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Happiness Expression Recognition at Different Age Conditions

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Abstract—Recognition of different internal emotions of human face under various critical conditions is a difficult task. Facial expression recognition with different age variations is considered in this study. This paper emphasizes on recognition of facial expression like happiness mood of nine persons using subspace methods. This paper mainly focuses on new robust subspace method which is based on Proposed Euclidean Distance Score Level Fusion (PEDSLF) using PCA, ICA, SVD methods. All these methods and new robust method is tested with FGNET database. An automatic recognition of facial expressions is being carried out. Comparative analysis results surpluses PEDSLF method is more accurate for happiness emotional facial expression recognition.
Keywords- Facial expression recognition, score level fusion, Principal Component, mean, standard deviation.

I. INTRODUCTION

Facial expression recognition is one of the most robust applications of decades of research on facial image processing. Several facial expression recognition algorithms and systems have been proposed in the literature and constant efforts are being made to improve the performance of these systems in terms of both accuracy and time [25]. Over the years, researchers have studied the role of illumination changes; pose variations, facial expressions etc. in affecting the performance of face recognition systems. Other than these external factors, aging is another phenomenon that affects performance of face recognition systems. So it is also important to consider the role played by aging when designing an efficient face recognition system. Automatic matching of faces as people age is useful for tasks like passport renewal, identifying missing persons where authorities need to verify if the old and new photographs belong to the same person. Some facial recognition algorithms identify facial features by extracting landmarks, or features, from an image of the subject's face. For example, an algorithm may analyze the relative position, size, and/or shape of the eyes, nose, cheekbones, and jaw. These features are then used to search for other images with matching features[7]. Other algorithms normalize a gallery of face images and then compress the face data, only saving the data in the image that is useful for face recognition. A probe image is then compared with the face data. One of the earliest successful systems is based on template matching techniques applied to a set of salient facial features, providing a sort of compressed face representation.

II. PROBLEM STATEMENT

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 facial expression recognition systems that verify the identity of individuals from a pair of age separated face images. Understanding the role of age

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progression in affecting the similarity between two face images of an individual is important in such tasks. This manuscript is intended to address the following problem: The manner in which similarity between two images of an individual is affected by age progression and the confidence associated with establishing the identity between two face images of an individual of different age of same expression.

III. EXISTING METHODS

Ramanathan and Chellappa [1] worked on the effects of age progression on facial similarity between a pair of images of the same individual. They used a Bayesian framework to classify pairs of face images based on age separation and further extended the approach to perform face verification across age progression. Mahalingam and Kambhamettu studied [5] the problem of facial expression verification with age variations using discriminative methods. Face image is holistically represented using the hierarchical local binary pattern feature (LBP) descriptor. The LBP provides an effective representation across minimal age variations, illumination, and minimal pose variations, which makes it a suitable descriptor for description of images across age. The spatial information is incorporated by combining the LBP at each level of the Gaussian pyramid constructed for each face image. They presented an AdaBoost classifier that identifies the intrapersonal and extra-personal image pairs across age gaps. X. Geng et al. [2] introduced an Aging pattern Subspace (AGES) on the assumption that similar faces age in similar ways for all individuals. Their basic idea is to model the aging pattern, which is defined as a sequence of a particular individual's face images sorted in time order, by constructing a representative subspace. The proper aging pattern for a previously unseen face image is determined by the projection in the subspace that can reconstruct the face image with a minimum reconstruction error, while the position of the face image in that aging pattern will then indicate its age. Yadav et al. proposed an algorithm that improves the performance of face recognition by applying the bacteria foraging fusion algorithm.

3.1. Principal Component Analysis

It is a statistical subspace technique used in face recognition system to convert high dimensionality data into low dimensionality data to save memory space and high speed recognition. The main purpose of using PCA is to find projection vectors that are best account for variation of facial expressions in face images in the entire space of images are called components. These vectors are called eigenvectors. PCA is used to project the spaces that give significant variations among known face images. The significant features are called eigenfaces. Basically these eigenvectors and eigenvalues are of the covariance matrix. To reconstruct the images largest eigenvectors and eigenvalues are used. Eigenvectors are the coordinates that defines directions of the axes whose length are given by the eigenvalues. PCA method is useful in feature extraction at constant illumination conditions.

3.2 Independent Component Analysis

Independent component representations for face recognition by M. S. Bartlett say that ICA can also be used to create feature vectors that uniformly distribute data samples in subspace. This conceptually very different use of ICA produces feature vectors that are not spatially localized. Instead, it produces feature vectors that draw fine distinctions between similar images in order to spread the samples in subspace. ICA method improves the recognition rate under different intensity of lights.

Input data is decorrelated by PCA method using second-order statistics and there by generates compressed data with minimum mean-squared reprojection error, ICA minimizes

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both second-order and higher-order dependencies in the input. Its goal is to decompose an observed signal into a linear combination of unknown independent signals.

3.3 Singular Value Decomposition

Singular Value Decomposition (SVD) is based on a theorem from linear algebra which says that a singular value matrix *W* can be represented by the product of three matrices, an orthogonal matrix *U* is a square matrix, a diagonal matrix *D*, and the transpose of an orthogonal matrix *V* is a square matrix. The theorem is usually presented as *W*

$$W = UDV^T$$

Where $U^T U = I, V^T V = I$; the coloumns of *U* are orthonormal eigenvectors of AA^T or covariance matrix *C*. Similarly the columns of *V* are orthonormal eigenvectors of AA^T, and *D* is a diagonal matrix containing the square roots of eigenvalues from *U* or *V* in descending order.

IV. PROPOSE METHOD

Proposed Euclidean Distance Score Level Fusion (PEDSLF) method is a post processing approach which is used to perform facial expression recognition in the absence of noise and motion blur. The following algorithm illustrates a new robust score level fusion subspace analysis:

Step 1: Each algorithm: PCA, ICA, and SVD returns a score for each image in the database.
Step 2: The score is calculated as follows:
scorelist1: PCA- Euclidean distance
scorelist2: ICA - Euclidean distance
scorelist3: SVD - Euclidean distance
Step 3: We have 3 algorithms and M images hence we will have 3 vectors of size 1 x M.
Step 4: All scores, 1 x M vectors are normalized to its mean and standard deviation (std) value.
Step 5: Normalization of scores can be given by

$$\widehat{s_{ij}} = \frac{s_{ij} - mean(s)}{sd(s)}$$

z-scores are adaptive score normalizations that are computed in a straight forward manner. Normalized score is produced by subtracting the arithmetic mean of **s** from an original score and dividing this number by standard deviation *sd*.

```
ifstd(scorelist1)!=0
score_norm1 = (scorelist1-mean(scorelist1))/std(scorelist1)
else
score_norm1 = (scorelist1-mean(scorelist1))
end
ifstd(scorelist2) != 0
score_norm2 = (scorelist2-mean(scorelist2))/std(scorelist2)
else
score_norm2 = (scorelist2-mean(scorelist2))
end
ifstd(scorelist3) != 0
score_norm3 = (scorelist3-mean(scorelist3))/std(scorelist3)
else
score_norm3 = (scorelist3-mean(scorelist3))
end
```

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Step 6: Normalized scores are summed and Maximu fusion rule is applied.
final_score_fusion = (score_norm1 + score_norm2 + score_norm3)/3
Step 7: Maximum final_score is recognized as face image.

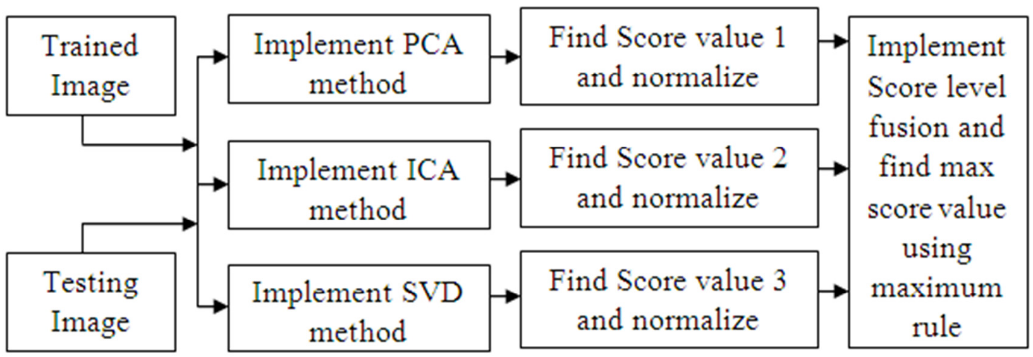

Figure 1. Proposed Subspace method for facial expression recognition

V. RESULTS AND DISCUSSIONS

PCA, ICA, SVD and Proposed Score Level Fusion (PEDSLF) methods are tested with aging database for happiness expression recognition. These methods are analyzed on FGNET Database 1 and Database 2 images. Table 2 shows recognition rates for Database 1 images. This experiment is carried out on 9 sample images of age of 1 to 5 as training images and age of 10 to 15 testing images as shown in Figure 2 and Figure 3 respectively.

Similarly Table 3 shows recognition rates for Database 2 images. This experiment is carried out on 6 sample images of age of 20 to 25 as training images and age of 30 to 35 testing images as shown in Figure 4 and Figure 5 respectively.

Each individual in FGNET Database 1 is assigned a separate class number. Hence after FGNET database is trained there would be 9 classes in database 1 and 6 classes in Database 2 respectively. Each class would contain one image of each individual. In this study images used are happiness facial expression recognition images.

Face recognition rate (FER) = (Total number of facial expression images recognized accurately / Total number of facial expression images available in the database) x 100. Facial expression recognition rate (FER) for PEDSLF method is obtained when 1 to 5 years is used for training and 10 to 15 years for testing is 81.8% and FER is obtained when 20 to 25 years is used for training and 30 to 35 years for testing is 72%. From the results we can understand that proposed method gives better facial expression recognition. All the scores of subspace methods are fused using maximum normalization rule. Maximum score value indicated the matching accuracy is increased.

FGNET Database	*Total no. of classes*	*Trained images /class*	*Total no. of trained images*	*Test images/ class*	*Total no. of test images*	*Dimension*
FGNET Database 1	***9***	***1***	***9x1=9***	***1***	***9x1=9***	***200x200***
FGNET Database 2	***6***	***1***	***6x1=6***	***1***	***6x1=6***	***200x200***

Table 1. FGNET database information used for facial expression recognition

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Database 1 Images

Figure 2. Training images of happiness expression of age between 1 to 5 years

Figure 3. Testing images of happiness expression of age between 10 to 15 years

Database 2 Images

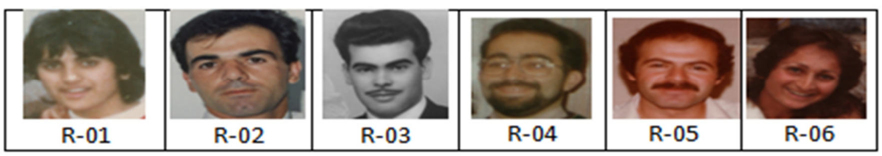

Figure 4. Training images of happiness expression of age between 20 to 25 years

Figure 5. Testing images of happiness expression of age between 30 to 35 years

SI. No	Subspace Methods	Facial Expression Recognition Rate For Database 1 images
1	PCA	78 %
2	ICA	78.5 %
3	SVD	78.5 %
4	PEDSLF	81.8 %

Table 2. Comparison of Face Recognition Rates of subspace methods with FGNET Database 1

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SI.No	Subspace Methods	Facial Expression Recognition Rate For Database 2 images
1	PCA	69 %
2	ICA	69.5 %
3	SVD	71 %
4	PEDSLF	72 %

Table 3. Comparison of Face Recognition Rates of subspace methods with FGNET Database 2

V. CONCLUSIONS

New robust Euclidean distance score level fusion method is proposed to recognize happiness emotional facial expression is illustrated and implemented on FGNET database of different age variations. It is concluded that PEDSLF method is designed using combinatory post processing approaches and z-Score normalization using the scores obtained from appearance based methods: Experimental results shows that performance enhancement of proposed score level fusion method using PCA, ICA, and SVD subspace methods. Proposed method surpluses the Face Recognition Rate. FRR obtained when 1 to 5 years is used for training and 10 to 15 years for testing is 81.8% and FRR obtained when 20 to 25 years is used for training and 30 to 35 years for testing is 72%

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