Classifying Student's Faces for Teaching Assistant System

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Abstract: - This paper describes the facial emotion recognition to determine the student's conditions. The facial emotion recognition could be envisioned to sense the student's attention state through a CCD camera. Therefore, facial images were analyzed to extract the features to characterize the variations between two categories of student's faces (understand or unsure/confused) images. The features extraction techniques apply was Principal Component Analysis (PCA), this algorithm finds the principle components of the covariance matrix of a set of face images. Then, the eigenvalues component will be used as an input to the Minimum Distance classifier. The ultimate goal of this research is to develop an intelligent system to investigate the relation between teaching quality contents and comprehension in learning according to the specific emotion state.

Key-Words: - **Face Recognition, Principal Component Analysis (PCA),** (6 - 10 words)

1 Introduction

In the process of learning, the main objective of the learning is to understand what has been taught by the lecturer or teacher. Currently, teaching and learning evaluation are evaluated using questionnaire given at the end of academic session. Meanwhile, student's academic performances are analyzed after the test or final examinations. Then, lecturers store the student's feedback and strengthen their knowledge for a better teaching delivery. They acquire new ideas and methods in the next coming academic session. However, they are shortcoming with this feedback strategy. Although questionnaires ask intentional questions and they are suitable for gathering information about what student wants to learn, it is difficult to determine which parameters of learning contents affect their understanding in teaching and learning process.

Therefore, the understand level of the students are quite important during the learning process. It determined how much the knowledge has been gained by them during the lecture. If the students do not understand during the learning process, meaning that the quality of the teaching technique will still not suit the students' level enough and the teacher or lecturer in charge should change their techniques or sharpening their skill during give lecturing.

In this paper, we proposed a system using CCD camera to capture student's faces and classify the image under two categories of student's faces (understand or unsure/confused). Besides that, a few surveys will be conducted to the students to support their faces representation. In this context, we used Principal Component Analysis (PCA) to extract the facial features and classify the images using Euclidean Distance Classifier. This facial recognition and classification can be used in a real-time system as a computer aided teaching assistant system which will have an indicator of the current student's understanding status during the class hour.

In the next section, we describe some related works and the differences between our study and existing research. We show the experimental setup in Section 4.We discuss the details of the analysis and the results in Section 5 and indicate our conclusion and future work in Section 6.

2 Related Works

For the synthesis of facial emotion recognition, many related research have been studied and apply for various application like automobile awareness system, age detection, customer decision support etc. Furthermore, some of the facial emotion recognition are happy, sad, angry, sleepy and stress faces. In our work, we present other facial emotion recognitions which are confident and unsure or confused. Meanwhile, research in face recognition was growth aggressively and many techniques were

used to analyze the facial images through estimation of optical flow [4], holistic spatial analysis [2], such as principal component analysis, independent component analysis, local feature analysis [7], and linear discriminant analysis (LDA); and methods based on the outputs of local filters [3], such as Gabor wavelet [4] representations and local principal components [5, 6]. This paper used the most popular technique for facial recognition which is Principal Component Analysis (PCA).

3 Principal Component Analysis

PCA is mathematically defined as an orthogonal linear transformation that transforms the data to a new coordinate system such that the greatest variance by any projection of the data comes to lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on.

The main idea of using PCA was a 2-D facial image can be represented as 1-D vector by concatenating each row (or column) into a long thin vector. Let's suppose we have *M* vectors of size *N* (= rows of image x columns of image) representing a set of sampled images. *pj*'s represent the pixel values.

$$x_i = [p_1 .... p_N]^T, i = 1 .... M \quad (1)$$

The images are mean centered by subtracting the mean image from each image vector. Let *m* represent the mean image.

$$m = \frac{1}{M}\sum_{i=1}^{M} x_i \quad (2)$$

And let *wi* be defined as mean centered image

$$w_i = x_i - m \quad (3)$$

Our goal is to find a set of *ei*'s which have the largest possible projection onto each of the w_i's. We wish to find a set of *M* orthonormal vectors e_i for which the quantity

$$\lambda_i = \frac{1}{M}\sum_{n=1}^{M} (e_i^T w_n)^2 \quad (4)$$

is maximized with the orthonormality constraint

$$e_l^T e_k = \delta_{lk} \quad (5)$$

It has been shown that the e_i's and λ_i's are given by the eigenvectors and eigenvalues of the covariance matrix

$$C = WW^T \quad (6)$$

where *W* is a matrix composed of the column vectors w_i placed side by side. The size of *C* is *N x N* which could be enormous. A common theorem in linear algebra states that the vectors e_i and scalars λ_i can be obtained by solving for the eigenvectors and eigenvalues of the *M x M* matrix W^TW. Let d_i and μ_i be the eigenvectors and eigenvalues of W^TW, respectively.

$$W^T W d_i = \mu_i d_i \quad (7)$$

By multiplying left to both sides by *W*

$$WW^T (Wd_i) = \mu_i (Wd_i) \quad (8)$$

which means that the first *M* - 1 eigenvectors e_i and eigenvalues ¸*i* of WW^T are given by Wd_i and μ_i, respectively. Wd_i needs to be normalized in order to be equal to e_i. A facial image can be projected onto $M' (\leq M)$ dimensions by computing

$$\Omega = [v_1 v_2 ... v_{M'}]^T \quad (9)$$

where $v_i = e_i^T w_i$. v_i is the i^{th} coordinate of the facial image in the new space, which came to be the principal component. the face class *k* that minimizes the Euclidean distance

$$\varepsilon_k = \|\Omega - \Omega_k\| \quad (10)$$

where Ω_k is a vector describing the k^{th} face class. If ε_k is less than some predefined threshold θ_ε, a face is classified as belonging to the class k.

The k^{th} class ω_k is represented by its mean vector m_k and covariance matrix which can be estimated from the training samples.

$$m_k = \frac{1}{N_k}\sum_{i=1}^{N_k} x_i^{(k)} (k = 1,..., c) \quad (11)$$

and

$$\Sigma_k = \frac{1}{N_k}\sum_{i=1}^{N_k} (x_i^{(k)} - m_k)(x_i^{(k)} - m_k)^T \quad (12)$$

A given pattern of unknown class is classified to ω_k if its Mahalanobis distance to ω_k is smaller than those to all other classes.

$$X \in \omega_k \quad iff \quad D_M(x,\omega_k) = \min\left\{ D_M(x,\omega_i) \quad i = 1,...,c \right\} \tag{13}$$

For simplicity, the distance $D_L(x,m_i)$ can be used to replace $D_M(x,\omega_i)$ above. As now only the mean vector of each class is used, the classification does not take into account how the classes are distributed in the feature space.

4 Facial Emotions Recognition

In this paper, the training set consists of the features extracted from known images of different persons. Thus, the task of the face detector is to find the most similar feature vector among the training set to the feature vector of a given test image. Here, the system will try to recognize image using PCA as a feature extraction and classify the image into (understand or unsure/confused) faces using minimum distance classifier.

In this project, the student's faces images were collected by using CCD camera. The CCD camera will be used to record the situation during the lecture. A questionnaire will also be give on the same time to investigate the emotion or face expression showed by the student was compatible with the image in the video. The image will be crop out in the dimension of 480x640. The images that collect must be in front side of the face to ensure the PCA give a better performance.

According to Fig. 1, the original face images were set as the training data and the eigenfaces was calculated from the training set. A face space was defined by these 75 images. Then, by projecting the face images onto the "face space", the corresponding distribution in 480x640 dimensional weight spaces for each known expression image was calculated. The contribution of each eigenfaces in represented the face image was described by the vector formed by the weight spaces. These vectors were a predefined face classes. Based on the eigenfaces values, a vector was formed by a set of weight that used in a standard pattern recognition algorithm to find which of a number of predefined faces classes. Finally, Euclidean distance was used to classify the image which had minimizes distance between the input face and train set.

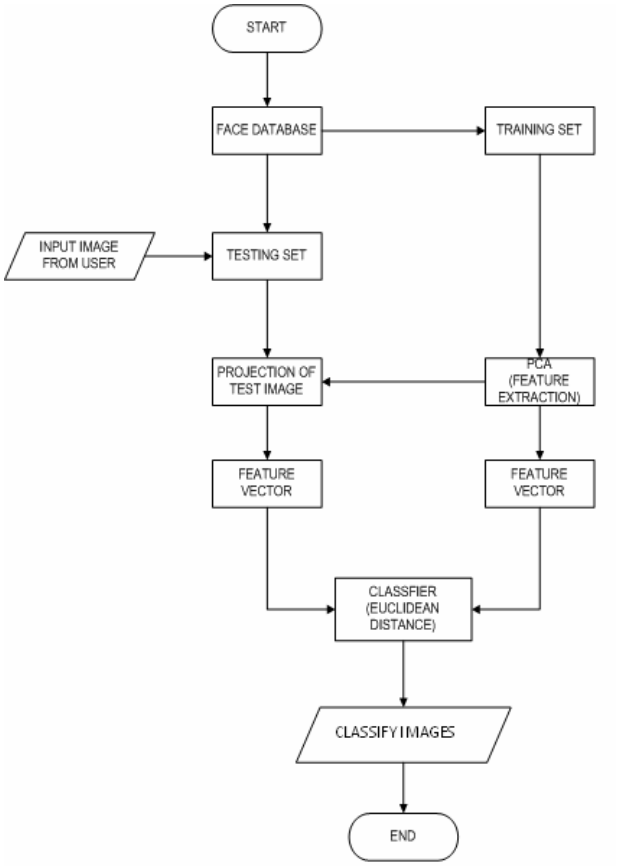
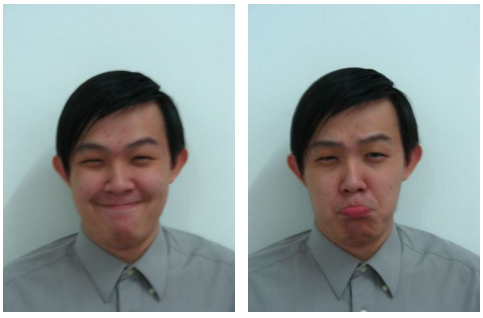


Figure 1: System Development Process

5 Classifications and Analysis

Testing images for classification were taken by these 30 images. Fig. 2 shows sample original image for understand and confused/unsure face image.



(a) (b)

Figure 2: Original Images (a) understand (b) confused/unsure

Then, a number of testing face images like in Fig. 3 will be used to test the classifier in order to determine the student's facial images classes into two categories of student's as discuss earlier. Therefore, for testing set images, a face image can

be approximately reconstructed using a mean of the eigenfaces obtained in Fig. 4. The mean values form a feature vector for face representation and recognition. Classification of an object is provided by minimum distance classifier. When a new test image is given, the weights are computed by projecting the image onto the eigenface vectors. Fig.5 shows the feature space form the projected images. The classification is then carried out by comparing the distances between the weight vectors of the test image and the images from the database.

Figure 3: Sample Images

Figure 4: Eigenfaces

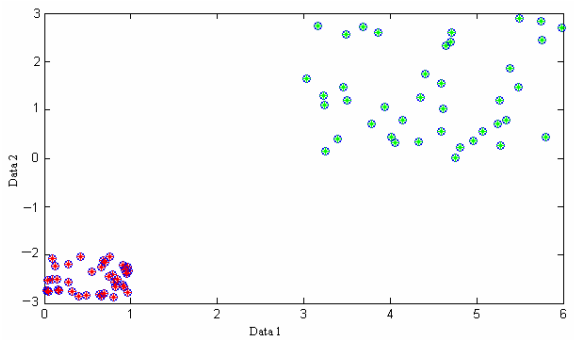


Figure 5: 2D feature space representation of hypothetical data

Table 1: Performance of Minimum Distance Classifiers

Emotions	Success	Failure	Success Rate
Understand	13	2	86.67%
Unsure/Confused	10	5	66.67%

Table 1 below represents the result of classifying student's facial emotions image using Minimum Distance Classifier. The lower success rate for unsure/confused faces is due to the head orientation, while the most images have very significant features around their forehead.

6 Conclusion and Future Works

As a conclusion, PCA give good effect in recognizing emotions images. Other technique like local point feature detector could be used to enhance the performance for this classifier. However, this paper has successfully produced results for the first stage in investigating student's behavioral and their learning conditions by detecting the facials emotions thus design the human-computer interaction of teaching and learning process for future education systems.

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