HIGH PERFORMANCE POSE INVARIANT FACE RECOGNITION

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Abstract: A novel pose invariant face recognition system based on grey level histogram matching is proposed. The proposed system in this paper uses grey level histograms as feature vectors for recognition of the different poses of faces. The process is performed by taking the cross correlation between the histogram of a test face and the histograms of the training faces in the database. The proposed system gives 98.80% recognition rate on the HP database of 15 face subjects. This rate is down to 92% in the case of conventional eigenfaces method.

1 INTRODUCTION

The advances in research and development of multimedia systems have increased the use of biometric authentication applications such as face recognition. The earliest work in computer recognition of faces is reported by Bledsoe (1964), where manually located feature points are used to recognize a faces. Kanade (1977) used a method of characterizing the face by geometrical parameterisation, whereby distances and angles between points such as eye corners, mouth extremities, nostrils, and chin top are used. Statistical face recognition systems, such as, principal component analysis (PCA) based eigenfaces method introduced by Turk and Pentland (1977) attracted a lot of attention by the researchers. In this method the eigenvectors of the covariance matrix of the training set of faces are used as the basis vectors and any test image is mapped to the representation vector in a low dimensional eigenspace before classification. Relhumeur et. al (1997) introduced fisherfaces method which is based on the linear discriminant analysis (LDA) that minimizes the discrimination within a class and maximizes the dircrimination between classes. Their class specific approach provided improved recognition results and showed robustness to illumination changes.

Another statistical descriptor can be considered to be the histogram of a gray level image which shows the distribution in terms of occurrence frequencies of gray level pixel intensities. Histogram of a face image can be considered as the signature of the face, which can be used to represent the face image in a low dimensional space. Images with small changes in translation, rotation and illumination still possess high correlation in their corresponding grey-scale histograms. This histogram characteristic prompts the idea of using grey-scale histograms for face detection and recognition.

There is very limited work in histogram based methods in face recognition. Yoo et. Al (1999) used chromatic histograms as a model of faces. They used histograms for the detection of faces by backprojecting a face histogram onto the entire image containing a face to search and detect the face in the backprojected image. Ojala et. al. divided a face into several blocks and then the Local Binary Pattern (LBP) feature histograms (2002) are extracted from each block and concatenated into a single global feature histogram which efficiently represents the face image. Some other work have cooperated with histogram to recognize faces (Chen, 2004, and David et. al, 2000). The recognition of the face is performed by simple distance based histogram matching.

In this paper, the gray level histogram of the entire face image is used as the face descriptor of a given face. The proposed face recognition system simply uses gray level histograms to describe faces and recognition is achieved by incorporating histogram

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matching by using the cross correlation between the histogram of the input face and the histograms of the faces in the training set. The results obtained from the proposed histogram based system provide a recognition rate as high as 99.60% for the ORL face database when 5 poses of each subject out of 40 persons are used to train and remaining 5 poses are used for performance testing. The proposed method clearly outperforms the classical face recognition systems such as PCA based eigenfaces and LDA based fisherfaces methods, where this rate is down to 78% and 87% respectively.

Additionally, due to the high correlation between the histograms of the faces at different scales, the proposed system is robust for scale changes. The recognition rate for smaller faces with sizes of only 30% of the images in the training set is 98.22%, which is within 2% reduction in the recognition rate. This result is expected, because the information loss measured by entropy encountered by image shrinking down to 30% of the original image is in the range of 2%.

2 HISTOGRAM BASED FACE RECOGNITION

One of the methods of describing an image in lower dimension is using histogram. Histogram of an image can be considered as feature vector representing of the image. In general, histogram of an image is a statistical description of the distribution in terms of occurrence frequencies of pixel intensities. The size of the image histogram depends on the number of quantization levels of the pixel intensities. Typical monochrome image with 8-bit representation has 256 gray levels. In a mathematical sense, an image histogram is simply a mapping η i that counts the number of pixel intensity levels that fall into various disjoint intervals, known as bins. The bin size determines the size of the histogram vector. In this paper the bin size is assumed to be 256 and the size of the histogram vector is 256. Histogram of a monochrome image, η i, meets the following conditions

$$N = \sum_{i=0}^{255} \eta_i \quad (1)$$

where N is the number of pixels in an image. Then, histogram feature vector, H, is defined by,

$$H = [\eta_0, \eta_1, \cdots, \eta_{255}] \quad (2)$$

The similarity between two images can be measured by using the cross correlation between the histograms of the respective images. The maximum correlation coefficient in the correlation vector is taken as the measure of similarity and used in the histogram matching process.

If H1,H2,….,HM be a set of raining face images with different poses and M be the number of image samples, then a given query face image, the histogram of the query image Hq can be used to calculate the correlation between Hq and histograms of the images in the training samples as follows:

$$\chi_i = \max(H_i \circ H_q) \ , \ i = 1, \cdots, M \quad (3)$$

Thus, the similarity of the ith images in the training set and the query face can be reflected by χ_i, the maximum cross correlation coefficient. The, image with the highest similarity measure, is declared to be the identified image in the set.

The proposed system using histogram as the face feature vector and maximum cross correlation coefficient as the histogram matching measure is tested on Head Pose face database (Gourier, 2004), which contains 15 subjects with 10 selected different poses. The face dataset is divided into training set of n (n≤5) images per subject and the rest images for the test set. The images used in the test set are not included in the training set. The correct recognition rates in percent are included in Table 1. Each result is the average of 500 runs, where we have randomly shuffled the faces in each class. The results of the proposed system are outstanding, because even a single image in the training set provides a correct recognition rate as high as 94.89%. This rate is down to 68.89% in the PCA based face recognition systems respectively.

The proposed method shows slight improvement as the number of training set images is increased. On the other hand PCA based systems reaches 92%. The results are very encouraging and the proposed face recognition system shows a clear superiority over the conventional face recognition systems.

Table 1: Performance of the proposed histogram based system compared with PCA based systems.

# of Training Images	PCA	Proposed Histogram Matching Method
1	68.89	94.89
2	81.67	94.62
3	89.52	98.14
4	92.22	97.33
5	92.00	98.80

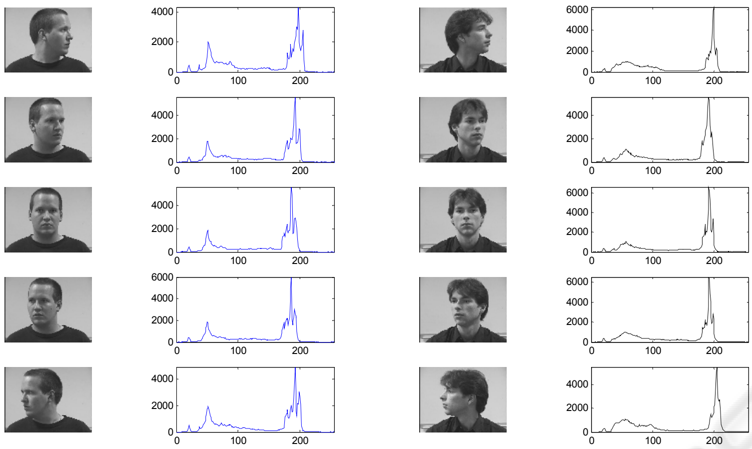

Figure 1: Faces with their PDF.

3 ROBUSTNESS ON POSE VARIANCE

As fig. 1 shows pose differences (planer rotations) on the images do not change the general distribution of the grey level PDFs. The shape of the PDF is more or less preserved, while only the amplitudes are changing as the angle of rotation of the image is changing.

So the shape of the histogram of a face image is its signature in representing the image. Hence, if the general distribution is preserved, then the correlation of the histogram of the image with high and low resolutions will be high.

Fig.2 shows the performance of the histogram based face recognition system for the changing poses. The dashed line of the figure gives the recognition rate of the PCA system for the images with different poses. The performance of the proposed face recognition system is always higher than the performance of the PCA. Obviously there is a limit of the angle of planer rotation, where the face image has been completely changed, e.g. only back of head is in the image.

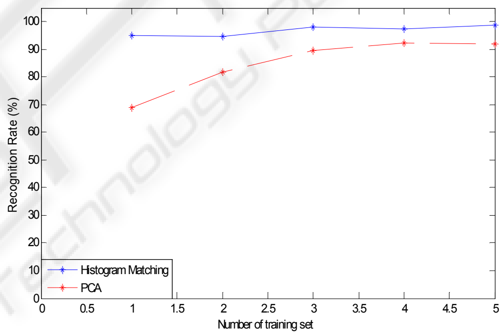

Figure 2: Recognition Rate (%) of images for changing poses.

4 CONCLUSIONS

In this paper we introduced a novel face recognition system based on grey level histogram matching. Maximum cross correlation coefficient between the histogram of a given face and the histograms of the faces in the database was used for histogram matching. 98.80% recognition rate on the HP database of 15 face subjects was obtained by using the proposed method while this rate was down to 92% in the case of conventional eigenfaces. It has been shown that due to the high correlation between the histograms of the faces at different poses, the proposed system is robust for pose changes.

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