Face Recognition using Image Gradient Regression Approach

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Abstract

This paper represents a robust face recognition system. The proposed face recognition system consist is useful in forming an effective face recognition. Proposed methodovercomes the problem of multi collinearity and also give good results in case of small sample size (SSS) problem . In Image Gradient Regression Approach (IGRA), first in preprocessing stage image is transformed by normalizing gradient of the image. Then image is converted into zero average data matrix. After preprocessing ridge regression is executed on projected data and identity is determined by calculating maximum correlation coefficient. Experiments carried out on faces94 and Pie facial databases reveal that the proposed framework outperforms the state-of-the-art methods and demonstrates promising abilities against face recognition.

Keywords: *IGRA, Principal component analysis(PCA), Principal component analysis with zero centredimage (PCAZ), FRR,FAR*

1. Introduction

Face recognition, as one of the most typical applications of image analysis and understanding, has attracted significant attention in many areas such as entertainment, information security, law enforcement, and surveillance [5].Most of the approaches have used PCA for building efficient recognition for subsequent representation. However if training images are taken under non-ideal conditions, then obtained orientation encompass undesirable effects [9].

The class of most similar vector is the result of recognition process. A typical face recognition system consists of the following three stages: face detection, face representation and face classification [5].Psychological studies suggest that face recognition by human beings can be featural, configurational, and holistic[6].Although PCA is the general method of face recognition by finding directions in which set of vectors are best represented in least square sense and larger variance[1]. In traditional PCA correlation of input data can be removed. Due to orthogonal property among eigenvectors one principal component cannot be predicted from other so instead of PCA we used to get better results using PCAZ. Linear regression coefficients also perform better results in case of illumination invariance while dropping principal coefficients[2]. *Javier Ruiz-del-Solaret. al.*[1]proposed that the performance of PCA depends upon no. of samples available whereas performance of KFD depends upon the number of target per class so in case of less no. of samples KFD gives better results. Eigenfaces or Fisherfaces are simple approaches however kernel method results in low processing speed but still kernel method performs better results.*Baochang Zhang, YongshengGao, Sanqiang Zhaoet. al.*[3] proposed a Linear LBP cannot provide a detailed description for faces by encoding the binary gradient directions. However, the higher order LDP can provide more detailed description by coding the higher order derivative direction variations. However LDP more than third order derivatives presents much noise.*Jiwen Lu and Yap-Peng Tanet. al.*[4]proposed PRLPP(Parametric

regularization) consistently outperforms PCA, LDA, and LPP in terms of recognition accuracy. Compared with PCA and LDA, PRLPP can better preserve the nonlinear manifold structure as LPP, which is more suitable for large-scale face recognition.*ShufuXie, Shiguang Shan, Xilin Chen, Jie Chenet. al.*[5]proposed Gabor wavelet captures salient visual properties such as spatial localization and orientation selectivity, this approach generally performs better than LBP. Using local Gabor XOR pattern dimensionality can be reduced by applying FLD but it also suffers from small size problem so BFLD is used. Similarity measure is necessary for face recognition. For histogramsimilarity, it is often to compute "distances" betweentwo faces, and then, use a defined distance metric for similaritymeasure. On the other hand, kernel-based schemes can beused for face recognition, where an inner product is performed. Most classical HBLDs(Histogram based local derivatives) can only be used to deal with the aligned shapes and are sensitive to distortion and quantization of the images [6].*Huiyu Zhou and Abdul H. Sadkaet. al.* [7] proposed GV-LBP approach for face recognition and CMI and LDA are utilized to reduce redundancy and make representation more compact.*Wonjun Hwang, Haitao Wanget. al.*[8] proposes face recognition system using illumination insensitive preprocessing method and hybrid fourier based feature extraction and score fusion scheme. *Dr. H.B.Kekre, Sudeep D. Thepade, Akshay Malooet. al.* [10] proposes CBIR a faster image retrieval technique based on feature vector on feature vector dimension reduction with Eigenvectors of Covariance Matrix using Row, Column and Diagonal Mean Sequences. Here the complexity of mage retrieval is tremendously reduced.

The novelty of this paper is to propose an improved face recognition approach, which could overcome theproblem of singularity in linear regression. PCAZ although gives better result as compared to PCA but IGRA gives much better results. IGRA used gradient image, as face shape of different persons are different moreover this technique may work for SSS (small sample size) database.

Rest of this paper is organised as follows: different approaches used in face recognition is described in section II. IGRA approach has been described in section III. Experimental result and analysis has been described in section IV. Conclusion has been summarised in section V.

1.1 PCA with Zero Average

The PCA is widely used for dimensionality reduction in computer vision fields, especially for face recognition technology[2]. It was found from that instead of PCA, PCAZ will gives much better result.

Given a set of N images the image data matrix becomes X=[x_1, x_2,x_3,......,x_N]. In PCAZ data vector would be subtracted by mean of row vector $\overline{x_m} = \frac{1}{L}\sum_{l-1}^{L} x_{m,l}$ i.einstead of mean of column vectors as was in traditional PCAi.e. each image data matrix will be converted into zero average data matrix, $\hat{X} = [x_1 - \overline{x_1}, x_2 - \overline{x_2},......., x_m - \overline{x_m}]$. Finally similar to PCA , the sample covariance matrix for PCAZ is given by

$\hat{\Sigma} = \frac{1}{M} \hat{X} \hat{X}^T$,After decomposition of covariance matrix we have $\hat{\Lambda} = \hat{P}^T \hat{\Sigma} \hat{P}$ where $\hat{P} = \left[\hat{P}_1, \hat{P}_2,......., \hat{P}_k\right]$ and $\hat{\Lambda} = diag\left(\hat{\lambda}_1, \hat{\lambda}_2,......\hat{\lambda}_k\right)$with eigenvalues as $\hat{\lambda}_1 \geq \hat{\lambda}_2 \geq ...... \geq \hat{\lambda}_k$ and their correspondingeigenvectors of $\hat{P}_1, \hat{P}_2,...... \hat{P}_k of \hat{\Sigma}$. Thus, the PCAZ projectionbecomes $\hat{Y} = \hat{P}^T \hat{X}$

B.FAR and FRR

FAR is the probability that the system incorrectly matches the input face to a non-matching template in the database. It measures the percent of invalid inputs which are incorrectly accepted. In case of similarity scale, if the person is imposter in real, but the matching score is higher than the threshold, then he is treated as genuine that increase the FAR and hence performance also depends upon the selection of threshold value.

FRR is the probability that the system fails to detect a match between the input face and a matching template in the database. It measures the percent of valid inputs which are incorrectly rejected.

2. Different Approaches used in Face Recognition

Basically there are two approaches: expressive and discriminative for face recognition. These approaches are shown in fig.1.
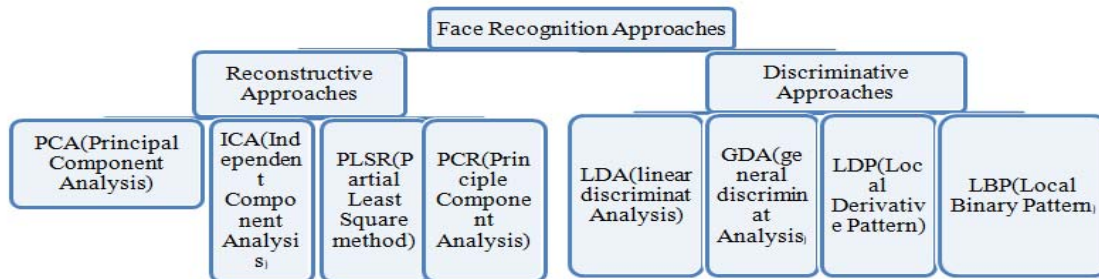
Fig.1: Face recognition approaches

Although recognition rate for discriminative approach is high but still it suffers some of the basic problems such as small sample size(SSS) problem which basically occurs when sample dimensionality is larger than the no. of available training sample per subject on the other hand the expressive approaches are not susceptible to the SSS and thus are applicable to most extreme case of such kind of problem[11].

3. Image Gradient Regression Approach

In this a novel face recognition system based on regression analysis is proposed. Most of the faces have similar structure and they are highly correlated so it is difficult to recognise face using least square method.

3.1 Preprocessing

It is found that face shape is also an important feature that we can obtain by finding gradient of image so we take the gradient map

$$\nabla \chi = \frac{\partial X}{\partial x} + \frac{\partial X}{\partial y}$$

However this method has one shortcoming: it blurs the step edge region of an image. To overcome this weakness we adopt anisotropic approach [8].Instead of taking $\nabla \chi$ for further operation we use to take

$$W = \alpha \nabla \chi + (1-\alpha)\chi$$

Where $0 \leq \alpha \leq 1$.

3.2 Ridge Regression

The goal of ridge regression is to find the maximum correlation of test image with training image. Let us consider N images then image data matrix becomes

$W=[W_1, W_2,W_3,......,W_N]$.Then this image data matrix is converted into zero average data matrix and we get matrix

$$W = [W_1 - \overline{W_1},W_2 - \overline{W_2},.........,W_N - \overline{W_N}]$$

Now
$\beta_i= (W_i^TW_i+\lambda I)^{-1}W_i^Ty$ where i=1,2,3.....,N
Now recognition of testing image y with training data w is found by

$$D=maxcorr(\|\beta_i\|,\|y\|)$$

To determine the accuracy of result we use to calculate FAR and FRR.

$$FR=\begin{cases}1 & D > \in \\ 0 & D < \in\end{cases}$$

Where $\in$ is the threshold for accepting a image i.e. if value of D is greater than $\in$ than this image will be treated as detected.

4. Experiment Results and Analysis

We have examined our algorithm on two publicly available databases Faces94 and Pie database all images are resized by 0.1 scaling factor i.e. Faces94 database pictures were resized to 20X18 pixels whereas pie database picture was approximately resized to 64X49 pixels. We compared the proposed method with PCAZ technique [2].

The Faces94 database contains images of 153 subjects with 20 samples per image. 20 subjects were used for evaluation taking 10 samples per image. In the Pie database 68 images of 68 subjects were used for evaluation moreover pie database also consist of images for different illumination for all the 68 subjects out of which 40 subjectsimages were used for evaluation taking 5 samples per image.FRR and FAR was calculated on the basis of above explained algorithm and results are as shown in table I.

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Results of different databasesusing IGRAare shown in figures. Wherefig.2, 3, 4 shows correlation of database with test image when original image has been used as input.fig. 5,6,7 shows correlation of database with test image when pre-processed image has been used as an input.
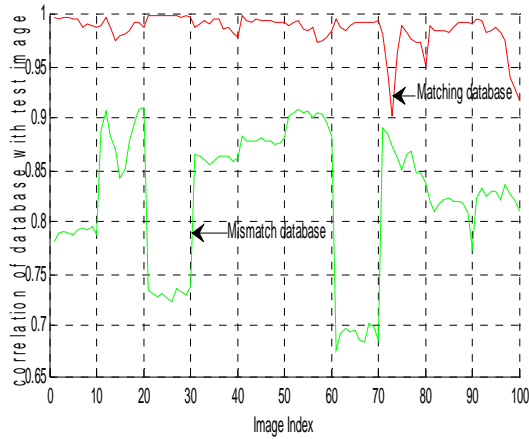

Fig. 2: Faces94 database correlation with test images when original image has been used as input image
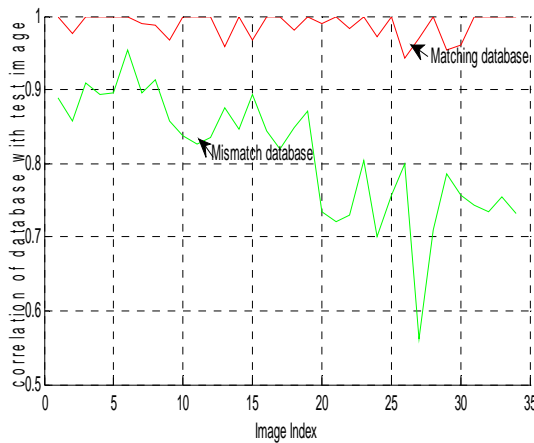

Fig. 3: Pie database(for SSS problem) correlation with test images when original image has been used as input image
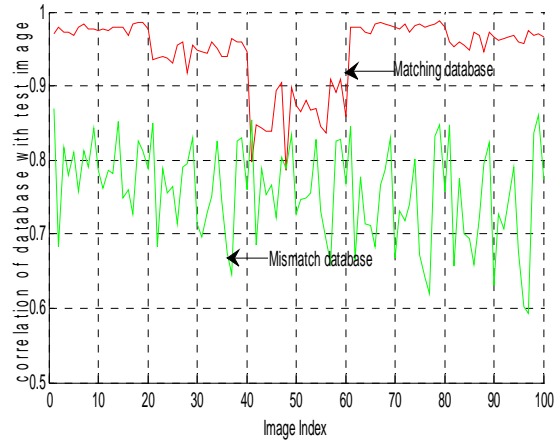

Fig. 4: Pie database (for illumination invariance) correlation with test images when original image has been used as input image
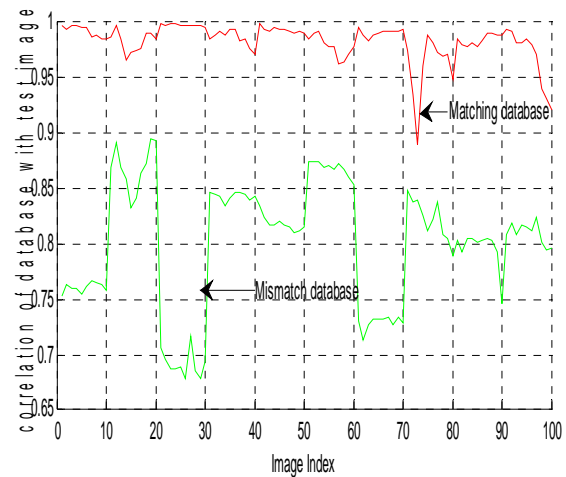

Fig. 5: Faces94 database correlation with test images when gradient image has been used as input image

Table 1: FAR and FRR on used Database

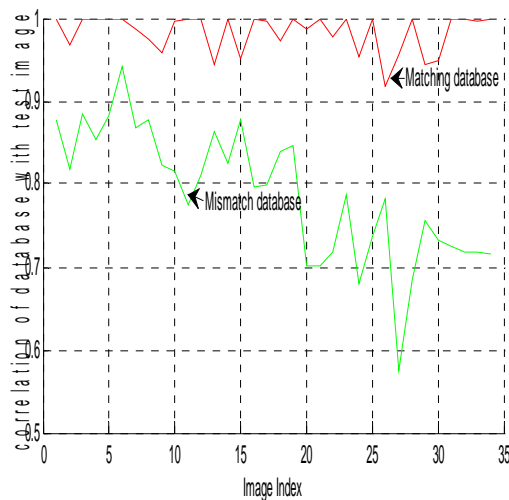| Database	PCAZ		PCAZ with INGI images		Face recognition using ridge regression analysis		Face recognition using ridge regression analysis with INGI	
	FRR(%)	FAR(%)	FRR(%)	FAR(%)	FRR(%)	FAR(%)	FRR(%)	FAR(%)
Faces94 database	41	0	10	0	1	1	1	0
Pie database	8.8235	2.9412	2.9412	17.6471	0	5.8824	0	2.9412
Pie database with illumination invariance	72	0	62	0	20	0	22	0

Fig. 6: Pie database (for SSS problem) correlation with test images when gradient image has been used as input image
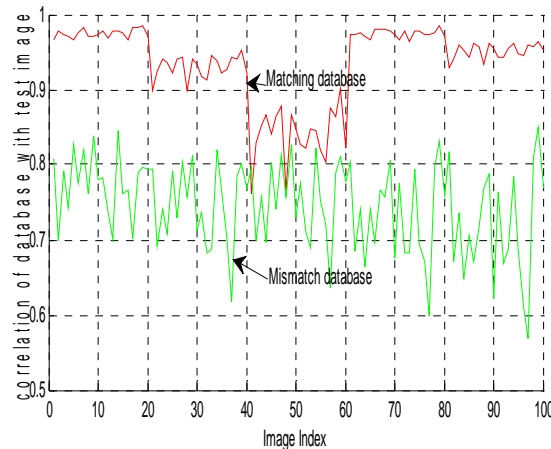

Fig. 7: Pie database (for illumination invariance) correlation with test images when gradient image has been used as input image

5. Conclusion

An image gradient regression approach has been proposed for face recognition. It Furthermore we have used our approach for three different kind of problem. First database contains large no. of samples per image it shows better results as compared to PCAZ. Second database contains small sample size problem i.e only one test image per sample is available. Third database to study illumination variation problem.The entire three problem have shown higher accuracy as compared to the PCAZ approach. Additionally, IGRA have advantages of fast computation, as compared with PCAZ.

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