Finger Vein and Hand Vein Identification System for Effective IT Security

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***Abstract*— The objective of this paper is to present a bimodal biometric verification system for physical access control based on finger vein pattern and hand vein pattern for high security access. The database of the proposed system contains 25 finger vein patterns and 25 hand vein patterns of different individuals. Feature vectors are created independently for query images and are then compared with the enrolment templates for each biometric trait to compute the matching score. The final decision is made by fusion at this matching score level architecture. Claimed identity is either accepted as a genuine user or rejected as an impostor. The system is implemented using MATLAB. Performance Measures used to validate the proposed system are Accuracy, Receiver Operating Characteristics (ROC) Curve, False Acceptance Rate (FAR) and False Rejection Rate (FRR).**

***Index Terms*— Finger vein, hand vein, enrolment, verification, matching score, fusion.**

I. Introduction

Biometrics has become a sparkling word in the world of science and technology today and is gaining more attention all over the world by scientist, researchers and engineers. With changed world scenario due to continual threats from terrorist organizations, India is also facing many challenges including cross border terrorism, during trafficking, ill-legal immigrants from neighboring countries and now Indian security systems have started including biometrics. In India, Biometrics is being adopted for highly secured identification and personal verification by the governments, defense services, corporate and other agencies in need of security, surveillance and safety. Biometrics is considered far superior to several other common means confirming identity and also helps in protecting of privacy by erecting a barrier between personal data and unauthorized access [1]. Besides bolstering security, biometric systems also enhance user convenience by alleviating the need to design and remember passwords.

These features make biometrics a promising solution for security management. Effective IT security is in high demand, and a large variety of industries such as banking and the military view biometrics solutions as a key part of the solution.

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High security access controls have long been a standard practice at nuclear power plants. Biometric authentication can be used to simplify boarding procedures as people depart the country.

It is a new era where biometric authentication systems capable of accommodating large diverse populations must meet stringent performance requirements for high security access and the proposed work includes vein biometrics of finger and hand to give an optimum solution for personal authentication in pervasive environment.

Vein based biometric system has several benefits when compared with other biometric methods. This recognition technology offers a promising solution to the challenges in biometric systems due the following characteristics.

1. Its Universality and Uniqueness such as individuals have unique features, so also they do have unique vein images.
2. Hand and finger vein detection methods do not have any known negative effects on body health.
3. The condition of the epidermis has no effect on the result of vein detection.
4. Vein features are difficult to be forged and changed even by surgery.
5. Vein is free from the impact of external contamination and minor injuries
6. Information characteristic is insensitive to the changes in humidity and temperature.
7. The vein is hidden inside the body and is mostly invisible to human eyes. The non-invasive and contactless capture of finger-veins ensures both convenience and cleanliness for the user.
8. The finger-vein pattern can only be taken from a live body. It is a natural and convincing proof that the subject whose finger-vein is successfully captured is alive.

These desirable properties make vein recognition a highly reliable authentication method. What is more, it is easy to collect, readable and so on. Because of the above unique advantages, the vein recognition is widely used in biometric identification.

II. Proposed Method

The target of this project has been to design and develop of a finger vein and hand vein identification system that could be used by a limited number of users in a networked environment[1]. Those and other different scenarios are pushing the development of more sophisticated systems based on biometrical information given the impossibility of a malicious individual to reproduce the information.

The acquisition of biometric parameters is a very hard procedure since it requires the conditions around the acquired parameter be as similar as possible. Fingerprint identification is one of the most common biometric systems to identify individuals. The main advantages are, it's easy to extract the fingerprint, the size of the device can be small and the algorithms used for identification have been widely researched, analyzed and tested. However, there is one unsolved problem in this area is falsification, since it is easy to obtain the fingerprint of an individual from any object that he/she has touched in the past.

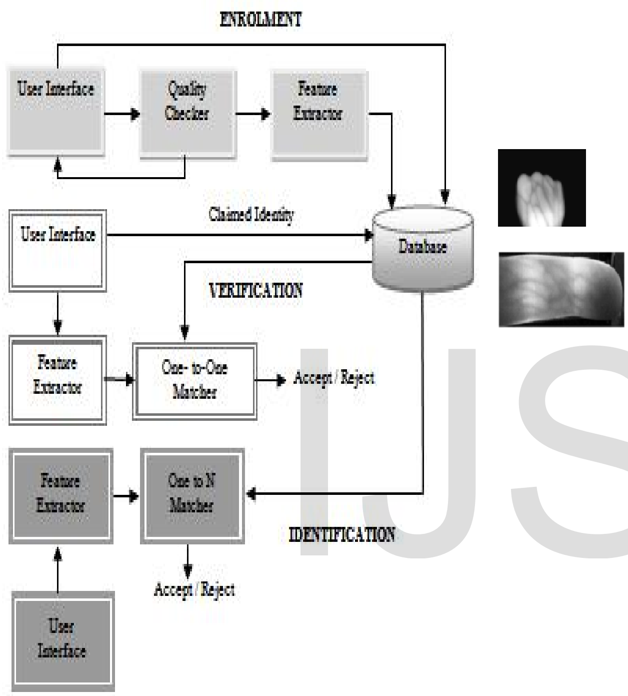

Fig. 1 Block Diagram of the Proposed Bimodal Authentication System

Thus, identification systems based on vein patterns has become one of the main trends of biometrical identification systems in recent years. Advantages of vein identification system are the vein is hidden inside the body and is mostly invisible to human eyes. The non-invasive and contactless capture of veins ensures the convenience for the user. However, one of the main disadvantages of finger vein identification is that the result run by the system is easily changed since the finger vein pattern extracted for the identification will be modified if the individual rotates his/her finger or revises the level curvature inside the device. Hence this paper proposes a bimodal biometric system that also includes hand vein patterns and is shown in Fig. 1.

III. Finger Vein Recognition

The Finger vein is a unique physiological biometric for identifying individuals based on the physical characteristics and attributes of the vein patterns in the human finger. It is a fairly recent advance in the field of biometrics that is being applied to different fields such as financial, law enforcement facilities and other applications where high levels of security or privacy is very crucial. This technology is very impressive because it requires small, relatively cheap single-chip design, and has a fast identification process that is contact-less and of higher accuracy when compared with other identification biometrics like fingerprint, iris, facial and others.

This higher accuracy rate of finger vein is not unconnected with the fact that finger vein patterns are virtually impossible to forge thus it has become one of the fastest growing new biometric technology that is quickly finding its way from research labs to commercial development[3-6]. For authentication purposes, the finger is scanned as before and the data is sent to the database of registered images. Overall, its advantages include uniqueness, live body identification, small sample file, internal characteristics, a higher level of security and so on. In the finger vein image acquisition process, the light intensity has a great impact on the quality of finger vein image. Stronger light can cause the overall image bright and make the vein disappear in the serious. The lower light can cause the overall image dim and make a very few difference between the blood vessels and the background. In order to finish sufficient extraction of the finger vein feature, the image needs pre-processing. The pre-processing is mainly divided into image de-noising and image enhancement. The methods of feature extraction mainly include threshold segmentation method. Finger Vein proved that each finger has unique vein patterns so that it can be used in personal verification. To obtain the pattern, an individual inserts a finger into an attester terminal containing a near-infrared LED light and a monochrome CCD camera. The haemoglobin absorbs near-infrared LED light, which makes the vein system. The camera records the digitized raw data and the image and sent to a database of registered images.

A. Image Normalization

The first stage in finger vein identification system is the normalization process[2]. In the proposed work, the acquired input image is it is normalized with a threshold value of 240, to coarsely localize the finger shape in the images, i.e., the eliminating number of connected white pixels being less than a threshold. Fig. 2 shows the sample of two input finger vein images.

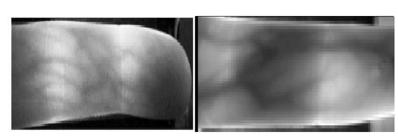

Fig. 2 Original Finger vein Image

B. *ROI Extraction*

The Edge detection is performed to highlight the Region Of Interest. ROI detected images are shown in Fig 3. Sobel operator is used for edge detection. The Sobel method uses the derivative to find edges, edges at those points where the gradient of the considered image is maximum.

Fig. 3 Detected Region of Interest

C. ***Image Enhancement and Segmentation***

It is difficult to extract precise details of the image because of the irregular noise and shades around the finger-vein. Hence the finger vein images are enhanced by median filtering and low pass filtering to preserve the edges[3]. Maximum curvature method is used for segmenting the enhanced images and the results of the two sample images are shown in Fig. 4.

Fig. 4 Segmented Images

D. ***Feature Extraction***

The feature extraction is done to extract the thickness, length and shape of the vein pattern. This is done using the Repeated Line Tracking algorithm [2] . It traces the veins in the image by choosing the directions according to predefined probability in the horizontal and vertical orientations, and the starting seed is randomly selected. Fig. 5 shows the results of repeated line tracking algorithm.

Fig. 5 Results of Repeated Line Tracking Algorithm

E. ***Matching***

Matching of the templates with the query image is done using hamming distance classifier. The accuracy of this technique reports to be 94%.

IV. HAND VEIN RECOGNITION

Hand Vein Patterns from World Academy of Science, Engineering and Technology (WASET) Database are used in this Hand vein recognition system. This is a dataset of 100 persons of different age group above 16 and of different gender, 5 right hand images per person acquired at different intervals, has been used. Hand vein images of right hand of a single person are shown in Fig. 6.

Fig.6 Hand Vein Images a Male Hand

A hand Vein Pattern Verification System consists of four individual processing stages: Hand Image Acquisition, Image Enhancement, Vein Pattern Segmentation and Matching by calculating their Hausdorff distances [7-10].

A. ***Image Enhancement***

Image enhancement techniques are used to emphasize and sharpen image features for display and analysis. The following procedure describes the various steps in the image enhancement process [8]

1. **Median filtering:** Median filtering reduces noise without blurring edges and other sharp details. This is particularly effective when the noise pattern consists of strong, spike-like components. A 5×5 median filter is used to remove the speckling noises in the hand vein images.
2. **Gaussian Low pass filtering:** Gaussian Low pass filtering is done to suppress the effect of high frequency noise.
3. **Contrast stretching:** Contrast stretching often called normalization is a simple image enhancement technique that improves the contrast in an image by stretching the range of intensity values it contains to span a desired range of values. Generally, image display and recording devices typically operate over a range of 256 gray levels. The result is an output image that is designed to accentuate the contrast between features of interest to the image analyst.
4. **Level slicing:** Level slicing is an enhancement technique whereby the Digital Numbers (DN) distributed along the x-axis of an image histogram is divided into a series of analyst-specified intervals of slices. All of DNs falling within a given interval in the input image are then displayed at a single DN in the output image.
5. **High Pass Filtering:** High pass filtering does the edge detection in spatial domain. The edges in an image contain mainly high frequency components and areas of constant gray level consist of low frequencies. Edges and sharp transitions in an image contribute significantly to high frequency content of its fourier transform. Regions of relatively uniform gray values in an image contribute to low-frequency content of its fourier transform. Hence, image sharpening is attained by high pass filtering.

B. ***Hand vein segmentation***

It divides hand vein image into foreground (veins in the back of the hand) and background (non-vessel) areas. Image Segmentation is implemented using thresholding method as it is computationally cheap and fast [9]. The method adapted for this thesis is Local adaptive thresholding. Thresholding segment the input image into two classes: one for those pixels having values below an analyst-defined gray level and one for those above this value. A parameter θ called the brightness threshold is chosen and applied to the image a [m, n] as follows:

For dark objects on a light background we would use:

If a [m, n] ≤ θ a [m, n] = object = 1
Else a [m, n] = background = 0

Local adaptive thresholding selects an individual threshold for each pixel based on the range of intensity values in its local neighborhood and the histogram of the image doesn't contain distinctive peaks. Hence, local adaptive thresholding algorithm is utilized to segment the vein patterns from the background. The algorithm chooses different threshold values for every pixel in the image based on the analysis of its surrounding neighbors. For every pixel in the image, its threshold value is set as the mean value of its 31×31 neighborhood. The segmented vein patterns are shown in Figure 7.

Fig. 7 Segmented Handvein Images

C. *Hand Vein Pattern Postprocessing and Skeletonization*

The resultant binary hand vein images after enhancement and segmentation contains some noise and un-sharp edges. For improving and validating the output binary hand vein pattern and for reducing the effect of these unwanted defects, post processing is done with a 7x7 median filter. Skeletonization reduces the width of lines to one pixel width and eliminates the unwanted isolated points [10]. As the size of veins grow as human beings grow, only the shape of the vein pattern is used as the sole feature to recognize each individual. A good representation of the pattern's shape is via extracting its skeleton.

This skeletonization is done using morphological thinning algorithm that successively erodes away the pixels from boundary while preserving the end points of line segments until no more thinning is possible. Fig. 8 shows the skeleton of the vein pattern after applying the morphological thinning operation.

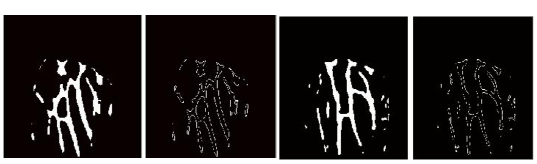

Fig. 8. Thinned Hand Vein Images after Postprocessing and skeletonization

V. Vein Pattern Matching

Matching of hand vein patterns is implemented by the Hausdorff Distance method. Hausdorff distance measures the degree of mismatch between two images. Hausdorff distance is the maximum distance of a set to the nearest point in the other set. The distance (e.g. Euclidean distance) between two points *a* and *b* is defined as d $(a, b) = \|a-b\|$, and the distance between point *a* and a finite point set B = $\{b_1, \ldots, b_N\}$ is commonly defined as in Eq. 1.

$$d(a,B) = \min_{b\in B}\|a-b\| \tag{1}$$

Given two finite point sets A= $\{a_{1\ldots}\ a_N\}$ and B= $\{b_1 \ldots b_N\}$, the Hausdorff Distance is defined as in Eq. 2.

$$H(A,B) = \max(h(A,B), h(B,A)) \tag{2}$$

where h (A, B) and h (B, A) represent the directed distance between two sets A and B. The directed distance h (A, B) is traditionally defined as in Eq. 3.

$$\begin{aligned} h(A,B) &= \max_{a\in A} d(a,B) \\ h(A,B) &= \max_{a\in A}\min_{b\in B} d(a,b) \\ h(A,B) &= \max_{a\in A}\min_{b\in B}\|a-b\| \end{aligned} \tag{3}$$

The function h (A, B) identifies the point a €A that is farthest from any point of B and measures the distance from 'a' to its nearest neighbor in B. Thus, the Hausdorff Distance H (A, B) measures the degree of mismatch between two point sets A and B. Using this matching classifier, the template image is matched with test images and by exhausting the whole database the optimal threshold is found to be 4.47. The accuracy of the hand vein system is found to be 96%.

VI. Integration of Biometric Systems

The performance of a biometric system is largely affected by the reliability of the sensor used and the degrees of freedom offered by the features extracted from the sensed signal. Further, it is now apparent that the proposed system using finger vein and hand vein features of an individual for verification purposes meet the stringent performance requirements imposed by various applications. Moreover, it will be extremely difficult for an intruder to violate the integrity of a system requiring multiple biometric indicators. Although the storage requirements, processing time and the computational demands of a multibiometric system are much higher than a unibiometric system, higher security present a compelling case for deploying multibiometric systems in large scale authentication systems[11].

Levels of Fusion: Evidence in a multibiometric system can be integrated in different levels. Three commonly used levels of fusion when combining multiple biometric systems are:

a. Fusion at the **feature extraction level**, where features extracted using multiple sensors are concatenated.
b. Fusion at the **score level**, where matching scores reported by multiple matchers are combined, and
c. Fusion at the **decision level**, where the accept/reject decisions of multiple systems are consolidated.

The match scores generated by the finger vein and hand vein are combined via sum rule in order to obtain a new match score. This score is then used to make the final decision.

Score Normalization is achieved by Min-Max (MM) method. A raw matching score is denoted as s from the set S of all scores for that matcher, and the corresponding normalized score as n.

Min-Max(MM):

This method maps the raw scores to the [0, 1] range.

The quantities max(S) and min(S) specify the end points of the score range.

$$n = \frac{s - \min(S)}{\max(S) - \min(S)} \quad (4)$$

$$N_{vein} = \frac{MS_{vein} - Min_{vein}}{Max_{vein} - Min_{vein}}$$

$$N_{finger} = \frac{MS_{finger} - Min_{finger}}{Max_{finger} - Min_{finger}}$$

The two normalized similarity scores N_{vein} and N_{finger} are fused linearly using sum rule as given in Eq. 4 to generate a new matching score. Matching score,

$$MS = \alpha \times N_{vein} + \beta \times N_{finger} \quad (5)$$

where α and β the two weight values assigned a value 1. The reliability of the proposed bimodal biometric system is described with the experimental results. The fusion is done at matching score level assigning equal weightage to each trait. The system has been tested on a database containing 75 hand vein and 75 fingerprint images. 3 images / person for 25 individuals (3×25 = 75 images). The accuracy of the integrated system will be in between 94% and 96%.

VII. Results and Discussions

To evaluate the vein pattern verification system, the performance measures include calculation of false accept rate and false reject rate. A Receiver Operating Curve (ROC) provides an empirical assessment of the system performance at different operating points that is more informative than FAR and FRR. Fig. 9 shows the sample Receiver Operating Characteristic curve.

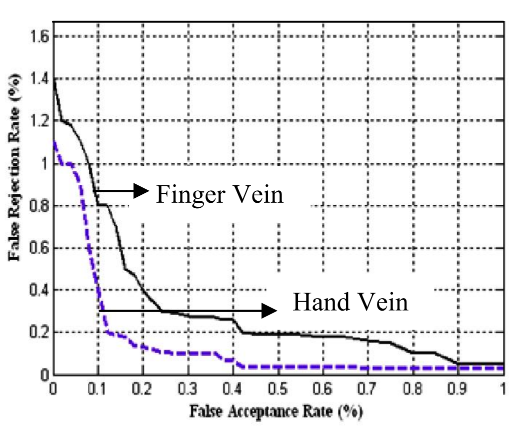

Fig. 9 Receiver Operating Characteristics Curve

A commonly used point to examine the quality of performance is the Equal Error Rate (EER) and it assumes that the costs of FAR and FRR are equal. The lower the EER, better is the system's performance.

VIII. Conclusion

The designed system is tested over a dataset of 25 finger vein and 25 hand vein patterns, each five images per person. Performance parameters are estimated for both. The finger vein system reported an accuracy of 94% and Hand vein reported an accuracy of 96%. The multimodal system will be more secure in IT Industry for authentication.

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