Image processing based emotion recognition

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***Abstract*—The goal of this paper is to build an emotion detect system which can analyze basic facial expression of human. In this study, a frame of emotion recognition system is constructed, including face detection, feature extraction and facial expression classification. In part of face detection, a skin detection process is adopted first to pick up the facial region from a complicated background. Through the feature detection of lip, mouth, and eyes, eyebrow, those feature points are found. Moreover, the changing of these facial feature points, the characteristic values of emotion state are computed. The experiment has shown that the proposed strategy is effective.**

***Keywords*—facial expression, emotion recognition, GMM,**

I. INTRODUCTION

The review of facial expression analysis should go back to the nineteenth century. Darwin demonstrated already in 1872 the universality of facial expressions and their continuity in man and animals. In 1971, Ekman and Friesen postulated six primary emotions in which each possess distinct content. These prototypic expressions are also called basic emotions. It seems related to ethnicities and cultures, and it comprises happiness, sadness, fear, disgust, surprise and anger.

The automated facial expression recognition system can be divided roughly into three stages, i.e., face detection, features detection and extraction, and facial expression classification. Generally, in face detection stage, it mainly uses template matching, feature based, PCA (Principal Component Analysis), color analysis, neural network and evolutionary computation, etc. The method using template matching [2][3][4][5] and characteristic [6][7] need a great deal of computing. The template and feature method may diverge for different people, and the corresponding model is not easy to build up. The color analysis uses different color space, like HSV, YCbCr, etc., [2][14][15] use specific neural network to separate skin color from background. However, it also needs a great deal of training data [8][9][10]. In facial expression classification stage, Ekman and Friesen have constructed the Action Unit (AU) in Facial Action Coding System FACS system. This paper is to develop a systematic method to analyze the facial expression of human in colorful background. The object is to recognize the human emotion expression includes happiness, sorrow, surprise, get angry, aversion, and frightened. This paper is organized as follows. In section 2, details of the system structure are depicted. Section 3, fourteen crucial characteristic points is defined firstly. In section 4, we devlope a novel GMM approach to compute the characteristic value of emotion state by recognizing the above-mentioned characteristic points. Accordingly, the facial emotion is then classification. In section 5, some experiment results are presented. The conclusion and the future research are made in section.

II. THE FRAMEWORK OF FACIAL EXPRESSION ANALYSIS

The automated facial expression recognition system can be divided roughly into three stages, i.e., face detection, features detection and extraction, and facial expression classification. Before analyzing a facial expression, the face must be detected in a scene firstly.

On those related works of skin color detection, Soriano's RGB normalization method [27] probably is the most useful skill, and have good performance in practice. It not only considers the camera property, but the light of environment.

After obtaining the skin color sample, let's convert it to normalized color coordinates (NCC), to reduce the color's dependence on brightness. The NCC result is shown as Fig 2.

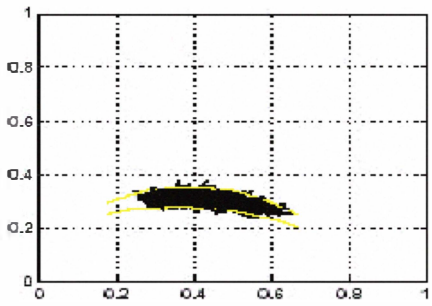

Fig. 1, NCC of skin distribution

Fig. 2. The skin color detected from environment

The skin color detected from environment is shown as Fig.2. Moreover, the proposed strategy of face detection is shown as Fig. 1.

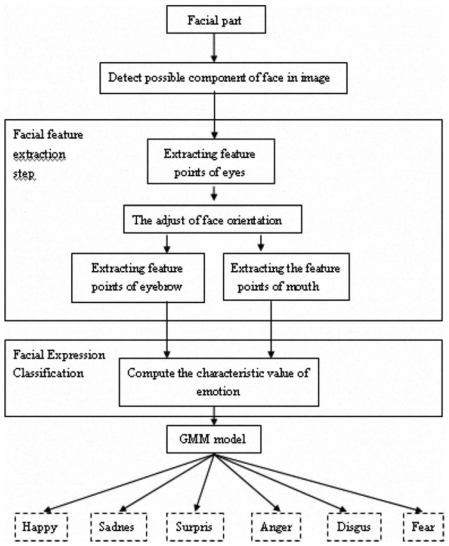

Fig. 3 The proposed emotion recognition system

III. FEATURE EXTRACTION

After the face has been detected in the scene, the next step is to extract the emotion information of the face in automatic way. It is known that the face representation and the kind of input image will affect the choice of the approach. Various analysis of face has been developed. For this, the Ekman has given some descriptions of emotion states related to facial points from physiologist point of view. According these relations, this paper originally define fourteen feature points as Fig. 4.

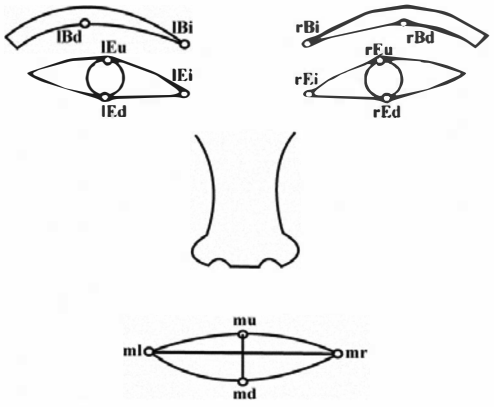

Fig. 4. The fourteen feature points defined in face

Since the emotion states is extracted according to the change of related position of those characteristic points. That is, for having correct position of face, the appropriate orientation adjustment of face is needed. Accordingly, some image processing process is applied here to get all characteristic points.

IV. FACIAL EMOTION CLASSIFICATION

According to those defined characteristic points in Fig. 4, we can compute the corresponding characteristic value (Fig.4), which represents the changing of emotion. Accordingly, those defined characteristic values $(a \sim o)$ that represent the changing of emotion for the corresponding characteristic point can be computed be using the distance measure. For instance, the x-y coordination of lBd is (lBd_x , lBd_y). $a = \sqrt{|lBd_x - lEd_x|^2 + |lBd_y - lEd_y|^2}$.

The research in this paper is concerned with realistic facial expression encountered in practical applications of human affective states identification. This section also describes the form of the Gaussian mixture model (GMM) and motivates its use as a representation of human affective states for emotion identification. Gaussian mixture model (GMM) is the extension of single gauss probability density function. It is successfully using in some classifications problem recently. The Gaussian mixture model and its parameterization are described. The use of the Gaussian mixture density for emotion identification is then motivated by two interpretations. First, the individual component gaussian in a emotion-dependent GMM are interpreted to represent some broad facial expression classes. Second, a gaussian mixture density is shown to provide a smooth approximation to the specific facial expression by a given person. Finally, the maximum-likelihood parameter estimation and emotion identification procedures are described.

A. Model description

A Gaussian mixture density is a weighted sum of M component densities, as depicted in Fig. 2 and given by the equation gaussion mixture density.

$$p(\vec{x} \mid \lambda) = \sum_{i=1}^{M} p_i b_i(\vec{x}) \tag{1}$$

where $\vec{x}$ is a D-dimensional random vector, $bi(\vec{x})$, $i = 1,..., M$, are the component probability densities function and , , are the mixture weights. Each component density is a derivate Gaussian function of the form

$$b_i(\vec{x}) = \frac{1}{(2\pi)^{D/2}|\Sigma_i|^{1/2}} \exp\left\{-\frac{1}{2}(\vec{x} - \vec{\mu}_i)' \Sigma_i^{-1}(\vec{x} - \vec{\mu}_i)\right\} \tag{2}$$

with mean vector $\vec{\mu}_i$ and covariance matrix Σi ; The mixture weights satisfy the constraint that $\sum Pi = 1$. The complete Gaussian mixture density is parameterized by the mean vectors, covariance matrices and mixture weights from all component densities. These parameters are collectively represented by the notation, shown as Fig.5.

$$\lambda = \{p_i, \vec{\mu}_i, \Sigma_i\} \quad i = 1, \ldots, M. \tag{3}$$

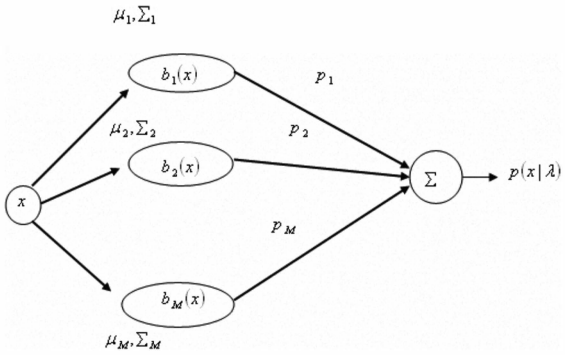

Fig 5 Gaussion mixture density diagram

ML parameter estimates can be obtained iteratively using a special case of the expectation-maximization (EM) algorithm. The basic idea of the EM algorithm is, beginning with an initial model A, to estimate a new model $\overline{\lambda}$, such that $p(X|\overline{\lambda}) \geq P(X|\lambda)$. We also can use K-means clustering method to set a better initial value. By using the above-mentioned GMM approach, we can establish the six basic emotion GMM model. Then, test data one by one to train emotion GMM model, and compute it's the post probability.

V. Experiment Result

This section will show some experiment for facial emotion recognition. All experiments are in the same environment condition, and the background can be complex. There is two database that used in this paper, *i.e.*, the JAFFE(the Japanese Female Facial Expression) database and the database from our Lab.

Fig. 6 The JAFFE Database

Fig. 7 The database from LAB

VI. Conclusion

This paper has provided a system method to recognize a facial expression automatically. The experiment result also shows the facial emotion recognition rate is about 90% for the well-known JEFFE database. Except for the problem of face rotation, there still exist many problems in image processing, such as detection of landmark of face and variance of color or light of environment. For future research, it can try other methods to improve the recognition speed.

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