It calculates, $Z = \sum_{I=1}^{M} Xi$

2) In the second step, it subtracts each image from the average mean,

$Ai = Xi - Z$

3) For the third step, it computes the covariance matrix,

$C = \sum_{I=1}^{M} Ai * Ai^T$

4) For the fourth step, it calculates Eigen values, Eigen vectors and Sort Eigenvalues.

5) Finally, it projects training samples onto Eigen faces.

Where A=Differnce, Z=Mean image, C= Covariance matrix

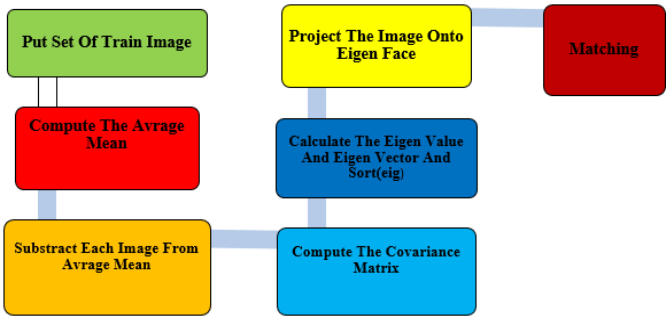

Figure 3 Workflow Representation of PCA[13]

B. Linear Discriminant Analysis

LDA or Fisher's Linear Discriminant (FLD) approach is a widely used method for feature extraction in face images .LDA could be a dimensionality reduction technique problems. This technique searching for out the projection path at some stage in which, pictures belonged to distinct training are separated maximally. In some cases, the Fishers faces is faster than Eigen faces, mathematically, it attempts to seek out the projection matrix (the weights) in such the most effective manner that the ratio of the between-class scatter matrix and the within-class scatter matrix of projected pictures is maximized. PCA and LDA rely on decomposing the matrices eigenvalues and Eigen vectors, but the biggest difference between the two are the relearning approach. Where PCA is unsupervised, LDA is supervised. Supervised learning is the process of providing the series of sample faces and comparing with the resultant faces with the expected outcomes [13] in a face detection and recognition are recognizing in supervised learning. Both are the classical dimensionality reduction algorithms. The Fisher face algorithm begins off evolved with acquiring the between-class and within class scatters for the data. A projection is constructed from this information that maximizes the ratio of the two scatters [14][15].

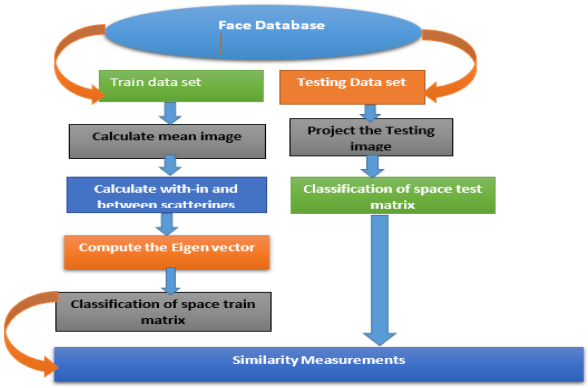

Figure 4 Workflow Representation of LDA

C. K-Nearest Neighbors

K-NN can be a pattern classification method and widely used classifier because of its simplicity and effectiveness. KNN classification of images uses a majority of its neighbors vote.The distance between the test pattern feature and each training pattern feature is used. The summation of the gap matrix is calculable and so it is more and more classified. The initial K components are chosen, so as classifying the image, finally, the worth of majority class is determined. K-Nearest Neighbor is employed in order to classify face images. Firstly, the classification is performed using only k-NN classifier [16] [17],. It is supervised learning algorithm and during this time the results of new instance quire is evaluated by supported majority of K-Nearest Neighbor class. The purpose of this method is predicated on attributes and training samples by classify a replacement object. The classifiers do now no longer use any models to match and simplest primarily based on memory. Considering a quire point, we attain K range of items or training points closest to the quire point. Many of this type uses the K item majority vote, any connects may be damaged randomly. The community classification task employs the K-Nearest Neighbor (KNN) algorithm to reduce the prediction cost associated with newly acquired images. Being a lazy training algorithm, KNN has been found to exhibit higher accuracy when lower values of k are utilized, while accuracy tends to decrease with higher k values, as evidenced in [17]. However, it is worth noting that the effectiveness of the KNN algorithm diminishes when dealing with large datasets and high-dimensional data.

The following stages could serve as an illustration of the KNN algorithm.
Step 1: is that k, the number of neighbors, is chosen as the value.
Step 2: involves calculating the Euclidean distance between k neighbors.
Step 3: K closest neighbors are calculated applying the obtained Euclidean distance.
Step 4: Each group counts the number of data points.
Step 5: Based on similarity, new data points have been assigned to a group.

VI. Results and Discussion

SIMULATION PARAMETERS

TABLE I. TYPES OF DATABASE WITH THE TRAIN AND TEST DATA SET

Type of Database	Train set	Test set	Total number of image
ORL	360	40	400
Yale face	65	40	105

In Table I, we are applied ORL and Yale face in face Recognition and detection to calculate the performance of recognition rate and detection accuracy. Describing the ORL database 360, 40 and 400 with respect to their train and test sets and total number of image respectively, Yale face database 60, 45 and 105 with respect to their train and test sets and total number of image respectively.

Face Recognition Under PCA

A.Varies Sample for Testing, Detecting and Equivalent Image

Figure 5 The Results obtained from Sample 1, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 6 The Results obtained from Sample 2, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 7 The Results obtained from Sample 3, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 8 The Results obtained from Sample 4, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 9 The Results obtained from Sample 5, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 10 The Results obtained from Sample 6, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 11 The Results obtained from Sample 7, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 12 The Results obtained from Sample 8, which are divided into three subfigures labeled as (a), (b), and (c).

The tested image and that is resulting detected and recognizing image based on the appropriate sample data that we setting. The accuracy of detection and recognition becomes more suitable value. The last figure 12 the face is not recognized from the input image. But, face detection is take place. In the test data set from yale face data set 45 test images are applied. 44 out of 45 are correctly recognized. But there one misrecognition, because of this that we should acquire 97.8% recognition accuracy and detection accuracy 100% in PCA and Voila-Jone algorithm respectively.

Face Recognition Using LDA

B. Varies Sample for Testing, Detecting and Recognize Image

Figure 13 The Results obtained from Sample 9, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 14 Tthe outcomes obtained from Sample 10, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 15 The Results obtained from Sample 11, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 16 The Results obtained from Sample 12, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 17 The Results obtained from Sample 13, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 18 The Results obtained from Sample 14, which are divided into three subfigures labeled as (a), (b), and (c).

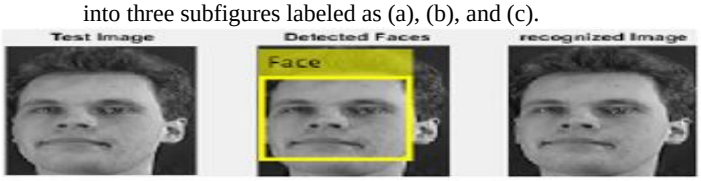

Figure 19 The outcomes obtained from Sample 15, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 20 The outcomes obtained from Sample 16, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 21 The outcomes obtained from Sample 17, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 22 The outcomes obtained from Sample 18, which are divided into three subfigures labeled as (a), (b), and (c).

Figure 23 the outcomes obtained from Sample 19, which are divided into three subfigures labeled as (a), (b), and (c).

In the above figure, shown 13,14,15,16,17,18,19,20,21,22 and 23, which is represented, varies samples the test, detected and recognize image in the same way from the PCA. When we are apply the tested image and that is resulting detected and recognizing image based on the appropriate sample data that we setting. The accuracy of detection and recognition becomes more value that is suitable. The last figure 23 the face is recognized from the input image. However, no face detection is take place. In the test data set from ORL, face data set 40 test images are applied. 40 out of 40 are correctly recognized. But there one misdetection, because of this that we should acquire 100% recognition accuracy and detection accuracy 97.5% in Linear Discriminant Analysis and Voila-Jone algorithm respectively.

KNN Algorithm Applying in Face Recognition

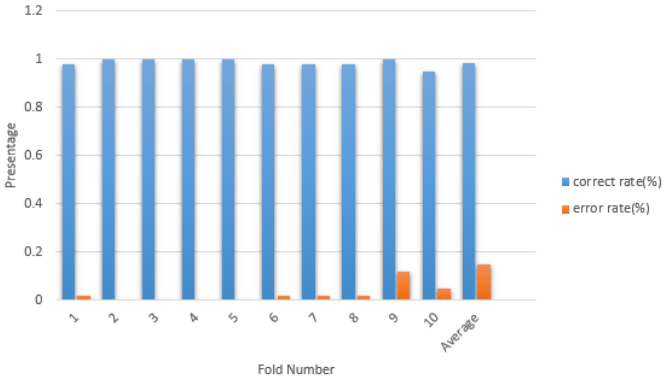

Figure 24 Classification Accuracy Of When K=1

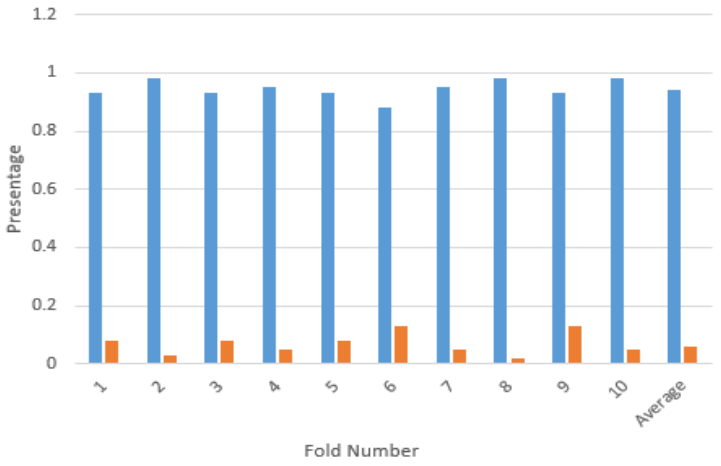

Figure 25 Classification Accuracy Of When K=2

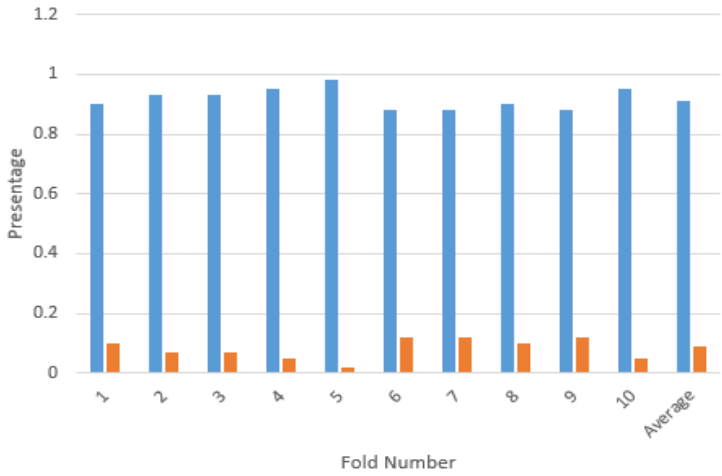

Figure 26 Classification Accuracy Of When K=5

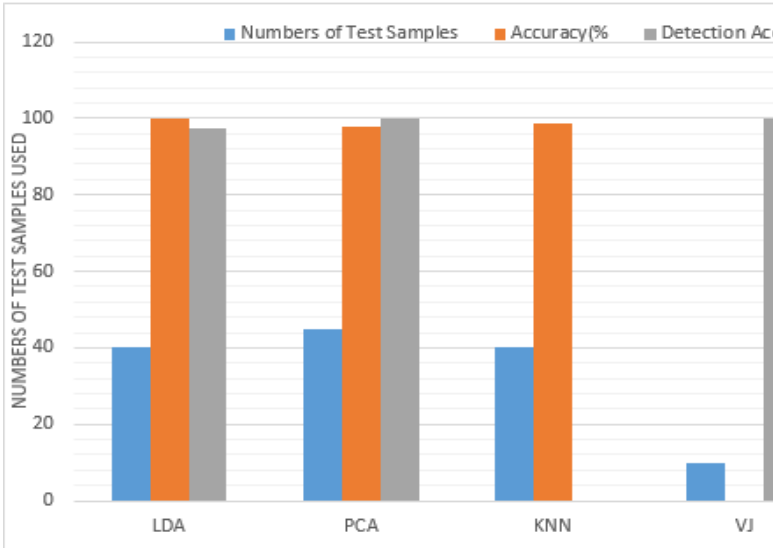

Figure 27 Comparison of Four Different Methods

VII. CONCLUSION

This work explores the extensive analysis of face recognition and detection techniques, highlighting their accuracy and detection accuracy. It is observed that LDA has 100% rate of accuracy of recognition for ORL. Using Viola-Jones face detection, PCA, LDA, and KNN approaches; we present the optimal approach for face detection and recognition in this study. Each approach's overall performance in the face recognition process is obtained by adhering to a separate set of guidelines. PCA and LDA are very powerful methods, which can be used in face recognition and detection. PCA is known to be a straightforward and efficient algorithm but it has less recognition rate than LDA. The LDA outperforms the other methods in terms of accuracy and computational efficiency. To show the performance of this method, we took 45 test images, which were obtained from Yale face database. When we implement PCA for this set of images, we found 44 images are correctly recognized. However, one image is misrecognized by PCA, which gives us recognition accuracy of 97.78%. On the other hand, when we use the same database using Voila-Jone algorithm, we got 100% detection accuracy which illustrating that Voila-one algorithm perform better than PCA for larger database. We have also compared LDA versus Voila-Jone algorithm using another data set from ORL face data set. In this case, we took 40 test images from the database and applied for both methods. When we tested LDA for this data set, all the images were correctly recognized which yields 100% recognition accuracy. For these results, Voila-Jone algorithm has shown 97.5% accuracy from this data set due to one misdetection. Therefore, when we applied for ORL face database it has shown the detection accuracy of 97.5%. The last technique we applied in this work KNN by applying 40 test images in ORL face data set. We got that the lower value of K gives better classification accuracy, while the higher value of k yields lower classification accuracy. In this case we obtained 98.5% Classification accuracy using KNN classifier which shows that in terms of classification accuracy KNN is more preferred.

References

[1] Devi, Ningthoujam Sunita and Hemachandran, K, "Face recognition using principal component analysis, International Journal of Computer Science and Information Technologies, volume,5, number,5, pages,6491–6496, 2014, Citeseer

[2] Naik, Yogish, Detailed survey of different face recognition approaches,International Journal of Computer Science and Mobile Computing, volume, 3, number, 5, pages, 1306–1313, 2014

[3] I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchangeanisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[4] Kasar, Manisha M and Bhattacharyya, Debnath and Kim, TH, "Face recognition using neural network: a review

[5] Kaur, Navpreet, "Review of face recognition system using MATLAB, volume, 4, year, 2016.

[6] Chen, Cunjian and Dantcheva, Antitza and Ross, Arun, "Automaticfacial makeup detection with application in face recognition,"2013 international conference on biometrics (ICB), pages, 1–8,, 2013,IEEE

[7] Kang, Qiong and Peng, Lingling, An Extended PCA and LDA for color face recognition. 2012 International Conference on Information Security and Intelligent Control, pages, 345–348, 2012, IEEE

[8] Borade, Sushma Niket and Deshmukh, Ratnadeep R and Ramu, Sivakumar,Face recognition using fusion of PCA and LDA: Borda count approach. 2016 24th Mediterranean conference on control and automation, pages, 1164–1167), 2016, IEEE

[9] Shinwari, Ali Rehman and Balooch, Asadullah Jalali and Alariki, Ala Abdulhakim and Abdulhak, Sami Abduljalil, A comparative study of face recognition algorithms under facial expression and illumination. 2019 21st International Conference on Advanced Communication Technology (ICACT), pages, 390–394, 2019

[10] Dang, Kirti and Sharma, Shanu, Review and comparison of face detection algorithms. 2017 7th International Conference on Cloud Computing, Data Science & Engineering-Confluence, pages, 629 633, 2017, IEEE

[11] Ansam Almatarneh, Evaluation of Face Recognition Algorithms under Noise, October 2019

[12] Sharmila, Raman S and Dhanajay K. Performance Analysis of Human Face Recognition Techniques,
978-1-7281-1253, 2019 IEEE.

[13] Ratnesh K.and Arvind K., Comparative Analysis of Machine Learning Based Approaches for Face Detection and Recognition, Vol.13, No.1, 2021

[14] Sanap, Yogesh B,Human Face Recognition Using PCA and Neural Network. International Journal of Management, IT and Engineering, volume, 6, number, 1, pages, 146–158, 2016.

[15] Fernandez, Ma Christina D and Gob, Kristina Joyce E and Leonidas, Simultaneous face detection and recognition using Viola-Jones Algorithm and Artificial Neural Networks for identity verification. 2014 IEEE Region 10 Symposium, pages, 672–676, 2014.

[16] Zhang, Haiyang and Chen, Guolong, The research of face recognition based on PCA and K-nearest neighbor, 2012 Symposium on Photonics and Optoelectronics, pages, 1–4, 2012, IEEE.

[17] M. Rajalakshmi1, S Srividhya2, a Comparative Analysis of Machine Learning Algorithms used For Training in Face Recognition, Volume 9, No.5, October 2020