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Pose Invariant Face Recognition and Measures of Performance Evaluation

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ABSTRACT

Face recognition is one of the important biometrics used now-a-days. This work mainly focuses on recognition of face irrespective of pose and occlusion. Occlusion here means the person has spectacles, different hairstyles etc.. There are various methods to handle above mentioned challenges such as occlusion and various poses. In this paper we will implement four of the methods namely Eigenfaces based on Principal Component Analysis(PCA), Fisherfaces, K-Nearest Neighbors(KNN), Naïve Bayes which are mainly used for pose and occlusion invariant face recognition. The results obtained from the above algorithms are compared to assess the good performer in terms of face recognition accuracy. First, Eigenfaces which is based on PCA is implemented. Training set images which include normal front faces of person are provided for learning purpose. Test set images include occluded images such as person wearing spectacles, different hairstyles, slightly tilted in the screen are used to perform testing of face recognition. Next, we implemented Fisherfaces, KNN, Naïve Bayes algorithms for pose invariant face recognition are applied on the same dataset. Now all these algorithms are tested with available test set to evaluate the face recognition accuracy.

Keywords— Face Recognition, Principal Component Analysis, Eigenfaces, Fisherfaces, K-Nearest Neighbors, Naive Bayes

I. INTRODUCTION

Face Recognition is nothing but a process of identifying the person in the image or a video. Face Recognition irrespective of variation in poses, illumination, occlusions is of wide importance these days because in real world scenarios we cannot expect all the conditions to be perfect. We have various methods for face recognition under various conditions mentioned above. Depending upon the requirements of the scenario we use different methods to achieve good face recognition accuracy. Here, this paper implements four algorithms namely Eigenfaces based on PCA, Fisherfaces, k-nearest neighbors(KNN), Naïve Bayes for face recognition irrespective of pose and occlusion. After employing all the above mentioned algorithms on our dataset, we obtain face recognition accuracy and they are compared to evaluate the performance.

II. LITERATURE SURVEY

Krishna Dharavath et al. compared the face recognition rate between the images before and after application of image pre-processing techniques in [1]. Various techniques such as face detection and cropping, Image resizing, Image normalization, Image de-noising and filtering are used for image pre-processing. One more proof putforth in this paper is that instead of applying single feature extraction technique, combined application of these techniques gives better performance in terms of face recognition rate

Yaqeen S. Mezaal in [2] designed a new model which is based on combination of image pre-processing, Co-occurrence Matrix of Local Average Binary Pattern and Principal Component Analysis, Face recognition experiments are performed. The digital face images which are taken to perform the experiment are varied across poses, ageing, expressions etc.

A new framework is designed by Xu, Yong, et al. to increase the accuracy of face recognition. The novel algorithm that is designed in [3] produces axis-symmetric virtual face images. It is notable that an algorithm which can produce virtual face images is very easy to implement and also mathematically easy to handle.

Face recognition accuracy is improved by Niloofar Amani et al. by applying a method that uses linear phase high-frequency for image filtering[4]. Histogram equalization is used to enhance the contrast of images thereby increasing the efficiency of face recognition methods.

Two new face image enhancement methods in [5] are proposed by Chiou Shi Lim and Haidi Ibrahim which are based on combination of histogram equalization with gamma intensity correction (CHEGIC) and homomorphic unsharp masking, partially overlap sub-block histogram equalization (POSHE). Performance of the above algorithms are compared with the conventional algorithms such as histogram equalization(HE), gamma intensity correction(GIC), and homomorphic unsharp masking(HUM).CHEGIC is proved to perform well.

An effective image enhancement algorithm is proposed by Zhengning Wang et al. which is called G-Log[6]. This is called G-Log, as it combines both gamma and logarithm transformation .This algorithm is mainly used for images that are taken from a long distance. Accuracy of face

recognition is greatly improved after processing with G-Log from original 95%,89%,70% to 98%, 98%, 95% for the distances 60m,100m and 150m respectively.

Hyunjong Cho et al. presented a computationally efficient hybrid face recognition method that is a combination of dual-stage holistic and local feature-based recognition algorithms. This hybrid algorithm in [7] uses PCA in the first step. If the recognition level is not as expected then Local Gabor Binary Pattern Histogram Sequence (LGBPHS) is used in the second step. Using this algorithm the average computation time for face recognition is reduced.

Priyanka Wagh et al. developed an efficient face recognition system for maintaining attendance records of classroom. In order to handle the problems that are caused by illumination, head pose in [8] techniques such as Principal component analysis, illumination invariant, Viola and Jones algorithm are used.

Y. C. See et al. presents a work on face recognition which is related to a Gabor Filter and Oriented Gabor Phase Congruency Image with Random Forest[9]. The proposed technique is applied on Georgia tech face database and had achieved a recognition rate of 89.2%. It is able to recognize different tilted faces and with expressions.

Changxing Ding and Dacheng Tao focused on improving face recognition (PIFR) accuracy irrespective of pose in [10]. Pose normalization proved to be the efficient technique for the above. Experiments are performed on four popular databases FERET, CMU-PIE, Multi-PIE and Pasc. Pose normalization technique is applied on these databases and compared with other state-of-the art algorithms which proved pose normalization to be efficient technique for PIFR.

Pose invariant face recognition(PIFR) is a challenging task, as there will be notable

appearance changes in face as the position changes. Mainly two methods are proposed by Changxing Ding et al. in [11], They are PBPR(Patch-based Partial Representation) and Multi-Task Feature Transformation Learning (MtFTL) to handle the challenges that are caused due to pose variations.

Luan Tran et al. proposed Disentangled Representation learning-Generative Adversarial Network (DR-GAN) in [12] for pose invariant face recognition.

Ali Moeini et al. devised a new method for PIFR in [13] which uses Sparse dictionary matrix. Using frontal face image as input it constructs a 3D model of face image based on a 3D Facial Expression Generic Elastic Model. Sparse Dictionary Matrix(SDM) is constructed from the obtained 3D model. These arrays from SDM are compared with test images to verify the recognition.

Deep Neural Networks gives significant results in improving face recognition accuracy. In [14], a new method is proposed by Peng, Xi, et al. which can handle large pose variations of face in the images. This method learns a feature representation that can deal with pose variations i.e., without requiring much training data.

Xiangyu Zhu et al. proposed a High-fidelity Pose and Expression Normalization(HPEN) method with 3D Morphable Model (3DMM) in [15].This a learning free algorithm which can form 3D model of face image with neutral expression or can be without any expressions.

Zheng Zhang[16] et al. proposed a method which recognizes face with varied poses in the following two ways, First landmark local features are taken to match the frontal face image and the image with various poses. Second, Fusion features are constructed from landmark local features can reduce the influence caused to recognize face due to poses.

Florian Schroff et al., developed a new system for face recognition called FaceNet[17], where the images of face are mapped to Euclidean space in which distances have a direct correspondence to similarity of faces. Face recognition, clustering and verification can be easily done using this Euclidean space.

A new model for face recognition under constrained conditions such as illumination changes, pose variations and expression changes in face images is devised by Prabhu, Utsav, et al. in [18], where 3D models are formed using single frontal face image as input. Based on the constructed 3D models , different 2D pose views are synthesized for matching. These 2D views that are synthesized are matched against test images for evaluation of model.

Abhishek Sharma et al., discussed about yet another approach to face recognition which is named as Discriminant Multiple Coupled Latent Subspace framework[19]. In this particular approach, various sets of projections are formed for various poses of the same person that correlated to the maximum in the latent subspace. Also a comparative analysis is performed on three well known latent space methods which are Partial Least Squares (PLSs), Bilinear Model (BLM) and Canonical Correlational Analysis (CCA). CCA proved to be the best method while using more than two poses.

Shervin and Josef Kittler in [20], presented a method based on Model image matching for Pose Invariant Face recognition. This approach mainly formulated on Markov Random Fields. When a test image is given, it is matched with the training images based on Energy match which is a measure of goodness of match. This method reduces the need of giving images of subjects with various poses.

A new concept of information set is presented in [21] by Madasu Hanmandlu and Soniya Singhal for recognizing the face

invariant of pose and illumination. Using Mamta-Hanman entropy function, feature set is derived. Non linear Shannon transform information set is formed, which is considered as the higher form of information set. To improve the effectiveness of face recognition algorithm in [21], the information set based features and Shannon transform features are combined using a technique called Pseudo-inverse Locality Preserving Projections.

A 3D-2D framework is designed in [22] by Ioannis A. Kakadiaris et al. which is used for face recognition and is proved to be more accurate than 2D-2D and can be more easily implemented than 3D-3D. This method is based on 3D deformable face model in which first we register 3D and 2D data, alignment of face and pose and illumination normalization. A method is applied for bidirectional relighting and also for pairwise similarity scoring, a correlation metric is used. This produces a unique normalized signatures which is used for verification and also identification of subjects.

A face recognition method is presented by Alpa Choudhary and Rekha Vig which is closely related to multi resolution hybrid wavelet approach. This method extracts features from enrolled images as well as test images with different expressions. It uses Kronecker product of DCT and Walsh transform matrices which generates a wavelet transform matrix and this matrix is used to extract features. To extract features [23] used a feature mapping energy compaction technique.

One more challenge in face recognition is addressed by Amith Lawrence et al. in paper [24], which is unnecessary background features. This method removes the features in the background as they are an obstruction to face recognition in the image. The method is namely Background Removal which is related to Eccentricity and is applied using

YCbCr and HSV color models. For handling pose variations. Multi-scaled fusion is used. This method is effective and is proved by experimenting on CMU-PIE and Caltech databases.

A method is presented by Hwanjong Song et al. which recognises 3D face accurately[25]. This method is based on Error Compensated Singular Value Decomposition (EC-SVD). This algorithm has two stages. First, a 3D nearest neighbours is used to select the candidates and next for final face recognition, template matching which is based on depth, is employed.

K. Nimmy and M. Sethumadhavan devised a face recognition methodology which is applied on MIT face database. In [26], KNN is the main technique used for classification thereby to identify the faces. PCA used for feature descriptor and for dimensionality reduction. Combining KNN and PCA, 98.66% of detection accuracy is achieved

III.COMPARISON OF FACE RECOGNITION ALGORITHMS

Fig. 1 represents the flow of our work in the paper. We have taken HeadposeImageDatabase as input to test the algorithms. Initially we applied PCA algorithm and tested it for partially occluded images. The algorithm works well and gives a good recognition accuracy for this dataset. Later we tested the images with various poses using algorithms such as Eigenfaces which is based on PCA, Fisherfaces, K-Nearest Neighbors, Naïve Bayes. Each of the algorithm is tested with HeadposeImageDatabase to obtain recognition accuracies which are later compared to evaluate the performance of the the algorithms.

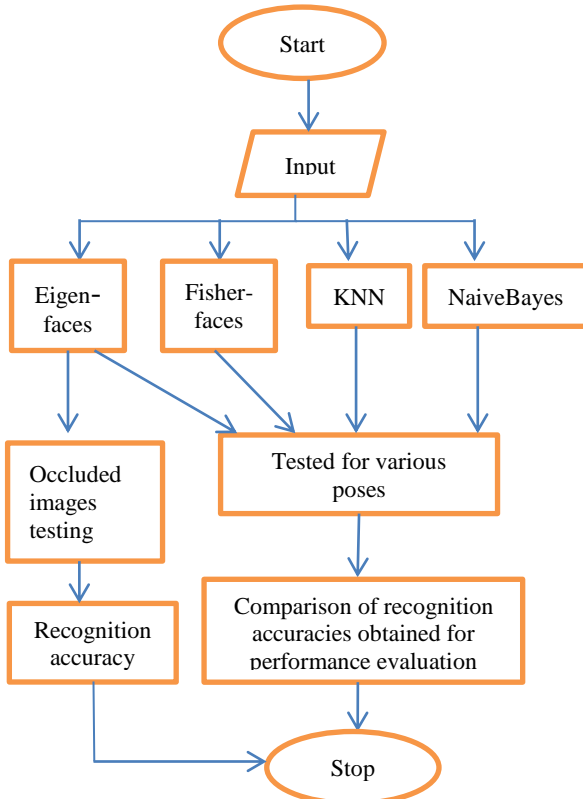


Fig 1: Workflow for comparison of face recognition algorithms

Image Dataset Details

Image dataset contains images for 15 persons, each subject has various images of different poses. For our work, we took 25 poses per person. So, all the algorithms are tested on a total of 375 images. Properties of images are given in Table 1 below:

Properties	Value
Type of file	.jpg image
Height	384pixels
Width	288pixels
Bitdepth	24

Table 1: Image dataset details

A. Eigenfaces based on Principal Component Analysis

Eigenfaces is nothing but a set of eigenvectors that are generated by

performing Principal Component Analysis on a set of images.

First the set of training images are provided which are reshaped into 1D column vectors. These training set vectors are called Eigenfaces as these are formed by processing on face images.

We separately tested for occluded images and images with various poses. The training set images that are provided include only front face images of 15 persons, while the testing images include persons wearing spectacles, different hairstyles etc., and also with various poses. In first testing phase, we provided only front face images with occlusion. In the second testing phase images of persons with various poses are included. All the 375 images are tested to arrive at the appropriate face recognition accuracy.

Fig 2 represents the procedure for Eigenfaces method.

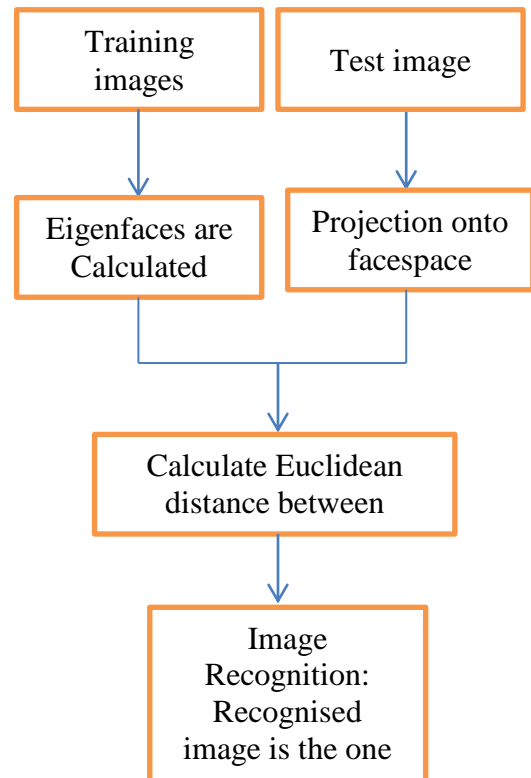


Fig 2: Eigenfaces procedure

B. Fisherfaces

Fisherfaces are nothing but the basis vectors that are obtained by performing Linear Discriminant Analysis(LDA).

We calculate fisherfaces for the training images which includes only front faces of the persons. The calculated fisherfaces are stored as a matrix and is used for face recognition when test images are provided.

Let us see the procedure for calculating fisherfaces. This procedure mainly focuses on minimizing the difference in between images that are present in same class and maximizing distance between images from different classes. Within class scatter matrix is given by :

$$S_w = \sum_{j=1}^c \sum_{i=1}^n (x_{ij} - \mu_j)(x_{ij} - \mu_j)^T \quad \text{--- 1}$$

Here x_{ij} is the sample i of class j , μ_j is the j th class mean

Similarly between-class scatter matrix is given by

$$S_b = \sum_{j=1}^c \sum_{i=1}^n (\mu_j - \mu)((\mu_j - \mu))^T \quad \text{--- 2}$$

For finding Fisherfaces, we use eigenvalue decomposition as given below:

$$S_b = S_w F D \quad \text{--- 3}$$

D is the diagonal matrix of corresponding eigenvalues. Fisherfaces are the eigenvectors of F that are corresponding to non-zero eigen values.

We tested the images with various poses with Fisherfaces algorithm. It's recognition accuracy is 76.267%.

Each of the 15 persons is mapped to different classes. When a image is provided for testing, it displays the corresponding class number as output.

C. K-nearest neighbors

We have implemented the K-nearest neighbors. First the Local Binary Pattern (LBP) features are extracted from all the images and stored as a vector.

Images of all persons with various poses are taken and divided into training and test sets. Many iterations are performed by taking few features for every iteration, we train the model using training set. Test data is given as input to the model to test it. The average of accuracies obtained from all the iterations performed is final recognition accuracy.

D. Naive Bayes

Naive Bayes is also implemented similar to KNN. First LBP features are extracted from all the images and stored as a vector. All the images that are provided are divided into training set and testing set randomly. For every iteration of different feature set, the training and test set also changes. we train the model using training set. Test data is given as input to the model to test it. The average of accuracies obtained from all the iterations performed is final recognition accuracy.

IV. RESULTS AND ANALYSIS

First, we implemented PCA algorithm and tested on front face images of the dataset. Training images are normal front face images and testing images are occluded images.

Later we tested Eigen faces algorithm on images with various poses. It's recognition accuracy is 66.93%.

Fig 3 represents the results for occluded images based on PCA algorithm.



Fig 3: Results for Eigenfaces tested with occluded images

Below are the results for Eigenfaces tested for various poses.

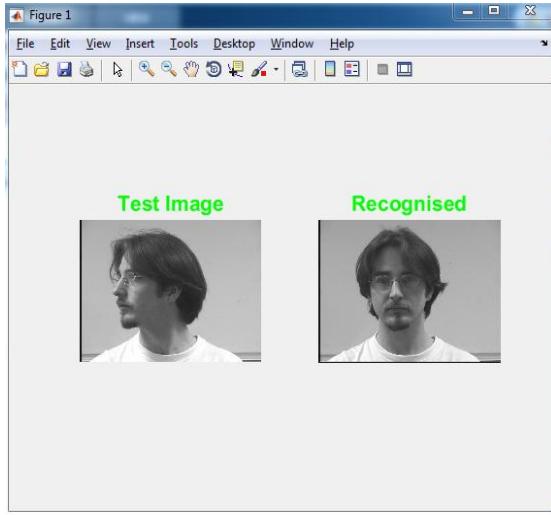


Fig 4: Results for Eigenfaces tested with images of different poses

In Fisherfaces, the tested image is mapped to corresponding predicted class. For example if we select the below image Fig 5 for testing, it calculates the distance with the nearest fisherface and the corresponding nearest class is displayed as output.



Fig 5: Sample image from database for testing

It displays the corresponding class number of the image that is being recognized for test image from database. The recognition accuracy obtained from Fisherfaces is 76.266%.

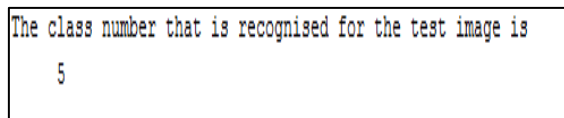


Fig 6: Result for Fisherfaces

In KNN and Naive Bayes, we get the average recognition accuracy for all the iterations as output.

Recognition accuracy for KNN and Naive Bayes is 96% and 91.7% respectively.

Comparison of face recognition accuracies of various algorithms is depicted in Table 2 below:

Algorithm Applied	Total Subjects	Poses per each person	Recognition Accuracy(%)
Eigenfaces	15	25	66.93
Fisherfaces	15	25	76.266
Naive Bayes	15	25	91.7
K-Nearest Neighbors	15	25	96

Table 2: Comparison of face recognition algorithms

V. CONCLUSIONS

As a result of research on related works, we found that it is very crucial to have a method for face recognition which is fast and accurate similar to the one's in surveillance applications. There are many methods for face recognition which learns from trained images and we can test accuracy with test images. In real world scenario, we may not get images under uniform conditions always (i.e.), the images may be blurred, faces may be tilted, pictures might have been taken in different angles, person in image may be wearing spectacles, illumination differences at various places, persons may change their hair styles. Considering the challenges such as variation in poses, occlusions we tested four algorithms to evaluate the performance. For the HeadPoseImageDataset that is considered, KNN proved to perform better compared with Eigenfaces, Fisherfaces and NaiveBayes.

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