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Analysis of Vascular Pattern Recognition Using Neural Network

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Abstract

Biometric identification using vein patterns is a recent technique. The vein patterns are unique to each individual even in twins and they don't change over age except their size. As veins are beneath the skin it is difficult to forge. BOSPHOROUS hand vein database is used in this work. Hand vein images are uploaded first and key points using Scale Invariant Feature Transform (SIFT) are extracted. Then the neural network is used for training these images. Finally neural network is used for testing these images to check whether the image used for testing matches with the existing database or not. Results are computed like False Acceptation Rate (FAR), False Rejection Rate (FRR), accuracy and error per bit stream.

Index Terms: Neural Network, Scale Invariant Feature Transform, False Acceptation Rate, False Rejection Rate, Canny Edge Detector

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1. Introduction

Biometric is the term used in computer science to refer to the field of mathematical analysis of unique human features [2]. It refers to the identification of humans by their characteristics and traits. Traditionally authentication is based on token based identification systems for example Passport, driving license etc. and knowledge based system for identification such as a password, personal identification number etc. As threats and attacks are increasing day by day, so there is a need of reliable security mechanism. Traditional methods are not as efficient that can provide sufficient security, so biometric systems are created to overcome the limitations of traditional systems. Biometrics is the science of identifying a person using its behavioral and physiological features [2]. Biometrics systems are classified in 2 categories that are physical and behavioral. Physical systems are related to the shape of the body such as fingerprints, face recognition, DNA, vascular patterns, iris of the eye etc. Behavioral biometrics system are related to behavior of a person like voice, gait etc. Advantages of these systems are that they are difficult to copy or forge; hence these systems are more secure

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and offer more reliable performance. Vascular pattern is the network of blood vessels beneath a person's skin. These vascular patterns can be used to authenticate the identity of an individual. The shapes of vascular patterns are unique in each individual even in twins [6].As blood vessels are hidden beneath the skin and are not visible to human eye, so these patterns are very hard to copy as compared to other biometric traits such as fingerprints. Vascular patterns can only be taken at live body. All these characteristics make this biometric system more secure and reliable.

2. Previous Work

J.M. Cross, C.L. Smith [1] proposed a system based on low cost automatic thermo graphic imaging system. Matching can be done by comparing a given signature against a single template or library of templates. By setting the minimum forward and reverse percentages to 75% and 60% respectively, it constitutes a FRR of 7.5% and FAR of 0%. T. Tanka [3] proposed a system using phase only correlation and template matching which yields FAR of 5.82% and FRR of 16% at threshold 0.40. Mohammed Shahin et al.[6] proposed a system based on spatial correlation of hand vein patterns. They obtained FAR of 0.02% and FRR of 3.00% at threshold 80. Chetna Hegde et al. [8] proposed a system to overcome the limitation of authentication due to damaged veins using modularization and constitutes FAR of 2.1% and FRR of 1.274%. S. Manikanda et al. [10] proposed a palm based authentication system with the help of energy feature based on wavelet transform. They obtained FAR and FRR between 0.7 to 1.0%. V.Krishna Sree, P.Sudhakar Rao[12] They proposed a technique in which linear hough transform is used for extraction of features of query and database images. For matching between query image and database K- Nearest neighbor search is used. The extraction of these vascular patterns was obtained by morphological techniques. To enhance the vein patterns noise reduction filters are used.In this system FAR is 20 % and FRR is 3.75%. N.V. Krishnaveni at al. [13] proposed a sytem based on hand vein triangulation. They have used BOSPHOROUS database and obtained FAR between 1 to 1.5% and FRR between 0 to 1.25%.

3. Proposed Work

The hand vein authentication approach in this work is based on the neural network. There are four stages in this authentication process.(i) Image Acquisition (ii) Image Normalization (iii) Feature Extraction (iv) Training of hand vein images using Neural Network (v) Testing with Neural Network. The methodology of the proposed work is shown in Figure 1.

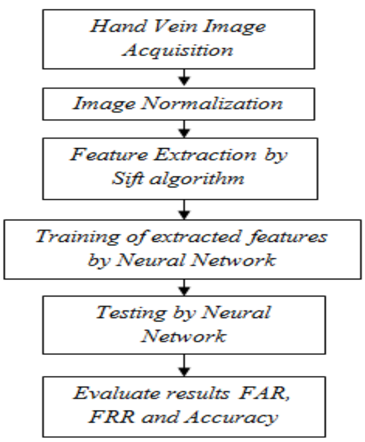

Fig. 1. – Methodology of proposed work

3.1 Image Acquisition

Image Acquisition is the process of getting the images that are required for the authentication process. BOSPHOROUS Hand vein database was collected from BOGAZICI University, Turkey [4].

The structure of the hand vein images can be captured with two types of imaging technologies namely Near Infrared (NIR) imaging, Far Infrared (FIR) imaging [9]. FIR technology works within the range 8-14 nm. It is more suitable for capturing large veins in the back of the hand, but it is very sensitive to ambient conditions so doesn't provide a stable quality image. NIR imaging works within the range 700-1000 nm produces good quality images when capturing vein images [9]. This range is more tolerant to changes in ambient conditions. Therefore NIR imaging technique is used in this database. Each subject underwent four imaging sessions that consists of the left hand

- After having squeezed an elastic ball repetitively for one minute (A),
- After having carried a bag weighing 3 kg for one minute (B),
- Under normal conditions (N),
- After holding an ice pack on the surface of the back of the hand (I).

We have taken 20 images of left hand from BOSPHOROUS [4] database under normal conditions which is shown in Figure 2.

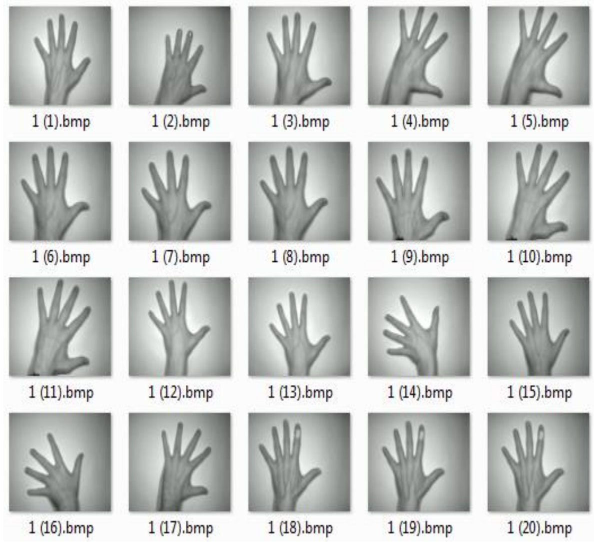

Fig. 2. – Images for Training

3.2 Image Normalization

Image Normalization is the process that makes something more normal or makes the image more suitable for further processing. In pre processing of the hand vein image first of all it is converted to gray scale image, then histogram processing is done and edges are detected using 'Canny' edge detector. There are many edge detection techniques available but canny edge detector is most suitable option here. As it provides low error rate [7] and better detection of edges especially in noise state with the help of thresholding method [9]. The steps of image normalization are shown in Figure 3.

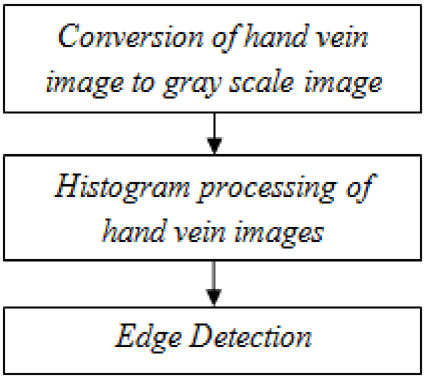

Fig. 3. - Image Normalization steps

3.2.1 Conversion to Gray Scale Image

First step of Image normalization is to convert the colour image into gray scale mode so that edges can be easily detected in gray scale image.

3.2.2 Histogram Processing

The histogram of the image is a plot of the number of occurrences of the gray levels in the image against the gray level value. It provides a convenient summary of intensities in an image, but it is unable to convey any information regarding spatial relationships between pixels. It is shown in Figure 4.

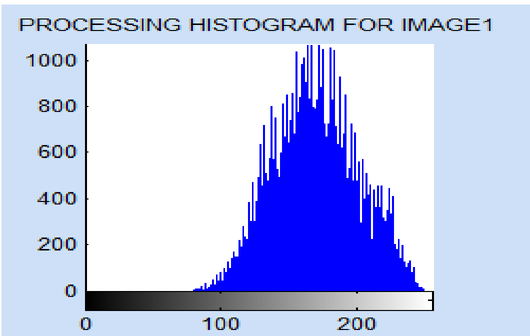

Fig. 4. - Histogram Representation

3.2.3 Edge Detection

Edge detection refers to the process of identifying & locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene [7]. Canny edge detector is used in the proposed system. The objectives of canny edge detector [14] are as follows:

1. Low error rate
2. Edges points should be well localized.
3. Single edge point response

Canny Edge Detector Algorithm

1. Smoothing of an image: In canny edge detector image is smoothed with the Gaussian filter. Edges are detected by smoothing the image with a circular 2D Gaussian function by computing the gradient of the result and then this gradient magnitude is used for estimating edge strength and direction at every point.

Let *f(x, y)* be the input image and *G(x, y)* be the Gaussian function:

$$G(x, y) = e^{-\frac{x^2+y^2}{2\sigma^2}} \tag{1}$$

We get a smoothed image, $f_s(x, y)$, by convolution of G and f:

$$f_s(x, y) = G(x, y) * f(x, y) \tag{2}$$

2. Compute the gradient magnitude and angle images: The gradient magnitude and angle are computed using equations 4.3 and 4.4 respectively.

$$M(x, y) = \sqrt{g_x^2 + g_y^2} \tag{3}$$

and

$$\alpha(x, y) = tan^{-1}\left[\frac{g_y}{g_x}\right] \tag{4}$$

3. Apply nonmaxima suppression to the gradient magnitude images: For this following steps are performed:

(i) Find the direction d_k that is closest to $\alpha(x, y)$.

(ii) If the value of *M(x, y)* is less than at least one of its neighbours along d_k, let $g_N(x, y) = 0$(suppression); otherwise let $g_N(x, y) = M(x, y)$

Where $g_N(x, y)$ is the non maxima-suppressed image.

4. To detect and link edges use double thresholding and connectivity analysis: The final operation is to threshold $g_N(x, y)$ to reduce false edge points. Canny's algorithm uses hysteresis thresholding which uses two thresholds: a low threshold T_L and a high threshold T_H.

Thresholding operation is visualized as creating two additional images

$$g_{NH}(x, y) = g_N(x, y) \geq T_H \tag{5}$$

and

$$g_{NL}(x, y) = g_N(x, y) \geq T_L \tag{6}$$

where, initially , both $g_{NH}(x, y)$ and $g_{NL}(x, y)$ are set to 0. After thresholding, $g_{NH}(x, y)$ will have fewer nonzero pixels than $g_{NL}(x, y)$, but all the nonzero pixels in $g_{NH}(x, y)$ will be contained in $g_{NL}(x, y)$ because the later image is formed with the lower threshold.

After all the thresholding operations all strong pixels in $g_{NH}(x, y)$ are assumed to be valid edge pixels and so marked immediately. The edges detected by canny edge detector are shown in Figure 5

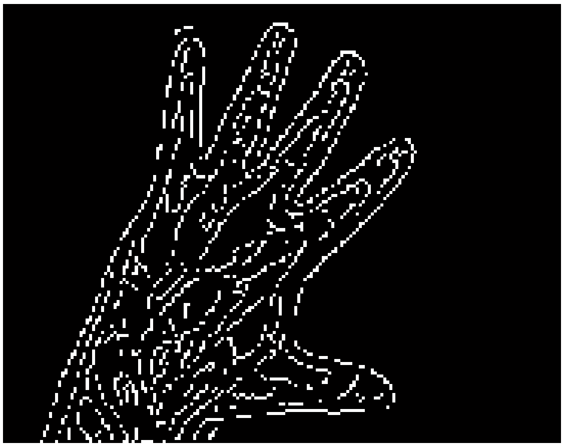

Fig. 5. - Edge Detection

3.3 Feature Extraction

The feature is the process in which key points are extracted from the image. These key points are used for the further matching process. In this work SIFT algorithm is used for extraction of features. SIFT [11] is used for extraction and extracting local features of an image. The first step of SIFT algorithm is to find the scale space Difference-of-Gaussian (DoG) convoluted with the hand vein image to detect key points locations which is invariant to scale changes. The DoG is calculated by following equations:

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y) \quad (7)$$

$$D(x, y, \sigma) = G(x, y, k\sigma) * I(x, y) - G(x, y, \sigma) * I(x, y)$$

$$D(x, y, \sigma) = L(x, y, k\sigma) - L(x, y, \sigma) \quad (8)$$

where $I(x, y)$, $G(x, y, \sigma)$, $L(x, y, \sigma)$and $D(x, y, \sigma)$ represents the image, Gaussian function , scale space of the image and DoG function respectively. The DoG function is calculated using equation 9

$$G(x, y, \sigma) = \frac{1}{2\pi\sigma^2} e^{-(x^2+y^2)/2\sigma^2} \quad (9)$$

The next step is to detect the local maxima and minima of $D(x, y, \sigma)$by comparing the each pixel value of hand vein image with the neighbor pixel values. They are selected if the pixel value is higher or lower related with the neighbour pixels.

These selected values are named as key points. To eliminate the low contrast points along the edge of the image, Taylor's expansion method is used. After applying the Taylor expansion, stable key points are selected and located by eliminating the low intensity pixel key points. The orientations of key points are assigned for the selected key points. For each detected key point, a feature vector is extracted as a descriptor from the gradients of sampling points within its neighbourhood [5]. Figure 6 shows the key points extracted by SIFT.

Fig. 6. – Key points

3.4 Training and Testing with Neural Network

In this stage obtained images are trained with neural network and then classification is done to ensure whether the test image has been matched or not matched with the trained database. Each neuron in the input layer is fed directly to the hidden layer neurons via a series of weights. The sum of the products of the weights and the inputs is calculated in each node. The calculated values are fed directly to the output layer neurons via a series of weights. As in hidden layer, the sum of the products of the weights and the hidden layer neuron outputs is calculated in each node in the output layer. If the error between calculated output value and the desired value is more than the error ratio, then the training (changing the weights and calculating the new output by using the new weights) process begins. This training process can be finished by obtaining the desired error rate for all input combinations. The architecture of Neural Network is shown in Figure 7.

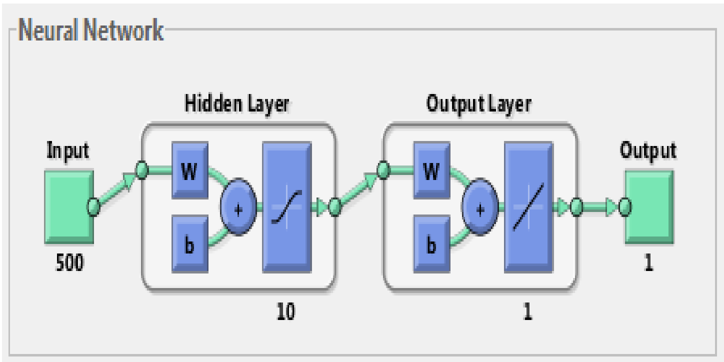

Fig. 7. – Architecture of Neural Network

4. Results and Discussions

In this work BOSPHOROUS hand vein database was utilized. This database uses near infrared imaging technology under adverse conditions. The proposed work is based on neural network. MATLAB software is used to obtain simulation results. We used 20 images of left hand under normal conditions. First of all images are uploaded. Then histogram processing of images, edge detection is done and key points are saved for the image. In this work cross points and end points of hand vein images are also saved. When all the images are processed and key points are saved neural network is used for training the feature set. Finally testing is done to check whether the test image matches with the trained images or not. For each image FAR, FRR, Accuracy and Error per bit stream are calculated. The values for all these parameters are shown in Table 1. These parameters for all images are shown in graphs. The proposed system gives 0.46 error rate per bit stream. Figure 8 shows the graph of FAR of all images which ranges between 0.01 to 0.035%.

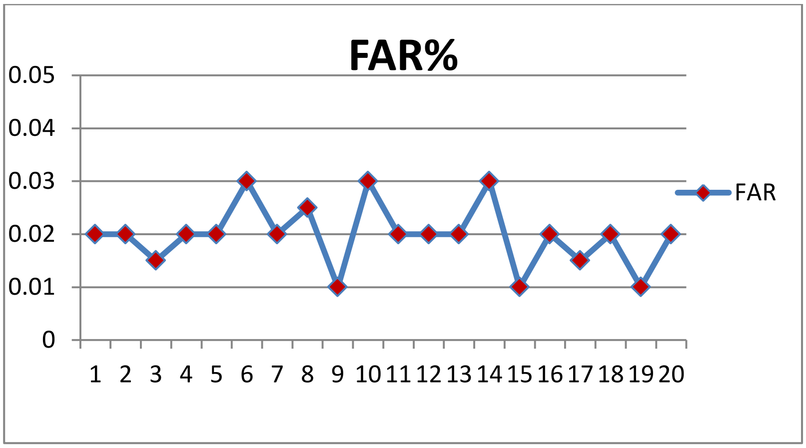

Fig. 8. – False Acceptation Rate

Figure 9 shows the graph of FRR% of all hand vein images used in the system.

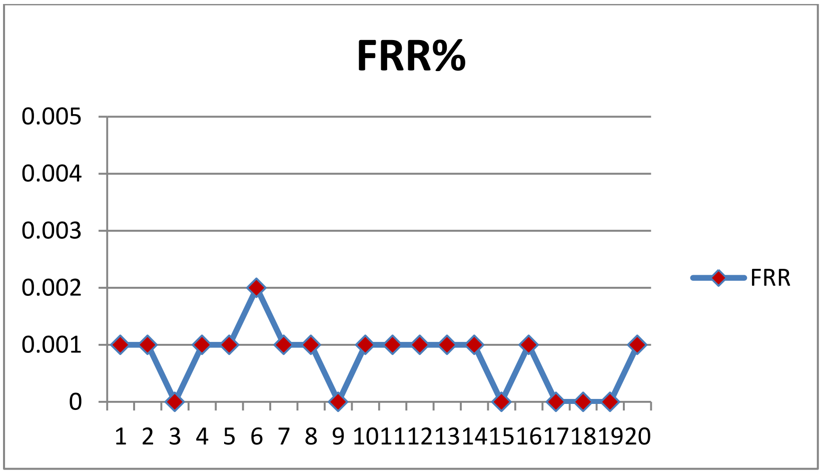

Fig. 9. - False Rejection Rate

Figure 10 shows the graph of Accuracy achieved for all images.

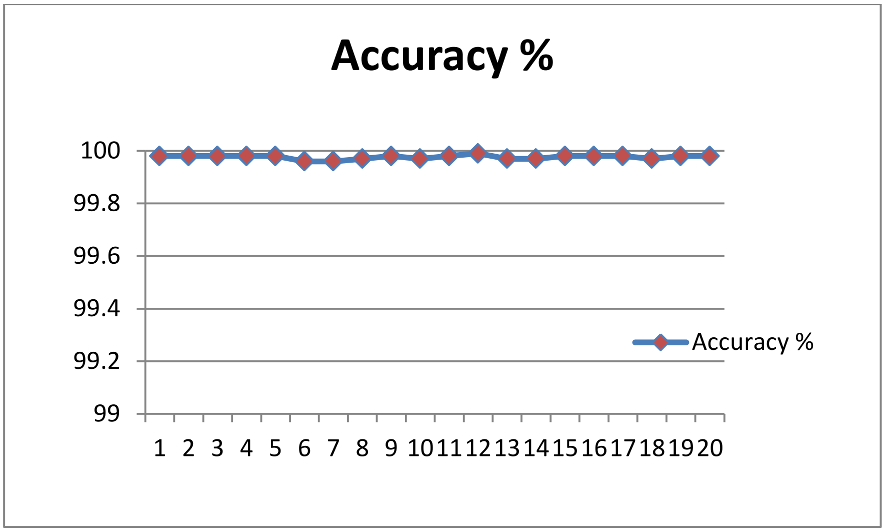

Fig. 10. - Accuracy

In this proposed system approximately 100 images are tested. All the twenty images that are trained by neural network are matched in testing process. Images that are not trained did not match. Experimental results showed that the proposed method achieved correct classification rates up to 100%.

Table 1. – Experimental Results

Image No.	FAR (%)	FRR (%)	Accuracy (%)	Error (per bit stream)
1	0.02	0.001	99.98	0.47
2	0.02	0.001	99.98	0.45
3	0.015	0.0006	99.98	0.38
4	0.02	0.001	99.98	0.48
5	0.02	0.001	99.98	0.48
6	0.03	0.002	99.96	0.58
7	0.02	0.001	99.96	0.47
8	0.025	0.001	99.97	0.50
9	0.01	0.0006	99.98	0.38
10	0.03	0.001	99.97	0.51
11	0.02	0.001	99.98	0.48
12	0.02	0.001	99.99	0.52
13	0.02	0.001	99.97	0.52
14	0.03	0.001	99.97	0.51
15	0.01	0.0001	99.98	0.41
16	0.02	0.001	99.98	0.46
17	0.015	0.0006	99.98	0.39
18	0.02	0.0009	99.97	0.43
19	0.01	0.0005	99.98	0.37
20	0.025	0.001	99.98	0.50

5. Conclusions

This section covers a brief introduction to biometric systems, their classification, characteristic, applications and limitations. Vascular pattern recognition systems have been discussed along with their characteristics. Neural Networks with their advantages have been discussed in the introduction part. A literature review by different researchers along with literature gaps is presented in this dissertation work. Various existing methods in this field are briefly explained here.

The proposed system aims to analyze the vascular pattern recognition using Neural Network. The proposed work is implemented in MATLAB software. The introduction to MATLAB with its advantages and characteristics is given in this dissertation work. The proposed system attempts to reduce the FAR, FRR and to increase the accuracy of the system in authenticating the persons. In this proposed system the hand vein images are taken from BOSPHOROUS database, BOGAZICI University, Turkey. Near Infrared (NIR) imaging technique is used in this database. Each subject underwent four imaging sessions that consists of the left hand in this database. First of all these vein images are uploaded. In Image Normalization coloured images are converted to gray scale images, histograms are processed for these hand vein images and edges are detected using 'Canny' edge detector. In feature Extraction key points are extracted using SIFT algorithm. The cross points and end points of hand vein images are also calculated. Then neural network is used for training these hand vein images. Then testing is performed using Neural Network. Then FAR, FRR, error per bit stream and accuracy are evaluated. The proposed system gives 99.97% of accuracy, 0.02% of FAR, 0.0009% of FRR and 0.46 errors per bit stream. Experimental results showed that the proposed method achieved correct classification rates up to 100%.

6. Future Scope

In this dissertation work, we tried to achieve better results like FAR, FRR, Accuracy and error per bit stream for all the images. We used 20 images for training set and in Testing more images are taken into consideration to check the efficiency of the system. Although all the images which are tested gave accurate results but in future we will try to use more images for training set so that it can be used in real time applications. However the proposed system tried to achieve the best results like FRR is less than 0.0009%, FAR of 0.02% and accuracy of 99.97% but still we will try to lower these values. We will also try to minimize the training time. In future the work will also be done on palm images.

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