RESEARCH ARTICLE

Hand Palm Recognition using Combination of Freeman Chain Code and Texture Features with Fuzzy Logic Classifier

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Abstract— In this paper we propose a system for hand palm recognition and analysis based on features presented by hand palm lines. The proposed system based on images taken from free Indian Institute of Technology Delhi (IITD) palmprint database of hand palm. Firstly we extracted the region of interest (ROI) from hand palm image in order to find two groups of features, the first group contain 6 texture features represented by (mean, standard deviation, smoothing, third moment, uniformity, entropy) from gray ROI whereas the second group contain 10 features extracted from (white-black) ROI, 8 of them are extracted from freeman chain code depend on 8 neighbors (0,1,2,3,4,5,6,7) the ninth and tenth features represent the area and entropy respectively. These two groups consist the vector features which contain 16 values for each ROI image which stored in our database prepared to be used in recognition phase by using fuzzy logic classifier with mamdani rule. The proposed system is applied on 120 images 60 samples are used for training and the remaining 60 samples are used for testing. The proposed system's accuracy is 90% for testing group with average of execution time is 13.6 second using Matlab environment. Thus, the recognition rate is higher when using the combination of freeman chain code and texture features with fuzzy logic classifier.

Key Words— Biometric measure, Image process, Freeman Chain Code, Texture Features, Palm Print.

I. INTRODUCTION

Biometric authentication systems have certain advantages compared to traditional authentication systems such as password, pin, etc. The information security can be guaranteed because only authorized user who is able to access the personal information. The system requires the person being authenticated to directly present their uniquely personal data at the moment of authentication [1]. Thus, biometric-based authentication system is a reliable and secure choice. Biometrics is a method to recognize human based on intrinsic features or characteristics that human has [2]. Physiological biometrics use unique

physical characteristics of human such as fingerprint, face, palm print, iris, or DNA to identify user and has proven to be a powerful method for authentication systems [3].

The main advantage of biometrics is that these are not prone to theft and loss, and do not rely on the memory of their users. Moreover, they do not change significantly over time and it is difficult for a person to alter own physiological biometric or imitate that of another person's. Among different biometrics, in security applications with a scope of collecting digital identity, the palm-prints are recently getting more attention among researchers [3, 4].

Palm-print recognition is a complicated visual task even for humans. The primary difficulty arises from the fact that different palm-print images of a particular person may vary largely, while those of different persons may not necessarily vary significantly. Moreover, some aspects of palm-prints, such as variations in illumination, position, and scale, make the recognition task more complicated [6].

A palm print refers to an image acquired of the palm region of the hand. It can be either an online image (i.e. taken by a scanner, or charge-coupled device (CCD)) or offline image where the image is taken with ink and paper. The palm itself consists of principal lines, wrinkles and ridges. It differs to a fingerprint in that it also contains other information such as texture, hollows and marks which can be used when comparing one palm to another. Palm has unique distinguishing line patterns which can be used to identify people uniquely. It is a physiological biometric. A user is asked to put his/her hand in a surrounded unit having fixed illumination and a platform that restricts hand motion. It may have pegs to further fix the position of the hand. Scanners or cameras can then be used to capture the image. Palm print has high user acceptability with few hygiene based concerns characteristic of all contact based biometric. But there has been a move towards developing contactless recognition systems[7].

There are two types of palm print recognition research,
1. high resolution
2. low resolution

The high resolution approach employs high resolution images, and is suitable for forensic applications, such as criminal detection. In general, high resolution refers to 400 dpi [8].In high resolution images, researchers can extract ridges, singular points and minutia points as features can be detected. The low resolution approach employs low resolution images, and is more suitable for civil and commercial applications such as access control. Palm print images can be acquired with low resolution cameras and scanners and still have enough information to achieve good recognition rates. Low resolution refers to 150 dpi or less. The Low resolution images are generally use principle lines, wrinkles and texture[7].
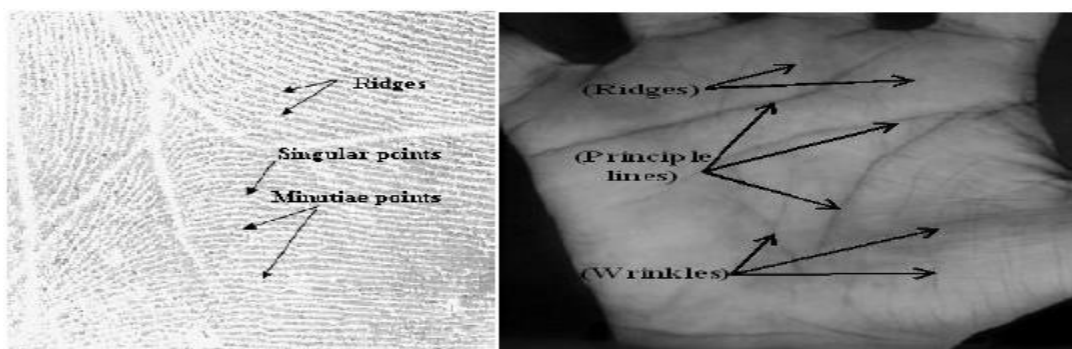
Figure(1) Palm print features in (a) a high resolution image and (b) a low resolution image.

This paper is organized as follows: In section II, briefly preliminaries is introduced for Chain Code and Texture Features, in Section III the proposed method is presented it consists of read hand palm's image, preprocessing, find ROI region, feature extraction and classification stages. The experimental results are given in section IV and finally conclusions are reported in section V.

II. PRELIMINARIES

1-2 Freeman Chain Code

Chain codes are one of the shape representations which are used to represent a boundary by a connected sequence of straight line segments of specified length and direction. This representation is based on 4-connectivity or 8- connectivity of the segments [9]. The direction of each segment is coded by using a numbering scheme as shown in Figure2 below. Chain codes based from this scheme are known as Freeman chain codes (FCCD).
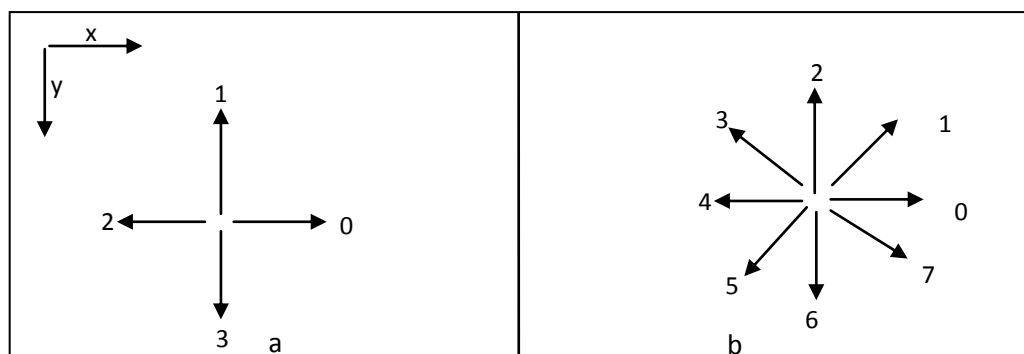
Figure(2) Direction numbers for (a) 4-directional chain codes, (b) 8-directional chain code

A coding scheme for line structure must satisfy three objectives [10]:
   a. It must faithfully preserve the information of interest.
   b. It must permit compact storage and convenient for display.
   c. It must facilitate any required processing.

Chain codes are a linear structure that results from quantization of the trajectory traced by the centers of adjacent boundary elements in an image array. A chain code can be generated by following a boundary of an object in a clockwise direction and assigning

a direction to the segments connecting every pair of pixels. First, we pick a starting pixel location anywhere on the object boundary. The aim is to find the next pixel in the boundary [11].

There must be an adjoining boundary pixel at one of the eight locations surrounding the current boundary pixel. By looking at each of the eight adjoining pixels, we will find at least one that is also a boundary pixel. Depending on which one it is, we assign a numeric code of between 0 and 7 as already shown in Figure 2. For example, if the pixel found is located at the right of the current location or pixel, a code "0" is assigned. If the pixel found is directly to the upper right, a code "1" is assigned. The process of locating the next boundary pixel and assigning a code is repeated until we came back to our first location or boundary pixel. The result is a list of chain codes showing the direction taken in moving from each boundary pixel to the next. The process of finding the boundary pixel and assigning a code is shown in Figure3 [11].
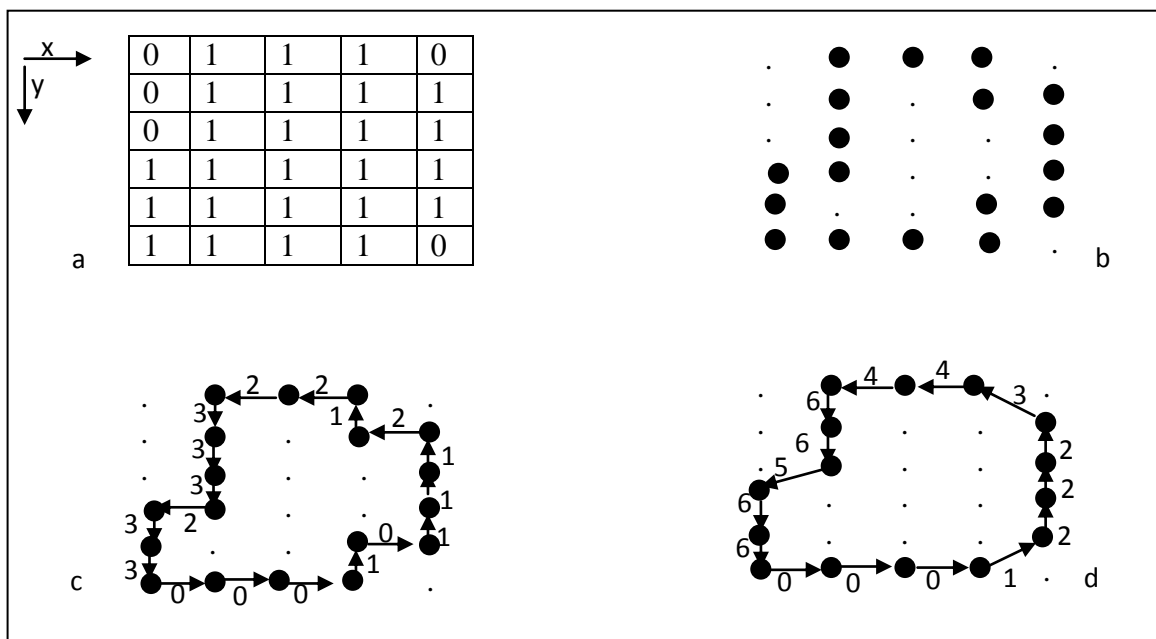
Figure(3) a & b) A 4-connected object and its boundary; c & d) Obtaining the chain code from the object in (a & b) with (c) for 4-connected and (d) for 8-connected

2-2 Texture Features

An important approach for describing a region in image is to quantify its texture content. A frequently used approach for texture analysis is based on statistical properties of the intensity histogram. one class of such measures is based on statistical moments. The nth moment about of the mean is given by equation1 [12].

$$m_n = \sum_{i=0}^{L-1} (z_i - m)^n p(z_i) \ldots (1)$$

where z_i is random variable indicating intensity, $p(z)$ is the histogram of the intensity levels in a region, L is the number of possible intensity levels and m is the mean (average) intensity. In the list below, there are some common descriptors based on statistical moments and also uniformity and entropy [12].

1- Mean (m) is a measure of average intensity as in equation 2.

$$m = \sum_{i=0}^{L-1} z_i\, p(z_i)\dots(2)$$

2- Standard deviation(σ) is a measure of average contrast as in equation 3.

$$\sigma = \sqrt{m_2(z)} = \sqrt{\sigma^2}\dots(3)$$

3- Smoothness(R) shown in equation 4 measures the relative smoothness of the intensity in region. R is 0 for a region of constant intensity and approaches1 for regions with large excursions in the values of its intensity levels. In practice, the variance used in this measure is normalized to the range [0,1] by dividing it by $(L-1)^2$.

$$R = 1 - 1/(1 + \sigma^2)\dots(4)$$

4- Third moment (m_3) as shown in equation 5 measures the skewness of a histogram. This measure is 0 for symmetric histogram , positive by histograms skewed to the right (about the mean) and negative for histogram skewed to the left. Values of this measure are brought into a range of values comparable to the other five measures by dividing m_3 by $(L-1)^2$ also, which is the same divisor we used to normalize the variance.

$$m_3 = \sum_{i=0}^{L-1} (z_i - m)^3\, p(z_i)\dots(5)$$

5- Uniformity (U) as shown in equation 6 measures uniformity. this measures is maximum when all gray levels are equal (maximally uniform) and decreases from there.

$$U = \sum_{i=0}^{L-1} p^2(z_i)\dots(6)$$

6- Entropy (e) as shown in equation7 is a measure of randomness.

$$e = -\sum_{i=0}^{L-1} p(z_i) \log_2 p(z_i)\dots(7)$$

III.PROPOSED METHOD

The problem is solved in this paper is concerned with automatic recognition of person's palm using hand palm images which are selected from IITD palmprint database. A group of 120 images are selected which belong to 20 person from this database with average 6 image for each person, half of these images are used for training and the other half for testing. The system is trained by using 3 samples of each person's hand palm image and then tested by the 3 remaining samples. The architecture schematic of our proposed system is shown in figure 4.
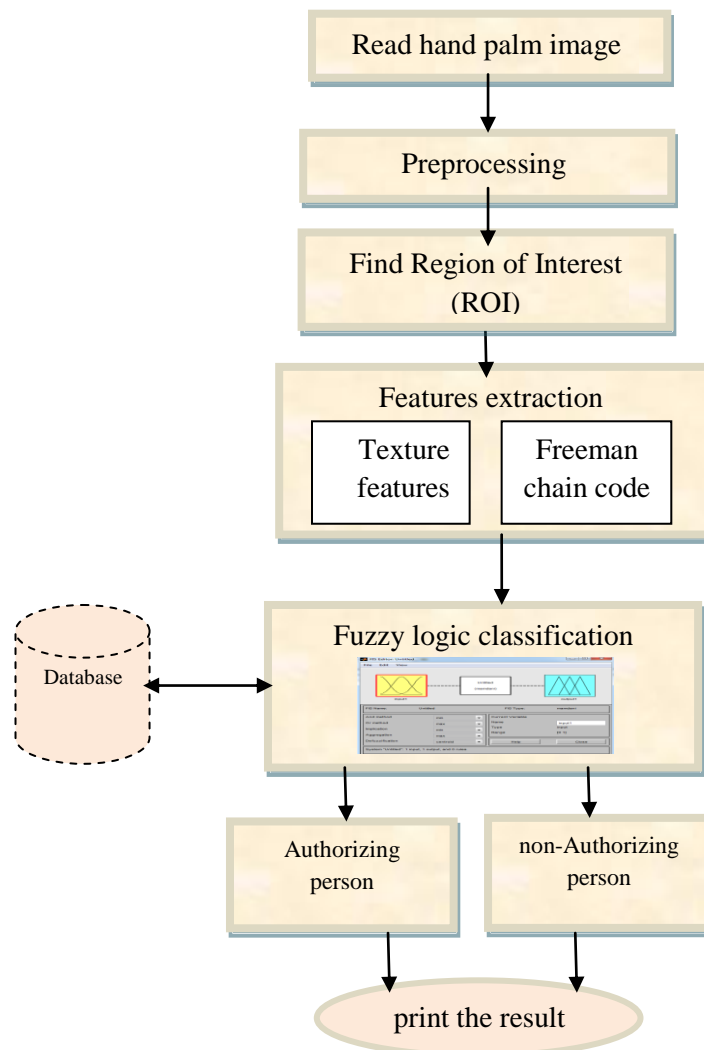
Figure (4) architecture schematic of the proposed method

1-3 Read hand palm image

First step is read the hand palm image from IITD palmprint database. Figure5 shows one of color image used in this system during reading step, Where all images have the following properties:

1- Image format is jpeg.
2- Image Color representation is red green blue (RGB).
3- Color depth is 24.
4- Vertical and horizontal resolution is 180 dpi.
5- The width of image is 1600 pixel and height is 1200 pixel.

Figure (5) hand palm image with true color

2-3 Pre-processing

This stage consists of four steps starting from a to d:

a) Convert color image to gray scale image:

A color image consists of three layers color and coordinate matrix. Color matrixes are known as Red (R), Green (G) and Blue (B). The designed system is based on gray scale images; therefore, colored image must be converted to gray scale to increase the speed of computation and easy in processing.

b) Filtering image

Motion filter is applied with size (5×5) and angle 180° in order to smooth image and increase the strength the tiny details of hand palm and decrease the intensity background (border of box which hand placed in it during capture the image) of hand palm image.

c) Edge detection

Canny filter is used to find all edges details in hand palm image where the result will be binary image with white color for edge and black color for background the threshold of canny filter is [0.04 0.10] and sigma is 3.5 this value is determined with try until canny filter reach to tiny details in hand image as shown in figure (6-a), then apply same canny filter with other value threshold is [0.1 0.4] and sigma is 90 in order to use this resulted image (after it is dilated in next system's step) in region of interest (ROI) algorithm as it discuses in section 3-3, this image shown in figure (6-b).
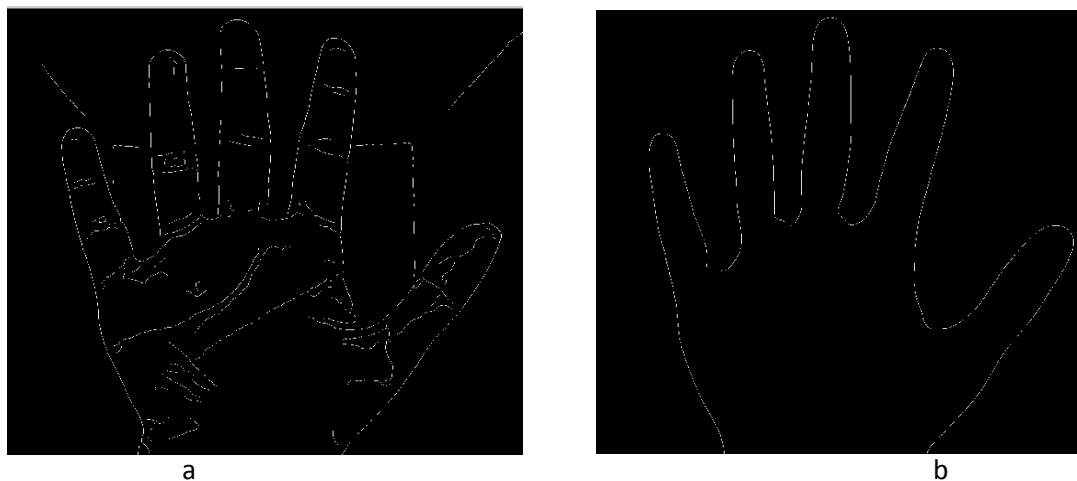
<div align="center">a   b</div>

Figure (6) hand palm image after canny filter

d) Image Dilation

Morphological dilation process is applied on the two logical images are resulted from apply canny filter in previous step. The aim of apply morphological dilation is to connect the broken found in borders and principles lines of hand palm image's. Morphological dilation is applied using line shape structural element with length 3 and angle $0^{°}$, the resulted images after apply dilation are shown in figure 7(a,b).

<div align="center">a   b</div>
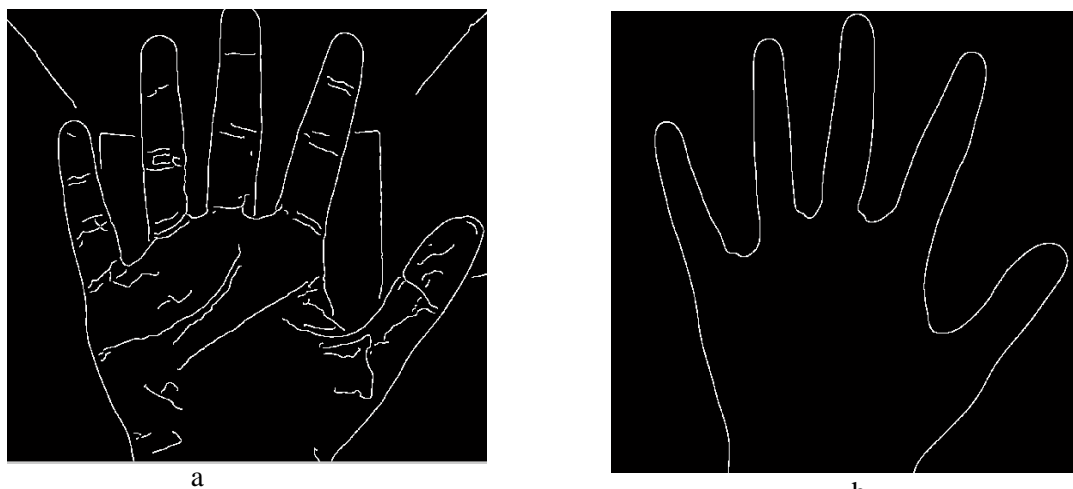
Figure(7) dilation on hand palm image

3-3 Find Region of Interest (ROI)

This stage aim to extract two ROI one from gray image by using the proposed algorithm1, this region (ROI1) is prepared to extract texture features from it. The other ROI is extracted from dilated image by using the proposed algorthim2, this region (ROI2) is prepared to extract freeman chain code for major principle lines from it.

Algorthim1:

1- Remove fingers region from gray image by find the number of rows in image then extract the region from (number of rows)/2 for all column to last row for all column.

2- Apply horizontally Scan on resulted image from 1 starting from left to right and determine the first position (row, column) in which the difference in intensity

gray between the current pixel and next neighbors pixel column is more than 10.

3- Apply horizontally Scan in reverse order on image resulted from 2 where we start scan image from right to left and determine the first position (row ,column) in which the difference between the current pixel and past neighbors pixel column is more than 10.

4- Extract the image region of column's positions determine in step2 to step3 with all row in order to remove outer uninterested part, as shown in figure8.

Figure (8) ROI1 in gray hand palm image

Algorithm 2

1- Remove all empty row and column (zeroes rows and columns) on dilated image in figure (7-b) and determine the positions of (row and column) of first and last nonempty rows and columns to extract the region from dilated image in figure (7-a) among this positions only.

2- In the resulted image from 1 remove fingers region from binary image by find the number of rows in image then extract the region (number of rows)/2 for all column to last row for all column.

3- Remove the left and right outer of hand edge by scan the image columns's in the first ten columns and last ten columns and assign this column to zero value.

4- Extract only nonzero row and column in image resulted from 3 so we get ROI2 as shown in figure9.

Figure (9) ROI2 in logical dilated image

4-3 Feature extraction

In this stage feature's vector contain 16 value extracted from ROI2, ROI1 as following step:

step1: The region containing longest seven lines in ROI2 is extract this line represent the principle lines, wrinkles lines in hand palm, this perform by searching in region

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ROI2 about objects boundaries which it is length more than 50 pixels and zeros all objects have less than this length, 10 features are extracted from this region eight of them extracted by apply freeman chain code on neighbors (0,1,2,3,4,5,6,7), this step focused on compute total number of variations pixels in freeman chain code for each one of 8 directions and place it as alone features. The ninth and tenth features are area and entropy respectively for region contain longest line in ROI2. Table(1) display 10 features of ROI2 for one person in our dataset in training group.

Step2:The remain six features are extracted from ROI1 which are mean, Standard deviation, Smoothness, Third moment, Uniformity and Entropy as it is discussed in section 2-2. Table(2) display this numerical values of these six features for one person on our dataset in training group. Figure10 shows graph of 16 feature's vector for person number one.

Table (1) ten feature vector for ROI2 person one in training group

entropy	area	Fccd (7)	Fccd (6)	Fccd (5)	Fccd (4)	Fccd (3)	Fccd (2)	Fccd (1)	Fccd (0)	Image
0.332045	27789	108	432	905	1326	110	435	900	1333	1a.jpg
0.316427	28258	109	330	664	1355	107	332	664	1353	1b.jpg
0.342062	25182	143	709	715	720	146	711	710	728	1c.jpg

Table (2) six feature vector for ROI1 in person one in training group

Entropy	uniformity	third moments	smoothing	std	mean	Image
7.547656	0.00628	-3.54076	0.0638	66.56816	154.4563	1a.jpg
7.647046	0.00564	-3.1302	0.074438	72.31617	144.0193	1b.jpg
7.466373	0.006462	-3.80762	0.057914	63.22459	163.382	1c.jpg
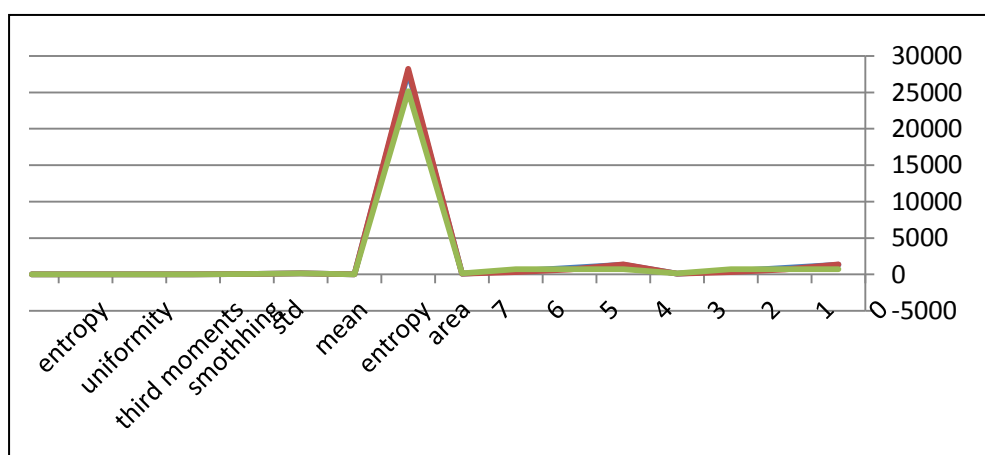
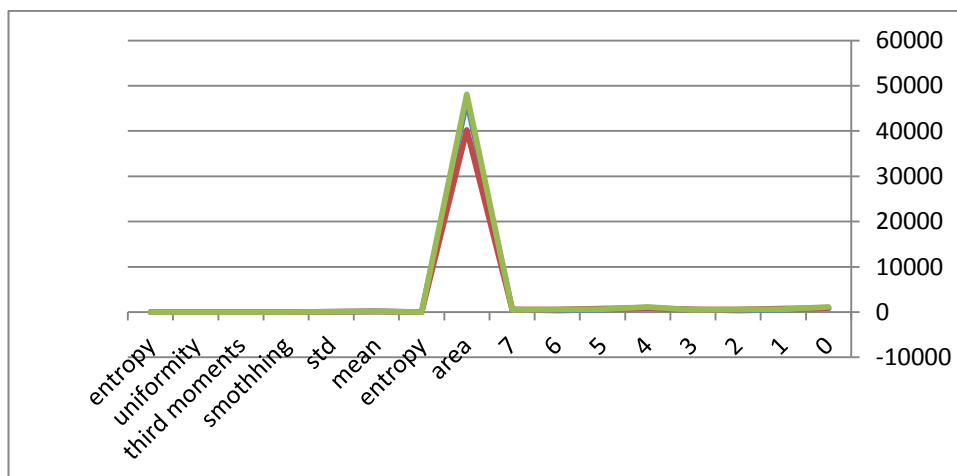Figure(10) graph of 16 feature's vector for person number one

Table(3) and table(4) display feature's vector extracted from ROI2 and ROI1 for person two in training phase. Figure11 shows graph of this 16 features for person number two.

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Table (3) ten feature vector for ROI2 person two in training group

entropy	area	Fccd (7)	Fccd (6)	Fccd (5)	Fccd (4)	Fccd (3)	Fccd (2)	Fccd (1)	Fccd (0)	image
0.466367	46696	556	314	557	847	557	322	548	857	2a.jpg
0.404641	40209	561	577	739	885	566	572	739	890	2b.jpg
0.444606	48102	495	532	650	1153	490	543	644	1154	2c.jpg

Table (4) six feature vector for ROI1 in person two in training group

Entropy	uniformity	third moments	smoothing	std	mean	image
7.191942	0.007932	-3.39935	0.05103	59.13268	143.2966	2a.jpg
7.425358	0.006558	-2.75576	0.056697	62.51636	138.5235	2b.jpg
7.116503	0.008575	-3.95784	0.05276	60.18159	148.3659	2c.jpg

Figure(11) graph of 16 feature's vector for person number two

5-3 Classification

Fuzzy logic provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. Furthermore, fuzzy logic emulates how a person makes decisions and performs reasoning; however, fuzzy logic does it much faster [13, 14].

There are many types of fuzzy neural network, for the forward multi-layer fuzzy neural network, the typical ones are Mamdani model, Sugeno model and Tsukamoto model. The simple and widely used Mamdani model is applied in this paper. For simplicity, as shown in figure12 we assume the and rules between input features vector which map to training vector in the fuzzy reasoning system of Mamdani model to know if the person who present hand palm image to the system authenticate or un-authenticate.After training phase for each person's hand palm image the system give each person solo identification number (id) this number not repeat for any person enter its data set im-

age to our system in futures. In testing phase the system ask from person to enter his identification number and image of his hand palm in order to test if he is the authorize person or not and to near the classification problem to nearest data set and decrease the required search time in big data set. Based on the degree of membership for each input the system decided whether the person is authenticate or not whereas threshold is placed to help the system on make decision this threshold is if the input vector match the training data set in 8 input with maximum degree of membership and the id of this person identical to the id in data set then the system result in this person is authorize to enter to the system else the person not authorize .
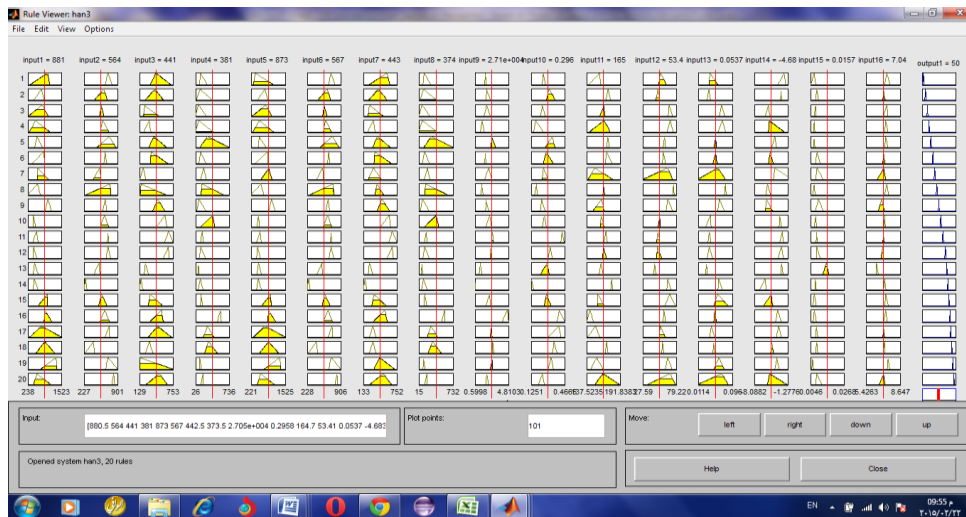

Figure (12) fuzzy logic rules for the proposed system

IV. EXPERIMENTAL RESULTS

Many experiments are performed to explore the possibility of the best parameters selection for hand palm image recognition with fuzzy logic classifier. Table (5) and table (6) display various experimental results of the multi-layer fuzzy neural network trained for the recognition of hand palm for two persons as examples. The proposed system success in recognize the hand palm image's person. The system obtained on recognition rate is 100% in training phase and rate 90% in testing phase. The system achieve using free IITD palmprint database.

In tables bellow the symbols p1..p20 mean number of person, The number in each column represent number of matching between the input vectors and the range of inputs for each person in the system in dataset with training phase which entered previously. The six row represent number of image entered to the proposed system the first three in training phase images and the last three represent testing phase images.

Table (5) various experimental results of the multi-layer fuzzy neural network for person 19

type	p20	p19	p18	p17	p16	p15	p14	p13	p12	p11	p10	p9	p8	p7	p6	p5	p4	p3	p2	p1
train	6	16	0	7	3	4	4	0	3	1	0	7	4	5	5	4	6	4	5	7
train	5	16	3	9	6	7	2	0	4	1	2	6	3	5	6	6	9	6	7	10
train	8	16	3	8	3	10	2	1	6	6	6	3	6	9	6	9	9	6	6	11
test	8	12	1	6	2	8	4	3	1	0	1	7	4	6	4	6	6	7	6	5
test	4	12	0	5	1	4	4	0	3	0	0	3	2	5	3	4	4	2	3	9
test	8	9	2	7	6	5	1	2	4	2	4	6	4	5	5	7	7	3	3	6

Table (6) various experimental results of the multi-layer fuzzy neural network for person 7

type	p20	p19	p18	p17	p16	p15	p14	p13	p12	p11	p10	p9	p8	p7	p6	p5	p4	p3	p2	p1
train	10	5	9	9	3	8	6	3	0	2	4	4	7	16	6	11	10	8	11	6
train	5	3	4	4	2	0	1	3	2	0	3	7	5	16	3	2	6	6	2	6
train	9	4	4	6	6	12	6	3	2	3	9	8	7	16	9	11	10	12	10	7
test	10	5	6	10	6	8	3	3	2	3	6	5	8	11	9	13	7	7	11	7
test	10	3	4	3	2	5	3	4	2	2	4	8	5	15	4	2	6	8	7	6
test	10	7	6	9	4	9	1	3	2	1	5	7	5	15	8	7	7	9	11	9

V. CONCLUSIONS

The method described here is founded to be successful in dealing with tilted and forged hand palm image. The features set formulated are founded to be effective enough to capture finer variations in the hand palm image's. Freeman Chain code is used because it faithfully preserve the information of interest and it isn't sensitive to orientation on hand and it depend on the compute the variations in direction of the pixels in boundary's lines of region. Texture analysis used to find statistical properties of the intensity histogram of an image which describe quantitatively by using statistical moments. All the persons in the database are in the age group 14-56 years the method presented in this work can be an effective verification system. The proposed system can be used as security tool before enter to interest information system which can be used in banking sector and other vital organizations where users'/clients' privacy and security are key to the success of such organizations.

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