Face Recognition System: An Approach Based on Principal Component Analysis

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Abstract: face Recognition is one of the key areas that is considered to be always growing as there is no completely secure and accurate approach that can recognize the correct match. Over the years many techniques for face recognition has been evolved and most of it are quite accurate under specified conditions that is pose, illumination and expressions. This paper is a take on the Principal component analysis technique that use dimensionality reduction and eigenface for face recognition. Gray scale equalization is used earlier to achieve better results. We used three separate databases to obtain the result. ORL, Yale, CMU and other popular databases are used by researchers in experimenting and implementing the methods proposed by them.

Keywords **– Face Recognition, PCA, LDA, Eigenface.**

I. INTRODUCTION

Face recognition is one of the trending and important field in computer vision system and pattern recognition field. Face recognition is the more familiar functionality of visual surveillance systems it has received significant attention for decades due to its numerous potential applications some of these applications are national security low enforcement surveillance public safety field. Pose, expression and illumination are few important factors that affects face recognition. Face recognition has gained its popularity in recent years as it has many applications. Images in the database are normalized and passed to recognition phase for verification and identification. In Verification, a person face is matched with the existing face image of that person so it is a one to one matching. In case of identification single image is processed and is compared with other images to find a suitable match so it is a one to many approaches. Several algorithm and methods for face recognition are proposed by researchers over the decades but in recent years improvement has been made in recognition under variation in pose, expression and illumination. Since the facial recognition itself deals with images as every pixel is considered to represent a coordinate of an N dimensional space where N is total number of pixels per image. Now suppose that there is a collection of several images that forms a library of faces sthat serve as candidates for recognition since each image is a point in space and N can be a relatively large number it would be convenient and computationally efficient to reduce the dimensionality of the dataset.

II. LITERATURE REVIEW

In [1], H. Duan Et al. proposed face recognition method that is based on PCA but update has been done by using cluster-based feature projection method. This method can improve the face recognition efficiency of PCA as it lacks in considering the information of a class. Eigenfaces are generated by using the complete image database so there is big difference in eigenfaces of a class. Proposed method reduces difference between images of same class and enhance feature difference in different classes. The feature obtained by traditional PCA are description features, as mentioned earlier classification features cannot be obtained by PCA, in calculation of eigenfaces all training images are involved. Computation of eigenvectors gets more if we add more training images into the face dataset. Vectors must be calculated again if we add or modify the existing images as it results in greater change in the average vector as well. Which indeed is an exhaustive process. Classification of training images is done by creating classes of different person and then using these classes for training and individual eigen-subspace creation. Next step is to check the test image against every eigen subspace. Class with minimum difference or similar feature is selected for recognition. One more advantage of the proposed methodology is that for every new update in either classes or images algorithm does not need to perform the complete calculation again, instead only the related eigen-subspace is updated. It increases the speed and accuracy of traditional face recognition.

In [2], Nan Liu et al. used LDA & PCA two most popular techniques used for feature extraction. Evolutionary Weighted Principal Component Analysis is proposed by them EWPCA works in a similar fashion as LDA, it increases the ratio of variation between classes and within class and results obtained are better in comparison of original PCA. GA is used for selecting optimal weights. ORL database is used for testing and training. Results obtained are better than PCA and LDA. PCA maximizes the total scatter among classes and all the unnecessary information due to variation in illumination and pose is included as well. High quality images require more memory space to store covariance matrix due to higher dimensionality. Image preprocessing is performed at first stage to reduce the dimensionality of images. Discrete Cosine Transform is used for dimensionality reduction. However significant features are kept during this process. Images are converted into frequency domain and then face vector is calculated using EWPCA.

In [3], N.N. Mohammed et al. suggested weighted and normalized mahalanobis distance based PCA for face recognition. PCA_WNMD improves the face recognition rate when tested with student database. Regular PCA uses Euclidean distance that is tried and tested distance matrix used globally. Mahalanobis distance gives better results than Euclidean distance. It was introduced in 1936. It uses distance between point P and distribution D. If P is on D then mahalanobis distance is nil. Distance increases as p moves away from average axis. It calculates the standard deviation between point and mean distribution.

In [4], S.B. Parvathy et al. proposed that face recognition system is said to be efficient if it can detect and recognize face in different illumination condition and variation in expression and pose. Modular PCA as proposed by researchers can enhance the whole process as it is less susceptible to light and pose. 2D and 3D systems are used separately to extract features from images. FRAV3D database for implementation. Results shows that modular PCA gives better efficiency in recognition. 3 Dimensional images is taken in point cloud and then are projected in 2 Dimensional plane. Same process is repeated for extracting depth and texture features and then final face recognition is performed by template matching, test image is used against training eigenface to measure the mean vector and based on the difference in weight. Face matching is performed.

In [5], Poon B. et al. used PCA based method for implementation of face recognition system. Database used are ORL database and CMU database are used for training and testing. Proposed method chooses traditional PCA to identify recognition rates based on certain change in the number of training images, noisy training data and blurred training set with test data variation. What a change in dimension of image can offer to the face recognition rate. Alignment of faces can increase the recognition rate. Increase in number of training image may result in greater efficiency. Blurry and noisy training set degrades the efficiency and dimensionality reduction may increase the speed of face recognition but it has no effect in improving the recognition accuracy. Proposed method offers 97% accuracy rate in AT&T face data set and 100% in CMU face dataset.

In [6], C.LI et al. describes face recognition as a trending research in pattern recognition field. PCA and BDPCA are used for recognizing the images. Proposed methodology is used for grayscale images with a matrix size of M x N (64 x 64). Face information is extracted by using the K-L transform and SVD is used for computing the eigenvectors. Testing images are projected into eigenface space to get eigenvectors and then it is compared with eigenvectors of training images, on the basis of Euclidean distance threshold is determined to match face. Bidirectional Principal Component Analysis is used for dimensionality reduction and the end results gives a better recognition rate than PCA. BDPCA outperforms PCA if training set is small in size.

In [7], Dashun Que et al. proposed modular weighted Principal component Analysis. According to researchers many face recognition techniques are there but all of them are based on multi-sample technique. But there can be situations where only single image is available to recognize the image e.g. Passport or ID verification usually contains a single sample which is used for identification of a person. So most of the available techniques are inefficient in that scenario. 2DPCA is used for that purpose which measure the results by different eigenvectors. Only the required details of face is obtained by image blocking method Membership degree mean is used for face recognition.

In [8] A.L. Ramadhani et al. considers that a human face is a distinct feature that can distinguish a person from other as two different person cannot have exactly similar face. There might be a difference in both faces which is used in recognition. Cited researchers chose PCA face recognition method that is integrated in Ry-UJI robot. Once the face is detected robot search for similar features in its face database or training set and when match is found the face recognition is completed. PCA involves a procedure for face recognition. First stage is face detection using cascade classifier method then image preprocessing for dimensionality reduction. After that training set is created which is finally used for face recognition.

Youngsang Woo et al. [9] Proposes faster face recognition using GPU. PCA Algorithm is used for recognition purpose as it is very simple and fast algorithm. Face recognition offers a beneficial role in many application such as security and surveillance. If training set contains a large number of images or high definition images then it slows down the process of face recognition. In that case Graphical Processing Units can be beneficial as it is popular now. Every mid range computer consists of a GPU. It is that much common now, and this can be a important factor is speeding up the process of face recognition. As we know capturing and processing of an image may require a fast CPU in real world and with GPU pattern recognition and computer vision process takes less time.

In [10], Ying Wen, suggested 2DPCA for face recognition. It creates 2D matrices which is a matrix that contains of M numbers of rows and N number of columns. 2DPCA requires more coefficient than standard PCA. Feature extraction is performed on the actual image using 2DPCA. AT&T and Yale databases are used for acquiring the results based on proposed methods. However the results shows that PCA accuracy result is similar or even better than 2DPCA with the dataset used. IPCA is proposed over the 2-Dimenional principal component analysis as it requires less coefficient of eigenspace and results in similar recognition rate or even higher in some cases.

In [11], Vo Dinh Minh Nhat says PCA is a very simple and well researched technique of face recognition. Over the year multiple enhancement and improvement has been performed in field of image recognition. Images are converted into vector in PCA technique. Recently 2DPCA technique is proposed by many researchers. 2DPCA directly applies PCA on the 2Dimensional image without converting it to 1Dimensional vector. Proposed method is based on improved 2DPCA which enhance the performance. PCA and 2DPCA lacks in accomplishing task of distinguish images separately based on the cluster. Reason is both are linear techniques that are unsupervised in nature.

In [12], C. Liu et al. describes that standard PCA is a linear technique and is not able to solve the non linear problems. Methodology proposed uses kernel Principal Component Analysis that combines 2 kernel function and is able to deal with non-linear pixels. For implementation and testing purpose ORL and FERET face database. Result may vary based on the training set. Kernel-PCA can result in optimized training set creation and accurate face recognition. Another advantage of Kernel-PCA over traditional PCA is that it can deal large dataset better and offers robustness.

In [13], Kai Liu proposed a dual-stage technique which uses local and global feature extraction for face recognition. First stage consists of usual image recognition based on PCA and if threshold is achieved than result is displayed and process is completed. But if in any case match image is not in required threshold range then process continues to execute HDLBP. This is second stage of face recognition HDLBP is similar to LBP it is just able to employ High Dimension Local Binary Pattern. Proposed method is tested against PIE face database. Acquired results are superior to PCA.

In [14], Md. Abdullah et al. discussed how optimized feature extraction can lead to better face recognition. An efficient feature extraction technique offers greater classification and reduced computing time. PCA is a popular algorithm for a reason, it has tendency to extract feature information without losing the information it is not completely lossless but it is very effective. HOG can calculate the local gradient of images. Methodology is tested on ORL database and very high accuracy rate is measured. Images of different sizes or resolution can be used for input data or training & testing set. All images are greyscale images as these offers better result in less time. Feature extraction is a very important aspect of image recognition system. UPSD method is proposed for feature extraction and its accuracy rate is 91.25%. Standard Deviation is another approach for feature extraction but it creates ambiguity when applied on a group of pixels.

In [15], Esra Jasem Harfash proposes PCA as a method to achieve pattern recognition and signal processing for feature extraction and dimensionality reduction. It can search for patterns in database and use these patterns to find similar face images and neglecting the dissimilar one PCA can also deal with high dimensional data by reducing the dimension space without losing much information. PCA uses eigenfaces which are the global feature of training set. Proposed method is tested against face94 and face95 database. Many researchers have worked on the feature extraction to test the accuracy. However, this method cannot be applied to face recognition in video, as images are in motion and they keep changing with the frames so information cannot be classified by using traditional approach.

In [16], A.S. Syed Nawaz et al. describes that face recognition is among the difficult vision problems. It has many applications like law enforcement, security, ID verification, User access control and surveillance. Automated face recognition works on two different functions that serves for a same purpose. Face detection generally related to identification of human face in a natural image. Several AI techniques are used for this and it is one of the complex parts of automated face recognition system. Other half is face recognition which deals with template matching test images are compared with the eigenfaces of training images and based on that result is obtained. Face detection systems also used supervised approach as images of faces are fed into train directory to train the algorithm whether the face is present is the current display window or not.

In [17], Kavita et al. showcased survey report on current trends in Face Recognition Techniques Face recognition has been an active research area over last 40 years. Research in face recognition includes several fields in itself computer vision system, pattern recognition techniques, artificial Intelligence and machine learning is among them. Face recognition combines face extraction with classification. Similar person face images are put in one class and test images are identified and similar class is chosen based on the Euclidean distance. Problems that reduces the efficiency of an algorithm is change in illumination, pose and facial expression. Other variation can be ageing, with glasses or without glasses, beard, presence of obstruction in images can be a challenge. Hybrid approaches like use of radial Basis Function with Principal component Analysis can offer better accuracy with variation in test images.

In [18], Yingchun Li et al. works on the method of detection of face in complex images. Next step is preprocessing the images and then projecting it to recognition module. It is a challenge as in real world, surveillance system may not be able to recognize or identify a person because of continue movement. Images obtained from surveillance camera may contain blurred samples. Accuracy is affected in such situations. Proposed FRVT can perform face recognition of a varied face pose similar to those images that are front aligned. But change in degree of pose can result in less accuracy. Images captured with pose angle higher than 30 degree reduces the efficiency of face recognition system. 3D Face recognition technique is used to overcome that as it can offer similar results up to 180 degree.

In [19], they work on method for face recognition of noisy data of human faces. Proposed method is a combination of PCNN, PCA and SVM. In first step Pulse Coupled Neural Networks is used for clustering the characteristic region of face i.e. eyes, nose, lips, forehead. Then in next step, PCA is used for feature extraction and dimensionality reduction. In last SVM is used fo4 face recognition. ORL database is used for the experiment purpose which is dataset of 40 people each having 10 images and noisy training samples are created from this database and same is used for testing. Result shows that this method has good recognition rate and high robustness.

In [20], T. Archana et al. Proposed face recognition approach based on template matching. Algorithm used for feature extraction by them is PCA. It uses eigenspace for projection of image database and then eigenvectors are calculated based on the distance from principal axis. Only Grey scale images are used in experiment. PCA results in 70-75% accuracy with used database as it is not able to keep accuracy with change in pose and illumination. Template matching however performs better result than the traditional approach and is not affected to all above factors.

III. Conclusion

In this study, PCA is applied for the task of face recognition. It converts the pixels into a number of eigenvectors, these eigenvectors are testes against newly added face images and based on the similarity image is recognized.

An improvement to have a larger data set to work with. This study confirms that measuring and analyzing facial features is used to recognizing a person's face by comparing facial structure to that of a known person. With clean and normalized data, this type of analysis was accomplished with a linear combination statistical model. Solving problems and interpreting data is getting more sophisticated and user-friendly with time. Matlab can be used for implementation, it is an analytical tool that gives meaning to numbers and creates useful models to be used again and again.

The computational models, which were implemented in this project, were chosen after extensive research, and the successful testing results confirm that the choices made by the researcher were reliable. Results can improve if PCA is used with other technique to overcome the drawback of PCA. Hybrid approach may result in high degree of accuracy. The real-time automated pose invariant face detection and recognition system would be ideal for crowd surveillance applications. If such a system were widely implemented its potential for locating and tracking suspects for law enforcement agencies is immense.

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