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Face Recognition Using Neural and Fuzzy Techniques

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Abstract
Face is a primary focus of attention in social intercourse, playing a major role in conveying identity and emotion. The human ability to recognize faces is remarkable. People can recognize thousands of faces learned throughout their lifetime and identify familiar faces at a glance even after years of separation. This skill is quite robust, despite large changes in the visual stimulus due to viewing conditions, expression, aging, and distractions such as glasses, beards or changes in hair style.
In this work, a system is designed to recognize human faces depending on their facial features. Also to reveal the outline of the face, eyes and nose, edge detection technique has been used. Facial features are extracted in the form of distance between important feature points. After normalization, these feature vectors are learned by artificial neural network and used to recognize facial image.

Keywords
Image Processing, Artificial Neural Network, Edge Detection, Feature Extraction.

I. Introduction

A problem of personal verification and identification is an actively growing area of research. Face, Voice, Lip movements, Hand geometry, Odours, Gait, Iris, Retina, Fingerprint are the most commonly used authentication methods. All of these behavioural and psychological characteristics of a person are called biometrics. The biometrics have a significant advantage over the traditional authentication techniques due to the biometric characteristics of individuals are not easily transferable, are unique of every person, and cannot be lost, stolen or broken. Face Recognition is one of the methods to identify the features of face of every individual. Research in this area has been conducted for more than 30 years, using a pre-stored image database, the face recognition system is able to identify or verify one or more persons in the database. The face is recognized by considering features viz., eye distance, nose distance, lip distance etc.

Thai Hoang Le[1] presented Applying Artificial Neural Networks for Face Recognition. That paper introduces some novel models for all steps of a face recognition system. In the step of face detection, they proposed hybrid model combining AdaBoost and Artificial Neural Network (ABANN) to solve the process efficiently. Shamla Mantri and Kalpana Bapat [2] proposed Neural Network Based Face Recognition Using Matlab. In this paper, they proposed to label a Self-Organizing Map (SOM) to measure image similarity. The SOM method was trained on images from one database. The novelty of that work comes from the integration of Images from input database, Training and Mapping.

Aborisade, D.O [3] proposed Novel Fuzzy logic Based Edge Detection Technique. This paper is based on the development of a fuzzy logic based edge detection technique in digital images. The proposed technique used three linear spatial filters to generate three edge strength values at each pixel of a digital image through spatial convolution process. Mandeep Singh Sandhu, et al. [4] presented Image Edge Detection by Using Rule Based Fuzzy Classifier. In that research work Fuzzy image processing was used for edge detection, which was a collection of fuzzy logic and image processing that understand, represent and process the images as fuzzy sets.

Face recognition is a visual pattern recognition problem. In detail, a face recognition system with the input of an arbitrary image will search in database to output people's identification in the input image.

Advanced image processing or computer vision techniques will enhance the quality of symbolization of faces in video corpus. Robust face detection and tracking in videos is still challenging. The advantage of using neural networks for face detection is the feasibility of training a system to capture the complex class conditional density of face patterns. However, one drawback is that the network architecture has to be extensively tuned (number of layers, number of nodes, learning rates, etc.) to get exceptional performance. Many research efforts have been made in face detection, especially for surveillance and biometrics.

Broadly, face recognition methods can be categorized into two groups: feature-based and appearance based. In feature-based approach, a set of local features is extracted from the image such as eyes; nose, mouth etc. and they are used to classify the face. The major benefit of this approach is its relative robustness to variations in illumination, contrast, and small amounts of out-of-plane rotation. The appearance-based approaches use the entire image as the pattern to be classified, thus using all information available in the image. However, they tend to be more sensitive to image variations.

In this paper, a system has been designed which is based on edge detection and feature extraction.

A general block diagram is shown below:

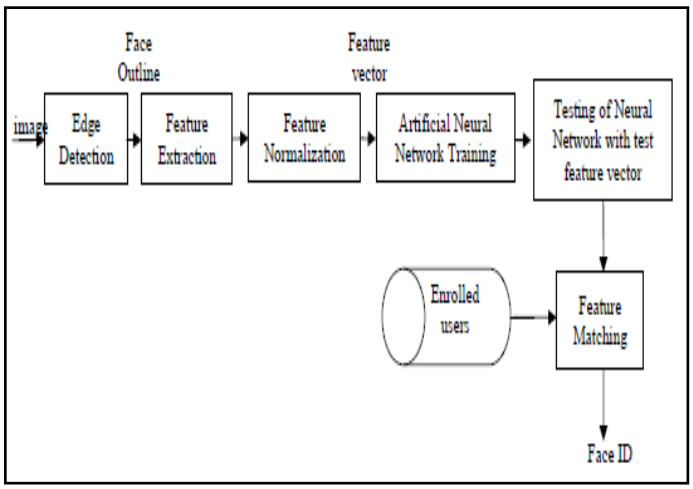

Fig. 1: Block diagram

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II. Edge Detection

An edge is sharp change in intensity of an image. If the edges in an image are identified accurately, all the objects are located and their basic properties such as area, perimeter and shape can be measured. In this paper, Uncertainty of image processing is handled within the frame work of fuzzy logic. Figure 2 shows the essential components of fuzzy logic system.

The FIS designed in this thesis is given four inputs and one output. The four inputs P1, P2, P3 and P4 are the four pixel values of the window mask used. The triangular membership functions are used both for the inputs and the output.

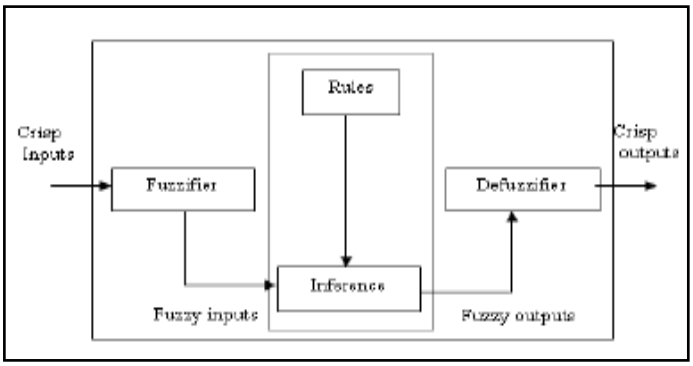

Fig. 2 : Fuzzy logic system

A. Design of FIS for edge detection

Two fuzzy sets are used for the input Black and White and three fuzzy sets are used for the output. Fuzzy sets for input and output variables are designed as shown below:

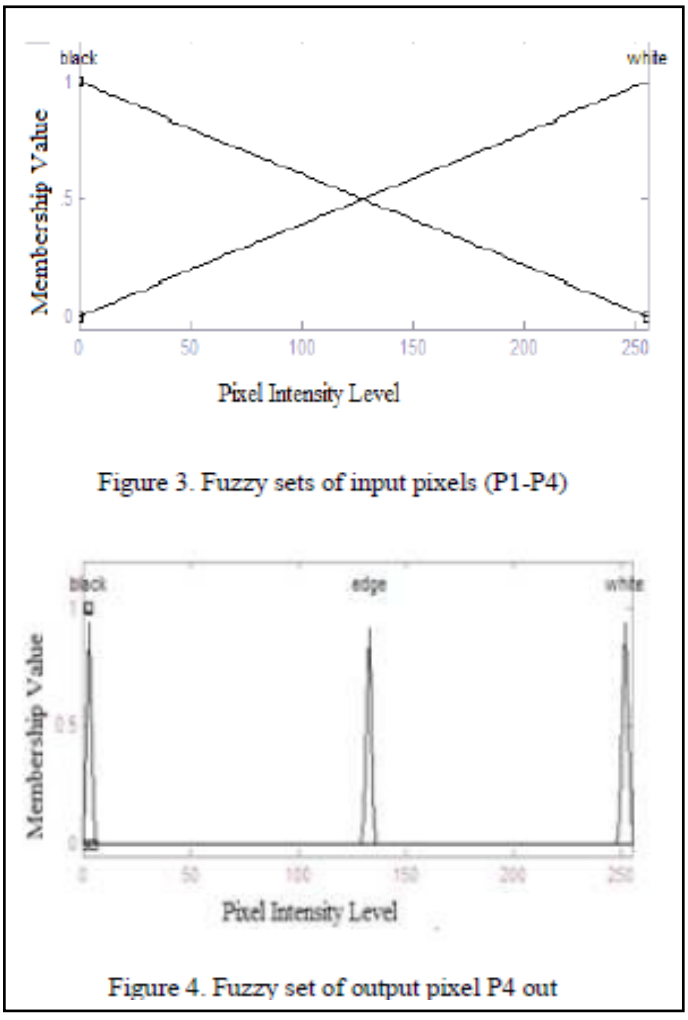

Figure 3. Fuzzy sets of input pixels (P1-P4)

Figure 4. Fuzzy set of output pixel P4 out

Rules for the FIS are enlisted in the form of a matrix in Table 1.

Table 1 : Fuzzy Rule Base

Fuzzy Inputs				Fuzzy Outputs
P1	P2	P3	P4	P4_out
B	B	B	B	B
B	B	B	W	E
B	B	W	B	E
B	B	W	W	E
B	W	B	B	E
B	W	B	W	E
B	W	W	B	E
B	W	W	W	W
W	B	B	B	E
W	B	B	W	E
W	B	W	B	E
W	B	W	W	E
W	W	B	B	E
W	W	B	W	E
W	W	W	B	E
W	W	W	W	W

B. Results of Edge Detection

Initially, the facial image was captured in true color format. But it is so large, the process of extracting features spent a lot of times and memory space. Therefore the experiments were done with grayscale image with 256 gray levels. Following are the results of edge detection algorithm using FIS. From this edge detected image, we can extract the features.

The task of the feature extraction and selection methods is to obtain the most relevant information from the original data and represent that information in a lower dimensionality space. The goal is to select, among all the available features, those that will perform better. In this paper, following 15 features have been used , all the features are in the form of distance.

· Feature 1: width of nose
· Feature 2: left eye to right eye
· Feature 3: width of mouth
· Feature 4: left eye to left side of nose
· Feature 5: right eye to right side of nose

· Feature 6: left side of nose to right side of mouth
· Feature 7: right side of nose to left side of mouth
· Feature 8: left eye to middle of nose
· Feature 9: right eye to middle of nose
· Feature 10: vertical distance from mouth to nose
· Feature 11: horizontal distance from left edge of face to left side of nose
· Feature 12: horizontal distance from right edge of face to right side of nose
· Feature 13: horizontal distance from left edge of face to left side of mouth
· Feature 14: horizontal distance from right edge of face to right side of mouth
· Feature 15: vertical distance from eye to nose

The value of feature vector represents absolute distance between feature points. For example, let the left eye (X,Y) and middle of nose (X,Y). Then, their absolute distance is calculated by

$$fe(8) = \sqrt{(X2 - X1)^2 + (Y2 - Y1)^2}$$

III. Feature Normalization

Since it is not possible to get the facial image as same size all the time, though he is same person, therefore, the feature vector has to be normalized so as not to be sensitive of the size. Feature vectors are represented using fuzzy linguistic variables. In this work, fuzzy linguistic variable concept has been proposed to settle above problems in representing feature vector.

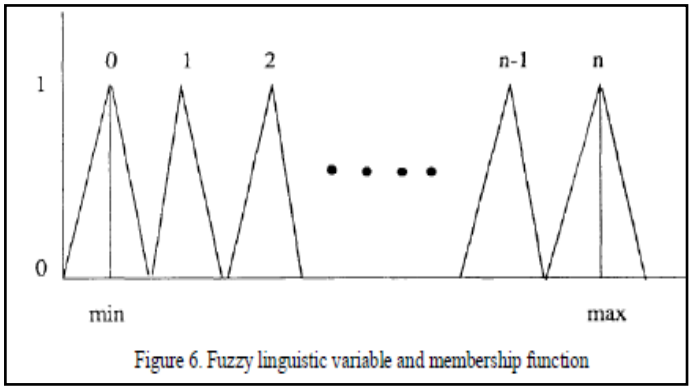

Figure 6. Fuzzy linguistic variable and membership function

Table 2. Real Value of Feature Vector

Fe1 = 16.245123
Fe2 = 26.654345
Fe3 = 21.567322
Fe4 = 25.654126
Fe5 = 20.245621
Fe6 = 22.654667
Fe7 = 21.245342
Fe8 = 36.654121
Fe9 = 27.245654
Fe10 = 21.654343
Fe11= 36.245345
Fe12 = 29.654678
Fe13 = 26.245234
Fe14 = 20.654562
Fe15= 30.245213

Table 3. Fetaure vector represented as fuzzy linguistics variables

Fe1 = 1.000000
Fe2 = 3.000000
Fe3 = 3.000000
Fe4 = 2.000000
Fe5 = 1.000000
Fe6 = 1.000000
Fe7 = 1.000000
Fe8 = 7.000000
Fe9 = 3.000000
Fe10 = 1.000000
Fe11= 7.000000
Fe12 = 3.000000
Fe13 = 3.000000
Fe14 = 1.000000
Fe15= 3.000000

IV. Recognizing Facial Image

After extracting feature vector having 15 elements, a face pattern recognizer has been designed which learns relationships between features using 3-layered artificial neural network system. Figure 7 shows the architecture of the face pattern recognizer.

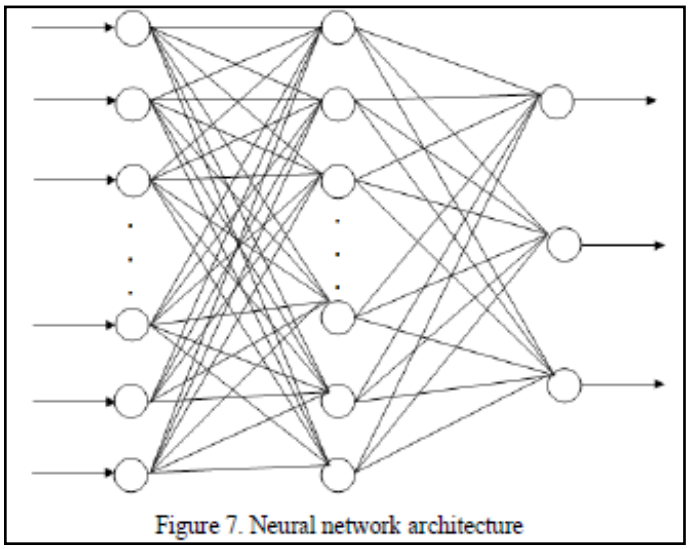
Figure 7. Neural network architecture

Fig. 7 : Neural Network Architecture

Face patterns are learned by Error Back Propagation Algorithm [7]. A Back Propagation network learns by example. You give the algorithm examples of what you want the network to do and it changes the network's weights so that, when training is finished, it will give you the required output for a particular input. The input and its corresponding target are called a Training Pair. Back Propagation networks are ideal for simple Pattern Recognition and Mapping Tasks. As just mentioned, to train the network you need to give it examples of what you want – the output you want (called the Target) for a particular input.

The training using Back Propagation Algorithm involves four stages:

1. Initialization of weights.

2. Feed forward.
3. Back Propagation of errors.
4. Updating of weights and biases.

V. Experiments and Results

A neural network model is used consisting of 15 input units, 25 hidden units and 3 output units, and is fully connected. There is one input element for each feature. Output unit represents the binary equivalent of the enrolled faces. Back propagation algorithm has been used for learning of the neural network. 5 iterations of training and learning are employed. Table 4 shows the data used for experiments. Figure 8 shows the performance curve for the neural network training.

After training, the neural network is tested for the test feature vector. The test feature vector from any enrolled user is given as input to the pattern recognizer network. At the output, the network gives the binary equivalent number of the enrolled user. In this experiment, the neural network has been trained for faces of 5 persons and could recognize all persons correctly.

S.No.	Image	Corresponding Feature vector														Output Target (binary of image no.)		
1		16	26	21	25	20	22	21	36	27	21	36	29	26	20	30	0	0	0
2		13	17	25	18	21	19	18	25	20	23	27	27	21	23	26	0	0	1
3		20	25	31	36	34	29	30	31	41	29	44	30	31	4	23	0	1	0
4		11	21	18	16	16	20	19	25	16	20	31	23	27	24	17	0	1	1

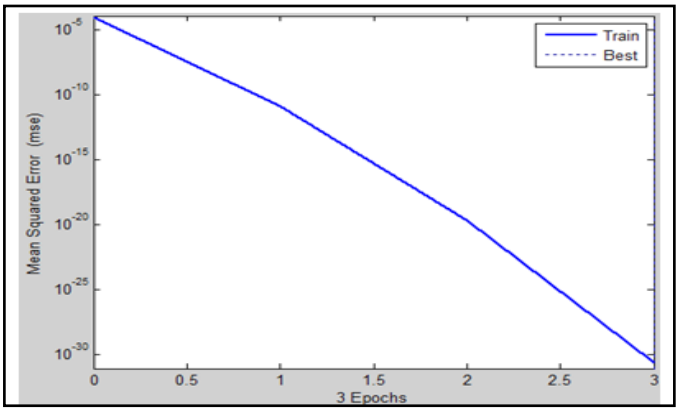

Fig. 8 : Performance plot for neural network training

VI. Conclusion

We have developed a method to extract feature vector that is very important to recognize facial image. We used edge detection technique to reveal the outline of the face. And then, we found other facial features using facial outline and eyes' location. So, we got a feature vector having 15 elements. We proposed fuzzy linguistic variable to settle normalization of them. We design a face pattern recognizer which learns relationships between facial features using 3-layered artificial neural network system. It was learned faces of 5 persons and could recognize all persons correctly.

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