Facial expression recognition based on Local Binary Patterns

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Abstract

Extraction methods of facial expression characteristics have disadvantages according to Classical LBP such as complexity and high dimensions of feature vectors that make it necessary to apply dimension reduction processes. In this paper, we introduce an improved LBP algorithm to solve these problems that utilizes Fast PCA algorithm for reduction of vector dimensions of extracted features. In other words, proffer method (Fast PCA+LBP) is an improved LBP algorithm that is extracted from classical LBP operator. In this method, first circular neighbor operator is used for features extraction of facial expression. Then, an algorithm of Fast PCA is used for reduction of feature vector dimensions. Simulation results show that the proposed method in this paper in terms of accuracy and speed of recognition, has had a better performance compared with the same algorithm.

Keywords: Facial Expression Recognition, Local Binary Pattern, Support Vector Machine, Principal Component Analysis, Linear Discriminant Analysis

1-Introduction

Since 1965 has been a high growth area in image processing research. In addition to spatial researches, the techniques of image processing are used in some other cases including face recognition and the recognition of facial expression can be noted. The system of facial recognition is a biometric-based recognition system that uses \automated and smart approaches in detecting the facial expression of a person [1]. The facial expression recognition system is composed of three sections according to figure 1 as follow: face detection, feature extraction and classification. Facial detection is the detection of human face recognition from the image background which is a solved problem. Second stage is the extraction of effective features from the images of face (by the use of facial properties-based algorithm or appearance-based methods) in such a way that it provides an appropriate pattern for the separation of different face expression from each other.

2-The Overall Structure Of Facial Expression Recognition

The last and third stage is the classification of extracted feature vectors of face images in order to be used for face expressions recognition. Designing a suitable classifier that can discriminate different face expressions carefully and speed atop of each other، possible has been especially important [2].

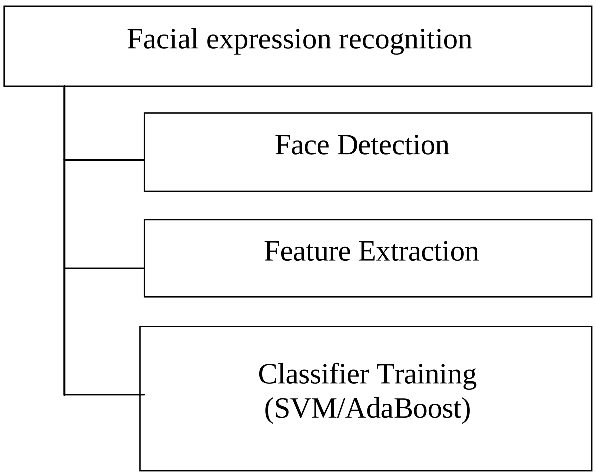

Fig .1 . Facial expression recognition system [2]

The goal of the above mentioned stages is that first by the use of face images by specified and predetermined expression, classifier is being trained. Then, the recognition system has to able to detect the face expression to a test image automatically. In many cases, 7 expressions that show figure 2 are considered as the predetermined expressions for the face images in the training of classifiers.

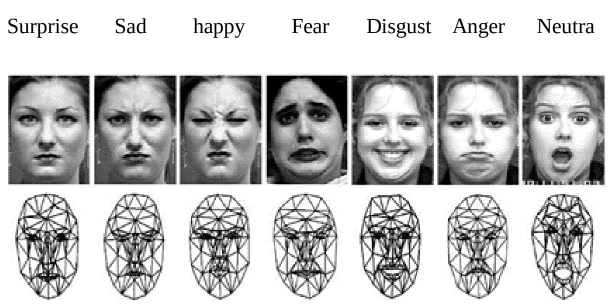

Fig.2.seven canonical expression of facial expression

3-Local binary pattern (LBP)

One of the common methods for the extraction of effective features of face images is LBP. LBP features were originally proposed for texture analysis and recently been used for extraction feature to analyze the face image [3]. The most important properties of LBP features are their resistance against illumination changes and their low computation complexity [4]. For example, LBP features compared by the extracted features by using Gabor filter and it was concluded that LBP based features for low resolution images redound in better results [2].

4- Proffer Method

The proffer algorithm in this paper is based on the LBP based feature extraction method and then, reduction of feature vectors dimension is based on Fast PCA method. In the following, proffer method is illustrated step by step:

1) To locate and extraction face in images by using the common detection algorithms;
2) To convert the images to gray levels (in the case of being color) and balancing the images histogram in order to enhance the uniformity against illumination in different areas of the face;
3) division of areas and LBP algorithm based feature extraction;
4) Collecting all of the blocks to generate a complete histogram of image face expression;
5) Reduction dimension of the LBP feature vectors by Fast PCA algorithm;
6) Using an appropriate classifier for facial expression recognition;

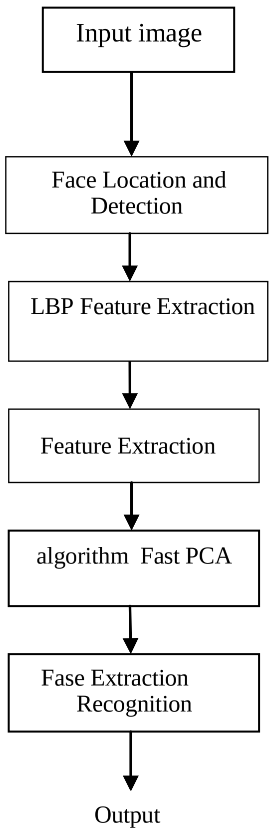

Fig .3.Facial expression recognition based offer methods (Fast PCA+LBP)

In the first part of algorithm, facial image must be logged to system. The images used in this paper were chosen from JAFFE database which contain 213 images. These images belong to 10 different people and include 7 standard face expression (anger, Disgust, Fear, Happy, Neutral, Sad, Surprise) through which almost there are two or three face expressions for every person.

In this paper, for every person an image of every expression were taken as a test data. In fact, for 10 person and 7 different face expression, 70 images were taken as the test data and 143 images as the training data. As a result, training data comprised %67 and test data formed %33 of all used images

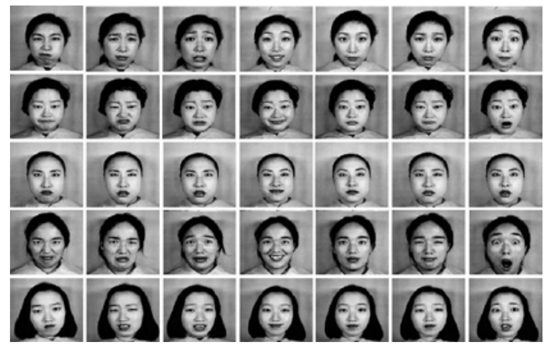

Fig .4. The sample faces expression images from the JAFFE database [5]

In the second part of the algorithm, we should put about preprocessing images that at this stage using the histeq command in MATLAB environment, the smoothing of histogram on all images is done. Then, if the images are colorful; they were converted to gray scale.

Given the pixel position (x_c, y_c) with the gray scale value g_c, we define texture local $T = t(g_c, g_0, g_1, ..., g_7)$ through which, g_i $(i = 0,1,...,7)$ environs denote the 8 pixel gray scale. To compare the related densities between the central pixel and its neighboring pixel, we rewrite T such a binary $T \approx t(S(g_0 - g_c), ..., S(g_7 - g_c))$ that function $S(x)$ is defined as follow:

$$S(x) = \begin{cases} 1 & when\ x > 0 \\ 0 & when\ x \le 0 \end{cases} \quad (1)$$

So, the binary pattern of pixel local is defined as a series orderly of binary compounds and the value of result is given by:

$$LBP\left(x_c, y_c\right) = \sum_{i=1}^{7} S\left(g_i - g_c\right)2^i \qquad (2)$$

At the end of this stage, local binary pattern is represented as a vector for any image and then, the binary pattern of all images is saved in a matrix that will be used in the next stage. The next part of the algorithm is the reduction of the dimension of feature vectors in order to simplify the statistical distribution of data prior to entering into classifier. For this purpose, we apply the improved algorithm of principal component analysis called Fast PCA.

The process of the reduction of the dimensions of feature vectors is so important; because high dimension of LBP feature vectors (in our experiments equals to 2478), lowers the effectiveness of classification stage (either in the training stage or test one). Distribution of extracted feature vectors from the face images presented in the above database is such that most of facial images by the same expression focus in the special area of coordinate system; while the different facial expression and different positions of main components such as eye, nose, and mouth are distributed in the scattered areas of feature space. so, based on data distribution in the feature space we can find that the necessary mean dimensions for feature vectors is between 300 and 500, that this reduction of dimension in the proffer method in paper is done by Fast PCA algorithm. Having a training image D, in the size $m \times n$ and the dimensions equal to $N = m \times n$, the experiment begins. We transpose the training sample of i-th image in the one dimensional column vector, so the set of training sample D image equals to:

$$X = \left\{x_1, x_2, \ldots, x_N\right\} \qquad (3)$$

The average training sample is equals to:

$$X = \frac{1}{N}\sum_{i=1}^{N} x_i \qquad (4)$$

Since the size of the sample X matrix is equal to $d \times n$ (d is n dimensional feature vector); the covariance matrix S is equal to $n \times n$ through which the dimensions of d is big and the calculations are very complicated. So, for computing the value of nonzero characterization of matrix S according to intrinsic vectors, we apply Fast PCA. $Z_{d \times n}$ is a matrix calculated from any sample matrix X minus sample mean $\overline{X}$, so covariance matrix S is equal to $\left(Z^T Z\right)_{d \times d}$.

Given that n dimensional column vectors are the characteristic value $\vec{v}$ of R, thus:

$$\left(Z^T Z\right)\vec{v} = \lambda\vec{v} \qquad (5)$$

Both sides are multiplied in z^T and we apply correlation law of matrix multiply, so:

$$\left(Z^T Z\right)\left(Z^T \vec{v}\right) = \lambda\left(Z^T \vec{v}\right) \qquad (6)$$

Eq. 6 shows that $Z^T\vec{v}$ is the characteristic value of covariance matrix $S = \left(Z^T Z\right)_{d \times d}$ and illustrates characteristic value $Z^T\vec{v}$ by converting small characteristic value $\vec{v}$ of matrix $R = \left(ZZ^T\right)_{n \times n}$ and obtains multiplying it to Z^T which is obtained through covariance matrix $S = \left(Z^T Z\right)_{d \times d}$.

5-Imagery And Experiments Results

At this paper, Classifier KNN for extracted feature vectors classification from face expression was used by use of proffer method. As mentioned previously; in the tests at this stage, for training we use %67 of database images and test data with the remaining images. Test images' labels are compared by KNN classifier output labels of specified expression samples (7 standard expressions) and then, the results obtained from comparisons are used to compute the recognition rate of proposed algorithm.

The finding results are summarized in table 1 and figure 5. In addition to the results of proposed method, the results obtained from classic feature extraction algorithm LBP are shown, too. As it can be seen in table1, recognition accuracy of hate, fear angry and natural expressions by the use of Fast PCA + LBP is more than classic algorithm. Also, the mean recognition rates of standard face expressions by the proposed Fast PCA + LBP algorithm is more than circular neighborhood LBP algorithm (classic feature extraction method). In other words, the proposed methodology in the present paper in the feature extracting of images for recognition of face expression is accurate and effective. Test and training time for identification of face expressions is 0.74 by our suggested approach which is done in relatively during a little time compared to other methods. The obtained times are shown in table 2.

Table.1.Compared recognition accuracy LBP and Fast PCA+LBP with radius 1/5 and Neighborhood 4

Expression	LBP	SVM	Fast PCA+LBP
Anger	78/7	82/8	80
Disgust	85	84/5	100
Fear	61/7	68	90
Happy	90/4	91/7	70
Sad	72/4	69/5	60
Surprise	92/4	92/2	80
Neutral	70/3	74/3	90
Average	78/7	80/42	81/43

Table. 2 .Compared train and test time LBP, SVM, Fast PCA+LBP

	Test time	Train time
LBP	0/84	1/02
SVM	0/81	0/87
Fast PCA+LBP	74/0	74/0

CONCLUSIONS

As seen from the test result, the proposed method for facial expression (Fast PCA + LBP) in comparison with LBP classic has more accuracy and high recognition rate. And also it can be argued that the facial expression recognition speed compared with classic method is high because of utilizing Fast PCA algorithm after applying LBP algorithm results in reduction of feature vectors that, in turn, causes reduction of test time. In general, it can be concluded that the proposed algorithm in the paper has a rather high efficiency and performance regarding both speed and accuracy aspects.

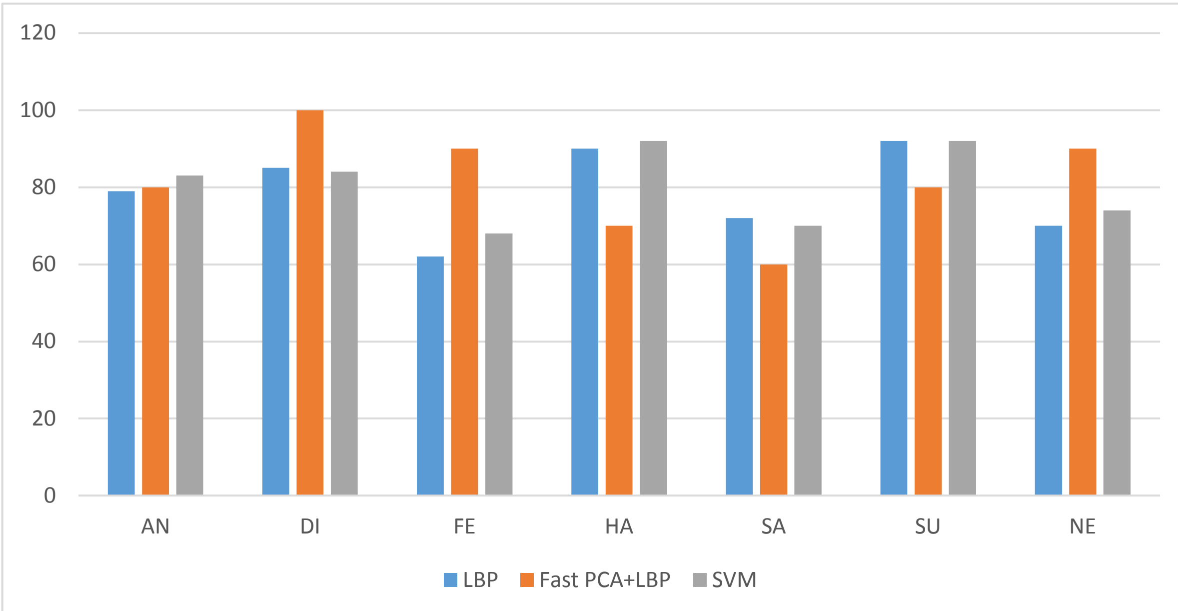

Fig .5.recognition accuracy LBP and Fast PCA+LBP with radius 1/5 and Neighborhood

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