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Analysis of Facial Expression and Recognition Based On Statistical Approach

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Abstract:-Facial Expression Recognition is rapidly becoming area of interest in computer science and human computer interaction. The most expressive way of displaying the emotions by human is through the facial expressions. In this paper, Recognition of facial expression is studied with the help of several properties associated with the face itself. As facial expression changes, the curvatures on the face and properties of the objects such as, eyebrows, nose, lips and mouth area changes. Similarly, intensity of corresponding pixels of images also changes. We have used statistical parameters to compute these changes and computed results (changes) are recorded as feature vectors. Artificial neural network is used to classify these features in to six universal expressions such as anger, disgust, fear, happy, sad and surprise. Two-layered feed forward neural network is trained and tested using Scaled Conjugate Gradient back-propagation algorithm and we obtain 92.2 % recognition rate.

Index Terms:- Facial expression Recognition, Human Computer Interaction, Scaled Conjugate Gradient, Statistical parameters.

I. INTRODUCTION

The computer-based recognition of facial expression has received a lot of attention in recent years because the analysis of facial expression or behavior would be beneficial for different fields such as lawyers, the police, and security agents, who are interested in issues concerning dishonesty and attitude. Some researchers used only four expressions for analysis using computer and some used six expressions. We have used JAFFE database with seven expressions for analysis through the computer. Several facial expression recognition methods have been proposed in literature: for example, FACS [1] Facial Point tracking [2] and moment Invariant [3]. Ekman and Friesen [4] developed the Facial Action Coding System (FACS) for describing expressions, such as anger, disgust, fear, happy, neutral, sad, and surprise. Their objective was to describe all the visually distinct local facial muscle movements using 46 actions units (Aus): each AU is associated with the physical behavior of specific facial muscle, giving an appearance-based description of faces. In that way, a facial expression corresponds to the combination of a set of AUs. James J. Lien and Takeo Kanade have developed Automatic facial expression recognition system based on FACS Action Units in 1998 [5]. They have used affine transformation for image normalization and Facial feature point tracking method for feature extraction. Classification is done using Hidden Marko Model (HMM).

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The Maja Pantic and Marian Stewart [6] do machine analysis of facial expressions. L. Ma and K. Khorasani developed constructive Feed-forward Neural Network for facial expression recognition [7]. They generated the difference image from neutral and expression image, 2-D DCT coefficient of difference images are considered as input to the constructive neural network. Praseeda Lekshmi. V and Dr. M. Sasikumar proposed a Neural Network Based Facial Expression Analysis using Gabor Wavelets. They used Gabor Wavelets as a feature extraction method and neural network used as classification technique [8]. Facial expression recognition process has two phases, representation and classification, both of which recurring topics in computer vision. The main task of representation is to find efficient relevant features from facial images and these silent features are used to classify the facial expressions. In this paper, we would like to discuss some of the key parameters, which can help in classifying the facial expressions.

This paper is organized as follows. Section II depicts methods and materials, which consist of dataset, image normalization, feature extraction using statistical parameters and classification with neural network. Section III depicts the experimental results and it discusses the performance, measures and accuracy levels of classification. Finally, in section IV conclusions are drawn.

II. METHODS AND MATERIALS

A. Data Set

For our experimental studies: we have used JAFFE (Japanese Female Facial Expression) Database [9]. The database contains 213 images of six facial expressions (anger, disgust, fear, happy, sad and surprise) in addition to one neutral face posed by 10 Japanese female models. The size of each image is 256 × 256. For our experiment, we selected 210 images from the database; few of them are shown in fig. 1. There are 21 images come from one subject with 6 expressions with one neutral face, i.e. three images per expression of a subject.

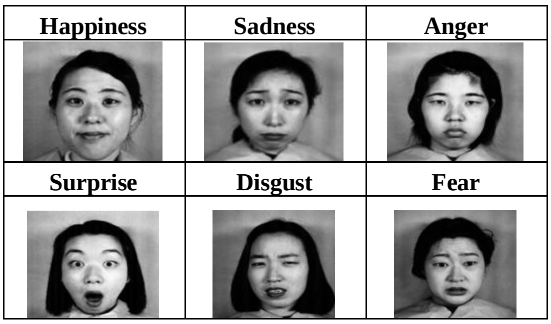

Fig. 1 Sample Images from JAFFE database

Fig. 2 Sample Average Faces

B. Image Normalization

All the images in the database were in the .tiff file format. We have converted all images into .bmp format. We know that when facial expression changes, the curvatures on the face and properties of the objects such as, eyebrows, nose, lips and mouth area also changes. Therefore, we extract the average face (eyes, nose and mouth) from all the images of same size i.e. 125X106. Figure 2 shows some sample images of average faces. We computed the difference images by subtracting neutral average faces from corresponding expression faces.

The figure 3 shows difference images. Features are extracted by using these difference images with the help of MATLAB software.

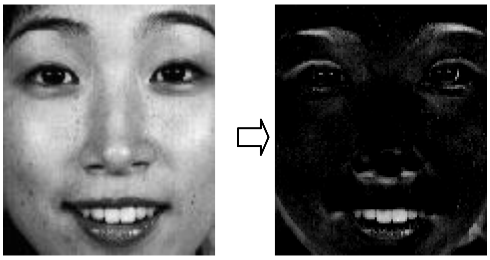

Fig. 3 Average Face with Corresponding Difference Face

C. Feature Extraction

For extracting the features, we have used following statistical parameters:

Entropy is a statistical measure of randomness in an image, the pixel values, x_i occur with probabilities $p(x_i)$, which are given by the bin heights of the normalized histogram; the available pixel values run from 0 to $2^n - 1$. First-order statistics assume that the statistical properties of the pixels do not depend on neighboring pixels. A first-order estimate of the entropy E of an image is given by the sum of the information content of each pixel:

$$E = -\sum_{i=0}^{2^n-1} p(x_i) I(x_i) \qquad (1)$$

Skewness is a measure of the asymmetry of the data around the sample mean. On the other hand, skewness refers to the asymmetry or latch of symmetry in the shape of a frequency distribution. If skewness is negative, the data is spread out more to the left of the mean than to the right. If skewness is positive, the data is spread out more to the right. The skewness of the normal distribution (or any perfectly symmetric distribution) is zero. The skewness of a distribution is defined as

$$s = \frac{E(x-\mu)^3}{\sigma^3} \qquad (2)$$

Where μ the mean of x, σ is the standard deviation of x, and $E(x)$ represents the expected value of the quantity x.

We applies following formula to calculate Skewness from the difference image

$$s = \frac{\frac{1}{n}\sum_{i=1}^{n}(X_i - \bar{X})^3}{\left(\sqrt{\frac{1}{n}\sum_{i=1}^{n}(X_i - \bar{X})^2}\right)^3} \qquad (3)$$

Kurtosis is a measure of how outlier-prone a distribution is. The kurtosis of the normal distribution is 3. Distributions that are more outlier-prone than the normal distribution have kurtosis greater than 3; distributions that are less outlier-prone have kurtosis less than 3. The kurtosis of a distribution is defined as

$$k = \frac{E(x-\mu)^4}{\sigma^4} \qquad (4)$$

Where μ the mean of is x, σ is the standard deviation of x, and $E(x)$ represents the expected value of the quantity t. We applied following formula to compute skewness from the difference image.

$$K = \frac{\frac{1}{n}\sum_{i=1}^{n}(X_i - \bar{X})^4}{\left(\frac{1}{n}\sum_{i=1}^{n}(X_i - \bar{X})^2\right)^2} \qquad (5)$$

D. CLASSIFICATION

For classification purpose, we used the two layered feed forward neural network in which learning assumes the availability of a labeled set of training data made up of N input and output.

$$T = \{(X_i, d_i)\}_{i=1}^{N} \qquad (6)$$

Where, X_i is input vector for the i^{th} example, d_i is the desired output for the i^{th} example, N is the sample size.

A two layer feed forward neural network with sigmoid activation function is designed with 213 input neurons, 30 hidden neurons and 6 output neurons for the classification. Created neural network is trained and tested by using Scaled Conjugate Gradient Backpropogation algorithm.

Scaled Conjugate Gradient Method

SCG is a second order conjugate gradient algorithm that helps minimizing goal function of several variables. SCG algorithm was proposed by Moller [10] in 1993. Minimization is a local iterative process in which an approximation to the function, in a neighborhood of the current point in the weight space, is minimized. The Scaled Conjugate Gradient (SCG) algorithm denotes the quadratic approximation to the error E in the neighborhood of a point w by:

$$E_{qw}(y) = E(w) + E'(w)^T y + \frac{1}{2} y^T E''(w) y \quad (7)$$

SCG belongs to the class of Conjugate Gradient Methods. SCG use a step size scaling mechanism and avoids a time consuming line-search per iteration, which makes the algorithm faster than other methods and second order algorithms.

III. EXPERIMENTS AND RESULTS

In this work, statistical parameters such as entropy, skewness and kurtosis are used to extract the features. In the first step average face is extracted, then we compute the difference image. Statistical information is retrived from difference images. Entropy retrives one value from each image, skewness and kurtosis retrieve 106 values respectively. Combination of all these values are used as a feature vector for each image which helped for classification. Table 1 depicts features of face1, face2 and face 3 for six expressions respectively. Skewness and kurtosis retrives 106 values from image respectively. For showing the results in table we compute standered deviation of features of skewness and kurtosis.

Table 1. Features Extracted from sample faces

Facial expression	Entropy	Skewness	Kurtosis
Face1			
Anger	2.20	3.47	15.40
Disgust	1.93	4.01	21.30
Fear	2.01	3.65	18.44
Happy	3.51	2.90	12.17
Sad	2.62	3.66	19.20
Surprise	1.98	3.99	20.23
Face2			
Anger	3.73	2.64	10.51
Disgust	2.18	3.32	14.13
Fear	2.82	3.33	16.89
Happy	3.09	3.06	14.43
Sad	2.83	3.31	15.18
Surprise	3.43	2.85	12.50
Face3			
Anger	3.00	3.73	17.65
Disgust	4.19	2.89	12.74
Fear	3.99	3.09	14.90
Happy	2.73	3.47	15.49
Sad	2.59	3.84	19.50
Surprise	4.09	3.30	15.75

By using Feedforword neural network classification is done. Scaled Conjugate Gratdient Backpropogation algorithm is used to train and test the network. The implementation of neural network and the training method were done with the Neural Networks Toolbox of MATLAB 7.11.0.584.

The SCG training algorithm outperformed in this experiment by classifying the input data in 773 epochs with the average training time of 15 seconds.

The performance measured and outcome of the network are depicted in table 1.

Table 2. Performance Measures

Number of Epochs	773
Training Performance	0.0033
Testing Performance	0.1241
Validation Performance	0.0792
Classification accuracy	92.2%
Mean Squared Error	$1.8669e^{-2}$
Percent Error	7.8%

Confusion Matrix:

The confusion matrix gives the accuracy of the classification problem. 180 images of 10 subjects are classified into six categories with 92.2% accuracy. The diagonal elements in the confusion matrix show the classified groups.

For the input we gave 30 images of every class. Resultant Confusion matrix illustrates that, out of 30 samples 27 samples are fall in anger class and remaining one in disgust and two are in class surprise. Similarly classification is done with all classes as shown in confusion matrix. Therefore total average accuracy of classification is 92.2% and misclassification or error rate is 7.8%.

Confusion Matrix

	Anger	Disgust	Fear	Happy	Sad	Surprise
Anger	**27 90.0%**	**1 3.0%**				
Disgust	**1 3.3%**	**27 90.0%**	**1 3.3%**			**1 3.3%**
Fear		**1 3.3%**	**28 93.3%**			
Happy			**1 3.3%**	**29 96.7%**	**2 6.0%**	**1 3.3%**
Sad		**1 3.3%**		**1 3.3%**	**28 93.3%**	**1 3.3%**
Surprise	**2 6.6%**					**27 90.0%**

Fig. 4 Confusion Matrix

IV. CONCLUSION

This paper presents the methodology for an efficient facial expression analysis and classification. Expression analysis is done on the basis of statistical parameters such as entropy, skewness and kurtosis. Features are extracted from difference images. These features are classified using the two layer feed forward neural network. For training this neural network Scaled Conjugate Gradient Backprapogation algorithm is used. The six universal expressions i.e. anger, disgust, fear, happy, sad, and surprise are recognized with 92.2% classification accuracy.

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