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Extraction of Expressions from Face Images using Neuro Fuzzy Approach

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Abstract – Body language is a form of communication between human beings. Facial expressions are a form of nonverbal communication. Facial expressions can often communicate a person's mood than a word. Here, the authors extract the facial features from facial points. Extracted feature points are tracked using a cross-correlation based optical flow to extract feature vectors. These vectors are used to categorize expressions, using RBF neural networks and Fuzzy Inference System. Recognition results from two classifiers are compared with each other.

Index Terms – Facial Expression, FIS, Neuro Fuzzy, RBF

I. INTRODUCTION

Human communication takes place in every part of life, every time 2 or more people interact. It happens through different means. When a person is talking or lettering, he or she is communicating. When people are with others, their body language communicates messages. Facial expressions are a type of communication as well. Communication between people constructs rapport and influences how people are viewed by other people. Body language is a type of communication among human beings. Body language can be as enlightening than words, since body language is subconscious, while words are filtered through conscious thought before they are presented. Facial expressions are a type of nonverbal communication. Human beings possess 80 muscles in their faces and use all of these muscles in various combinations.

Facial expressions can often communicate a person's mood without a word said. Facial expressions convey anger, fear, excitement, happiness and even apathy. Facial expressions can sometimes even give clues as to whether a person's words are sincere or not.

II. RELATED WORKS

Face plays a vital role in interpersonal communication. Automating facial expression analysis might carry facial expressions into Human Computer interaction. The authors of [1] suggested six main emotions that each groups an individual content together with an exclusive facial expression. These basic emotional exhibits are referred as basic emotions. They appear to be widespread across human societies and traditions and include happy, disgust, sad, surprise, anger and fear. In the past few years, there was a huge deal of study on recognition of faces and facial expressions. The objective of expression recognition is to discover a model for nonrigid patterns of facial expressions, so that the expressions can be classified without a wide range of variation. The authors of [2] utilize a cross approach to represent the face. They fix a quadratic grid of size 8x10 to normalized face image. Then, an averaged optical flow is computed in each 8x10 sections. The degree and the route of the computed optical flows are cut down to ternary value degree in the vertical direction alone. The detail about a horizontal direction is expelled. The face must be without hair and glasses on the face and no rigid head movement may be identified for the method to work properly. They pull out eighty facial movement factors which explain the change between a face without expressions and the properly inspected facial expression. They applied Hopfield Neural Network to identify 4 expressions (sad, happy, anger, and surprise) and the average identification rate was 92%. The same images were used for training and testing.

In [3], the authors exploited local parameterized methods of image motion for analyzing facial expressions. Non-rigid motions of facial features within the local facial areas of mouth, eyebrows, and eyes, are characterized by affine-plus-curvature method. The initial regions and the facial features were selected manually and then tracked automatically. In [4], the authors used a Back Propagation Neural Network for categorization of expression into one of six basic emotions. The elements of the input layer correspond to the number of brightness distribution data pulled out from an input image, while each unit of the output layer corresponds to an emotion among six. The network was trained by ninety images of six basic expressions shown by fifteen individuals and it has been tested on a set of ninety facial images shown by another fifteen individuals. The average identification rate was 85%.

Cohn and Kanade [5] developed a method based on optical-flow which is receptive to delicate alterations in facial expression. From the images of 125 young adults, action units and action unit combinations in the forehead and lips areas were chosen for analysis, if they took place minimum of 50 times in database. Chosen facial features were tracked without human intervention using a hierarchical algorithm for calculating optical flow approximately. Image sequences were divided into training and test sets randomly. The authors of this paper suggested two different approaches. First approach suggests the use of Eigenspaces [6] and the second approach suggests the use of Neural network [7] alone.

In this paper, the authors projected two schemes for categorizing the facial expressions from unbroken video sequences. 7 features pulled out from 21 feature points and form a feature vector for each expression.

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These vectors were used to train a Radial Basis Function Neural Network classifier and rule base were used in the Fuzzy Inference System classifier to categorize input feature vectors into one of six basic emotions.

III. METHODOLOGY

A. Image Database

There are number of image sets available freely for research purpose like JApanese Female Facial Expression (JAFFE) database, Cohn-kanade database, Indian Face Database from IIT, and Beihang University database upon a kind of agreement. For this work, the authors used Cohn-Kanade database [8] which consists of expression sequences of subjects, starting from neutral and ending in peak facial expression. There are 97 subjects in the database. Since all the six expressions sequences were not available for some subjects, the authors used a division of 50 subjects for which at least four expression sequences were available. For every person, there are 10 frames for each expression on average. Image sequences were digitized into 640 by 490 pixel array for frontal views. The ages of subjects in database were between 18 and 50. They were 59%, female 41% male, 76% Euro-American, 15% Afro-American, and 9% other groups. Some facial expressions of one subject in Cohn-Kanade database is shown in Fig. 1.

B. Optical flow based feature point tracking

Around facial landmarks, 21 key feature points were marked manually in the first frame with a mouse as shown in Fig. 2. Each and every point was the center of a flow window of size 11x11 which includes both horizontal and vertical flow. In the image sequence, Feature points were tracked automatically using optical flow method based on cross correlation. This method is illustrated in Fig. 3.

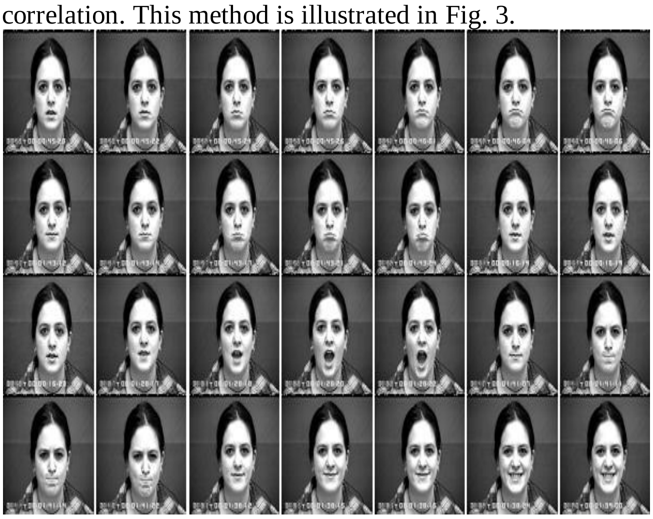

Fig. 1. Expressions of a subject in Cohn-Kanade Database.

Cross-correlation of an 11x11 window and a 21x21 window were computed and position of feature point at the next frame from the evaluation of the position with maximum cross correlation of two windows. By subtracting its normalized position in the first frame from its current normalized position, each and every feature point was computed. The position of all feature points was normalized by position of the top of nose.

C. Feature extraction

From the position of feature points in both the first and the end frame, seven features were extracted. The feature vector for each expression was formed from these features and was used to categorize that expression to one of the six basic expressions using neural network or fuzzy inference system. Extracted features are given below.

Eyes width

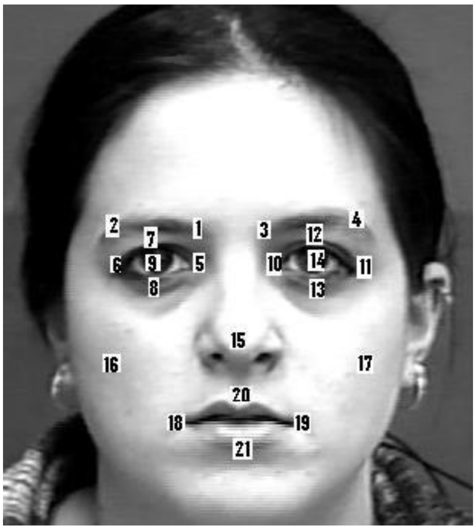

Fig. 2. 21 feature points marked manually

$$ew = ((X11 - X10) + (X5 - X6)) / 2 \quad (1)$$

Eyebrows height 1

$$eh1 = ((Y15 - Y4) + (Y15 - Y2)) / 2 \quad (2)$$

Eyebrows height 2

$$eh2 = ((Y15 - Y3) + (Y15 - Y1)) / 2 \quad (3)$$

Mouth width

$$mw = X19 - X18 \quad (4)$$

Mouth openness

$$mo = Y21 - Y20 \quad (5)$$

Distance between lip corners & nose tip

$$ln = ((Y18 - Y15) + (Y19 - Y15)) / 2 \quad (6)$$

Distance between cheek & eye

$$ce = ((Y16 - Y9) + (Y17 - Y14)) / 2 \quad (7)$$

IV. RADIAL BASIS FUNCTION NEURAL NETWORK CLASSIFIER

The authors used Radial Basis Function Neural Network [9] for their study which is represented in Fig. 4:

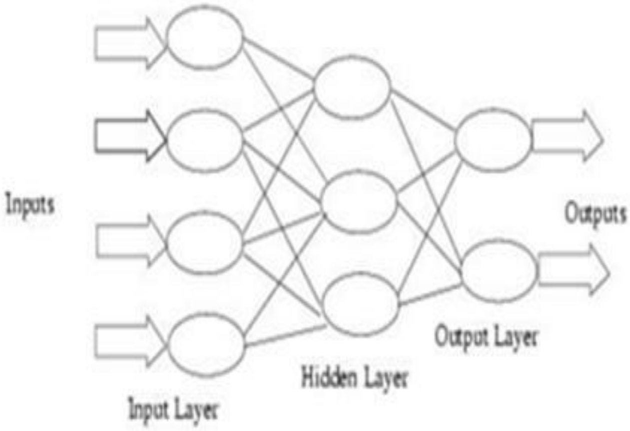

Fig. 4. Schematic diagram of RBF Neural Network

An RBF neural network can be considered as a special three-layer network which is linear with respect to the output parameters after fixing all the radial basis function centers and nonlinearities in the hidden layer. The segment of overlap between every hidden unit and the hidden units near it is determined by the width sigma such that a soft interpolation over the input space is permissible. Therefore the complete architecture is set by deciding the hidden layer and the weights between the middle and the output layers.

The number of input layer units has to be equal to the extracted seven features, and the number of output layers which matches six types of facial expressions. The training of network is conducted by back propagation algorithm.

V. FUZZY INFERENCE SYSTEM CLASSIFIER

The diagrammatic representation of the Fuzzy Inference System classifier [10] which was used for this work is given glow in Fig. 5.

A rule base was used to categorize the input feature vectors into one of the six basic expressions based on the extracted features and the same is shown in Table 1.

All the feature values were normalized between [0, 1] and Gaussian membership functions (MF) were used for them and for the classifier outputs. Shape and position of these membership functions decided based on the maximum, minimum and average of training set extracted features.

Table 1. FIS rule base (VS: Very Small, S: Small, M: Medium, L: Large, VL: Very Large)

	EW	EH1	EH2	MW	MO	LN	CE
Happy	M	M	M	VL	S	S	S
Surprise	VL	VL	L	M	VL	VL	L
Sad	S	M	L	M	VS	M	M
Anger	M	M	S	S	S	M	S
Disgust	M	VS	S	M	S	S	S
Fear	L	L	L	S	M	M	M

VI. RESULTS

In the Radial basis function classifier, the authors used the sequence of a few subjects as test sequences (15 subject), and the sequence of the remaining subjects as training sequence. This test is repeated four times, each time leaving different subjects out. Table 2 shows the recognition rate of the test for this classifier and Table 3 shows the recognition rate of the Fuzzy Inference System classifier:

Table 2: Test results of RBF network classifier

Expression	Recognition rate
Happiness	100 %
Surprise	100 %
Sadness	88.6 %
Anger	92.7 %
Disgust	96.9 %
Fear	85.3 %
Average Recognition Rate	93.9 %

Table 3: Test results of FIS classifier

Expression	Recognition rate
Happiness	96.3 %
Surprise	99.0 %
Sadness	86.8 %
Anger	88.7 %
Disgust	92.8 %
Fear	83.6 %
Average Recognition Rate	91.2 %

VII. CONCLUSION

In this work, the authors offered two different systems for categorizing the facial expressions from the continuous video inputs. In the Radial Basis Function classifier, seven facial features extracted from twenty one facial feature points were used as training and test sequences. The trained network was tested by facial features which are not used in training and attained a high recognition rate of 93.9 %. In the Fuzzy Inference System Classifier, for inputs and outputs of the system, the authors used Gaussian Membership Functions. A rule base was used to categorize input feature vector and obtained a recognition rate of 91.2%. The comparison of both the systems shows that first one works better than second and first offers higher recognition rate but acquire more processing time. Second one is preferred for the real time problems.

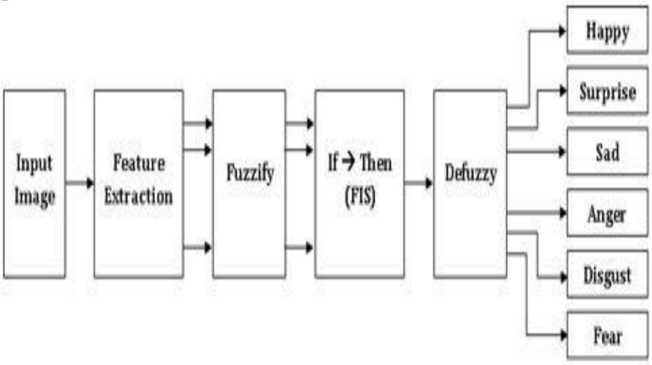

Fig. 5. Diagrammatic representation of Fuzzy Inference System

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