Automatic Facial Expression Recognition Using Gabor Filter And Expression Analysis

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Abstract—**Facial expression extraction is the essential step of facial expression recognition. The paper presents a system that uses 28 facial feature key-points in images detection and Gabor wavelet filter provided with 5 frequencies, 8 orientations. In according to actual demand, It can extract the feature of low quality facial expression image target, and have good robust for automatic facial expression recognition. Experimental results show that the performance of the proposed method achieved excellent average recognition rates, when it is applied to facial expression recognition system.**

Keywords-Facial expression recognition;Gabor filters; Facial key-points;Feature extraction

I. INTRODUCTION

In recent years, many researchers and experts show a growing interest in facial expression analysis. It is argued that the facial expressions play an important role in social interactions with other human beings. Facial expressions can contain a great deal of information and the desire to automatically extract this information has been continuously increasing. It is a visible and mutative manifestation of human cognitive activity and psychopathology. With the rapid development of computer vision and artificial intelligence, facial expression recognition becomes the key technology of advanced human computer interaction. More and more people have been paying attention to expression recognition. The research objective of facial expression recognition is how to automatically, reliably, efficaciously use its conveying information. It is a typical issue in model-identification that the automatic recognition system's property is decided by the represented facial expression feature. Detection of facial feature key-points is often the necessary step of facial expression recognition. The precise localization of the facial feature key-point detection highly affects the recognition system performance efficiency. In this study, it proposes here a robust, highly accurate method for detecting 28 facial key-points in images. Of course, the feature extraction is also very important to the facial expressions recognition process. If inadequate features are provided, even the best classifier could fail to achieve accurate recognition. In most cases of facial expression classification, the process of feature extraction yields a definitively large number of features and subsequently a smaller sub-set of features needs to be selected according to some optimality criteria. Gabor filters have been proved to be effective for expression recognition because of its superior capability of multi-scale representation. Gabor wavelet can use very better description of biological visual neuron about receptive field, .According to the needs of special vision, it can adjust the spatial and frequency properties to face expression characteristic wanted, so Gabor filter wavelet is suitable for people face analysis and treatment of expression.

The remainder of this paper is organized as follows: Section 2 is composed of two parts: the first part describes Cohn-Kanade expression database; the second part presents the image capture and preprocessing. Section 3 introduces Gabor filter's principle, property and the feature characterization in detail. Then the adaptation scheme for choosing the orientation and frequency of Gabor filter to extract the facial expression feature will be performed. The convolution output of the original image is also presented in Section 3. In Section 4,some experimental results are shown and explained. Finally, conclusions and future work are given in Section 5.

II. IMAGE ACQUISITION AND PRE-PROCESSING

A. Expression Database

Research in psychology has indicated that at least six emotions are universally associated with distinct facial expressions. The experiments is performed by using Cohn-Kanade AU-Coded Facial Expression Database[1]. Sample expressions of six expressers from the database in Fig.1. Image data consist of approximately 500 image sequences from 100 subjects. Subjects range in age from 18 to 30 years. Sixty-five percent were female; 15 percent were African-American and three percent Asian or Latino.

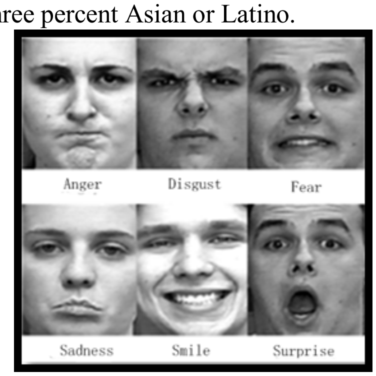

Figure.1 Six images with six universal facial expressions

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This database contains images of individual female subjects performing a variety of facial expressions. The number of images corresponding to each of the 6 categories of expression(anger, disgust, fear , sadness, smile, and surprise)is almost the same. Image sequences were digitized into 90 by 100 pixel arrays with 8-bit precision for grayscale values.

B. Image Preprocessing and Facial Key-points Localization

The recognition process begins by first acquiring the image using an image acquisition device like a digital camera or computer camera. Then, the image acquired at 236 ×236 pixels. It must be pre-processed. Normally, the image pre-processing step comprises of operations like normalizing intensity, contrast, uniform size and shape. We need to crop the face region using a rectangle according to face model and scale the face expression image at 90×100 pixels. Fig.2 is the result of the image obtained from computer camera has been preprocessed.

Figure.2 The result of the image preprocessed is shown

Facial key-points are important features for a number of different tasks in automatic face expression processing. It is that facial key-points rather have an anatomical perfect definition than a base one. We use these facial key-points to further derive the other facial features. The shape models shown in Fig.3 are used to fit the facial features for each set of facial key-points. There are four points in the forehead, six points in the eyebrow, six points in the eye, three points in the nose, eight points in the mouth, one point in the chin. Subsequently, we can use the detected positions of the image and divide the face into 28 regions so that each of the points to be localized.

Figure.3 Model of the facial key-points

III. FEATURE REPRESENTATION

The Gabor filter is a good model of simple cell receptive fields in cat striate cortex [2] [3][4][5][6][7][8] and it can be used for object recognition and face expression recognition. In this study, Gabor filters have been applied to various image recognition problems for feature extraction due to its optimal localization properties in both spatial and frequency domain. A Gabor filter can be formulated by the following equation:

$$\Psi_{u,v} = \frac{\|k_{u,v}\|^2}{\sigma^2}\exp\left\{-\left(\frac{\|k_{u,v}\|^2\|z\|^2}{2\sigma^2}\right)\right\}\left[\exp(izk_{u,v})-\exp\left\{-\left(\frac{\sigma^2}{2}\right)\right\}\right] \quad (1)$$

Where $k_{u,v} = (k_v \cos\phi_u / k_v \sin\phi_u)$, $\phi_u = \pi u / k$,

$$k_v = 2^{-\left(\frac{v+2}{2}\right)}\pi$$

where z=(x, y) is the pixel position in the spatial domain, k_v and ϕ_u are separately modulating frequency and modulating orientation. U is the orientation of a Gabor filter and v is the scale of a Gabor filter. The wavelength is decided by v. Further more, the second term of the Gabor filter($\exp\{-(\sigma^2/2)\}$) compensates for the direct current component value because the cosine component has nonzero mean while the sine component has zero mean. Gabor filter has good resolution both in spatial field and frequency field. It also have obvious speciality of orientation selection and frequency selection.

Feature extraction is the key step of facial expression recognition. In order to extract exact facial expression feature, each facial image was convolved with a multiple spatial resolution, multiple orientation set of two-dimensional Gabor filter..Provided input image I(x, y), The Characterization of the image can be written as below formula(2): a convolution of the image I(x, y) with the Gabor kernel $\Psi_{u,v}$ (x,y).

$$O_{u,v}(x,y) = I(x,y) * \Psi_{u,v}(x,y) \quad (2)$$

In this study, suppose a discrete set of Gabor kernels is used that comprises of 5 spatial frequencies and 8 distinct orientations. Then, there are 5×8=40 Gabor wavelet kernel filters. For example, in order to show the facial expression extraction in practice,Fig.4 is the typical response of the Gabor filters, Gabor filter kernel frequency k_v =0.2, orientation $\phi = \pi$ to an input image. On the left of Fig.4, the first little image is an original image of Cohn-Kanade AU-Coded Facial Expression Database, On the right of the original image, there are the image of double conversion, the Gabor filter, the feature extraction output from left to right in turn. As the same with Fig.4, Fig.5 is also the other typical response of the Gabor filters, Gabor filter kernel frequency k_v =0.18, orientation $\phi = \frac{\pi}{2}$ to an input image. It can be observed from the figure how the changes in orientation and wave-factor in the Gabor filter affect the response of the image. The amplitude of Gabor filter vary slowly, while the phases are very sensitive[8][9][10].

Figure.4 The Gabor filter kernel's frequency is 0.2, orientation is π

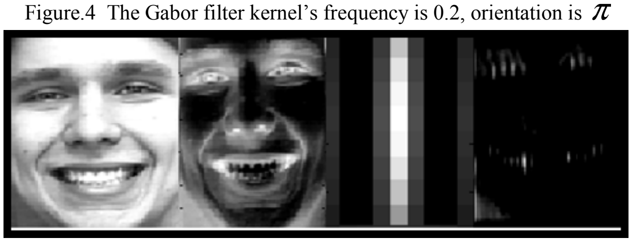

Figure.5 The Gabor kernel 's frequency is 0.18, orientation is $\pi/2$

Seeing from the figures, they presents the output location of Gabor filter is mainly in eyebrow, eye, nose, mouth. Then the Characterization direction information which is obtained by a series of different angle. Gabor filters is greatly different. The Gabor filters($\phi=\pi$)extract sensitively the characteristics of the horizontal component, Such as eyes, mouth region is especially obvious. The Gabor filters($\phi=\frac{\pi}{2}$)extract sensitively the characteristics of the vertical component, Such as nose, face region is specially significant. Forty characteristic vectors($G_{0,0}, G_{0,1}, \ldots\ldots, G_{4,7}$)are provided by 40 Gabor kernels. They compose the Gabor feature vector.

$$X = (G_{0,0}, G_{0,1} \ldots\ldots, G_{4,7})^T \quad (3)$$

T stands for matrix transposition. The significant key points' Gabor vector mode $\|X\|$ is higher.

IV. EXPERIMENTAL RESULTS

To obtain the facial expression feature, each segmented image will be converted into 40 Gabor filters with five spatial frequencies and eight orientations. The dimension is high. So the Principle Component Analysis (PCA) [11][12][13][14][15]is applied to select the features. PCA is a linear transformation commonly used to simplify a data set by reducing multidimensional data sets to lower dimensions. Finally, the classification of these patterns is done through K nearest neighbour (KNN) [16][17][18][19][20]classifier. The K Nearest Neighbour (KNN) finds out the K nearest neighbours to a test case from the training cases, based on the Euclidean distances between them.

In order to further verify the effectiveness of the proposed method, we selected a set of 300 images from Cohn-Kanade AU-Coded Facial Expression Database to perform the experiments. The recognition results with and without the method are given by Table1.

TABLE I. RECOGNITION RATES WITH AND WITHOUT THE PROPOSED METHOD (%)

Method	**Six Experimental Basic Emotions**					
	Anger	***Disgust***	***Fear***	***Sadness***	***Smile***	***Surprise***
No	79	71.2	75	76	86	72
Yes	83	75.6	79	75	89	77

From Table1 it is obvious to see that the proposed method is effective for achieve high performance. Its average recognition rate is 80%, and it improved 3% or so than the average recognition rate without the method.

V. CONCLUSIONS AND FUTURE WORK

In this paper, we have proposed the method to improve the accuracy of a static facial expression recognition system by applying 28 facial key-points and Gabor filter. As experimental results shows, the method has leaded to a more accurate expression recognition. Meanwhile, we have presented an automatic facial expression recognition system utilizing visual C++,which adopts Gabor wavelets to extract facial feature and an KNN classify the facial expression emotion. The features for facial representation are selected by PCA. The KNN is used to classify the facial expression characterization. There are deficiencies of the proposed approach, such as the image database to further examine. The proposed method is also limited; the effectiveness of extraction expression feature is completely dependent on the effectiveness of pre-processing of the raw image,

Further work involves taking many effective measures to improve the recognition accuracy. Such as creating a custom-built image database to conduct extensive experimental studies, and designing effective primitive features without any pre-processing on the facial expression images. In addition, mixed-emotions(for example, happiness and surprise, fear and disgust) is promising in the human face, we should concentrate ourselves to the study.[21][22]

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