Analysis of Facial Expressions from Video Images using PCA

Praseeda Lekshmi V., Dr.M.Sasikumar, Naveen S.

Abstract—**Face recognition and expression analysis is one of the most challenging research areas in the field of computer vision. Though face exhibits different facial expressions, which can be instantly recognized by human eyes, it is very difficult for a computer to extract and use the information content from these expressions. In this paper we present a method to analyze facial expression from video images by focusing on the regions such as eyes, mouth etc whose geometries are mostly affected by variation in facial expressions. Face regions are extracted from video images. Skin color detection is used for identifying skin region and recognized using Principal Component Analysis (PCA) method. Face images are projected on to a feature space and the weight vectors are compared to get minimum variation. The geometric coordinates of highly expression reflected areas are extracted for analyzing facial expressions. Our method reliably works even with faces, which carry heavy expressions. This method exhibits a good performance ratio.**

Index Terms —**Pattern recognition, Principal Component Analysis, Face recognition, Facial expression, Video sequence.**

I. Introduction

The technological advances in the area of digital processing and pattern recognition has lead to the development of different algorithms for various applications such as automated access control, surveillance, Human-Computer Interaction (HCI) etc.

Manuscript received March 21, 2008.

F. A. Praseeda Lekshmi.V, Assistant Professor is with the College of Engineering Kidangoor Kottayam dist, Kerala, India, phone: 09447963211; e-mail: vplekshmi@yahoo.com.

S. B. Dr.M.Sasikumar, Professor is with Marian Engineering College, Trivandrum, Kerala, India. e-mail: drmsasikumar@yahoo.com.

T. C.Naveen.S, M-Tech Student, College of Engineering, Trivandrum, Kerala, India. e-mail: naveen_1176@yahoo.co.in

For automated access control, most common and accepted method is face recognition. Face recognition is one of the active research areas with wide range of applications. .

Generally pattern recognition problem rely on the features inherent in the pattern for efficient solution. The challenges associated with face detection and recognition problem are pose, occlusion, expression, varying lighting conditions etc. Facial expression analysis has wide range of applications in areas such as Human Computer Interaction, Image retrieval, Psychological area, Image understanding, Face animation etc. Humans interact with each other both verbally and non-verbally.

Conversations are usually dominated by facial expressions. A baby can communicate with its mother through the expressions on its face. But there are several problems in analyzing communication between human beings through non-verbal communication such as facial expressions by a computer because expressions are not always universal. It varies with ethnicity. Further facial expressions can be ambiguous. They have several possible interpretations. To analyze the facial expression, face regions have to be detected first. Next step is to extract and represent the facial changes caused by facial expressions. In facial feature extraction for expression analysis, two types of approaches are there. Geometric based methods and Appearance based methods. In Geometric based method, the shape and location of facial features are extracted as feature vectors. In Appearance based method, image filters are applied either to whole face or to specific regions of facial image to extract facial features.

In this paper, video frames are extracted from image sequences. A holistic approach for face recognition is implemented. We have addressed the geometric based method for facial expression analysis from the recognized face. The feature points are located and their coordinates are extracted. Our method yields a good performance ratio for both face identification and expression analysis individually. The results are still good when we

combined the identification and expression parts.

Rest of the paper is organized as follows. Section 2 gives back ground and related works. Section 3 discusses the proposed method. Results are given in section 4. Conclusions and future works are given in section 5.

II. BACKGROUND AND RELATED WORK

Most face recognition methods fall into two categories: Feature based and Holistic [4]. In feature-based method, face recognition relies on localization and detection of facial features such as eyes, nose, mouth and their geometrical relationships [6]. In holistic approach, entire facial image is encoded into a point on high dimensional space. Images are represented as Eigen images. A method based on Eigen faces is given in [8]. PCA [2] and Active Appearance Model (AAM) for recognizing faces are based on holistic approaches. In another approach, fast and accurate face detection is performed by skin color learning by neural network and segmentation technique [5]. Facial asymmetry information can be used for face recognition [1]. In [11], ICA was performed on face images under two different conditions: In one condition, image is treated as a random variable and pixels are treated as outcomes and in the second condition which treated pixels as random variables and image as outcome. Facial expressions are extracted from the detailed analysis of eye region images is given in [3]. In the appearance based approaches given in [7], facial images are recognized by warping of face images. Warping is obtained by automatic AAM processing.

Another method of classification of facial expression is explained in [10] in which the geometry and texture information are projected in to separate PCA spaces and then recombined in a classifier which is capable of recognizing faces with different expressions.Kernal Eigen Space method based on class features for expression analysis is explained in [9].

III. METHOD

Our proposed method consists of training stage, face recognition and expression classification stages.

A. Training stage

We have considered the face image sequences with certain degree of orientation, wearing glasses and large variations in the facial expressions. As a first step, frames with peak expression called key frames are identified. Face regions from these key frames are extracted using skin color detection method. Skin regions are identified and connected component labeling is done to classify the sub regions in the image. Faces are detected from these detected skin regions. Fig .1 shows detected face regions from skin areas. Frontal looking faces with neutral expressions called normal faces and faces with set of non-neutral expressions form the database. There were 'K' frames with 'N'expressoins for each face so that 'K x N' face images were used as the database.

Fig. 1. a. Skin region identified

Fig. 1. b. Connected component labeling

Fig. 1.c. Detected face regions

Normalization is done to make the frames with uniform scale. The normalized faces are shown in Fig 2.

Fig. 2. Normalized faces

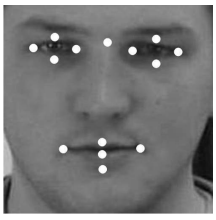

Fig. 3. Marking points

Facial expressions are highly reflected in eyes and mouth regions. Fourteen markers as mentioned in [10] are used to automatically select for registering important facial features. A triangulation method is applied to fit

the mask on the faces. The marking points represented as white dots are shown in Fig 3. The coordinates are used for further verification.

B .Face Recognition and Expression Classification

Face recognition has long been a primary goal of computer vision, and it has turned out to be a challenging task. The primary difficulty in attempting to recognize faces from image gallery comes from immense variability of face appearance due to several factors including illumination, view points of camera, facial expressions, poses, and occlusions. This method treated face recognition as a 2-D recognition problem. PCA is a useful statistical technique that has found applications in the fields such as face recognition; image compression etc. It is a common technique for finding patterns in the data of high dimensions. In PCA, face images are projected into feature space or face space. Weight vector comparison was done to get the best match.

Let the training set of face images be X_1, X_2, $X_3 \ldots Xn$, then the average set or mean of faces be defined as

$$m = \frac{\sum_{i=1}^{n} X_i}{n}$$

Notice that the symbol m to indicate the mean of set *X*.
The average distance of each face from the mean of the data set is given by

$Q_1 = X_1 - m$; $Q_2 = X_2 - m \ldots$ $Qn = Xn\text{-}m$

which is the standard deviation

The covariance matrix is given by

$C = A*A'$

where A= $[Q_1\ Q_2\ Q_3 \ldots\ldots\ldots\ldots Qn]$.

In order to reduce the dimensionality, co-variance can be calculated as

$C = A'*A$.

Eigen values and Eigen vectors are calculated for the covariance matrix
All the face images in the database are projected in to Eigen space and weight for each image is calculated.
Then image vectors for each face image is obtained as

Image Vector = $\sum_{i=1}^{10} weight(i) * Eigevector(i)$

Usually while using PCA, normal images are used as reference faces. To overcome the large variations in transformations, mean image is used as the reference face.

We used ten face image sequences, each with five facial expressions as the database. Mean faces of five key frames with peak expressions and Eigen faces are shown in Fig. 4 and Fig. 5.

Fig. 4. Mean faces of six persons

Fig. 5. Eigen faces

The probe image is also subjected to preprocessing steps before projecting it into feature space. The weight vector is calculated to identify the image from the database with closest weighting vector.

So far we have identified a reference face for each testing face. After recognizing the face, the coordinates of the facial features are extracted as explained in section 3.1. The coordinates of each testing face is compared with its reference face by calculating the mean square error between the testing face and all the prototypes of same individual. This mean square error tells us how far the expression on the testing face is from each type of expressions and thus can be used to classify expressions.

IV. RESULTS

We selected ten face image sequences from FG-NET consortium with variations in lighting conditions, small orientations, wearing glasses, heavy expressions etc. The expressions used were 'happy', 'sad', 'normal', 'surprise', and 'anger'. Frames with peak expressions from color face image sequences were extracted. Face regions were identified using skin color. Eigen faces were used for recognizing faces. These faces were converted to gray scale and normalized to a size 192X192. Fourteen points were marked at the highly expression reflected face regions. The face images in the database and the test image were projected to face space for face recognition and their coordinates were verified to identify which expression

belongs to the test face. The performance ratios are 100 % for expression recognition from extracted faces, 88% for expression recognition from frames and 88 % for the combined recognition.

Table 1.Expression recognition from Extracted face

Expressions	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
Anger	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Happy	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Neutral	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sad	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Surprise	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 1.Expression recognition from frames

Expressions	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
Anger	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Happy	Y	N	Y	Y	N	Y	Y	Y	Y	Y
Neutral	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sad	Y	N	N	Y	Y	Y	Y	Y	Y	Y
Surprise	N	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 1.Combined Performance

Expressions	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
Anger	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Happy	Y	N	Y	Y	N	Y	Y	Y	Y	Y
Neutral	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sad	Y	N	N	Y	Y	Y	Y	Y	Y	Y
Surprise	N	Y	Y	Y	Y	Y	Y	Y	Y	Y

A comparison was made between the approaches for different databases are given in the table 1, 2 and 3.

V. CONCLUSION

In this paper, face recognition and expression classification from video image sequences are explained. Frames were extracted from image sequences. Skin color detection method is applied to detect face regions. A holistic based approach in which whole face was considered for the construction of Eigen space. As a first step, images are projected to PCA space for recognizing face regions. After recognizing the face, our system could efficiently identify the expression from the face.

Our logic performs well for recognition of expressions from face sequences. The computational time and complexity was also very small. We have proposed a method to improve the efficiency and to increase the database by including more complex expressions as a future work. It is also proposed to extend the work to identify the face and it's expressions from 3D images.

IV. ACKNOWLEDGEMENT

We thank FG-NET consortium for providing us the database for the experiment.

REFERENCES

[1] Sinjini Mitra, Nicola.A.lazar, Yanxi Liu,"Understanding the role of Facial Asymmetry in Human Face Identification", DOI 10.1007/s 1222-006-9004-9, Stat Comput (2007) 17:57-70

[2] Sami Romdhani, Shaogang Gong and Alexandra psarrou,"A Multi-view Nonlinear Active Shape Model using Kernel PCA, BMVC99

[3] Tsuyoshi Moriyama, Takeo Kanade, Jing Xiao and Jeffrey F. Cohn" Meticulously Detailed Eye region Model and It's Application to Analysis of Facial Images", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol.28, No.5, May 2006

[4] Chellappa.R, Wilson.C and Sirohey.S, "Human and machine recognition of faces: A Survey" In Proc.IEEE, 83(5): 1995, 705-740

[5] Hichem Sahbi, Nozha, Boueimma, Tistarelli, J. Bigun, A.K.Jain (Eds), and "Biometric Authentication"LNCS2539, Springer Verlag Berlin Heidelberg 2002, pp: 112-120

[6] Stefano Arca, Paola Campadelli, Raffaella anzarotti "An Automatic Feature based Face recognition system"

[7] Hui Li, Hui Lin and Guang Yang," A New Facial Expression Analysis System Based on Warp Images", Proc. of Sixth World Congress on Intelligent Control and Automation, Dalian, China, 2006

[8] Turk. M, Pentland A "Face Recognition using Eigen Faces", In Proc. of IEEE conference on Computer Vision and Pattern Recognition", 1991,pages: 586-591