International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Facial Expression Recognition for Color Images Using Log Gabor filter and PCA

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Abstract: ***Facial expression recognition (anger, sad, happy, disgust, surprise, fear expressions) is application of pattern recognition and classification task. Through facial expression human beings can show their emotions. Its applications are in human-computer interaction (HCI), robotics, border security systems, forensics, video conferencing, user profiling for customer satisfaction, physiological research etc. This paper presented a Facial Expression Recognition system based using Log Gabor Filter and PCA. Euclidean distance is used as a classifier. The proposed system is designed and tested with FEI database. Two emotions to be recognized are happy and neutral.***

Keywords: Log-Gabor filter, PCA, Euclidean distance, FEI database, YCb Cr.

1. Introduction

Facial expression is one of the most powerful and natural means for human beings to show their emotions. It is the position or movement of the muscles beneath the skin of the face. This movements show the emotional state of an individual. The research study by Mehrabian [2] has indicated that 7% of the communication information is transferred by linguistic language, 38% by paralanguage, and 55% by facial expressions in human face-to-face communication. This, therefore, shows that facial expressions is important and give a large amount of information in human communication.

Recognition of facial expression is often a hard task. FACS (Facial Action Coding Systems) describes the changes in facial expression that human can detect by observing changes in facial muscles. Each component of facial movement is called an Action Units. It was published by Ekman and Friesen in 1978 [1]. FACS describes 44 Action Units. Facial expression recognition is an interesting and challenging area. Its application is found in many areas like human-computer interaction (HCI), robotics(AIBO robots), border security systems, forensics, machine vision, video conferencing, user profiling for customer satisfaction, physiological research etc.

Facial expression analysis consists of two different approaches and each approach has two different methodologies. When whole of the frontal face is use and processes in order to end up with the classifications of 6 universal facial expression prototypes: disgust, fear, joy, surprise, sadness and anger gives the outlines the first approach. Instead of using the whole face images, we can divide them into some sub-sections for further processing and this form up the main idea of the second approach for facial expression recognition. Geometric Based Parameterization is an old way which consists of tracking and processing the motions of some spots on image sequences. Facial motion parameters and the tracked spatial positioning & shapes of some special points on face, are used as feature vectors for the geometric based method. Rather than tracking spatial points and using positioning and movement parameters that vary within time, color (pixel) information of related regions of face are processed in Appearance Based Parameterizations.

This paper is organized as follows: In Section 2 pre-processing task is explained. Section 3 provides a detailed of proposed methodologies. Section 4 describes the experimental results that were obtained. Finally, conclusions are in Section 5.

2. Image Preprocessing

Initially the color images are grouped into testing and training images. Training and testing images are normalized into uniform intensity, size and shape.

2.1 Face detection

Face detection is the first step of facial expression recognition system. The aim of face detection is to obtain the detected face with normalized intensity, size and shape. The input images are in RGB format.

2.1.1 Color Transformation:

RGB components are subjected to lightning conditions. Therefore if lightning condition changes, face detection may fail. So RGB images are first converted to YCbCr color space, where Y contains luminance information, Cb and Cr contain chrominance information. The obtained images are normalized using the formula:

$$new\_Y = 255*(Y-minY)/(max\,Y-min\,Y)$$

2.1.2Skin Extraction

In the skin color detection process pixels was classified as skin or non-skin based on mean and standard deviation of Cb and Cr component.

2.1.3 Noise Removal

Noise like background, hairs etc. are removed using median filter. In median filter a window slides along the image and the median intensity value of the pixels becomes the output intensity of the pixel that is being processed.

3. Methodology

3.1 Feature Extraction

Feature extraction is one of the Feature extraction is one of the most imporatnt part of facial expression recognition. It is the process of extracting and isolating imporatant desired feature from the face. Feature extraction converts pixel data into a higher-level representation - of shape, motion, colours, texture, and spatial configuration of the face or its components. Deriving an effective facial representation from original images is an important step for successful facial expression recognition. If inadequate features are used, even the best classifier fails to achieve accurate recognition. In this paper we will discuss Gabor filter, Log-Gabor filter, Local Binary Pattern for feature extraction.

3.1.1 Log Gabor filter

Gabor filters are a traditional choice for obtaining localized frequency information. They offer the best simultaneous localization of spatial and frequency information. However they have two main limitations. The maximum bandwidth of a Gabor filter is limited to approximately one octave and Gabor filters are not optimal if one is seeking broad spectral information with maximal spatial localization. An alternative to the Gabor function is the Log-Gabor function proposed by Field [1987]. Log-Gabor filters can be constructed with arbitrary bandwidth and the bandwidth can be optimized to produce a filter with minimal spatial extent. Gabor filters are not optimal to achieve broad spectral information with the maximum spatial localization. Furthermore, the Gabor filters are band pass filters, which may suffer from lost of the low and the high-frequency information. To achieve the broad spectral information and to overcome the bandwidth limitation of the traditional Gabor filter, Field proposed Log-Gabor filter. The response of the Log-Gabor filter is Gaussian when viewed on a logarithmic frequency scale instead of a linear one. This allows more information to be captured in the high-frequency areas with desirable high pass characteristics. One cannot construct Gabor functions of arbitrarily wide bandwidth and still maintain a reasonably small DC component in the even-symmetric filter. Log-Gabor functions, by definition, always have no DC component.

$$G(f) = exp\left\{\frac{-\left[log\left(\frac{f}{f0}\right)\right]^2}{2\left[log\left(\frac{f}{f0}\right)\right]^2}\right\}$$

Therefore Log-Gabor filter can achieve better performance than Gabor filter. The sample image after normalization is shown in figure 1 and its corresponding Gabor Features are shown in figure 2.

Figure 1: Sample Image

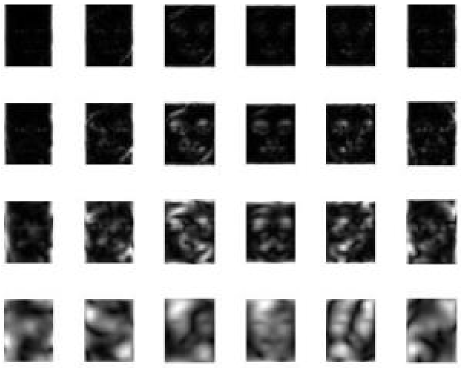

Figure 2: The magnitudes of the Gabor feature representation of the sample face image

3.2 Feature Reduction

Feature reduction or feature compression is a process of reducing excessive dimensionality of extracted feature from feature extraction step. Linear methods project the high dimensional data onto a lower dimensional space. PCA (Principle Component Analysis) can be used for feature reduction.

3.2.1Principle Component Analysis (PCA)

Principle Component Analysis also known as Karhunen-Loeve method is one of the most popular method for dimension reduction. It is also known as Eigenface method. PCA is mathematically defined as an orthogonal linear transformation that transforms the data to a new coordinate system. The greatest variance by any projection of the data comes to lie on the first coordinate (called the first principle component), the second greatest variance on the second coordinate and so on. [3].

Consider a set of N sample images, $\{X_1,X_2,....X_N\}$ represented by t-dimensional Gabor feature vector. The PCA can be used to find a linear transformation mapping the original t-dimensional feature space into a g-dimensional feature subspace, where normally $g<<t$, the new feature vector is conducted with following equation [5] [4]:

$$y_i = W_p X_i i = 1... N$$

Where $W_p$is the linear transformations matrix, i is the number of sample images.

The columns of Wpare the g eigenvectors associated with the g largest eigenvalues of the scatter matrix $S_{T,}$ which is defined as:

$$S_T = \sum_{i=1}^{N}(X_i - \mu)(X_i - \mu)^T$$

$$\mu = \frac{1}{N}\sum_{i=1}^{N} X_i$$

3.3 Classification

Different expressions are categorised by a classifier. The two main types of classes used in facial expression recognition are action units (AU_s) [6], and the prototypic facial expressions defined by Ekman [7]. The 6 prototypic expressions are happiness, sadness, anger, surprise, fear, and disgust. An AU is one of the 46 atomic elements of visible facial movements or its associated deformation. These AU_s are described in Facial Action Coding System (FACS).

3.3.1 Euclidean Distance

1) The extracted features of train images by using Log Gabor filter are utilized to make a low dimensional face space. This feature reduction process can be done by performing Principal Component Analysis in the training image set and taking the principal components with greater Eigen. In this process, projected versions of all the train images are also created.
2) The test images also projected on face space, all the test images are represented in terms of the selected principal components.
3) In order to determine the intensity of the particular expression its Euclidean distance from the mean of the projected neutral images is calculated.
4) The Euclidian distance of a projected test image from all the projected train images are calculated and the minimum value is chosen in order to find out the train image which is most similar to the test image.
5) The test image will be in the same class that the closest train image belongs to.

The formula for the Euclidean distance is given by:

$$ED = \sqrt{\sum (x_2 - x_1)^2}$$

4. Experimental Result

Facial Expression Recognition was performed using FEI dataset. All images were resized into same dimension of 280×180 dimension. A total of 90 images depicting two different facial expressions: happy and neutral were selected. For training phase a total of 48 images, 24 from each category were used. In the testing phase 42 images were taken, 20 happy images and 22 neutral images were classified. Images taken in the training phase were not included in the testing phase. The input color images were first transformed into YCbCr for illumination compensation. Then the skin region was selected by setting threshold value. The input image and their corresponding luminance and chrominance output is shown in figure 3.

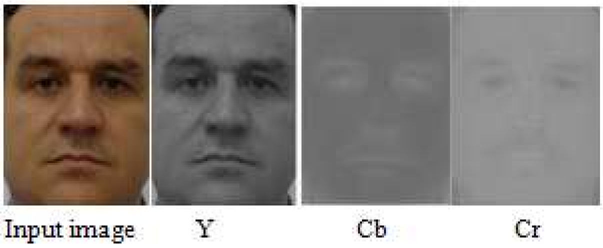

Figure 3: YCbCr output

Noise is removed using median filter. By using bounding box face image is detected. The input image and the detected face is shown in fig 4.

Figure4: detected face image

In first experiment detected faces were directly applied to PCA for feature reduction. In second experiment the features were first extracted from the detected face using Log Gabor filter then the extracted features were applied to PCA for feature reduction. The selected features were then classified using Euclidean Distance. The intensity of each images were also calculated using Euclidean distance from the mean of the projected neutral images. The classification rate obtained using Log Gabor filter and PCA is shown in table 1:

Table 1: Recognition Rate

Expressions	Number of Images		Recognition Rate (%)	
	Training	Testing	PCA	Log Gabor
Happy	24	20	88.81	95
Neutral	24	22	92.31	90.90
Average			90.56	92.95

On average, the Log Gabor classifies correctly 92.95% of cases, whereas the PCA method alone gave overall rate of 90.56% using Euclidean Distance Classifier.

5. Conclusion

We have implemented a facial expression recognition system using Principal component analysis and Log Gabor Filter method. The experiment was performed inFIE image database. The experiment results state that the recognition rate of Principal component analysis is 90.56% and that of Log Gabor filter is 92.95% on average. The classification was done using Euclidean Distance classifier. Though Log Gabor filter outperform PCA producing largest improvement in recognition rate, its computation load is complex and time consuming. The percentage of correct classification varied across happy and neutral expressions.

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Author Profile

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