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Facial Expression Recognition based on Affine Moment Invariants

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Abstract

Facial Expression Recognition is rapidly becoming area of interest in computer science and human computer interaction because 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. We have used Affine Moment Invariants to compute these changes and computed results (changes) are recorded as feature vectors. We have introduced a method for facial expression recognition using Affine Moment Invariants as features. We have used Artificial Neural Network as a classification tool and we developed associated scheme. The Generalized Feed-forward Neural Network recognizes six universal expressions i.e. anger, disgust, fear, happy, sad, and surprise as well as seventh one neutral. The Neural Network trained and tested by using Scaled Conjugate Gradient Backpropogation Algorithm. As a result we got 93.8% classification rate.

Keywords: *Artificial Neural Network, Facial Expressions, Affine Moment Invariants, Human computer Interaction.*

1. Introduction

The computer-based recognition of facial expression has received a lot of attention in recent years. 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. The eventual goal in research area is the realization of intelligent and transparent communication between human being and machines. Some researchers used only four expressions for analysis using computer and some used six expressions. We have used Japanese Female Facial Expression (JAFFE) database with seven expressions for analysis through the computer. Several facial expression recognition methods proposed in literature. For example Facial Action Coding System (FACS) [1, 2] Facial Point Tracking [3] and Moment Invariant. Ekman and Friesen [1] developed the Facial Action Coding System (FACS) for describing expressions, such as anger, disgust, fear, happy, neutral, sad, and surprise. The Maja Pantic [4] did machine analysis of facial expressions. 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 as well as Hidden Marko Model (HMM) was used for classification. L. Ma., K. Khorasani developed Constructive Feed-forward Neural Network for facial expression recognition [6]. First they generated the difference image from Neutral and expression image, 2-D DCT coefficients of difference images considered as input to the constructive neural network. Praseeda Lekshmi 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 as a classification technique [7]. Guoying Zhao and Matti have developed local binary patterns for dynamic texture recognition which was further applied for facial expression recognition [8]. Y. Zhu. L. C. DE. Silva used moment invariants as a feature extraction from facial expressions and Hidden Marko Model for classification [10]. But they classified only four types of expressions i.e. anger, disgust, happy and surprise. Using Hu moment invariants facial expression recognition is done with 92.4% recognition accuracy [11]. In this research work we have tried to classify facial expressions into seven categories with the help of Affine Moment Invariants as feature extraction technique and artificial neural network as classification. This paper is organized as follows. Section 2 introduces Database and image normalization. Section 3 describes Feature extraction technique. Section 4 describes neural network process like training algorithm. Section 5 depicts the experimental results and it discusses the confusion matrix and accuracy levels of classification. Finally, conclusions are drawn in section 6.

2. Data Collection and Normalization

This method is trained and tested on the JAFFE (Japanese Female Facial Expression) Database [12]. The database contains 213 images of seven facial expressions (6 basic facial expressions + 1 neutral) such as anger, disgust, fear, happy, neutral, sad and surprise posed by 10 Japanese female models. For our experiment, we selected 210 images from the database for the expression recognition. There are 21 images come from one subject with seven expressions i.e. three images of one expression. Some sample images from database are in Fig. 1.

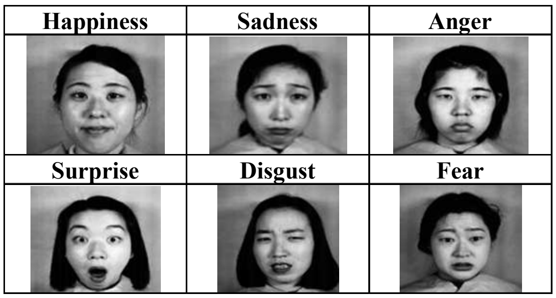

Fig. 1 Sample images from database

It is observed that facial features contributing to facial expressions mainly lie in some regions, such as eye area and mouth area and nose area. Facial classification needs information that is more useful. These regions contain such type of information. The important features of expressions reflected through the eyes and mouth. Therefore, we extract average face of size 125 x 106 from original image. Again, the average images divided in to three blocks to extract the more features such as upper, middle and lower as shown in Fig 2.

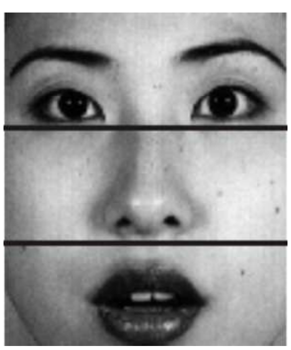

Fig. 2 Average face divided into three blocks

We have decided to extract the features from edges and boundaries of images. For extracting the edges we have used Sobel edge detection operator. Fig. 3 shows the image after applying Sobel edge detection operator.

Fig. 3 Image after applying Sobel edge detection operator

3. Feature Extraction

Moment invariants are invariant under shifting, scaling and rotation. They are widely used in pattern recognition because of their discrimination power and robustness. We divide face into three areas for feature extraction, which are upper, middle and lower areas of face. Images are converted into binary images for extracting the boundary values using Sobel edge detection operator.

Affine Moments:

In order to understand how to utilize moment invariant method, let f_b be a binary digital image with size X x Y and $f_b(x, y)$ is the gray level value for the pixel at row x and column y. The two-dimensional moments of order $(p+q)$ of $f_b(x, y)$ which is variant to the scale, translation and rotation is defined as

$$m_{pq} = \sum_{x=1}^{X} \sum_{y=1}^{Y} x^p y^q f_b(x, y) \tag{1}$$

The central moments of order $(p+q)$ of $f_b(x, y)$ is defined as

$$\mu_{pq} = \sum_{x=1}^{X} \sum_{y=1}^{Y} (x - x_c)^q (y - y_c) f_b(x, y) \tag{2}$$

Where

x_c And y_c are the centers of mass of the object defined as

$$x_c = \frac{m_{10}}{m_{00}} \, and \; y_c = \frac{m_{01}}{m_{00}} \tag{3}$$

The moment invariant under scale is defined as

$$\eta_{pq} = \frac{\mu'_{pq}}{(\mu'_{00})^{\gamma}} \tag{4}$$

Where $\gamma = \frac{p+q}{2} + 1$ (5)

$$and\, \mu'_{pq} = \frac{\mu_{pq}}{\alpha^{(p+q+2)}} \quad (6)$$

Normalized un-scaled central moment is then given by

$$\nu_{pq} = \frac{\mu_{pq}}{(\mu_{00})^{\gamma}} \quad (7)$$

The Affine moment invariants are derived to be invariants to translation, rotation, scaling of shapes and under general 2D Affine transformation. The six Affine moment invariants used are defined as follows:

$$I_1 = \frac{1}{\mu_{00}^{4}}(\mu_{20}\mu_{02} - \mu_{11}^{2}) \quad (8)$$

$$I_2 = \frac{1}{\mu_{00}^{10}}(\mu_{30}^{2}\mu_{03}^{2} - 6\mu_{30}\mu_{21}\mu_{12}\mu_{03} + 4\mu_{30}\mu_{12}^{3} + 4\mu_{03}\mu_{21}^{3} - 3\mu_{21}^{2}\mu_{12}^{2}) \quad (9)$$

$$I3 = \frac{1}{\mu_{00}^{10}}(\mu_{20}(\mu_{21}\mu_{03} - \mu_{12}^{2}) - \mu_{11}(\mu_{30}\mu_{03} - \mu_{21}\mu_{12}) + \mu_{02}(\mu_{30}\mu_{12} - \mu_{21}^{2})) \quad (10)$$

$$I_4 = \frac{1}{\mu_{00}^{11}}(\mu_{20}^{3}\mu_{03}^{2} - 6\mu_{20}^{2}\mu_{11}\mu_{12}\mu_{03} - 6\mu_{20}^{2}\mu_{21}\mu_{02}\mu_{03} + 9\mu_{20}^{2}\mu_{02}\mu_{12}^{2} + 12\mu_{20}\mu_{11}^{2}\mu_{03}\mu_{21} + 6\mu_{20}\mu_{11}\mu_{02}\mu_{30}\mu_{03} - 18\mu_{20}\mu_{11}\mu_{02}\mu_{21}\mu_{12} - 8\mu_{11}^{3}\mu_{0}^{3}\mu_{30} - 6\mu_{20}\mu_{02}^{2}\mu_{30}\mu_{12} + 9\mu_{20}\mu_{02}^{2}\mu_{21}^{2} + 12\mu_{11}^{2}\mu_{02}\mu_{30}\mu_{12} - 6\mu_{11}^{2}\mu_{02}^{2}\mu_{30}\mu_{21} + \mu_{02}^{2}\mu_{30}^{2}) \quad (11)$$

$$I_5 = \frac{1}{\mu_{00}^{6}}(\mu_{40}\mu_{04} - 4\mu_{31}\mu_{13} + 3\mu_{22}^{2}) \quad (12)$$

$$I6 = \frac{1}{\mu_{00}^{9}}(\mu_{40}\mu_{04}\mu_{22} + 2\mu_{31}\mu_{22}\mu_{13} - \mu_{40}\mu_{13}^{2} - \mu_{04}\mu_{31}^{2} - \mu_{22}^{3}) \quad (13)$$

The algorithm of Affine Moment is implemented as:

1. Calculating the value of $x_c and y_c$ based on Equation (3).
2. Computing each value of $\mu_{00}, \mu_{11}, \mu_{01}, \mu_{20}, \mu_{21}, \mu_{12}, \mu_{22}, \mu_{03}, \mu_{30}, \mu_{31}, \mu_{13}, \mu_{40} and\, \mu_{04}$ using Equation (2).
3. Calculating the value of Affine Moments $I_1 - I_6$ according to equation (8) to (13).

Two sets of six features using Affine Moment functions, are computed in this research, one set derived from the area of average face and the other from the boundary of average face. Therefore, 12 features are generated from one section; total 36 features are generated from one image.

4. Classifications

For classification purpose, we have 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.

$$T = \{(X_i, d_i)\}_{i=1}^{N} \quad (14)$$

Where, X_i is input vector for the i^{th} example, N is the sample size. A two layered feed forward neural network with sigmoid activation function is desired with 36 input neurons, 30 hidden neurons and 7 output neurons for classification. Created neural network is trained and tested 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 [13] 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:

$$E_{qw}(y) = E(w) + E'(w)^{T} y + \frac{1}{2} y^{T} E''(w) y \quad (15)$$

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.

5. Experimental Results

In this work, Affine Moment Invariants are used to extract the features. In the first step average face is extracted then the average face is divided into three parts such as upper, middle and lower. We have extracted the edges or boundaries of average images using the Sobel edge detection operator. Using the Affine moment invariants six features are extracted from each part of the image as well as its edges or boundaries. We compute the 36 feature values from each average face. With the help of these features we classify 210 images of 10 subjects of seven facial expressions into seven classes such as anger, disgust, fear, happy, neutral, sad, and surprise.

By using Feed forward neural network classification is done. Scaled Conjugate Gradient 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 confusion matrix gives the accuracy of the classification problem. 210 images of 10 subjects are classified into seven categories with 93.8% 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 (Fig. 4) illustrates that, out of 30 samples 30 samples are fall in anger class. Out of 30 samples of disgust class 29 falls in disgust and remaining one is in fear class. Similarly classification is done with all classes as shown in confusion matrix. Therefore total average accuracy of classification is 93.8% and misclassification or error rate is 6.2%.

Confusion Matrix							
	Anger	**Disgust**	**Fear**	**Happy**	**Neutral**	**Sad**	**Surprise**
Anger	**30 100%**				1 3.3%		1 3.3%
Disgust		**29 96.7%**	1 3.3%			2 6.6%	
Fear		1 3.3%	**28 93.3%**				
Happy				**30 100%**		1 3.3%	1 3.3%
Neutral			1 3.3%		**27 90%**	1 3.3%	1 3.3%
Sad					1 3.3%	**26 86.7%**	
Surp-rise					1 3.3%		**27 90%**

Fig. 4 Confusion Matrix

6. Conclusions

In this paper, an efficient facial expression recognition methodology is introduced. Here the facial expression recognition is based on Affine Moment Invariants. Feature vectors are computed by using functions of Affine Moment Invariants. These features are classified using the two layers feed forward neural network. For training this neural network Scaled Conjugate Gradient Backpropogation Algorithm is used. The six universal expressions i.e. anger, disgust, fear, happy, sad, and surprise as well as seventh one neutral, are recognized with as high as 93.8% accuracy with the combination of 10 subject's images.

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