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Recognition of Facial Expressions with Principal Component Analysis and Singular Value Decomposition

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ABSTRACT
This paper presents a new idea for detecting an unknown human face in input imagery and recognizing his/her facial expression. The objective of this research is to develop highly intelligent machines or robots that are mind implemented. A Facial Expression Recognition system needs to solve the following problems: detection and location of faces in a cluttered scene, facial feature extraction, and facial expression classification. The universally accepted five principal emotions to be realized are: Angry, Happy, Sad, Disgust and Surprise along with neutral. Principal Component Analysis (PCA) is implemented with Singular value decomposition (SVD) for Feature Extraction to determine principal emotions. The experiments show that the proposed facial expression recognition framework yields relatively little degradation in recognition rate due to facial images wearing glasses or loss of feature points during tracking.

Keywords
Feature Extraction, Facial Expression Detection, Principle component Analysis (PCA), Singular Value Decomposition (SVD), etc

1. INTRODUCTION
Facial expression is one of the most powerful, natural, and immediate means for human beings to communicate their emotions and intentions. Facial expression carries crucial information about the mental, emotional and even physical states of the conversation. . It is a desirable feature of the next generation human-computer interfaces. Computers that can recognize facial expressions and respond to the emotions of humans accordingly enable better human-machine communication development of information technology Recognition of facial expression in the input image needs two functions: locating a face in the image and recognizing its expression. We believe recognition of human facial expression by computer is a key to develop such technology. In recent years, much research has been done on machine recognition of human

Facial expressions. 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 when we watch two photos of a human face, we can answer which photo shows the facial expression more strongly. Accordingly, as extending the step of facial expression recognition, we think it is important to develop a measurement method of the strength of facial expressions. One of the key **re**maining problems in face recognition is to handle the variability in appearance due to changes in pose, expression, and lighting conditions. There has been some recent work in this direction. The increasing progress of communication technology and computer science has led us to expect the importance of facial expression in future human-machine interface and advanced communication, such as multi-media and low-bandwidth transmission of facial data In human interaction, the articulation and perception of facial expressions form a communication channel, that is additional to voice and that carries crucial information about the mental, emotional and even physical states of the conversation [6][7]. Face localization, feature extraction, and modeling are the major issues in automatic facial expression recognition [12] [13] [14].

2. RELATED WORK
Bartlett explores and compares techniques for automatically recognizing facial actions in sequences of images. These techniques include analysis of facial motion through estimation of optical flow; holistic spatial analysis, such as independent component analysis, local feature analysis, and linear discriminant analysis; and methods based on the outputs of local filters, such as Gabor wavelet representations and local principal components[5].Donato compared several techniques, which included optical flow, principal component analysis, independent component analysis, local feature analysis and Gabor wavelet representation, to recognize eight single action units and four action unit combinations using image sequences that were manually aligned and free of head motions[6]. 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 [7]. 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[8].This paper provides a new fully automatic framework to analyze facial action units, the fundamental building blocks of facial expression enumerated in Paul Ekman's Facial Action Coding System (FACS). The action units examined in this paper include upper facial muscle movements such as inner eyebrow raise, eye widening, and so forth, which combine to form facial expressions[9].In this paper, **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 [19]. Lee and Kim [14] approached a method of expression-invariant face recognition that transforms

input face image with an arbitrary expression into its corresponding neutral facial expression image. To achieve expression-invariance, first extract the facial feature vector from the input image using AAM. Next, transform the input facial feature vector into its corresponding neutral facial expression vector using direct or indirect facial expression transformation. Finally, perform the expression-invariant face recognition by distance-based matching techniques nearest neighbor classifier, linear discriminant analysis (LDA) and generalized discriminant analysis (GDA). Geetha et al. [11] a method was described for real time face/head tracking and facial expression recognition. A face is located by extracting the head contour points using the motion information. Among the facial features, eyes are the most prominent features used for determining the size of a face. The visual features are modeled using support vector machine (SVM) for facial expression recognition. Sebe et al. [4] 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.

3. FACIAL EXPRESSION DATABASE

The Database used in my research paper for facial expression system is JAFFE. The Japanese Female Facial Expression (JAFFE) Database contains 213 images of 7 facial expressions including neutral posed by 10 Japanese female models. Each image has been rated on 6 emotions adjectives by 60 Japanese subjects. For the implementation of face recognition a real time as well as JAFFE database captured face data is used. Face database contains 24 colored face images of individual. There are 4 images per subject, and these 4 images are, respectively, under the following different facial expressions or configuration. In this implementation, all images are resized to a uniform dimension of 256 x 256. Following Figure shows the database images considered for face Expression recognition.

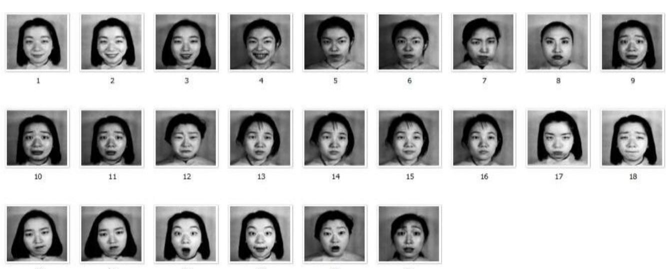

Fig 1: 24 Facial Images of Individual in Database

4. SINGULAR VALUE DECOMPOSITION

The singular value decomposition is an outcome of linear algebra. It plays an interesting, fundamental role in many different applications. On such application is in digital image processing. SVD in digital applications provides a robust method of storing large images as smaller, more manageable square ones. This is accomplished by reproducing the original image with each succeeding nonzero singular value. Furthermore, to reduce storage size even further, images may approximate using fewer singular values. The singular value decomposition of a matrix A of m x n matrix is given in the form, $A=U\Sigma V^T$ Where U is an m x m orthogonal matrix; V an n x n orthogonal matrix, and ∑ is an m x n matrix containing the singular values of A along its main diagonal. A similar technique, known as the Eigen value decomposition (EVD), digitalizes matrix A, but with this case, A must be a square matrix. The EVD digitalizes an as in equation Where D is a diagonal matrix comprised of the Eigen values, and V is a matrix whose columns contain the corresponding eigenvectors. Where Eigen value decomposition may not be possible for all facial images, SVD is the result. Let A be an m x n matrix. The matrix ATA is symmetric and can be diagonal zed. Working with the symmetric matrix ATA, two things are true: The Eigen values of ATA will be real and nonnegative. The eigenvectors will be orthogonal. To derive two orthogonal matrices U and V that digitalizes an m x n matrix A. To find the V of the singular value decomposition, $A= U \Sigma V^T$. Rearrange the Eigen values of ATA in order of decreasing magnitude. Some Eigen values are set equal to zero. Rearranging the eigenvectors of ATA in the same order as their respective Eigen values to produce the matrix V= [v1, v2, .vr, vr+1, .vn] Let the rank of A be equal to r. Then r is also the rank of ATA, which is also equal to the number of nonzero Eigen values. V1= [v1, vr] be the set of eigenvectors associated with the nonzero Eigen values. V2= [vr+1, .vn] be the set of eigenvectors associated with zero Eigen values. It follows that:

$AV2= (Avr+1, .Av^n)$

AV2= (0….0)

AV2=0 Where this zero is the zero matrix.

AV=U∑

$$A[v_1,...,v_r,v_{r+1},...v_n] = [u_1,...u_r,u_{r+1},...u_n]\begin{bmatrix} \sigma_1 & & & & & \\ & \cdots & & & & \\ & & \sigma_r & & & \\ & & & 0 & & \\ & & & & \cdots & \\ & & & & & 0 \end{bmatrix}$$

$$[Av_1,...Av_r,Av_{r+1},...,Av_n] = [\sigma_1 u_1,...\sigma_r u_r,0...0]$$

Therefore, for j=1, .r

Avj = σj uj

So uj= Avj/ σj

As seen in matrix V, the matrix U defined as:

U= [U1, U2]

$$\begin{aligned} U\Sigma V^T &= [U_1, U_2]\begin{bmatrix} \Sigma_1 & 0 \\ 0 & 0 \end{bmatrix}[V_1 V_2]^T \\ &= [U_1, U_2]\begin{bmatrix} \Sigma_1 & 0 \\ 0 & 0 \end{bmatrix}\begin{bmatrix} V_1^T \\ V_2^T \end{bmatrix} \\ &= [U_1, U_2]\begin{bmatrix} \Sigma_1 V_1^T \\ 0 \end{bmatrix} \\ &= U_1\Sigma_1 V_1^T + 0 \\ &= U_1\Sigma_1 V_1^T \\ &= AV_1V_1^T \\ &= AI \\ &= A \end{aligned}$$

$$U\Sigma V^T = A$$

5. EXPERIMENT

The block schematic of facial expression recognition system is given in figure. We have developed a program in MATLAB to obtained SVD of the images in the dataset. Vigorous experimentation is done by selecting proper number of epochs, number of runs, step size on randomize data set to generalize the problem. Input image forms the first state for the face recognition module. To this module a face image is passed as an input for the system. The input image samples are considered of non-uniform illumination effects, variable facial expressions, and face image with glasses. In second phase of operation the face image passed is transformed to operational compatible format, where the faceImage is resized to uniform dimension; the data type of the image sample is transformed to double precision and passed for Feature extraction. In feature extraction unit runs the SVD algorithm for the computation of face features for recognition. The unit calculates the U, V, S matrix using SVD operation for given face image. The obtained facial expressions are the SV used as facial feature for face recognition. These features are passed to the classifier unit for the classification of given face query with the knowledge created for the available database. For the implementation of face recognition a real time captured face data as well as JAFFE database used. For the implementation of the proposed recognition architecture the database samples are trained for the knowledge creation for classification. During training phase when a new facial image is added to the system the features are calculated and aligned for the dataset formation. Comparing the weights of the test face with the known weights of the database is found by calculating the norm of the differences between the test and known set of weights, such that a minimum difference between any pair would symbolize the closest match.

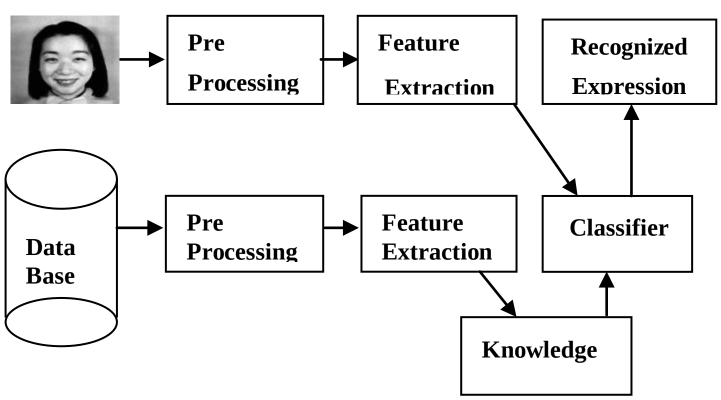

Fig 2: Methodology of Facial Expression Recognition

6. RESULTS

The optimally design Singular Value Decompositions tested on the training dataset. The results obtained are excellent. The recognition rate for all five principal emotions namely Angry, Disgusts, Happy, Sad and Surprise along with Neutral is obtained which is more than previous existing techniques. Finally the network is tested on the real time dataset with excellent recognition rate.

Table 1. Recognition Rates of Various Facial Expressions on Test Images using Euclidean Distance Measure

Facial Expression	Recognition Rate using PCA
HAPPY	95.00
DISGUST	70.00
SURPRISE	85.00
ANGRY	60.00
SAD	90.00

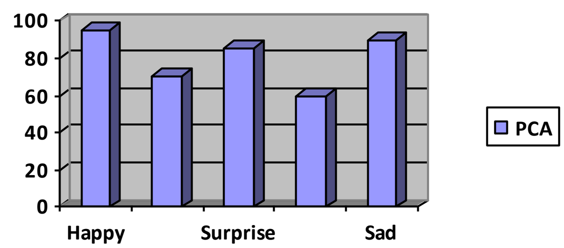

Fig 3: Recognition Rate of various Facial Expressions Represented on Bar Chart

Fig 4: Query Image

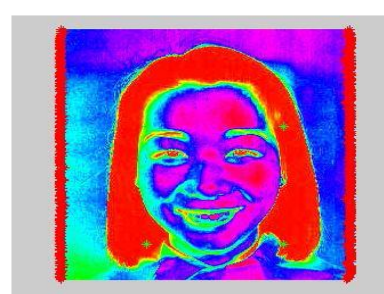

Fig 5: Extracted Face region

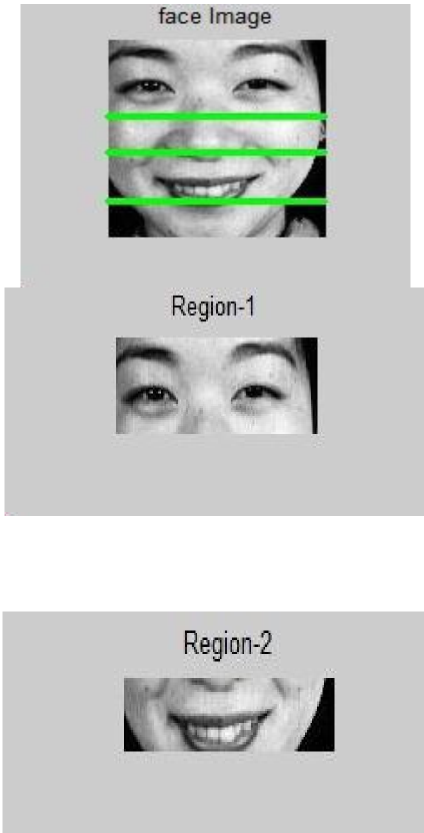

Fig 6: Feature regions

7. CONCLUSION

In this research paper we proposed PCA for classification of emotions using Singular Value Decomposition. We achieved excellent classification results for all principal emotions along with Neutral on training dataset. The proposed algorithm is implemented on both real time as well as JAFFE database. Each image is enhanced, localized and its distinct features are extracted using SVD. Experimental results show that algorithm can effectively distinguish different Expressions by identifying features. The elimination of errors due to reflections in the image has not been implemented but the algorithms used are computationally efficient.

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