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Neuro-fuzzy inference system based face recognition using feature extraction

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ABSTRACT

Human face recognition (HFR) is the method of recognizing people in images or videos. There are different HFR methods such as feature-based, eigen-faces, hidden markov model and neural network (NN) based methods. Feature extraction or preprocessing used in first three mentioned methods that associated with the category of the image to recognize. While in the NN method, any type of image can be useful without the requirement to particular data about the type of image, and simultaneously provides superior accuracy. In this paper, HFR system based on neural-fuzzy (NF) has been introduced. In the NN system, backpropagation (BP) algorithm is used to update the weights of the neurons through supervised learning. Two sets of the image have been used for training and testing the network to identify the person. If the test image matches to one of the trained sets of the image, then the system will return recognized. And if the test image does not match to one of the trained sets of the image, then the system will return not recognized. The feature extraction methods used in this paper is Geometric moments and Color feature extraction. The recognition rate of 95.556 % has been achieved. The experimental result illustrations that the association of two techniques that provide better accuracy.

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1. INTRODUCTION

Recently, human face recognation is an important research topic in the fields of artificial intelligence and pattern identification. HFR has several issue such as: hair and expressions can change the face; similarity between different faces; and also there are different angles the face can be viewed. A good HFR system must be robust to overcome these issues [1]. HFR system divided into three stages: detection; feature extraction; and recognition [2, 3] .

Artificial neural networks (ANN) were used widely for constructing intelligent computer systems based on image processing and pattern recognition [4]. The backpropagation neural network (BPNN) is the most common ANN model that can be trained using BP algorithm [5]. A lot of studies about HFR system, each one of them depends on different methods such as: eigenvalues of face, features, graph matching, matching of template, and ANN methods [6].

In [7], Neuro-fuzzy (NF) fusion in a multimodal face recognition using PCA, ICA and SIFT is introduced. In this work, multimodal face recognition is discussed and the implemented of with NF combination. The principal component analysis (PCA) and independent component analysis (ICA) as well as

feature extraction based on SIFT are used. The recognition ID determine based on NF inference system. In [8], face recognition using neuro-fuzzy and eigenface is introduced. In this work, a human presence is detected by extracting the skin area by using the Eigen value of face method. Then bu using a neuro-fuzzy method, the face is recognized. In [9], face recognition system using adaptive neuro fuzzy inference system (ANFIS) is introduced. In this work, ANFIS with PCA algorithm has been proposed by considering different contributions of the training samples. In [10] face recognition (FR) based on descion level fusion is introduced. In this paper, a new method named C2D CNN is proposed. In [11] facial recognition based on adaptive neuro fuzzy (ANF) inference system is introduced. In this work, the manin contribution is based on feature extraction and classification. The aim of this paper is to develop a HFR system based on feture extraction by using Neuro-Fuzzy Interferance system. The proposed system consist of two stages: first stage face recognition by using NN and second stage is to evaluate the performance of the proposed algorithm with fuzzy system.

2. FACE RECOGNITION TECHNIQUES

The main steps to face recognition are; extracting the features from the images, store features in data base, design NN, train feature on network, and test the old and new data NN.

2.1. Face feature extraction with moments

Feature extraction is a section of pattern recognition techniques which intent to extract or retrieve the individual values from an object that differentiates it from other objects [12]. Feature extraction for an image can be done by using several methods such as invariant moments and color feature extraction. In image analysis applications, the Image introduce effective description. The main advantage of using image for analysis application is their capability to introduce invariant measures of shape [13]. Moment based feature description have developed into a extrodenary tool for image analysis applications [14].

2.1.1. Geometric moments (GM)

GM proved to be an effective analysis method for image application. GM can be used for different application such as: aircraft identification, character recognition, shape and image analysis, normalization of image, color texture recognition, detection of accurate position, retrieval of image and many types of image processing applications. For a 2D density function p(x,y), the (p+q)th order GM m_{pq} are defined by [15, 16]:

$$m_{pq} = \sum_{x=1}^{M} \sum_{y=1}^{N} x^p \, y^q f(x,y) \quad (1)$$

2.1.2. Color moments (CM)

CM are measurements which can be used for contrasting images according to color features of the images. The basis of CM is based on the hypothesis that the color distribution in an image can be explained as the distribution of probabilities (PD). PD are notable by a number of unique moments [17]. The first moment is mean, the second is standard deviation, and the last one is skewness. The CM have been demonstrated to be efficient in representing images color distributions [18].

a. Moment 1- mean

$$E_k = \frac{1}{MN} \sum_{x=1}^{M} \sum_{y=1}^{N} f^k(x,y) \quad (2)$$

b. Moment 2- Standard Deviation;

$$SD_k = SQRT(\frac{1}{MN} \sum_{x=1}^{M} \sum_{y=1}^{N} (f^k(x,y) - E_k)^2) \quad (3)$$

c. Moment 3- Skewness

$$S_k = (\frac{1}{MN} \sum_{x=1}^{M} \sum_{y=1}^{N} (f^k(x,y) - E_k)^3)^{1/3} \quad (4)$$

where $f^k(x,y)$ is the image pixel and M, N represent the hight and wiedith of the image respectively [19].

2.2. The NN techniques

The goal of the NN technique is distinguish a human face (HF) by training the network. In the NN technique, there are two phases to recognize a HF. The first phase is the training and the second phase is the testing. In the training phase, the set of training data contain input set up with it's output as a consequence.

Then the NN is training based on the data to regulate thresholds and weights of the network's to reduce predictions error [20].

2.2.1. Back-propagation neural network (BPNN)

BPNN has three main layered structure which are: the input layers, hidden and output layers. In BPNN the weights of the network's are obtained through learning. The complexity of training depends on the number of the hidden layers, where the complexity of training increase with increasing of hidden layer number. The BPNN training is achieved in three steps [21, 22] which are input feed-forward (FF), error and weights computation and error back-propagation (EBP).

The external inputs feds the units of the input layer without connection into a layer. Then the first hidden layer feds by the input layer. The hidden layer receives a weighted bias after implements the activation function. The next hidden layer feds by the output of the previously hidden layer. This procedure carries on till the last hidden layer. The output layer feds by the outputs of the last hidden layer. Although the training of BPNN is so slow, the moment that the NN is trained, it fulfills the results quickly [15].

2.3. Fuzzy logic (FL)

FL is a method of logical value. It concerning of reasoning that is convergent insted of exact and fixed. Traditionally, the binary gathers true or false values. The ranges of true value is between 0 and 1. In FL the idea of fractional truth has been used, where the range could be fully false and fully true. Moreover, a specific functions may be used to manage linguistic variable. Irrationality can be described in terms of what is known as the fuzzjective [23-25]

3. THE PROPOSED ALGORITHM

Recentaly, many algorithms for HFR are introduced. In these algorithms, the processing related to the type of image or feature extraction is used mostly. In this paper, all types of images can be used as inputs to the proposed algorithm. The proposed algorithm is consist of two stages: the training and recognition stage and the FL stage.

3.1. Training and recognation of the NN

Figure 1 shows that the NN training consists of three stages. In the first stage, the set of images are training to supply the data to network. Therefore, the designing structure of input required the identical row from the image matrix as shown in Figure 2. In the proposed algorithm, BPNN has a layered structure as: 18, 37, 5. These layers are input, hidden and output layer. The hidden layer in the network can be more than one, but one layer is appropriate to reach our goal. Figure 2 shows the designed NN architecture. The designed NN network is trained until the outputs of NN are equal to desired outputs. The output results of the proposed NN become more accurate when the trained value become matching to the desired output. So, the proposed NN can be trained up to 4 to 5 times to get the desired outputs.

Figure 1. Training of neural network

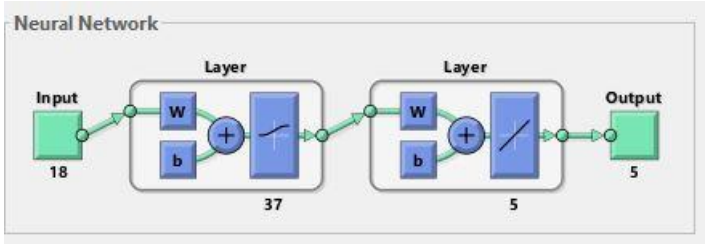


Figure 2. Design the neural network architecture

Figure 3 shows the block diagram training and testing of NN. In this figure, there are two stages in the system: training and testing stage. In the training stage, the sets of training image used to training NN.

The first step in the training phase is feature extraction. Where the GM and CM are sued to extract 18 features form each single train image. Then these features stored in the database of the system to be used in the training stage. The NN designed according to the set of input data and the size of the desired outputs. After that, the designed NN will be training to recognize the image stored in the database of the system. In the testing stage, the sets of test image that used to test the accuracy of the designed NN. The first step in the testing phase is the feuture extraction by using GM and CM. Then the extracted features used in testing stage to find in they match with feature that stored in database of the system.

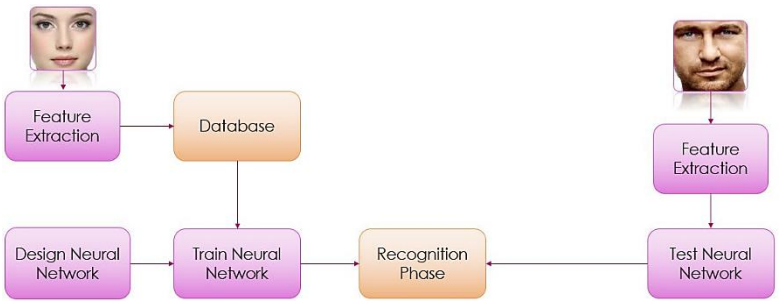


Figure 3. Training and testing of the neural network

3.2. Fuzzy logic

Two parameters are used to define the accuracy of the designed NN which are Gradient and Epochs. The gradient is the optimization method used for the learining system. Gradient parameters refer to find the slope of error and decreasing the error slop by modifying the weights and bias until minimizing the level of error. Epochs parameter refers to the number of time that the algorithm processes the dataset. In Epochs parameter three terms are very significant which are: the number of epochs, time, and value. The network learns in slight reiterations when the number of epochs is fewer. The time in epochs refers to the network to reach its objective shortly and easily. And when the value of epochs is low that means the network is higher accuracy. The neuro fuzzy block diagram is shown in Figure 4. Figure 4 shows that the two output parameters (Epochs and Gradient) of NN is feed FIS such as inputs that accordingly of which accuracy is considered.

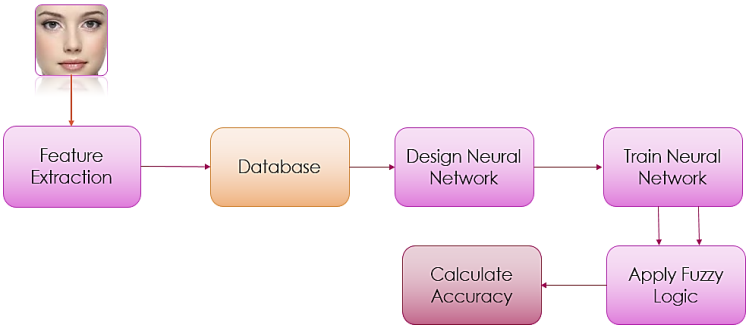


Figure 4. Neuro fuzzy block diagram

The FIS inputs is introduced through the membership function (MF) that is allocate the position of two input values lie in range of values. The range of epochs that used in this paper is selected as 0 to 70. While the range of gradient that used in this paper is selected as 0 to 0.8. Any membership function can be selected from which are already customized or defined membership. Figure 5 the designed MF of Gradient and Epochs inputs by using Matlab. While Figure 6 shows the designed MF of Gradient and Epochs inputs by using FIS. Figure 7 shows the MF of the output variable (accuracy). The range of of accuracy used in this paper is selected as 0 to 100. When the Gradient and Epochs inputs are low in range, the accuracy is set up according to the rules. These rules are based on the amalgamation of Gradient and Epochs input parameters to fulfill the desired output as shown in Figure 8. The fuzzy rules are necessary for each input, the set of rules must be repeated for the input parameter. The rule in Figure 8 (a) is implemented by using Matlab code while the rules in (b) are implemented by using FIS.

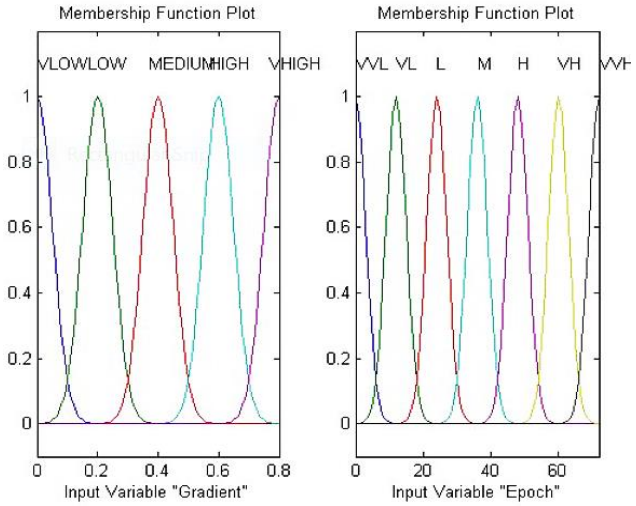
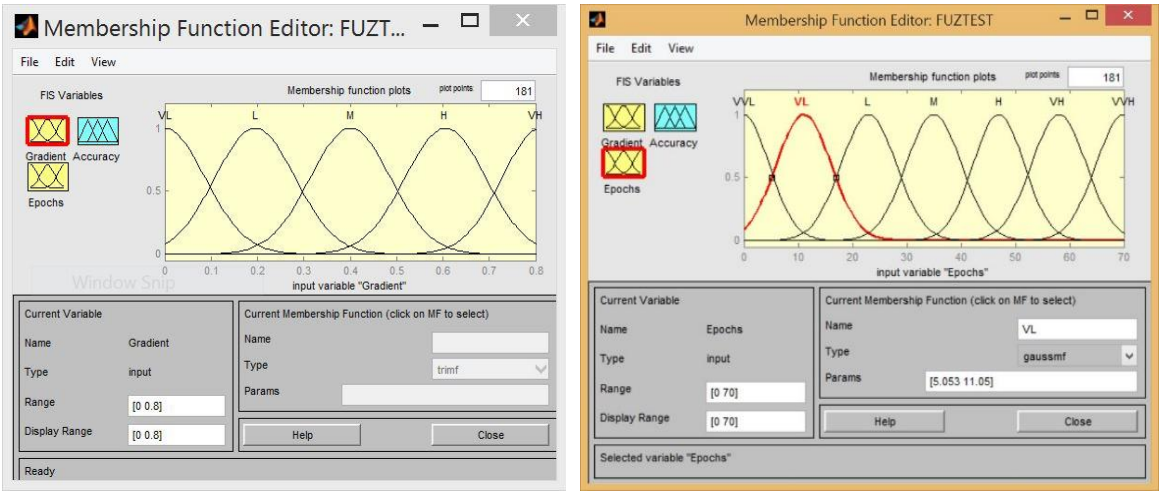
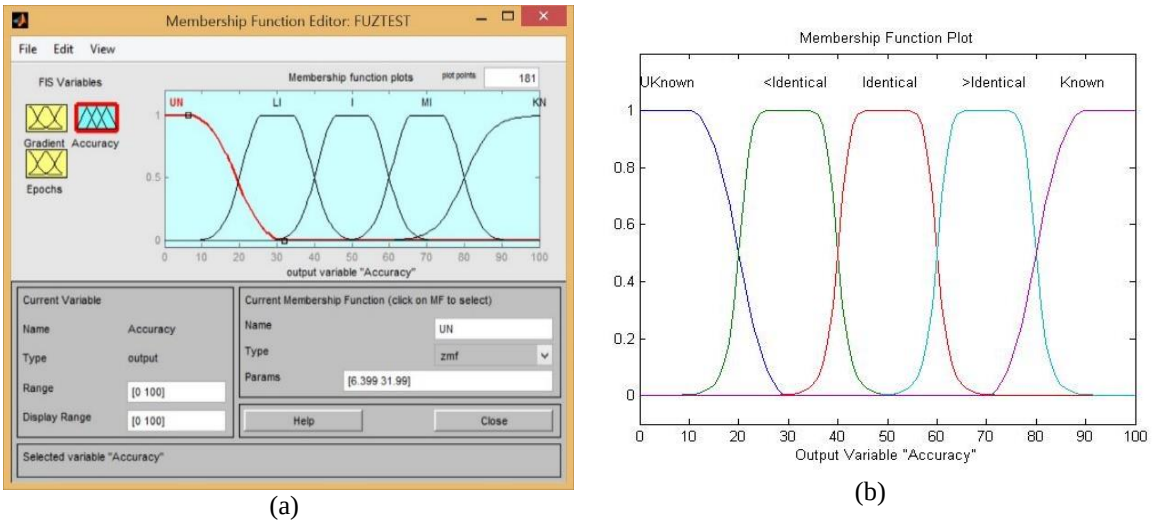


Figure 5. Membership function for input gradient and epoch by using mtlab code



(a) (b)

Figure 6. Membership function by using FIS function: (a) for input gradient, (b) input epochs



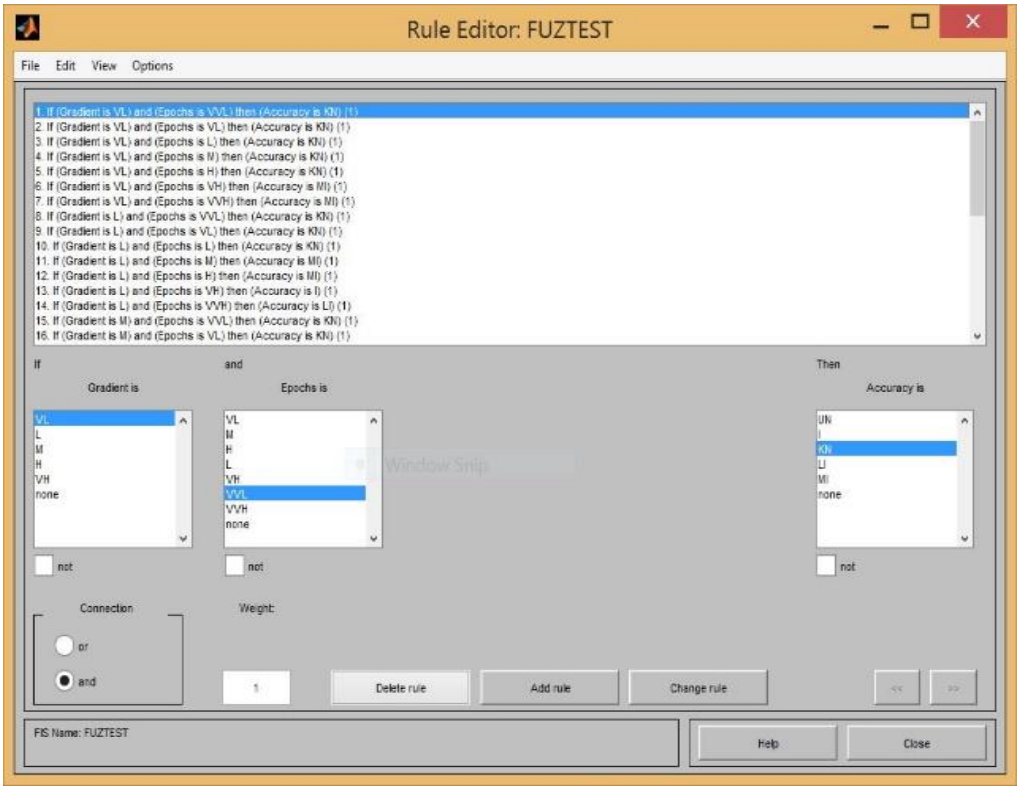
(a) (b)

Figure 7. Output membership function: (a) by using FIS function, (b) by using mtlab code

```
%%%% GR VLOW
if GR<=0.1
    if GR ~=0
    G1=gaussmf(GR,[0.05 0]);
        G2=gaussmf(GR,[0.05 0.2]);
        end
        if EP<=12
        VV=gaussmf(EP,[3 0]);
    Accurcy='Known';                    AC=(G1*90+G2*70)/(G1+G2);
elseif EP>12&&EP<=24
    Accurcy='Known';                    AC=(G1*90+G2*70)/(G1+G2);
 elseif EP>24&&EP<=36
    Accurcy='Known';                    AC=(G1*90+G2*70)/(G1+G2);
    elseif EP>36&&EP<=48
    Accurcy='Known';                   AC=(G1*90+G2*70)/(G1+G2);
    elseif EP>48&&EP<=60
    Accurcy='Known';                   AC=(G1*90+G2*70)/(G1+G2);

    elseif EP>60&&EP<=72
    Accurcy='>Identical';   AC=(G1*70+G2*50)/(G1+G2);
    elseif EP>72
    Accurcy='>Identical';   AC=(G1*70+G2*50)/(G1+G2);
    end
    %%%% GR LOW
elseif GR>0.1&& GR<=0.3
    if GR ~=0.2 && GR <0.2
    G1=gaussmf(GR,[0.05 0]);
        G2=gaussmf(GR,[0.05 0.2]);
    else
         G1=gaussmf(GR,[0.05 0.2]);
        G2=gaussmf(GR,[0.05 0.4]);
     end
```

(a)



(b)

Figure 8. The rules for the network, (a) is implemented by using matlab code while the rules in (b) are implemented by using FIS

4. RESULTS AND DISCUSSION

There are two stages of the results of the proposed algorithm: tarning and testing stage. In the training stage, human face will be recognized by the proposed system while the test set of image cannot be recognized by the proposed system because they are not in the database of the system as shown in Figure 9. The results of this stage is the output of neural network which is epoch and gradient. When the number of the epoch is minimum, that means the system gets the target output with minimum iteration that lead to decrease the time of training. Also, when the value of gradient is minimum, this means the system is learning with decresing the error slop by modify the weights and bias until minimizing the level of error. The number of feature that extract from face image and used as a database can be increased to enhance the accuracy of the proposed system. Figure 10 shows the training performance of the proposed system. The figure shows that the training curve is reached to its targets through modification of biases and weights. In this paper, two sets of the face image are used In order to evaluate the performance of the proposed system. The first set is the training image and the second step is the testing image. The performance evaluation of the proposed system is done by using these tow type of sets face image. The test images are used to the trained NN to determine the percentage of error and accuracy of the proposed system. A 30 set of face images are used as training images and a set of 15 face images are used as a testing image. Table 1 shows that the recognition results of the 45 face images. These results are analyzed to find the recognition rate (RT) of the proposed system as shown in Table 2. A recognition rate of 95.556% is calculated for the proposed system. This RT value is quite appropriate for face recognition systems. The second stage of the results, is to calculate the performance of the proposed algorithm with Fuzzy system. The output of the Neural Network system (epoch and gradient) used as input to Fuzzy System to identify the accuracy of the system as shown in Figure 11.

Figure 9. Recognization of the test and trained person: (a) trained image, (b) tested image

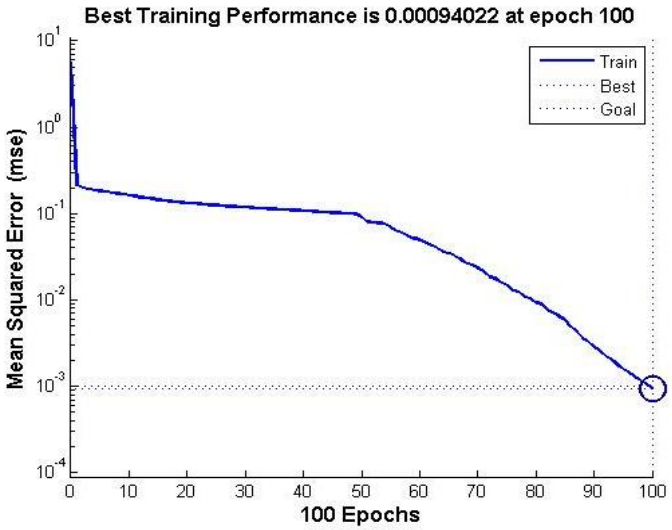


Figure 10. Training performance

Table 1. Recognation results

Image No.	Type	Results	Image No.	Type	Results
1	Traine	Recognised	24	Traine	Recognised
2	Traine	Recognised	25	Traine	Recognised
3	Traine	Recognised	26	Traine	Recognised
4	Traine	Recognised	27	Traine	Recognised
5	Traine	Recognised	28	Traine	Recognised
6	Traine	Recognised	29	Traine	Recognised
7	Traine	Recognised	30	Traine	Recognised
8	Traine	Recognised	31	Test	Not Recognised
9	Traine	Recognised	32	Test	Not Recognised
10	Traine	Recognised	33	Test	Not Recognised
11	Traine	Recognised	34	Test	Not Recognised
12	Traine	Recognised	35	Test	Not Recognised
13	Traine	Recognised	36	Test	Not Recognised
14	Traine	Recognised	37	Test	Recognised
15	Traine	Recognised	38	Test	Not Recognised
16	Traine	Recognised	39	Test	Not Recognised
17	Traine	Recognised	40	Test	Recognised
18	Traine	Recognised	41	Test	Not Recognised
19	Traine	Recognised	42	Test	Not Recognised
20	Traine	Recognised	43	Test	Not Recognised
21	Traine	Recognised	44	Test	Not Recognised
22	Traine	Recognised	45	Test	Not Recognised
23	Traine	Recognised			

Table 2. Result of face recognition rate

	Number of images	Recognition Rate %
Trained image	30	100
Tested image	15	86.667
Total Recognition Rate %		95.556

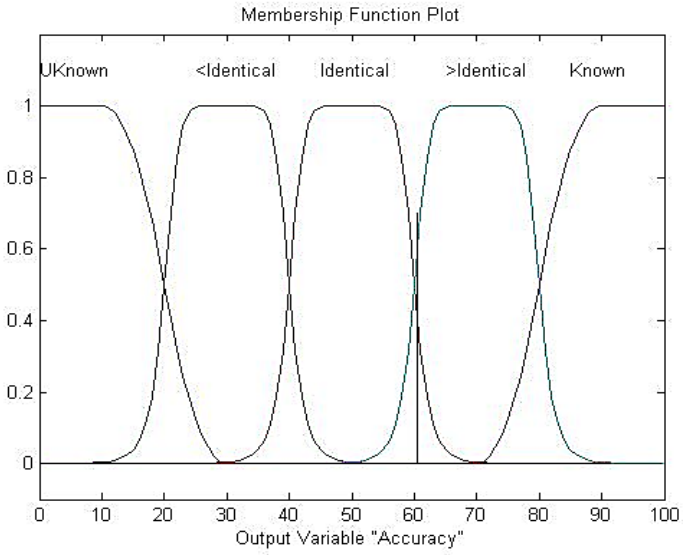


Figure 11. Accurcy of the system

5. CONCLUSION

In this paper NF based face recognition system has been introduced. The NN system consisted of two-stage which are training stage and testing stage. In this paper, two sets of image are used to evaluate the performance of the system. One of the set is used in the training stage and which are 30 images. And the second set of images are used in a testing stage which is 15 images. Recognition rate used in this paper to evaluate the performance of the system and the value of recognition rate that achieved of the proposed system is 95.556% of the images are opposed recognized used in training and testing stage. FIS used in the paper to enhance the performance of the system and to get more accuracy to identify the results.

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