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Face Recognition Across Age Progression By Using PCA

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ABSTRACT: In computer or automated system running through embedded software individual identity of human being can be established through face recognition system. Effectiveness of face recognition system has many challenges. One such challenge is age invariance. A face recognition system with the age invariance makes it robust but implementation is the most demanding. Aging brings about many changes in the structure and shape in the face. In this paper, an age-invariant face recognition system is proposed, which has four stages: Face Detection, Image Preprocessing, Feature Extraction and Feature Classification. Face Detection stage detects faces in the image .Face frontal alignment, cropping and noise removal is done in image preprocessing stage. Principal Component Analysis (PCA) is used to extract features of face in the image .Result of this analysis is achievement of the relevant features usable for age-invariant face recognition. Lastly, for classification multi support vector machine is used. The results show that the proposed system can be used efficiently in automated individual identification process and overcome challenges posed by aging. [1]

Keywords: - Face Recognition, Aging, Viola Jones, PCA, MSVM, Gabor Filter.

I. INTRODUCTION

Human aging is a major challenge in Face Recognition. Multiple studies have been done to overcome challenge of age invariance in face recognition .Most of them are based on age approximation and simulation. Designing an effective and efficient age invariant model has been an open problem.

Complication of smooth operation of age invariant model seems to arise from many factors. A few factors may be: (a) Outcome of the age progression on face varies across individual and is not the same even if two faces carry one or two same feature. (b) Environment, pattern of genes in chromosome, habits, food, etc impact the aging process. So feature extraction is useful to make model robust poses research problems. In this paper, an attempt has been made to design a model that addresses the defy age variance to certain degree.

Proposed model works in four stages. Face Detection stage detects faces in the image using Viola–Jones algorithm. Face frontal alignment, cropping and noise removal is done in image preprocessing stage. Gabor filter is used as filtering technique to reduce noise. Principal Component Analysis (PCA) is used to extract features of face in the image which results

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relevant features usable for age-invariant face recognition. Finally, multi support vector machine is used for classification. The model results good recognition accuracy. [2]

Rest of the Paper is organized as follows: Section II describes the researches work in this field in review of literature. All the steps and the approaches are explained under section III. Proposed Methodology is explained under IV section. Research outcomes are displayed under section V and the last section VI describes the conclusion of the research.

II. LITERATURE REVIEW

Age Invariant Face Recognition Systems were not widely studied earlier because availability of age Data base.

Zhao et al. (2020) proposed a joint disentangled representation learning and photorealistic cross-age face synthesis for face recognition with large gap in the age and other unconstrained distracters [3].

Chandana et al. (2020) reached to the conclusion that age patterns are different for different individual. They used local descriptor (HOG) and a local binary model (LBP) for Permanent facial features and Haar files in a waterfall for facial and eye recognition. [4].

Moustafa et al. (2020) applied the real-time feature-level multi-discriminate correlation analysis for fusion, which substantially reduces feature dimensions and results in the most relevant features to age-invariant face recognition. [5].

Mortezaie et al. (2019) compared various methods of age invariant face recognition methods and identity factors to increase performance face and recognize face based on simulated face [6].

Nimbarte et al. (2018) applied 7-Layer CNN architecture to develop model for age invariance face recognition. Their result showed that no complex preprocessing and feature extraction is required with the proposed CNN architecture and the classifier [7].

Sinha et al.(2022) for that preprocessing plays an important role in face recognition. It enhances the image which increases accuracy recognition. [8]

Ali et al. (2015) used collectively texture and shape feature sets by using LBP variance and found that fusing shape and texture features set gives better performance and accuracy [9].

Zhou et al. (2015) proposed a method in which one facial feature and the aged facial feature of a face image are correlated, so they are fused by using canonical correlation analysis to form a coherent feature for face recognition. [10].

Snehlata Barde et al. (2014) proposed a model where face, ear and iris area in image used as region of interest. PCA based neural network classifier yielded a better result on fused feature. [11]

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Tandon et al. (2014) proposed age invariant face recognition system that utilised area around eyes as the region of interest extracted feature using local binary patterns. Their model used Chi-square distance to compare between each region of interest pair [12].

Patel et al. (2014) used Walsh Hadamard Transform & Local Binary Pattern [WLBP] to make their model illumination, rotation and grayscale invariant and for feature extraction. They used principal component analysis for frontal face images recognition. Recognition rate was more than 99%. [13]

III THEORIES OF THE ALGORITHEM

The proposed approach of age invariant face recognition is made up of four steps: Face Detection, Image Pre-processing, Feature Extraction, Feature Classification as shown in Figure 3.1.

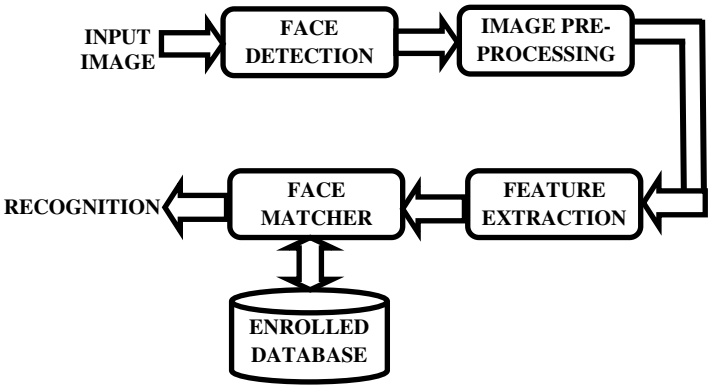

Figure 3.1 Proposed Approach Steps

Here Viola Jones Algorithm is used for detecting face from image .Then at pre processing stage cropping, resizing and noise removal is done with the help of Gabor filter (GF). To extract feature Principal Component Analysis is used. Then Multi class Support Vector Machine (mSVM) with Radial Basis Function (RBF) is applied for face recognition [14]. All of these techniques will be explained as follow:

3.1 Viola Jones Algorithm

Viola-Jones algorithm is rectangle object-recognition framework that is used to find face area in any image. Image is converted into grayscale. Converting image to grayscale reduces pixels on one hand and recognition result is achieved faster on the other. Then from that image haar like features are searched when found it draws a rectangle shape around the face. It outlines a box and searches for a face within the box. [15]

3.2 Gabor Filter

Gabor Filter alternatively known as linear filter enhances edges in image powerfully. It is used to extract features. It achieves optimal localization properties and is well suited for texture analysis and feature extraction. Two dimensional Gabor filter a sinusoidal plane wave, modulated by a Gaussian envelope. The function of the Gabor filter is represented as:

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$$G(a, b; \lambda, \theta, \psi, \sigma, \gamma) = \exp\left(-\frac{a'^2+\gamma^2 b'^2}{2\sigma^2}\right) \cos(2\pi x'+\psi)$$

Where $a' = a(\theta) + b\sin(\theta)$; $b' = -a(\theta) + b(\theta)$;

Here λ is used for wavelength of the sinusoidal factor, θ is used for orientation of normal to stripes of Gabor function, ψ is for phase offset, σ is for Standard Deviation of Gaussian envelope, γ is for spatial Ratio and specify the elliptically the support of the Gabor function.

The two dimensional Gabor function contains filter parameters such as wavelength, orientation, phase offset, aspect ratio, bandwidth. Changing these parameters suitably gets to the enhanced edges. In the proposed approach, wavelength (9) and orientation in rad (2π/3) are selected to eliminate problem of the illumination variation in the images. [16]

3.3 PCA

Principal Component Analysis (PCA) is a statistical dimensionality-reduction method. It is often used for feature extraction and the dimensionality reduction. It is used for capture the dominant patterns in the image. Steps Involved in the PCA [17]

A face image Γ(a, b) be a two dimensional X by Y array of intensity values. Here we used 160 × 160 pixels size image. An image can be assumed as vector of dimension X × Y, so 160×160 size image becomes a vector of dimension 25,600 or equally a point in a 25,600 dimensional space.

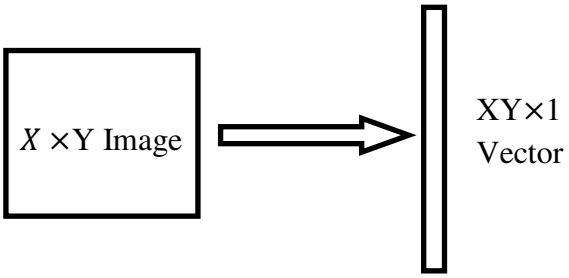

Fig. 3.2 Converting An Image In Vector

Step 1: Standardize the dataset.

We are using $F_1, F_2, F_3, F_4, F_5, F_6, F_7$ Images for Training which is of same size and already centred. Each face images F_i is transformed into a vector and placed into a training set S.

. $$S = \{ \Gamma_1, \Gamma_2, \Gamma_3, \Gamma_4, \Gamma_5, \Gamma_6, \Gamma_7 \}$$

Step 2: Compute Average Face Vector.

The average face vector (Ψ) can be calculated by using below given formula .

$$\Psi = \frac{1}{7}\sum_{n=1}^{7} \Gamma_1$$

Step 3 : Subtract the mean face

The average face vector (Ψ) is subtracted from the original face vector Γ_i and stored in variable Ω_i,Formula is

$$\Omega_i = \Gamma_i - \Psi$$

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Step 4 : Calculate the covariance matrix for the features in the dataset.
We will get covariance matrix Co by using following formula.

$$Co = \frac{1}{7}\sum_{n=1}^{7} \Omega_i \, \Omega_n^T \qquad = AA^T \quad (X^2 \times X^2 \text{ Matrix})$$

Where A = $[\Omega_1, \Omega_2, \Omega_3, \Omega_4, \Omega_5, \Omega_6, \Omega_7]$ $N^2 \times 7$ Matrix

Step 5: Calculate and sort the Eigen values and eigenvectors for the covariance matrix.
In this step, the eigenvectors (eigenfaces) u_i and the corresponding eigenvalues γ_i Are calculated. Then we sort it according to their values .

.

Step 6: Pick k Eigen values and form a matrix of eigenvectors.
Eigenfaces with low eigenvalues will be omitted, because they describe small part of the characterstics features of faces .

Step 7: Transform the original matrix.
The new face is transformed into its eigenface components and the resulting weights form the weight vectors.

$$\varphi_i = \mu_K^T(\Gamma - \Psi)$$

where φ= weight, μ = eigenvector, Γ = new input image, Ψ = mean face
The weight vector Ω_T is given by,

$$\Omega_T = [\varphi_1, \varphi_2, \varphi_3, \varphi_4, \ldots \ldots \varphi_k]$$

3.4 SVM

Support Vector Machine (SVM) is a supervised machine learning algorithm which is used for classification. A SVM model attempts to classify features in distinct classes' space such that the features belonging to a class are divided with a clear gap. The wider the gap between the classes the better it is because otherwise chances of wrong classification is very high. Input features are classified in above manner in training phase and testing features are predicted to belong to a class based on which side of the gap they fall in testing phase.

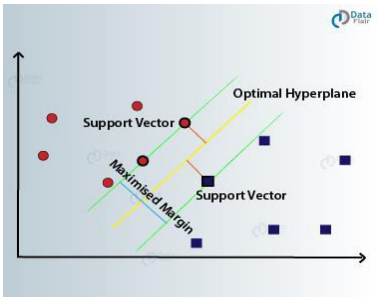

Fig .3.2 SVM Classifier

SVM is basically a binary classifier but for practical purpose more than two classes are required. Multiclass SVM classifiers are used to have desired number of classification. For a multiclass SVM classifier we have to use a kernel. A kernel is nothing but mathematical

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equation that is commonly called function. Its function is to transform multiclass into binary class. With the kernel of RBF function is used in face recognition and classification experiments to get a better classification rate than other kernels. The recognition rate is determined by the standard deviation parameters in the RBF function. [18]

IV RESULTS AND DISCUSSION

The proposed Age variant face recognition system is divided into given four steps as shown in figure 1. The results of each module as well as database are described in following sub section.

Step1. Age invariant Data Base

We have created our own age invariant database for performing experiments. The database has images with different age as shown in figure 4.1.At Present our database has images of 23 different persons and it has collection of 10 different images of every person. Here we are using 7 image for training and 3 image for testing purpose .

Figure 4.1 Example face images from database
(The number near each face image represents the age of the image)

Step 2. Face Detection

Viola-Jones face detector is utilized to the age invariant images in order to detect human faces from the given image. We trained detector using age invariant images. This algorithm is based on machine learning which require training of a lot of images. We have kept Merge Threshold property below 4 so that algorithm doesn't miss face in image. Reducing threshold property also increases chances of false detection but since we have our own database carefully selected images this possibility gets ruled out.

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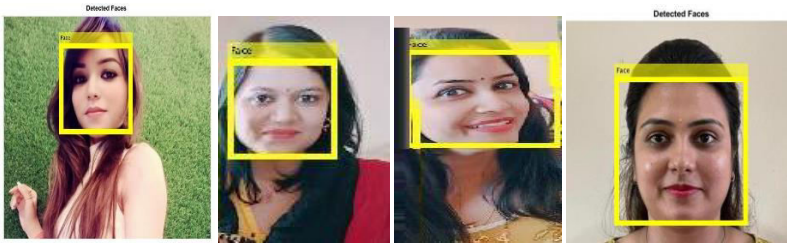

Figure 4.2 Face Detection in Various Images

Step 3. Preprocessing

Based on Face Detection, Face Area is cropped then change RGB image into gray image if our image is color then we use gabor filter to enhance the size of image and remove noise from the image then we resize each image at 160 x 160 pixels, on 256 gray scales per pixel.

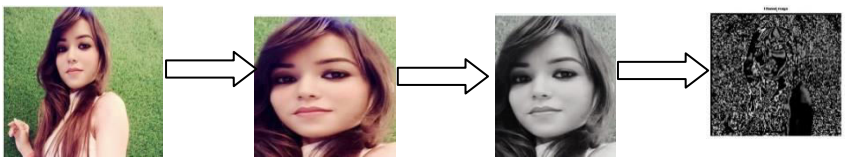

Fig. 4.3 Pre processing of Image using Gabor Filter

Step 4. Feature Extraction

A feature is desired portion or shape in a digital image under observation. Here we use Principal Component Analysis (PCA) which involves conversion of the 2D image in a form of 1D image vector. We calculated average of images and subtracted average from that. Then we calculated covariance from subtracted average. Then eigenvector has been calculated.

Step 5 Feature Matching

We need multi-class classification as we will always have many classes (the face images of different people). Simulation has been done on Matlab. We used Libsvm, a library for Support Vector Machines for performing multi-class SVM.It is a supervised learning algorithm as data labels are available. They are effective in high dimensional spaces. It is also memory efficient and versatile in nature.

The formula for recognition accuracy is given below:

$$RA = \frac{Number\ of\ Images\ Recognized}{Number\ of\ Utilized\ for\ Testing}$$

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Fig. 4.4 Some Correctly Recognize images

Table 1. Recognition Accuracy with Data Base.

Total Images (Only Frontal Images)	Training Images	Testing Images	Recognition Accuracy
230	161	29	95.77

The average of recognition accuracy is around 95.77 as shown in above table%.

The proposed approach using Multiclass Support Vector Machines (mSVM) with RBF kernel:

- Take access time around 20.43 seconds.
- High classification performance.

The average of recognition accuracy is around 95.77%.

V Conclusion

This paper presents a feature progressing system for age-invariant face recognition. The motivation of our approach is to apply the progressive aging features so that it is robust to age-invariant face recognition with both large and small age gaps. The proposed system applies an image preprocessing step, followed by features extraction and dimension reduction using PCA which is proven more suitable. Facial aging is a challenging problem that will require continued efforts to further improve the recognition performance [19]. Future work in this area would involve developing face database at different ages, improving performance of model with large and small gaps, and also find a method that is more tolerant to pose changes.

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