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Recognition of Human Facial Expression Through Component Analysis

Sangita Gudadhe

Assistant Professor, Dept. of CSE, Sipna College of Engineeing & Technology, Amravati, India

ABSTRACT: Face recognition system is a complex image-processing problem in real world applications with complex effects of illumination, occlusion, and imaging condition on the live images. It is a combination of face detection and recognition techniques in image analyzes. Detection application is used to find position of the faces in a given image. Recognition algorithm is used to classify given images with known structured properties, which are used commonly in most of the computer vision applications. On a basis of the extensive study of different approaches to the problem of face action representation, appropriate algorithms are selected for each stage of a system.

KEYWORDS: Face, face recognition, facial expression, image processing, images.

I. INTRODUCTION

Face plays significant role in social communication. This is a 'window' to human personality, emotions and thoughts. According to the psychological research conducted by Mehrabian, nonverbal part is the most informative channel in social communication. Verbal part contributes about 7% of the message, vocal – 34% and facial expression about 55%. Due to that, face is a subject of study in many areas of science such as psychology, behavioral science, medicine and finally computer science. In the field of computer science much effort is put to explore the ways of automation the process of face detection and segmentation. Several approaches addressing the problem of facial feature extraction have been proposed. The main issue is to provide appropriate face representation, which remains robust with respect to diversity of facial appearances.

Face recognition system is a complex image-processing problem in real world applications with complex effects of illumination, occlusion, and imaging condition on the live images. It is a combination of face detection and recognition techniques in image analyzes. Detection application is used to find position of the faces in a given image. Recognition algorithm is used to classify given images with known structured properties, which are used commonly in most of the computer vision applications. These images have some known properties like; same resolution, including same facial feature components, and similar eye alignment and referred as a standard image. Recognition applications uses standard images, and detection algorithms detect the faces and extract face images which include eyes, eyebrows, nose, and mouth. That makes the algorithm more complicated than single detection or recognition algorithm.

The first step for face recognition system is to acquire an image from a camera. Second step is face detection from the acquired image. As a third step, face recognition that takes the face images from output of detection part. Final step is person identity as a result of recognition part. Methods for face detection and recognition systems can be affected by pose, presence or absence of structural components, facial expression, occlusion, image orientation, imaging conditions, and time delay (for recognition). Available applications developed by researchers can usually handle one or two effects only; therefore they have limited capabilities with focus on some well-structured application. A robust face recognition system is difficult to develop which works under all conditions with a wide scope of effect.

The detection of faces and the interpretation of facial expression under varying conditions is an everyday task for humans, which we fulfill without effort. The identity, age, gender as well as the emotional state can be seen from someone's face. The impressions we get from a displayed expression will affect our interpretation of the spoken word and even our attitude towards the speaker himself. Humor and sympathy are just two examples for essential information that are primarily communicated via facial expressions. Hence, they have a high importance for our daily life even though we often are not aware of it. For computer based systems on the other side, it still is hard to open up this very important channel of communication. Progress in this field promises to equip our technical environment with means for more effective interaction with humans and hopefully one day with something like tact recognition.

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PCA is a useful statistical technique that has found application in fields such as face recognition and image compression, and is a common technique for finding patterns in data of high dimension. PCA is a powerful tool for analyzing data.A straightforward image projection technique, called two-dimensional principal component analysis (2DPCA), is developed for image feature extraction. As opposed to conventional PCA, 2DPCA is based on 2D matrices rather than 1D vectors. That is, the image matrix does not need to be previously transformed into a vector. Instead, an image covariance matrix can be constructed directly using the original image matrices. In contrast to the covariance matrix of PCA, the size of the image covariance matrix using 2DPCA is much smaller. We have proposed the system for designing and implementing the face recognition system under variations in expressions and developing a new feature set to detect mixed emotions—such as happiness and surprise. The system is further extended for classifying the expressions from faces such as Anger, Disgust, Fear, Joy, Happy, Sad and Surprise. The 2DPCA is used for extracting the features from face image and the performance will be evaluated on the Database.

As a result, 2DPCA has two important advantages over PCA. First, it is easier to evaluate the covariance matrix accurately. Second, less time is required to determine the corresponding eigenvectors.

II. RELATED WORK

The Facial Expression Recognition System (FERS) is designed for automatic analysis of facial actions. The FER system basically consists of three elements: face detection, feature extraction and expression recognition.

- **Face Detection**

Face detection system takes image as a input and find the face region by performing some image processing techniques on the images. The techniques for face detection, we can distinguish two groups: holistic where face is treated as a whole unit and analytic where co-occurrence of characteristic facial elements is studied.

Huang and Huang [7] used Point Distribution Model (PDM) which represents mean geometry of human face. Firstly, Canny edge detector is applied to find two symmetrical vertical edges which estimate the face position and then PDM is fitted. Pantic and Rothkrantz [8] proposed system which process images of frontal and profile face view. Vertical and horizontal histogram analysis is used to find face boundaries. Then, face contour is obtained by thresholding the image with HSV color space values.Kobayashi and Hara [9] used image captured in monochrome mode to find face brightness distribution. Position of face is estimated by iris localization. Kimura and Yachida [10] technique processes input image with an integral projection algorithm to find position of eye and mouth corners by color and edge information. Face is represented with Potential Net model which is fitted by the position of eyes and mouth. Essa and Pentland [11] created the “face space” by performing Principal Component Analysis of eigenfaces from 128 face images. Face is detected in the image if its distance from the face space is acceptable.Rowley et al. [12] proposed neural network based face detection. Input image is scanned with a window and neural network decides if particular window contains a face or not.

- **Feature extraction**

Features extraction consists in the second stage of FERS can be analyzed in terms of facial action occurrence. Features are usually used to describe facial expression: geometric features and appearance features to describe feature extraction. Pantic and Rothkrantz [8] selected a set of facial points from frontal and profile face images. The expression is measured by a distance between position of those points in the initial image (neutral face) and peak image (affected face).Essa and Pentland [11] proposed temporal approach to the problem of facial expression analysis. They used the multiscale coarse-to-fine Kalman filtering. The facial motion is represented by spatio-temporal energy templates.

Black and Yacoob [14] introduced local parametric models of image motion based on optical flow information. Models could describe horizontal and vertical translation, divergence and curl.

Edwards et al. [15] used Active Appearance Model which is statistical model of shape and gray scale information. Relationships between AAM displacement and the image difference are analyzed for expression detection. Proposed system operates on static images. Cohn et al.[16] developed geometric feature based system in which the optical flow algorithm is performed only in 13x13 pixel regions surrounding facial landmarks. Zeng et al. [17] used data extracted by the 3D face tracker called Piecewise Bezier Volume Deformation Tracker. The system was designed to recognize spontaneous emotions so three-dimensional tracking was beneficial. Littlewort et al. [18] proposed system which uses only appearance features to describe facial expressions. Facial texture is measured by Gabor wavelets. Shan et al. [19] investigated the Local Binary Pattern method for texture encoding in facial expression description. Two methods of feature extraction were proposed. In the first one, features are extracted from fixed set of patches and in the second method from most probable patches found by boosting.

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- **Expression Recognition**

To describe the facial expression set of features is formed. Feature set should be composed of features that are discriminative and characteristic for particular expression. Machine learning technique is chosen usually by the sort of a feature set. Finally, database used as a training set should be big enough and contain various data. Approaches described in the literature are presented by categories of classification output.

Pantic and Rothkrantz [8] introduced the expert system with rule based classifier, which can recognize 31 action units with accuracy rate of 89%. Cohn et al. [16] performed recognition with use of discriminant functions. Proposed method can distinguish 8 AUs and 7 AUs combinations. Tests were performed on 504 image sequences of 100 subjects and the system obtained accuracy rate of 88%. Huang and Huang [7] detected motion by analysis of difference image between neutral and expression image. The minimum distance classifier is used for recognition of six basic emotions. Recognition result is 84.5% Kobayasi and Hara [9] used 234x50x6 neural back propagation network for recognition of 6 basic emotions.

III. PROPOSED ALGORITHM

On a basis of the extensive study of different approaches to the problem of face action representation, appropriate algorithms are selected for each stage of a system.

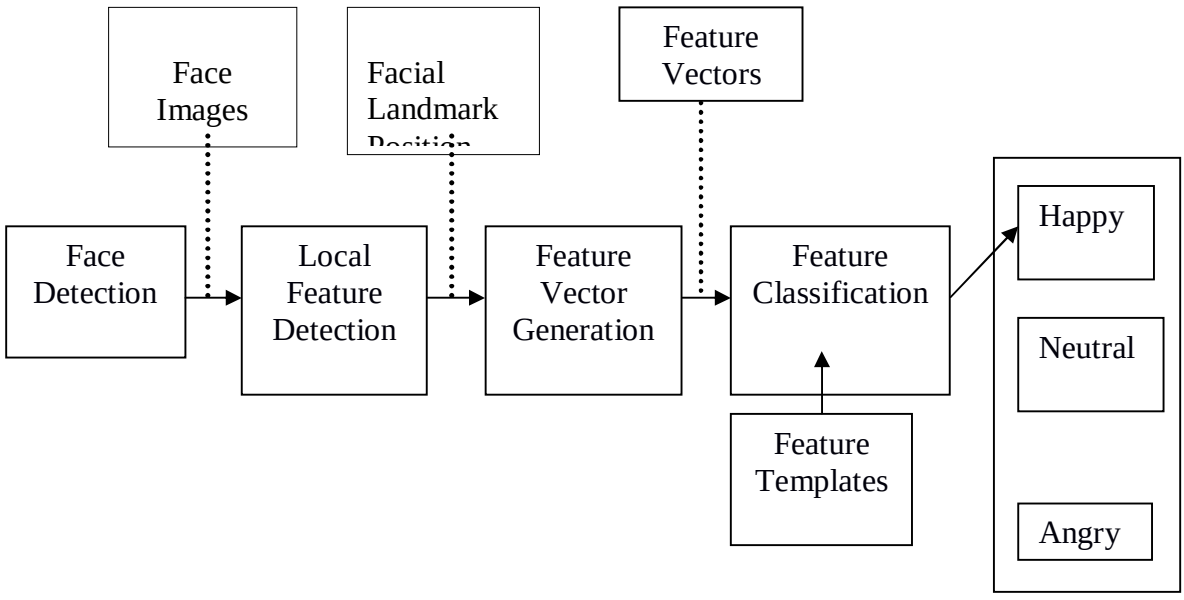

Fig. 1. An automatic facial expression recognition system

The two main stages in the system are: (i) feature extraction and (ii) feature classification. The feature extraction stage involves pre-processing stages such as face localization in the scene and scaling in addition to extraction of a feature of some kind for the region-of-interest (ROI). The feature classification process involves comparing the generated feature vector with vectors selected to represent a set of expressions.

IV. EXPERIMENTAL RESULTS

The The PCA and 2DPCA methods was used for face recognition and tested on face image database. The database was used to evaluate the performance of PCA and 2DPCA under conditions to recognize faces which are invariant to

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expression and developing a new feature set to detect mixed emotions—such as happiness and surprise and illumination conditions are varied. The results were analyzed in comparison to the PCA model and the 2DPCA model.

The recognition rate of 2DPCA was superior to PCA, ICA and Kernel Eigenfaces is shown in the following table:

Method	Recognition Accuracy
Kernel Eigenfaces	72.73%
ICA	71.52%
PCA Eigenfaces	71.52%
2DPCA	84.24%

Table.1. Comparison of the Performance of 2DPCA, Eigenfaces, ICA, and Kernel Eigenfaces Using the Database

The experimental result is shown by using one image from database.

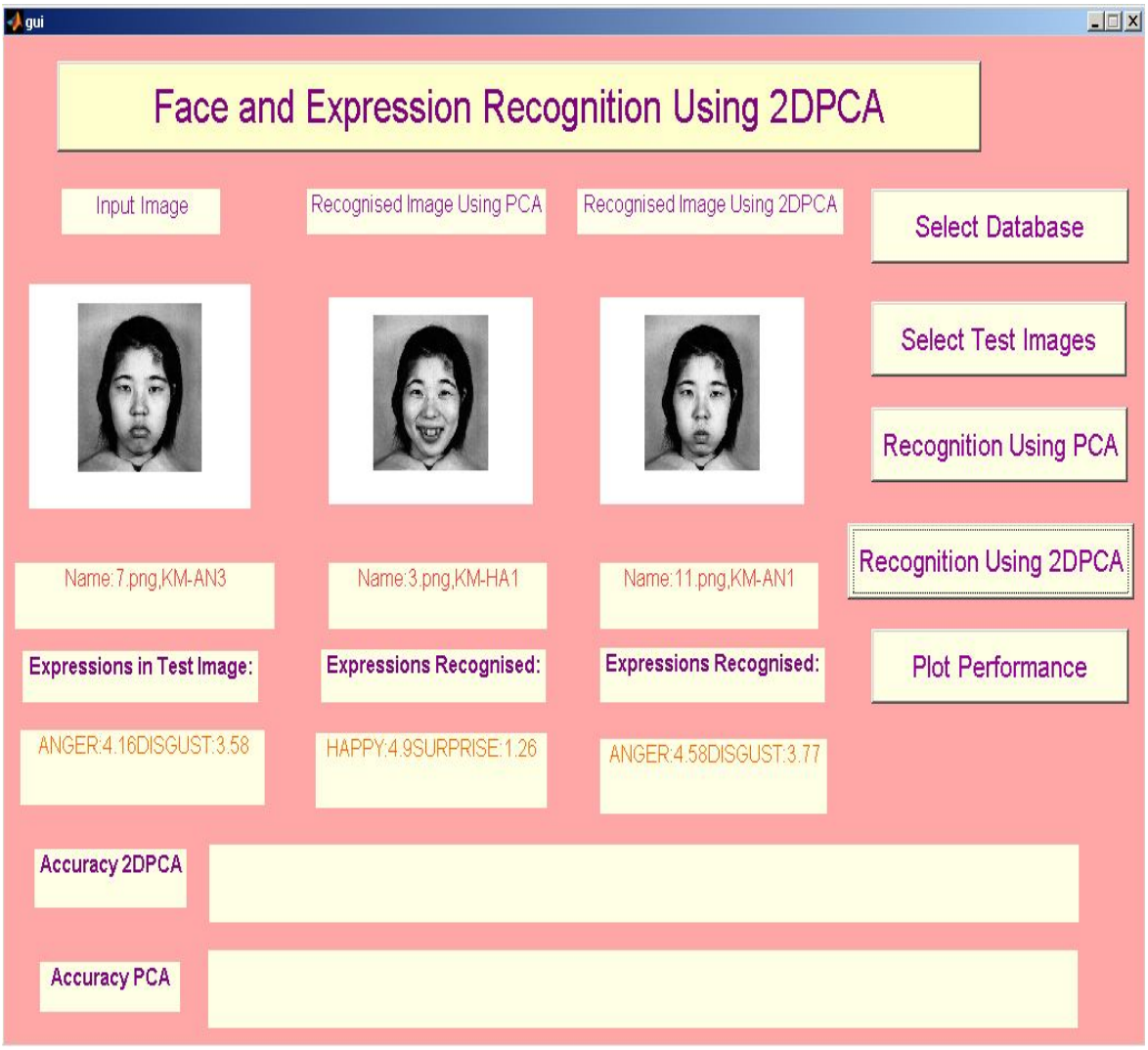

Fig. 2. Recognized image using PCA and 2DPCA

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V. CONCLUSION AND FUTURE WORK

Facial expression is an important channel for human communication and can be applied in many real applications. One critical step for facial expression recognition (FER) is to accurately extract emotional features. This proposal explores the issue of facial expression recognition using 2DPCA. In the PCA-based face-recognition technique, the 2D face-image matrices must be previously transformed into 1D image vectors. The resulting image vectors usually lead to a high dimensional image vector space in which it's difficult to evaluate the covariance matrix accurately due to its large size and relatively few training samples. Fortunately, we can calculate the eigenvectors (eigenfaces) efficiently using single value decomposition (SVD) techniques, which avoid the process of generating the covariance matrix.

Unlike conventional PCA, 2DPCA is based on 2D matrices rather than 1D vectors. That is, the image matrix doesn't need to be previously transformed into a vector. Instead, an image covariance matrix can be constructed directly using the original image matrices. In contrast to PCA's covariance matrix, the image covariance matrix's size using 2DPCA is much smaller. As a result, 2DPCA has two important advantages over PCA. First, it's easier to evaluate the covariance matrix accurately. Second, less time is required to determine the corresponding eigenvectors.

The future work of this project involves to focus on improving the recognition rate of the system. One of the possible solutions could be adding the motion information to the expression representation. The action could be described by geometrical features as well as appearance features. Finally, the time efficiency of the system can be improved in order to make it appropriate to use in different applications.

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