A Compressive Sensing Based Robust Face Recognition Method

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Abstract: In this paper an integrated face recognition method has been proposed to recognize the face images. This integrated framework combines the compressive sensing (CS) and Local Binary Pattern (LBP). The image is at first divided into small blocks and local binary pattern is generated corresponding to each block. Features are extracted from the LBP transformed image using blockwise histograms with variable no of bins. For classification we use compressive sensing based sparse representation classification (SRC). To study the robustness of our method, the classifier is studied on clean and occluded images. The experimental results give promising performance of the proposed face recognition method on JAFFE and ORL database

Keywords: Face recognition; compressive sensing; local binary patterens.

1 INTRODUCTION

Face recognition is a challenging problem in the field of image analysis and computer vision. Many researchers in face recognition have been dealing with the challenge of pose variations, illumination differences, facial expressions and occlusions. Efficient recognition algorithm can reduce the effect of noise and other challenges. Automatic face recognition accuracy involves two important steps: first one is facial feature extraction techniques and second is classifier design.

A number of methods have been developed for extracting features from the face images. Recently developed MGA tools are widely used in feature extraction, such as curvelet [1, 2], bandlet and contourlet [3, 4] etc. N. G. Chitaliya and A. I. Trivedi proposed a contourlet and Principal Component Analysis (PCA) based face recognition method in [5]. Their results show that the proposed method performs better than the method based on wavelet transforms. Wang et al. [6] have developed an efficient face recognition method based on contourlet and SVM. Huang et al. [7] built a face recognition method based on illumination invariant features in contourlet domain showing results which are effective and competitive with respect to other methods.

Classifier design is another important task in case of face recognition problem. Recently Compressive sensing based classifier named as sparse representation classifier (SRC) is widely used in face recognition. Actually Compressive sampling or compressive sensing technique presents a new method to capture and represent compressible signals at a rate significantly below the Nyquist rate. This CS based SRC classifier shows better performance than the other classifiers. At first Wright et al. [8] proposed the SRC classifier to solve the face recognition problem. In this work

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Wright et al. [8] deals with different type of features like Eigenface, Fisherface, Randomface.

In the paper, a novel face recognition method based on CS is presented where features are extracted using histogram analysis of LBP image. In real world scenario images are corrupted with noise. To study this problem, we presented a CS based new face recognition method which shows robustness under the effect of occlusion.

Rest of the paper is organized as follows: Section II presents background and mathematical preliminaries, Section III presents the proposed CS based face recognition method and in section IV results are presented, while section V concludes the paper with a brief discussion.

2 BACKGROUND AND MATHEMATICAL PRELIMINARIES

In this section we briefly discuss the LBP operator, SRC classifier and SRC algorithm for classification.

2.1 Local Binary Patteren(LBP)

A powerful method to describe the texture and shape of digital image is Local Binary Pattern (LBP), which is recently widely used for feature extraction in face recognition systems. LBP is a binary code for an image-pixel which gives information about the local neighborhood of that pixel. The original LBP operator was introduced by Ojala [9], as shown in Fig. 1. This operator works with eight neighbors of a pixel, using the value of this center pixel as a threshold. If a neighbor pixel has a higher gray value than the center pixel (or the same gray value) than a one is assigned to that pixel, else it gets a zero. The LBP code for the center pixel is then produced by concatenating the eight ones or zeros to a binary code.

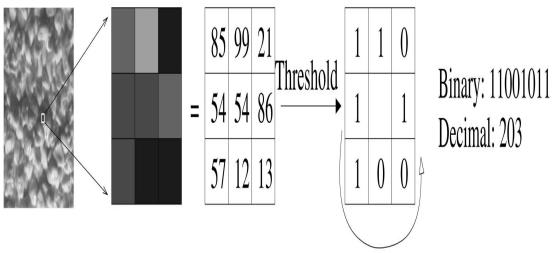


Fig. 1. The basic LBP operator [9].

2.2 Sparse Representation Classifier

In the sparse representation based classification (SRC) method the test image is considered as the linear combination of training images as y=Ax_0. The algorithm of SRC classifier is given below:

SRC Algorithm[8]

1. Input: A matrix of training samples

A= A= [A_1, A_1,..., A_k] $\epsilon R^{m\times n}$ for k classes, a test sample y ϵ R^m, (and an optional error tolerance $\epsilon>0$)

2. Normalize the columns of A to have unit l_2 norm.

3. Solve the l_1 minimization problem:

$$\left(\hat{x}_1\right) = {}^{\arg\min}{}_x \left\|x\right\|_1 s.t. Ax = y$$

(Or alternatively solve

$$\left(\hat{x}_1\right) = {}^{\arg\min}_{x} \left\|x\right\|_1 s.t. \left\|Ax - y\right\| \le \epsilon \text{)}$$

4. Compute the residuals $r_i(y) = \left\| y - A\delta_i\left(\hat{x}\right)\right\|_2$

5. Output identity(y) = ${}^{\arg\min}_{i} \{r_i(y)\}$

3 PROPOSED METHOD

The block diagram of the proposed method for face recognition is shown in Fig. 2, consisting of four main modules: pre-processing, LBP, feature extraction and classification.

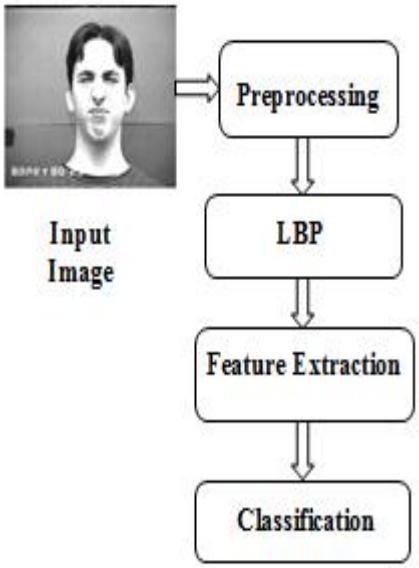


Fig. 2. Flow diagram of face recognition method.

At first Gaussian smoothing filter is applied on face image and image is resized. Then histogram equalization is performed to overcome the illumination differences. The preprocessed image is transformed to an image of texture pattern image by introducing LBP. The preprocessed image is first divided into small blocks, and we calculate LBP image of each block. The binary pattern for each block is obtained after thresholding and represented by equivalent decimal value. To extract features from the LBP image calculate the

histogram for each block. Concatenating the histogram of all blocks, features are obtained. Then SRC is used for the classification.

4 RESULTS

The proposed algorithm was tested on two publicly available database first one is JAFFE and another is ORL database. During experiment we have extracted features for different resized image and different block size, and for each block size we have calculated the histogram by increasing no. of bin from 5 to 59.

4.1 JAFFE Database

The database contains 230 images of 7 facial expressions (6 basic facial expressions + 1 neutral) posed by Japanese female models. The facial expressions of a Japanese female are shown in Fig. 3. This face database consists of 10 persons with 23 images per person. For each person first 10 images are used as training and others are used as test samples. For JAFFE database the resized image (32×32) and block size (8×8) gives the best recognition accuracy as shown in Table. I. The technique achieves maximum accuracy of 99% for 59 bins. We observe that the accuracy increases with increase of no of bins up to 59.

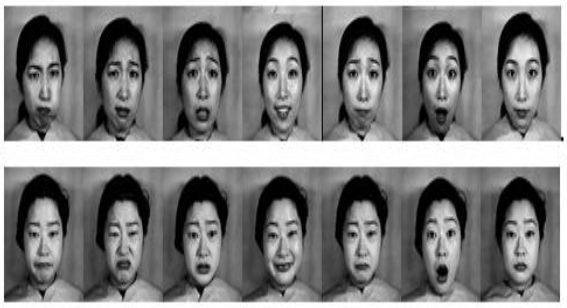


Fig. 3. Face images of different expressions.

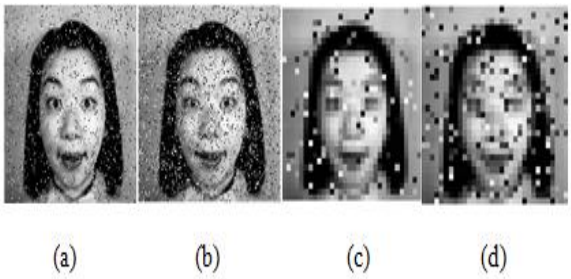
Table 1. Recognition rate for JAFFE database.

Image size	Block size	No of bin	Feature length	Recognition rate
32×32	8×8	9	144	81%
		15	240	94%
		23	368	97%
		33	528	98%
		45	720	98%
		59	944	99%

4.2 ORL Database

The ORL database contains images of 40 individuals, each providing 10 different images as shown in Fig 4. This database comprises 400 frontal and near frontal face images (rotation of the face up to 20 degrees) and some of facial images are with spectacles and various facial expressions (open or closed eyes, smiling or no smiling). There are also some variations in the scale of up to 10 percent and all the images are grayscale and normalized to 92×112 pixels. In this experiment our aim was to check the recognition accuracy under slight rotations, various expressions and with spectacles.

Fig. 4. Some sample images of ORL face database.



(a) (b) (c) (d)

Fig. 5. A corrupted image example (a)Resized to 128×128 with 10% corrupted, (b) Resized to 128×128 with 20% corrupted, (c) Resized to 32×32 with 10%corrupted (d) Resized to 32×32 with 20% corrupted.

Table 2. Recognition rate of ORL database.

Image size	Block size	No of bin	Feature length	Recognition rate
110×150	18×21	9	432	93%
		15	720	97.5%
		23	1104	98%
		33	1584	99%
		45	2160	99%
		59	2832	100%

4.3 Effect of Random pixel occlusion

Randomly chosen pixels location from the each test image are replaced by random values in the range [0, Mi], Mi is the maximum pixel value in the ith test image. This effect of pixelwise occlusion is depicted in Table III. We have varied the percentage of occlusion up to 20% and observed the recognition rate is slightly decreases. It is also noticed that upto 10% pixel occlusion, the proposed method is almost robust.

Table 3. Result of pixel Occlusion for JAFFE and ORL database.

Database	Image size	Block size	% of occlusion	No of bin	Recognition rate
JAFFE	32×32	8×8	10%	59	99%
			20%		91%
ORL	110×150	18×21	10%	59	99%
			20%		93%

5 CONCLUSION

In this paper we present a new technique for efficient face recognition method utilizing compressive sensing based classifier (SRC classifier). Classification accuracy shows effectiveness of the proposed feature extraction method. Experimental results on two widely use database JAFFE and ORL shows, that the proposed method is robust under the 10% pixel occlusion.

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