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Facial Expression Recognition using Principal Component Analysis with Singular Value Decomposition

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Abstract: ***Expression detection is useful as a non-invasive method of lie detection and behavior prediction. These facial expressions may be difficult to detect to the untrained eye. This paper implements facial expression recognition techniques using Principal Component analysis (PCA) with Singular Value Decomposition (SVD). Experiments are performed using Real database images. The universally accepted five principal emotions to be recognized are: Angry, Happy, Sad, Disgust and Surprise along with neutral. Euclidean distance based matching Classifier is used for finding the closest match.***

Keywords: Facial Expression Recognition, Principle component Analysis (PCA), Singular Value Decomposition (SVD), Euclidean distance Classifier.

I. INTRODUCTION

Expression is the most important mode of non-verbal communication between people. Recently, the facial expression recognition technology attracts more and more attention with people's growing interesting in expression information. Facial expression carries crucial information about the mental, emotional and even physical states of the conversation. Facial expression recognition has practical significance; it has very broad application prospects, such as user-friendly interface between man and machine, humanistic design of goods, and emotional robot etc. Face recognition is a technology which recognizes the human by his/her faces image. Although people can recognize facial expression easily, it is very hard to make computer do this. The main difficulty is about the face feature extraction on the accuracy and effectiveness.

Conventional methods extract features of facial organs, such as eyes and a mouth and recognize the expressions from changes in their shapes or their geometrical relationships by different facial expressions. Our aim is to explore the issues in design and implementation of a system that could perform automated facial expression analysis. In general, three main steps can be distinguished in tackling the problem. First, before a facial expression can be analyzed, the face must be detected in a scene. Next is to devise mechanisms for extracting the facial expression information from the observed facial images or image sequences.

Principal Component Analysis (PCA) is a statistical technique used for dimension reduction and recognition & widely used for facial feature extraction and recognition. The Singular Value Decomposition (SVD) is an outcome of linear algebra. SVD in digital applications provides a robust method of storing large images as smaller, more manageable square ones.

II. Related Work

Fasel fulfills the recognition of facial action units, i.e., the subtle change of facial expressions, and emotion-specified expressions. The optimum facial feature extraction algorithm, Canny Edge Detector, is applied to localize face images, and a hierarchical clustering-based scheme reinforces the search region of extracted highly textured facial clusters [7].

Yang, J., Zhang, suggested a new technique coined two- dimensional principal component analysis (2DPCA) is developed for image representation. As opposed to PCA, 2DPCA is based on 2D image matrices rather than 1D vector. But after 2DPCA, PCA must be applied which is unrealistic in such situation [1].

Sebe et al. experiment with different types of classifiers such as k-Nearest Neighbor (kNN), Support Vector Machines (SVMs), and Bayesian Networks and decision tree based classifiers in their work: Authentic Facial Expression Analysis.

Lien describes a system that recognizes various action units based on dense flow, feature point tracking and edge extraction. The system includes three modules to extract feature information: dense-flow extraction using a wavelet motion model, facial feature tracking, and edge and line extraction. "Humanoid Robots" was developed on the bases of Generalized Feed Forward Neural Network (GFFNN) and Multilayer Perceptron (MLP) for the classification stage while the Statistical Parameters and Discrete Cosine Transform (DCT) have been used for feature extraction. This report has achieved approximately 100% accuracy rate regarding testing and training data [2].

III. Facial Expression Database

This dataset is obtained by capturing the images from Panasonic camera with resolution of 14.1Mega pixel in daylight condition. Total 57 images of five persons with different expressions like happy, neutral, sad, surprise and anger are taken, out of that training set is consisted of 40 images. On the other hand, the test set contains 17 images that are consisted of random choosing images from every expression. I can get the recognition rate of every expression and average recognition rate of all test samples. The average recognition rate of 17 colour test samples with PCA using SVD is 65.42%. Fig.1 shows the sample database images.

Fig.1 Sample Colour Database Images

IV. Facial Expression Recognition System

This section describes facial expression recognition system architecture. Our system is composed by four modules:

Pre-processing, Principal Component analysis with Singular Value decomposition and expression classification using Euclidian Distance classifier. Fig.2 represents the basic blocks of facial expression recognition system.

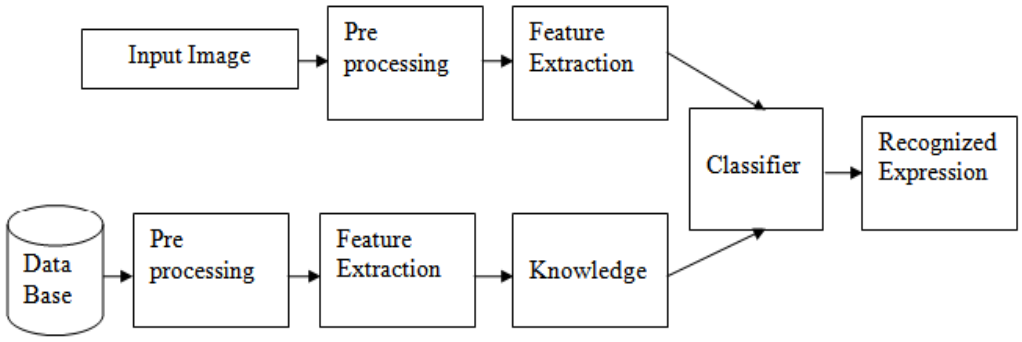

Fig.2 Facial Expression Recognition System Architecture

The data type of the image sample is transformed to double precision and passed for Feature extraction. In feature extraction unit runs the PCA with SVD algorithm. The Feature matrices of train images and testing images are passed to the classifier unit for the classification of given face query with the knowledge created for the available database. Then Euclidean distance based matching Classifier is used for finding the closest match. The mean of neutral images is calculated of train images. Then distance between the expression of test image and mean neutral expression is calculated which is Euclidean distance. Similarly, distance between the expression of train image and mean neutral expression is calculated. The minimum difference between any pair would symbolize the best possible matched facial Expression.

V. PCA WITH SVD METHOD

Principal Component Analysis (PCA) is a statistical technique used for dimension reduction and recognition, & widely used for facial feature extraction and recognition. PCA is known as Eigen space Projection. However, existing PCA-based face recognition systems are hard to scale up because of the computational cost and memory-requirement burden. 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 £ columns of image) representing a set of sampled images. pj's represent the pixel values.

$$xi = [p1,pN]T ; i = 1,.....,M$$

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

$$m = 1/M \sum_{i=1}^{M} xi$$

And let wi be defined as mean centered image

$$wi = xi - m$$

Our goal is to find a set of ei's which have the largest possible projection onto each of the wi's. The singular value decomposition is an outcome of linear algebra. SVD in digital applications provides a robust method of storing large images as smaller, more manageable square ones. The singular value decomposition of a matrix A of m x n matrix is given in the form,

$$A=U\Sigma VT$$

Where U is an m x m orthogonal matrix; V an n x n orthogonal matrix, and Σ is an m x n matrix containing the singular values of A along its main diagonal.

VI. EXPERIMENTAL RESULTS

The training database is consisted of 40 images. On the other hand, the test database contains 17 images that are randomly chosen from every expression. The main statistical measurements which were utilized to evaluate the facial expression recognition system are: Recognition Rate, Precision and Accuracy. The recognition is performed 10 times. Fig. 3 reveals the

comparison of the recognition rate for every expression with PCA using SVD methods about training set of 40 images and test set of 17 images. The recognition rate of the happy expression with PCA with SVD Algorithm is higher than other expressions for 17 test images. The following tables display the results that are collected from the text file. Table 1 demonstrates the system results of the testing 17 “colour images".

Table I System Performance for Testing 17 Colour Images using PCA with SVD

Target Recognition Rate	Happy [05]	Neutral [05]	Sad [03]	Surprise [04]	Average
Happy	04	00	01	00	
Neutral	01	02	00	00	
Sad	00	00	02	01	
Anger	00	03	00	00	
Surprise	00	00	00	03	
Precision	80%	66.67%	66.67%	100%	78.33%
Accuracy	88.24%	82.35%	94.11%	94.11%	89.70%
Recognition Rate	80%	40%	66.67%	75%	65.42%

Table II Recognition Rates for Colour Test Images using PCA with SVD

Facial Expression	Recognition Rate using PCA with SVD (%)
Happy	80
Neutral	40
Sad	66.67
Surprise	75

Table III Accuracy Rate for Colour Test Images using PCA with SVD

Facial Expression	Accuracy Rate using PCA with SVD (%)
Happy	88.24
Neutral	82.35
Sad	94.11
Surprise	94.11

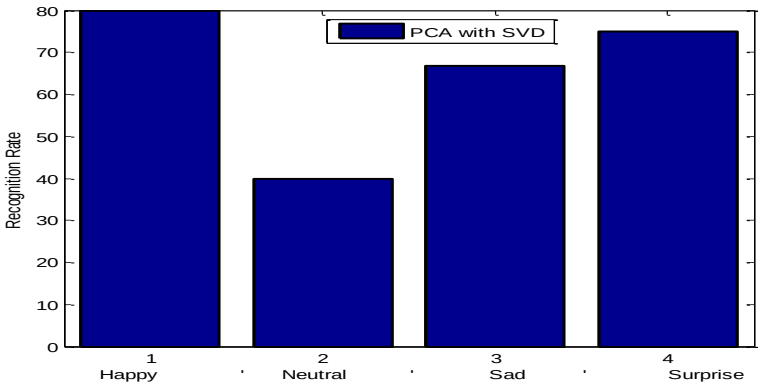

Fig 3 Bar Graph of Recognition Rate for Colour database Test Images using PCA with SVD

VII. CONCLUSION

We proposed PCA with SVD algorithm for classification of facial expressions. The algorithm is implemented on real database images captured from digital camera. This algorithm can effectively distinguish different expressions by identifying features. The average Accuracy of the system obtained is about 89.70%. We got 65.42% average recognition rate for all five principal emotions namely Angry, Disgusts, Happy, Sad and Surprise along with Neutral.

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