IOSR Journal of Computer Science (IOSR-JCE)
e-ISSN: 2278-0661, p-ISSN: 2278-8727
PP 68-73
www.iosrjournals.org

Study on Age Invariant Face Recognition System

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***ABSTRACT* :** *At present the Computer automated Face recognition systems are used for personal identification, but the Age variations of an individual poses a serious problem for it. Designing an appropriate feature representation and an effective matching framework for age invariant face recognition remains an open problem.*
In this paper we have focused on the use of appropriate Pre processing techniques for improving the quality of the input image and the use of Periocular region as the template for recognition as this region remains unchanged or stable for the lifetime in an individual.
The modified PCA algorithm called the Self-PCA is used for creating the Eigen Face for feature extraction for the recognition process.
The Self-PCA can be used in order to consider distinctiveness of the effects of aging of a person for age invariant face recognition.

Keywords- *Biometrics, Eigen Space, Face Recognition, Illumination Normalization, Periocular, Preprocessing, Pose correction, Self-PCA.*

I. INTRODUCTION

Humans have used body characteristics such as face, voice, and gait for thousands of years to recognize each other.
However a problem might arise in a scenario where a person cannot recognize the other person due to various changes like Facial Expressions, Age progressions, etc. Thus the use of Biometrics like Fingerprint, Iris, Face, Signature, Hand and Finger geometry, Palm print, etc came to being used for purposes of law enforcement, Passport Photo Verification, Image retrieval and Surveillance[8].
The researchers were interested in Face Recognition techniques in the 1960s, primarily by Woodrow W. Bledsoe with the U.S. Department of Defense and Intelligence Agency. Bledsoe designed and implemented a semi automated system, some facial coordinates are calculated manually by a human and then a computer calculates the information for Face recognition [1] [20].
Face recognition is a biometric approach that employs automated methods to verify or recognize the identity of a living person based on his/her physiological characteristics. Face recognition is a passive method which extracts the identity of a person in a friendly way [4]. To qualify any biological measurement as biometric, the permanence property should be satisfied. The permanence property is the one according to which the biometric should not vary over a period of time[2]. The aging of a person brings about a change in shape and texture of the face. The aging is a very complex process which depends on many factors like gene pattern, lifestyle, stress, environmental conditions etc. to name a few.
Since faces undergo gradual variations due to aging, periodically updating face databases with more recent images of subjects might be necessary for the success of face recognition systems. Since periodically updating such large databases would be a tedious task, a better alternative would be to develop face recognition systems that verify the identity of individuals from a pair of age separated face images.
Thus in this paper we will try to achieve an Age Invariant Face Recognition system to compensate for the aging variations and to identify or recognize a person irrespective of his time of life.
The recognition is mainly done by Algorithms like PCA (Principle Component Analysis), Self-PCA, MFDA (multi feature discriminant analysis).
The paper is divided in V sections, where section II describes the literature review, section III provides the proposed work and section IV gives the Conclusion and then the References.

II. RECENT WORK

Face Recognition Systems that are Age invariant were not widely studied earlier because of the lack of suitable databases, but the recent advent of FGNET and MORPH databases have made this area available for wide research field.

N Ramanathan and R Chellappa [7] presented a Bayesian age-difference classifier that identifies the age Separation between a pair of face images of an individual. While the method presented in this paper is suitable to handle age progression in adult face images, since it does not account for shape variations in faces, it is not effective for handling age progression in face images of children.

H Ling and S Soatto et al [6] proposed a robust face descriptor, the gradient orientation pyramid, for face verification tasks across ages. Compared to previously used descriptors such as image intensity, the new descriptor is more robust and performs well on face images with large age differences. In addition, the pyramid technique enables the descriptor to capture hierarchical facial information.

G Mahalingam and C Kambhamettu [10] presented a graph based image representation and an aging model constructed using GMM for each individual to model their age variations mainly in shape and texture. A two stage approach for recognition has been proposed in which a simple deterministic algorithm that exploits the topology of the graphs is proposed for efficient graph matching between the probe image and the gallery image.

In "Age Invariant Face Recognition based on Periocular Biometrics" by F L Xu and K Luu et al [2] proposed the use of robust Walsh-Hadamard transform encoded local binary patterns (WLBP) on preprocessed periocular region only. This WLBP feature of the periocular region remains constant throughout the lifetime.

Z Li and U Park et al [3] proposed a discriminative model to address face matching in the presence of age variation. The scale invariant feature transform (SIFT) and multi-scale local binary patterns (MLBP) serve as the local descriptors. Since both SIFT-based local features and MLBP-based local features span a high-dimensional feature space, to avoid the over fitting problem, we develop an algorithm, called multi-feature discriminant analysis (MFDA) to process these two local feature spaces in a unified framework.

J S Nayak and Indiramma M [4] proposed a novel self-PCA based approach in order to consider distinctiveness of the effects of aging of a person for age invariant face recognition. The region around the eyes is used as the input feature instead of the entire face as it is more stable part of the face.

J S Nayak and Nagarathna N et al [5] proposed this self-PCA based face recognition method to consider the aging effects by constructing the subspace at the individual level.

N R Syambas and U H Purwanto [1] focused on development of image pre- processing factors like contrast, Brightness, Sharpness in the Recognition System for improved recognition accuracy.

III. PROPOSED WORK

Holistic model based approaches have been applied efficiently in age invariant face recognition, they still have some drawbacks. Most face modeling methods require having face images with frontal pose, normal illumination and neutral expression to get the best fit results[10] . Although human faces have the same general manner when aging, each ethnic and gender group has distinct characteristics in face aging. Thus, it is insufficient to assume that similar faces age in similar ways for each and every individual.

In order to overcome these limitations, we propose to use periocular, the most age invariant facial region, to extract discriminative local features that are distinct for every subject [2]. Compared to the global feature based approaches, the local features inherently possess spatial locality and orientation selectivity. These properties allow the local feature representations to be robust to aging, illumination, and expression variations. Considering that the entire face with high structural complexity easily changes over time in terms of color, texture and structure [22]. That is why full face modeling for age invariance is difficult.

We propose to implement our Age Invariant Recognition System as follows:

3.1 Pre Processing of the Image

To achieve good performance under illumination changes, methods based on normalization or illumination invariant descriptions have been purposed. Several general purpose preprocessing algorithms have been used extensively for face illumination normalization. Commonly used is four segments approach based on Histogram equalization algorithm [11].

The Various steps under Image Pre Processing are:

A. Illumination Normalization

It is achieved using the Four Segment approach. It initiates by splitting up the face image into four sub images such that each segment or sub image could be handled and processed separately for illumination variation.
The nose in the face is taken as center for dividing a face image into four segments and it acts as a cross point of four sub images. The individual illumination normalization is done using histogram equalization. After the completion of individual normalization of each segment of image, these segments are merged to form the whole image again.
The two joining lines at the center of face image can be seen after merging of segmented images. These lines will be considered as noise. Pixel averaging is used to remove noise produced especially produced at joining edges. This is performed by giving each pixel a new value which is equal to the average of pixel itself and eight neighboring pixels. Lastly combination of filters is applied on image for further reduce the noise and to minimize the prominent lines appeared at the connection boundaries. Low pass Gaussian is applied followed by the 'Unsharp' filter for contrast enhancement [11].

3.2 Face Normalization/Pose Correction

For the test images, the AAM (Active Appearance Models) is used to obtain the coordinates of 68 vertices. These coordinates can be defined as the vertex locations of the mesh that describes the shape of the facial components. Then, each face in the training image is shape normalized by warping the original mesh onto the mean one. The mesh is triangulated by means of the Delaunay triangulation. A piecewise linear affine transformation is implemented between each triangle in the original mesh and the corresponding one in the mean mesh [9].
In detail, for each pixel $x=(x, y)^T$ in onetriangle $(x_i, y_i)^T$, $(x_j, y_j)^T$, and $(x_k, y_k)^T$ of the mean mesh, we map it to the image, and the corresponding pixel in the image can be calculated as

$$(x^t,y^t)^T=\alpha(x^t_i,y^t_i)^T+\beta(x^t_j,y^t_j)^T+\gamma(x^t_k,y^t_k)^T$$

Where $(x^t_i, y^t_i)^T(x^t_j, y^t_j)^T$, and $(x^t_k, y^t_k)^T$ are the vertices of the corresponding triangle in the original mesh of the image.
The three coefficients α, β, and γ can be easily computed by the following formulation:

$$(x, y)^T=\alpha(x_i,y_i)^T+\beta(x_j,y_j)^T+\gamma(x_k,y_k)^T$$
Where $\alpha+\beta+\gamma=1$

After the given process, a face is warped
to the mean shape domain.

3.3 Periocular Region Normalization

After Face Normalization or Pose Correction has been performed, the eyes are already well aligned on the images and hence we perform a simple crop to obtain the periocular region containing both the Eyes [2].

3.4 Feature Extraction

To perform feature extraction the PCA (Principle Component analysis) is the most commonly used method [4].

In PCA each training image is projected on the face space and expressed in terms of Eigen Face coefficients. For face recognition, any unseen face image is projected on the face space and is recognized as one of the training images based on the difference between average of all the training images and each training image. The approach works well when a face is to be matched with images of different persons [5].

In case of age invariant face recognition the training image set consists of age progressed images of the same person and the Eigen vectors should be in the direction of the variations in between the images of the same person[15][23]. The aging effects seen on the face vary from person to person and are unique to each person. Thus creation of the Eigen space is carried out at the individual level.
Thus a modified version of the PCA known as Self-PCA can be used in the recognition model so as to recognize a face despite having Aging effects.
The creation of Eigen for each person is done using age separated image of the person. The cropped periocular region is used as a template to create the Eigen space [5].

The Self-PCA algorithm differs from the PCA on the training phase as well as the testing phase. The algorithm creates Eigen space at the individual level. During testing the probe or Test image is matched independently with each Eigen space and match is considered on the basis of minimum Euclidian distance [4].

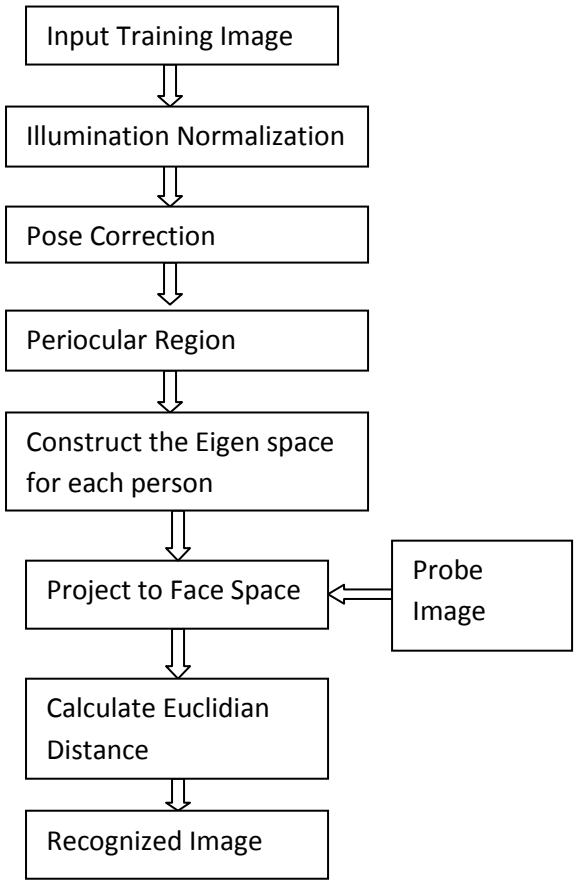

Fig: Proposed system design

Training Phase of Self PCA algorithm:
For each person 'j' in the database,
1. The 'M' age separated training images of size N x N pixels of person 'j' are converted to N^2 x 1 size vector. Let these vectors be …
$I_{1,j}$ $I_{2,j}$... $I_{M,j}$
2. The mean face vector of the person is calculated using
$m_j=1/M \sum^{M}_{i=1} I_{i,j}$

3. Subtract the mean face from the face vectors of person 'j', where $\phi = = I_{i,j} - m_j$
4.The Eigen vectors and Eigen values of the covariance matrix $C_j = A^T_j A_j$ is calculated, where $A_j = [\ \phi_{1,j}\ \phi_{2,j}\ \phi_{3,j} \ldots \phi_{M,j}\ ]$
5. The Eigen vectors ordered by sorting Eigen Values and the Eigen space is the matrix consisting of Eigen vectors as columns for each person j. The difference face vectors are projected onto the Eigen space of person 'j'

Testing Phase of the proposed algorithm:
A. For each person's Eigen space V_j created in the training phase
1. The test image is converted into a N^2 x 1 size vector and projected into the Eigen space of person V_j
2. The Euclidian distance between projected test image P and the projected training images T of each person is calculated using

$$d(P,T) = \sqrt{\sum_{j=1}^{n} (pj - tj)^2}$$

where $P=[\ p_1\ ,\ p_2\ ,p_3 \ldots p_n]$,$T=[\ t_1\ ,\ t_2\ ,t_3 \ldots t_n]$
B. The image with the minimum distance is the matched image.

IV. CONCLUSION

The approach that we have chosen concentrates on aging as a personal recognition problem. We can create an individual level Eigen space using self-PCA which considers the individuality of aging effects in a face. The approach focuses on the most complex and stable feature of the face that is the Periocular region. Also the performance of the face recognition system can be improved by performing the various Pre Processing techniques like Illumination Normalization, Pose Correction, etc.

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