Feature Extraction using Local Binary Pattern: An Application for Illumination Invariant Facial Expression Recognition

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Abstract—Facial expressions play an important role in the area of human computer interaction. They are most commonly used for interpretation of human emotions. Three are 6 emotions which are universally accepted. They are happy, sad, angry, disgust, fear, and surprise. In this paper, application of local binary pattern (LBP) for facial expression recognition in different illumination conditions has shown. The proposed method consists of mainly three sub tasks: Pre-processing, Facial feature extraction and Facial expression classification. LBP is used for feature extraction. The extracted features are used as an input to the classifier for expression classification. For experimental purpose, the JAFFE (Japanese Female Facial Expression) database and self created database containing images with variation in illumination are used.

Keywords—Feature Extraction, Local Binary Pattern, Illumination Variation, Expression Classification.

I. INTRODUCTION

Facial expressions are most powerful means for humans to express their emotions and intensions. A study by Mehrabian [1] says that 7% of message is expressed by words, 38% by voice pitch while 55% of message is conveyed by facial expressions. Facial expressions play an important role in human communications. Humans are capable of producing hundreds of facial actions during communication that carries different meaning. According to Ekman's theory [2], excluding neutral, there are six expressions that are universal for people of different nations and cultures. Those basic expressions are happy, sad, angry, disgust, fear, and surprise.

Numerous applications of automated facial expression recognition system include automated tools for behavioral research, psychological studies, face animation, speech synthesis, lip reading, video conferencing, robotics and many more [3].

Facial expression recognition task is considered to be very challenging task due to many reasons. Expressions vary from persons to persons. Also, the expressions do change at time and also depend on human mood. The most challenging problems in the task of facial expression recognition include variation in lighting condition, also known as illumination, non-frontal face images, that is pose variance and the occlusions, that is the presence of hair, various accessories like glasses etc.

Variation in lighting conditions affects the feature extraction process. The changes in illumination may make some of the features invisible or lightly visible, which finally may affect on the classification. Similarly, occlusion like presence of hair or spectacles may obscure some part of the face. Occlusions can introduce errors into the predicted expression or result in an incorrect expression due to the loss of few of the important features. Also, non-frontal faces need to be taken care differently. Here too, some part of the face will be invisible which will make feature extraction process more complex.

Plenty of work has been done on facial expression recognition [16-21]. An automatic classification of facial expressions consists of two stages: feature extraction and feature classification. The feature extraction is extremely important to the whole classification process. If insufficient features are used, even the best classifier could fail to achieve accurate recognition. In most cases of facial expression classification, feature extraction process produces sufficiently large number of features and consequently a smaller sub-set of features needs to be selected according to some optimality criteria.

This paper addresses the issue of change in illumination for facial expression recognition where Local Binary Pattern is used for feature extraction. The work presented here is experimented on two databases. JAFFE [15] (Japanese Female Facial Expressions) database contains images of different expressions of 10 subjects with different lighting conditions. Another database used for the experiments is self created. It also contains images of different expressions of 10 subjects, 08 female and 02 male, with different lighting conditions. Preprocessing

operations have been performed to normalize the image. Local binary pattern method is used for extracting features of the expressions. Finally, classification is done with the help of neural network.

The rest of the paper is organized as follows. Section 2 describes the facial expression recognition methodology with necessary steps to be followed. In section 3, LBP method, used for the feature extraction purpose, is described. Section 4 gives analysis of results. Section 5 summarizes the overall work.

II. FACIAL EXPRESSION RECOGNITION METHODOLOGY

As shown in figure 1, facial expression recognition is a process which consists of following three steps [IEEE paper].

- Pre-processing the image
- Extracting facial expression features from normalized image. This can be done by analyzing the change in the appearance of facial features or change in the location of facial features.
- Classification of expressions into six universal categories such as angry, happy, disgust, fear, sad and surprise with the help of extracted features.

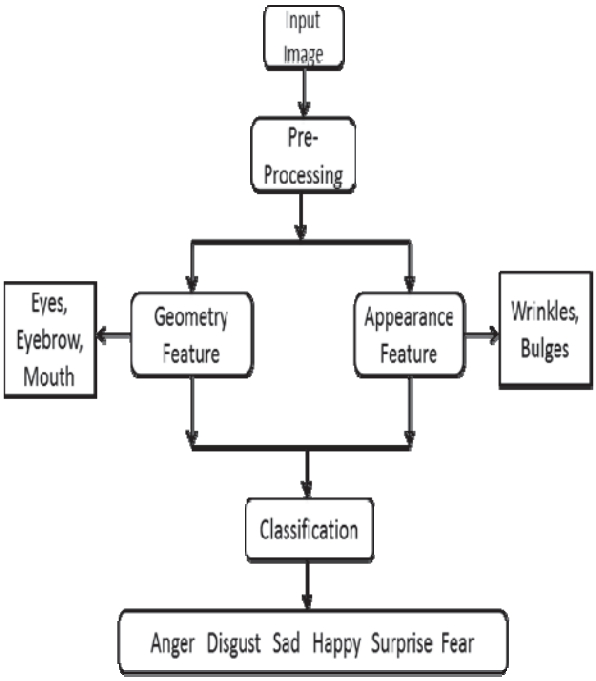


Figure1. FER Methodology

A. Pre-processing:

Recently, more researchers focus on robust facial expression recognition such as expression recognition systems invariant to pose and illumination variations. Illumination variation is still a challenging problem in face recognition research area, especially for appearance-based approaches. The same person can appear greatly different under varying lighting conditions. The human visual system usually cares about the main features of a face, such as the shapes and relative positions of the main facial features.

There are two approaches to deal with this issue. One approach is to apply image pre-processing techniques which normalize the images to appear stable under different lighting conditions. This approach removes illumination variations while keeping the main facial features unimpaired. Histogram equalization (HE), Gamma correction, logarithm transform, DCT normalization etc. are widely used for illumination normalization [4], [5], [6].

Second approach attempts to extract facial features which are invariant to illumination variations. Edge maps, derivatives of the gray-level, Gabor-like filters and Local binary pattern are few of the methods used for the stated purpose [7] [8].

B. Feature Extraction:

Feature extraction is the most important part of expression recognition process. Features are the characteristics of the face which carries significant amount of information about expressions. The recognition rate of the system highly depends upon how accurate the extracted features are.

For an expression recognition process, features that are generated by contractions of facial muscles are considered. It includes deformation of facial features such as eye lids, eye brows, nose, lips, mouth etc. Based upon the type of features, the feature extraction approaches are divided into two categories [9]:

- Focusing on facial features or areas that are prone to change with facial expressions.
- Focusing on those features which would be generated due to facial expressions.

C. Classification:

After the face and its appearance have been perceived, the next step of an automated expression analyzer is to identify the facial expression conveyed by the face. A fundamental issue about the facial expression classification is to define a set of categories we want to deal with. Facial expressions can be classified in various categories such as Anger, Disgust, Sad, Happy, Surprise and Fear [9] [10], as shown in figure 2.

Figure2. Universal Facial Expressions

The most popular classification methods include nearest neighbour, K-means classifier, neural network, and SVM.

The LBP operator was originally designed for texture description. The operator assigns a label to every pixel of an image by thresholding the 33-neighborhood of each pixel with the center pixel value and considering the result as a binary number. Then, the histogram of the labels can be used as a texture descriptor.

III. FEATURE EXTRACTION USING LOCAL BINARY PATTERN

LBP features were proposed originally for texture analysis [11] and recently have been introduced to represent faces in facial image analysis [12-14]. The most important properties of LBP features are their tolerance against illumination changes as well as their computational simplicity.

The LBP operator labels the pixel of an image by thresholding a 3*3 neighborhood of each pixel with the centered value and considering the result as a binary number (as shown in Figure 3) and 256-bin histogram of the LBP labels computed over region is used as a texture descriptor. The derived binary numbers (called LBP features or LBP codes) represents texture features including different types of curved edges, spots, flat areas, etc (as shown in Figure 4).

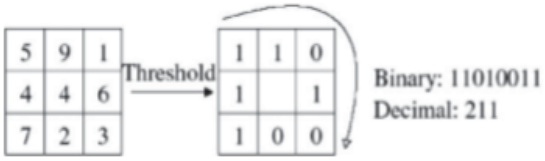


Figure3: The Basic LBP Operator

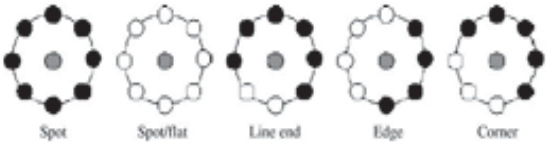


Figure4: Texture primitives which can be detected by LBP

After labeling an image with LBP operator, histogram of the labeled image F1(x, y) can be defined as

$$Hi = \sum_{x,y} I(F1(x,y) = i), i = 0,1 \ldots n-1$$

Where n is number of different labels produced by the LBP operator and

$$I(A) = \{1 \text{ if } A \text{ is true} | 0 \text{ if } A \text{ is false}\}$$

This LBP histogram contains information about the distribution of the local micro patterns; such as edges, spot and flat areas over the whole image, so it can be used to statically describe image characteristics.

IV. Implementation

The work in this paper presents an efficient illumination invariant facial expression recognition system using Local Binary Pattern. JAFFE (Japanese Female Facial Expression) database is used which contains 177 images of 6 facial expressions posed by 10 Japanese female models. IFE (Indian Facial Expression) database is used which also contain 177 images of 6 facial expressions posed by 10 Indian people including 2 males and 8 females. The IFE database is self created database. The expressions in this database are posed by Indian people.

Classification of expressions into six universal categories, [9][10] such as smile, happy, anger, disgust, sad and fear have been done with two approaches: Euclidian distance and Neural Network.

Euclidian distance is the measure between the features of input image and database images. The feature vector obtained from LBP histogram of the input image is compared with database images with the help of Euclidian distance. The one which is having minimum Euclidian distance is considered as best match.

In the case of classification using Neural Network approach, a feed forward neural network is used.

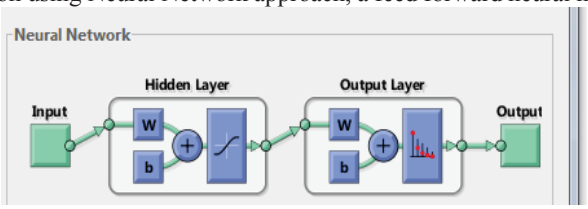


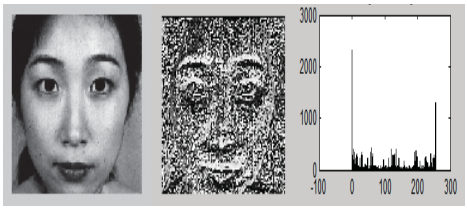
Figure5: Neural Network Architecture

In this network, input layer contains 256 neurons as LBP histogram with 256 bins is extracted from each input image and to be given as an input. The number of neurons in hidden layers is taken as 35 and output layer contains 6 neurons as there are 6 expressions to be classified.

V. Experimental Results

The results for each stage mentioned above are collected separately. The results are collected and analyzed for two databases viz. JAFFE and IFE. Also, the analysis has been shown between the results of two classifiers for both databases mentioned above.

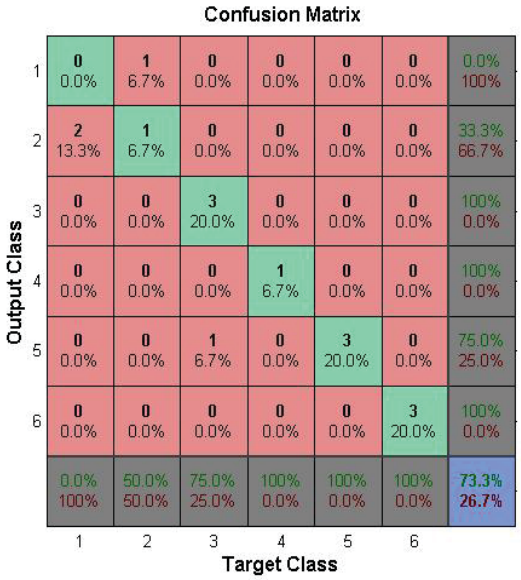
A. Result of LBP feature:.



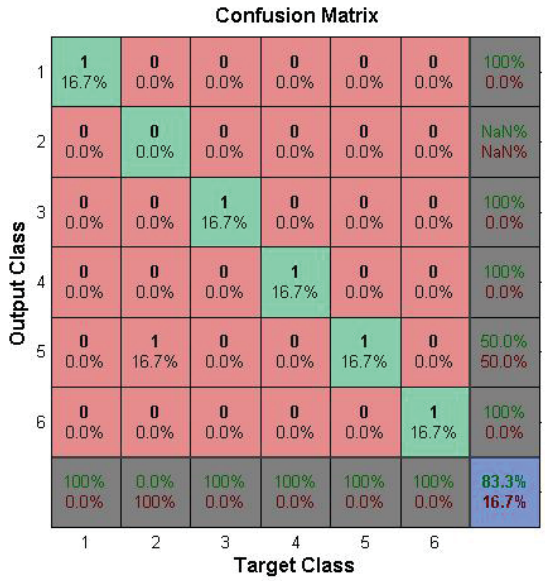
(a) (b) (c)

Figure6. (a) Input Image (b) LBP features (c) histogram of LBP features

B. Result of classification using Euclidian Distance:



C. Result of classification using Neural Network:



D. Result Analysis:

Following table shows the analysis of results collected for different number of test images for both databases. The numeric notation used for types of Expressions is: 1 to 6 for Angry, Disgust, Fear, Happy, Sad, and Surprise respectively.

Results for JAFFE Database								
No of Test Images	Type of Expressions						Recognition Rate	
	1	2	3	4	5	6	LBP with Euclidian distance	LBP with Neural Network
04	00	00	02	00	00	02	80%	50%
06	01	01	01	01	01	01	73%	83%
10	01	01	03	01	01	03	54%	50%
15	02	02	04	01	03	03	73%	50%
20	03	03	03	04	03	04	68%	47%
30	05	05	05	05	05	05	70%	30%
Results for IFE Database								
No of Test Images	Type of Expressions						Recognition Rate	
	1	2	3	4	5	6	LBP with Euclidian distance	LBP with Neural Network
04	00	00	02	00	00	02	50%	75%
06	01	01	01	01	01	01	83%	67%
10	01	01	03	01	01	03	70%	70%
15	02	02	04	01	03	03	87%	93%
20	03	03	03	04	03	04	75%	75%
30	05	05	05	05	05	05	93%	73%

VI. CONCLUSION

The work in this paper concentrates on performance of Local Binary Pattern for illumination invariant facial expression recognition for two different databases. LBP works satisfactorily well, even though the images are not pre-processed to remove illumination changes. It is concluded from the results that LBP turn to be an efficient method for feature extraction for the purpose of expression recognition, whatever may be the classifier. It works reasonably well with both databases, namely, JAFFE and IFE. The number of LBP feature points can be extracted from different regions of face and combined features can be used for better recognition rate.

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