Intelligent Technique for Human Authentication using Fusion of Finger and Dorsal Hand Veins

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Abstract:-Multimodal biometric systems have been widely used to achieve high recognition accuracy. This paper presents a new multimodal biometric system using intelligent technique to authenticate human by fusion of finger and dorsal hand veins pattern. We developed an image analysis technique to extract region of interest (ROI) from finger and dorsal hand veins image. After extracting ROI we design a sequence of preprocessing steps to improve finger and dorsal hand veins images using Median filter, Wiener filter and Contrast Limited Adaptive Histogram Equalization (CLAHE) to enhance vein image. Our smart technique is based on the following intelligent algorithms, namely; principal component analysis (PCA) algorithm for feature extraction and k-Nearest Neighbors (K-NN) classifier for matching operation. The database chosen was the Shandong University Machine Learning and Applications - Homologous Multi-modal Traits (SDUMLA-HMT) and Bosphorus Hand Vein Database. The achieved result for the fusion of both biometric traits was Correct Recognition Rate (CRR) is 96.8%.

Key -Words: - Biometric systems, pattern recognition, intelligent computing, image processing, machine learning.
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1. Introduction

A secure authentication system would ensure that only authorized users are able to access or manipulate information. There are four means used in authenticating users; using what they know such as passwords and pins, using what they own which involve tokens and smart cards, using what they do which involves use of behavioral biometric and using what they possess which are the physiological biometrics. Among all the authentication techniques present, biometrics is considered as the most reliable authenticators since they are unique to every individual and hard to get [1].

Biometric authentication is a process of identifying a person using physiological or behavioral features. Physiological features are Iris, DNA, hand, finger print and face behavioral features are voice, signature, password, keystroke etc. Among all the authentication techniques present, biometrics is considered as the most reliable authenticators since they are unique to every individual and hard to get. The technology of Vein Patterns (VP) as a type of biometric authentication was first intended in 1992.VP is the network of blood carriers below a person's skin layers. VP structure distinct and distinguishable patterns across various people and they remain the same irrespective of age. The patterns of blood veins are unique to each person, even among twins. There are internal and external biometric systems. External include face, Iris, finger print based systems. Palm vein, finger vein, dorsal veins structure the internal biometric frameworks. Veins are intra-skin elements, consequently this feature makes the frameworks exceptionally secure, and they are not influenced by state of the external skin [2].Generally, biometric system works in two modes namely :(i) verification mode in which biometrics can be used to verify a person's identity and (ii) identification mode in which biometrics can be used to determine a person's identity, even without that individual's information [3].

Hand vein technology works by identifying the vein patterns (palm, dorsal hand and finger veins) in an individual's hand. When a user's hand is held over a scanner, a near-infrared light maps the location of the veins. The red blood cells present in the veins absorb the rays and show up on the map as black lines, whereas the remaining hand structure shows up as white. This vein pattern is then verified against a preregistered pattern to authenticate the individual. As veins are internal in the body and have a wealth of differentiating features, attempts to forge an identity are extremely difficult, thereby enabling a high level of security [4].

Biometric authentication can be classified into unimodal and multimodal biometric systems.

Unimodal systems that use single biometric trait for recognition purposes; and suffers a several practical problems like non-universality, noisy sensor data, intra-class variation, restricted degree of freedom, unacceptable error rate, failure-to-enroll and spoof attacks. So, the performance of single biometric system needs to be improved. The techniques of multimodal biometric system can offer a feasible method to solve the problems coming from unimodal biometric system. Multimodal biometric system makes use of different biometric traits simultaneously to authenticate a person's identity. Robustness and high security of authentication can be achieved by using the multimodal biometric systems [5].

The rest of the paper is organized as follows. Section 2 presents a comprehensive analysis for the multimodal of recognition techniques and systems. We presented an overview of various levels of fusion in multimodal biometrics systems in section 3. We briefly explain our methodology of the fusion of finger and hand vein system in section 4.Section 5 presents the explanation of the process of biometric system. The discussion of results is introduced in section6.Finally; conclusions and future work are presented in section 7.

2. Analysis of Multi-modals Recognition Techniques and Systems

E. Stefani and C. Ferrari designed, implemented, and deployment a multi-modal biometric system to grant access to a company structure and to internal zones in the company itself. The chosen methodology for face identification is the Local Binary Patterns (LBP). Then, the LBP image is divided into local regions and a histogram is extracted from each one. Finally, the spatially-enhanced feature vector (called Local Binary Patterns Histograms (LBPH)) is obtained by concatenating all the local histograms. Daughman’s method has been chosen for iris recognition. It consists of several phases: segmentation normalization with the Daugman’s Rubber Sheet Model, encoding with the Log-Gabor wavelet and matching using the Hamming Distance [6].

L.Christo and A. Zimmer developed a multibiometric system using hand geometry and palm veins .For the hand geometry Data, an algorithm for determining finger tips and hand valleys was proposed and from there was possible to extract a handful of other features related to the geometry of the hand. The palm veins features were extracted from a rectangle generated based on the hand's center of mass. The Texture descriptor chosen was the Histogram of Gradients. In possession with all the biometric data, the fusion was done on feature level. Support Vector Machine technique was used for the classification [7].

S.Bharathi and R.Sudhakar developed hand vein-based multi-modal biometric technique using palm and dorsal hand vein images as two modalities for biometric recognition. At first, input images are subjected to the preprocessing stage where it is converted into suitable format to extract the vein from the images. Subsequently, the image is filtered and optimal threshold is identified to separate the vein part from background of input images using threshold-based segmentation. After that, features such as, location and width are extracted from the veins and those features are fused with vector concatenation. In recognition step, features are extracted from the test images and it is matched with the features stored in the database using distance measure. Based on the threshold value, decided whether the image of the corresponding person is presented in the database or not [4].

Shruthi.B.M et.al. employed a new approach to improve the authentication. The system simultaneously acquires the finger vein and low resolution fingerprint images and combines these two evidences using a two new score level combination strategy i.e., holistic and nonlinear fusion. A new approach is employed for the finger vein feature extraction using Gabor filters and 1-D Gaussian functions. The Localized Radon Transform (LRT) and Gabor Filter based Orientations Encoding techniques are used for fingerprint feature extraction [5].

R. Raghavendraet.al. [8] presented a robust imaging device that can capture both fingerprint and finger vein simultaneously. The presented low-cost sensor employs a single camera followed by both near infrared and visible light sources organized along with the physical structures to capture good quality finger vein and fingerprint samples. Extensive experiments are carried out on newly collected database that comprises of 1500 samples of fingerprint and finger vein from 150 unique fingers corresponding to 41 subjects. The results demonstrate the efficacy of the proposed sensor with a lowest Equal Error Rate of 0.78%.

R. B.Trabelsi et. al. [9] proposed a new multimodal biometric system based on fusion of both hand vein and finger vein modalities. For finger vein recognition, we employ the Monogenic Local Binary Pattern (MLBP), and for hand vein recognition an Improved Gaussian Matched Filter (IGMF). Experimental results confirm that the proposed multimodal biometric process achieves excellent recognition performance compared to unimodal biometric system. The Area Under Curve (AUC) of the proposed approach is very close to unity (0.98).

M.D.Dhameliya and J. P Chaudhari developed Multimodal biometric identification system based on palmprint& fingerprint trait. Typically in a multimodal biometric system each biometric trait processes its information independently. The processed information is combined using an appropriate fusion scheme. Successively, the comparison of data base template and the input data is done with the help of Euclidean-distance matching algorithm. The experimental results demonstrated that the proposed multimodal biometric system achieves a recognition accuracy of 87% .Multimodal biometric system provides optimal False Acceptance Rate (FAR) & False Rejection Rate (FRR), thus improving system accuracy &reliability [10].

J. Ajay Siddharth et.al. proposed biometric system uses two modalities, palm print and palm vein. From the acquired image, region of interest (ROI) is extracted. By this method of encryption, after ROI extraction, the storage of data consumes less memory and also provides faster access to the information. The encrypted data of both modalities are fused using advanced biohashing algorithm. The biohash code is matched with the information in database using matching algorithms, providing fast and accurate output. This approach will be feasible and very effective in biometric field [11].

G. Park and S. Kim [12] proposed a hand biometric authentication method based on measurements of the user's hand geometry and vascular pattern. To acquire the hand geometry, the thickness of the side view of the hand, the K-curvature with a hand-shaped chain code, the lengths and angles of the finger valleys, and the lengths and profiles of the fingers were used, and for the vascular pattern, the direction-based vascular-pattern extraction method was used, and thus, a new multimodal biometric approach is proposed. The proposed multimodal biometric system uses only one image to extract the feature points. This system can be configured for low-cost devices. The multimodal biometric-approach hand-geometry and vascular-pattern recognition method performs at the score level. The results of our study showed that the equal error rate of the proposed system was 0.06%.

V.Usharani and S.V.Saravanan [13] proposed a multimodal biometric system using palmvein and palmprint. Wavelet based texture features extract features from palmprint while autoregressive model based texture features are extracted for palmvein. Obtained features are normalized using z score normalization and are fused using concatenation. Feature selection is achieved by Correlation based Feature Selection (CFS) and classification by using K NN and Naive Bayes the proposed fused feature technique improves the recognition rate in the range of 5.05% to 7.65%.

Faris E. Mohammed et.al. proposed system fuse personal finger vein and iris which utilizes a vein feature matcher for finger vein and Hamming Distance Matcher for iris with matching score level to provide higher accuracy of 92.4%, with FAR and FRR of 0% and 7.5%, respectively. It has been more secure than a framework used a single identification of personal feature [14].

Razzak et al. [15] presented multimodal face and finger veins recognition systems in which multilevel score level fusion was performed used the CAIRO employer and students. The imposter and genuine score are combined using Fuzzy fusion to increase the face recognition system. Simulation results shows that proposed multimodal recognition system is very efficient in reducing the FAR on finger veins.0.05 and increasing GAR 91.4.

A. S. Makinde et. al. [16] presented an efficient way of extracting salient features in bimodal biometric systems. The proposed method uses face and fingerprint modalities from which the features were extracted. An image enhancement histogram equalization technique is used to enhance the face and fingerprint images. Salient features of the face and fingerprint were extracted using the Gabor filter technique. A dimensionality reduction technique is carried out on both images extracted features using a principal component analysis technique. A feature level fusion algorithm is used to combine each unimodal feature using the Mahalanobis distance technique. The performance of the proposed approach is validated and compared with other methods to get GAR98.11%.

Mohammed et. al. proposed multimodal biometric recognition system is considered a robust mixture of finger vein and iris keypoints that have matching score level with accuracy of 98% with FAR and FRR of 2% and 3%. The recommended system is a gentle secure and robust stable identification and recognition system [17].

Table 1 Analysis of multimodal recognition techniques

Ref No.	Modalities fused	Method of feature extraction	Method of matching	Fusion levels	Database size	Percentage of recognition
[4]	palm vein + dorsal hand vein	Proposed filter	Euclidean distance	Feature level	2400 images 250 images	HighFMR
[5]	finger vein + fingerprint	Gabor filters	Hamming distance	score level	6264 images	98.78%
[6]	Face +iris	LBP Daughman's	LBPH Hamming Distance	decision level	400 images 200 images	77%
[7]	Hand geometry + palm veins	proposed algorithm HOG	SVM	Feature level	7.200 images	98.7%
[8]	Finger Vein + Fingerprint	SMR	Weighted sum rule	score level	1500 images	99.22%
[9]	Finger Vein + Hand Vein	MLBP	IGMF	score level	3916 images 4846 images	98%
[10]	Palm print and Fingerprint	Gabor filters	Euclidean distance	Feature level	250 images	87%
[11]	Palm Print + Palm Vein	Gabor filter	Euclidean distance	Feature level	28 images	100%
[12]	Hand geometry + Hand Vein	median filter	Euclidean distance	score level	300 images	99.94%
[13]	Palm Print + Palm Vein	Wavelet packet tree	K NN Naive Bayes	Feature level	2400 images	95.95%
[14]	Finger Vein + Iris	Current tracking point	Hamming Distance	score level	120 images 140 images	92.40%
[15]	face + finger veins	PCA and LDA	Euclidean distance	score level	210 images 105 images	91.4%
[16]	face + fingerprint	Gabor filter	PCA	Feature level	400 images 136 images	98.11%
[17]	Iris + Finger Vein	SIFT	SVM SIFT	score level	756 images 756 images	98%

From the analysis of the above research, it can report the following important results;

1) Most models has very high rate to acceptability (accept to use) is hand (palm, dorsal hand and finger) and the low rate be in possession the iris model. Hand veins have high level of accuracy and security because it prevented inside the body so there is no influenced by state of the external skin. Hand veins are the best model to use because of high rate of acceptability, accuracy and security.

2) There are many algorithms used in researches based on the model used and the quality of images such as Gabor filter, LBP, median filter, PCA and SIFT algorithms. The most algorithms used in pattern veins are PCA, LBP and SIFT because they generate vector of features that represent the highest detailed variant information.

3) There are many algorithms used in researches based on the model used and features extracted from images such as Euclidean distance, SVM, Hamming Distance, Naive Bayes and K-NN classifier. The most algorithms used in pattern veins are K-NN and Euclidean distance classifier. K-NN classifier work better because of it perform much better if all of the data have the same scale, works well with a small number of input variables and when the number of inputs is very large, makes no assumptions about the functional form of the problem being solved, calculation time is very small and it has high accuracy.

4) There are various levels of fusion feature, score and decision level. Fusion at feature extraction level is most effective and hardest to perform simultaneously because features collected from various identifiers must be independent and in same measurement scale which would represent an identity in more discriminating feature space. Matching score level fusion is preferred as it is easy to obtain and combine matching scores of different biometrics but it is more complexity. The complexity come from matching scores cannot be used or combined directly; because these scores

are from different modalities and based on different scaling methods. Score normalization is required, by converting the scores into common similar domain or scale. Decision level fusion is very easy to implement and has high accuracy but it need more time than other level of fusion.

5) Only few multimodal databases are available publicly. BANCA and XM2VTS includes face and voice biometrics. BIOMET which includes face, voice, fingerprint, hand and signature. BIOSEC includes fingerprint, ace, iris and voice. SDUMLAHMT is a homologous database which includes face images from 7 angles, finger print images, gait videos, iris images. But these databases have some limitations. Homologous multi-biometrics dataset should be complete (contains all the biometrics for large population) for future research testing and multi-biometric system evaluation.

6) Percentage of recognition in multi-biometric systems that contain one or more trait vein has higher rate compared with other multi-biometric systems because of advantages of veins model accuracy and security.

3. Intelligent Fusion Levels and Techniques in Biometric Systems

H.S.Ali and M.I.Abdalla [18] have presented an overview of multimodal biometrics and have proposed various levels of fusion, various possible scenarios, the different modes of operation, integration strategies and design issues. The fusion levels proposed for multimodal systems are shown in Fig. 1 and described below.

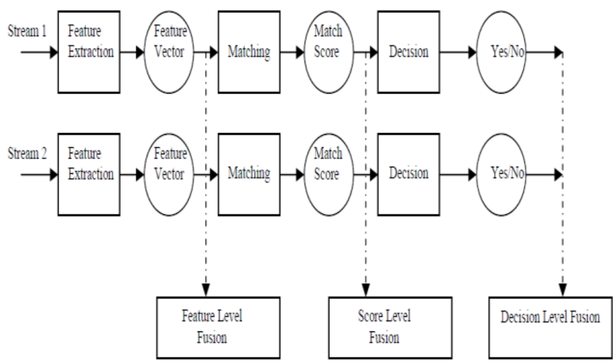

Figure 1 Fusion levels in multimodal biometric system

A. Fusion at the Feature Extraction Level

The data obtained from each sensor is used to compute a feature vector. As the features extracted from one biometric trait are independent of those extracted from the other, it is reasonable to concatenate the two vectors into a single new vector. The primary benefit of feature level fusion is the detection of correlated feature values generated by different feature extraction algorithms and improve recognition accuracy. The new vector has a higher dimension and represents the identity of the person in a different hyperspace. Eliciting this feature set typically requires the use of dimensionality reduction/selection methods and, therefore, feature level fusion assumes the availability of a large number of training data.

B. Fusion at the Matching Score Level

Feature vectors are created independently for each sensor and are then compared to the enrollment templates which are stored separately for each biometric trait. Each system provides a matching sore indicating the proximity of the feature vector with the template vector. These individual scores are finally combined into a total score (using maximum rule, minimum rule, sum rule, etc.) which is passed to the decision module to assert the veracity of the claimed identity. Score level fusion is often used because matcher scores are frequently available from each vendor matcher system and, when multiple scores are fused, the resulting performance may be evaluated in the same manner as a single biometric system. The matching scores of the individual matchers may not be homogeneous. For example, one matcher may output a similarity measure while another may output a dissimilarity measure. Further, the scores of individual matchers need not be on the numerical scale. For these reasons, score normalization is essential to transform the scores of the individual matchers into a common domain before combining them. Common theoretical framework for combining classifiers using sum rule, maximum and minimum rules are analyzed, and have observed that sum rule outperforms other classifiers combination schemes.

C. Fusion at the Decision Level

A separate identification decision is made for each biometric trait. These decisions are then combined into a final vote. Decision level fusion based examples include: majority voting rule and behavioral knowledge space method, weighted voting based on Dempster - Shafer theory, AND/ OR rules for deciding the decision , and that naïve Bayesian decision fusion as it works well, even if the matchers used in fusion are dependent to each other. The fusion process is performed by a combination algorithm such as AND, OR, etc. Also a majority voting scheme can be used to make the final decision. Majority voting method is the mainly used for decision level fusion. The input model with approved in majority of matchers is given the identity.

4. Proposed Methodology

In our study, we present a proposed intelligent paradigm to authenticate personal based on fusion of palm and dorsal hand veins. This paradigm is used to enhance the accuracy of vein authentication. Figure2 shows the methodology of the authentication model using fusion of palm and dorsal hand veins biometrics. The proposed multi-modal biometric system consists of several different submodules, each of them providing its own functionality. There are two sensor modules for palm and dorsal hand veins acquisition, which capture the biometric data. In the feature extraction modules, the acquired data is processed to extract a set of features. In the matcher modules, the extracted features are compared against the stored templates, providing a matching score. These last modules encapsulate the decision making modules, which can operate either in verification or identification mode. Moreover, there is the system database module, which stores the biometric templates of the enrolled users.

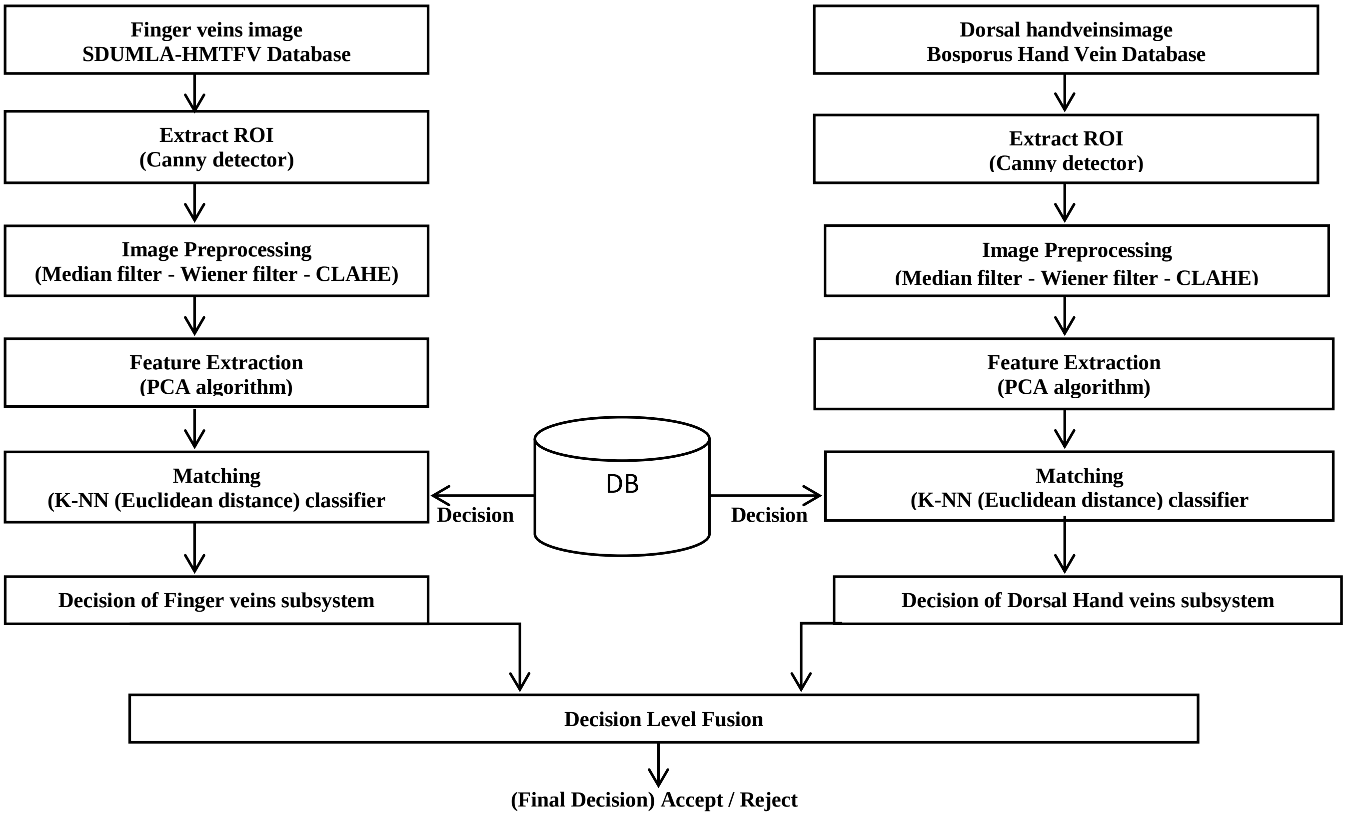

Figure 2 The methodology of the authentication model using fusion of finger and dorsal hand veins biometrics

5. Process of Biometric System

In this section, we describe the recognition process of finger and hand veins characteristics. The process of biometric system involves: image acquisition, extract ROI, preprocessing, feature extraction, matching, decision of each trait and fusion decision.

5.1 Image Acquisition System

A) Finger Veins Database

In our study, we used the SDUMLA-HMT Database [19].This database includes a multimodal data (face, finger vein, iris, finger print and gait) from 106 individuals. The SDUMLA-HMT is the first available open access database. The acquisition system is conceived by Joint Lab of Wuhan University for Intelligent Computing and Intelligent Systems. Each subject contains his/her code as index, middle and ring finger of both hands. The set of 6 fingers is repeated 6 times to obtain 6 finger vein images. Accordingly, finger vein database includes 3,816 images. All images are encoded in “bmp” format by a resolution of (320 × 240). At the end, finger vein database takes up around 0.85 GBytes approximately.

B) Dorsal Hand Veins Database

The experiments reported in this paper for the hand vein authentication the Bosphorus Hand Vein Database [20] is designed for research on biometry based dorsal vein patterns of the hand. The hand vein data is capture using NIR imaging innovation with a monochrome NIR CCD camera (WAT-902H2 ULTIMATE) equipped with an infrared lens. The back of the hand is illuminated by two IR light sources. The images have 300×240 pixel size with a gray-scale resolution of 8-bit. Every subject experienced four imaging sessions that comprised of the left hand under normal condition (N), after having carried a bag weighing 3 kg. for one minute (B), after having squeezed an elastic ball repetitively for one minute (A), after having cooled the hand by holding an ice pack on the surface of the back of the hand (I). We used the images taken under normal conditions (N: Normal). There are overall 600 images of 100 subjects distributed as: Three right-hand images and three left-hand images subject under normal conditions (N).

5.2 Extract ROI

A) ROI of Finger Veins

To detect ROI, we used canny edge detector (CED) to extract useful structural information from finger veins images. The edge detection is an important process in many of the image processing algorithms. Significant property of the edge detection is the detection of the specific edges along with the great orientation of the object in the image [21]. The proposed algorithm of ROI extraction of finger vein image includes 3 tasks, as show in figure 3.

1- Convert image to binary.
2- Detect finger edge from the binary image using canny operator.
3- A sub-image is detected and extracted as the ROI of finger vein image.

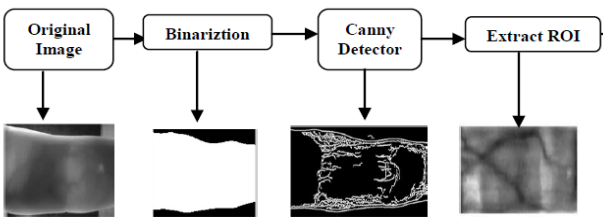

Figure 3 The steps to detect ROI of finger veins

B) **ROI of Dorsal Hand Veins**

The edge detection is an important process in many of the image processing algorithms. Significant property of the edge detection is the detection of the specific edges along with the great orientation of the object in the image [22]. In our technique the CED is used due to the following features, as show in figure 4.

1- Convert image to binary.
2- Boundaries from the binary image are detected by canny operator.
3- Valleys of hand between index and middle fingers and between little and ring fingers are detected.
4- A geometrical technique is investigated to draw the line connecting the two keys points determined in the previous step and the line perpendicular to it.
5- A sub-image is detected and extracted as the ROI of hand vein image.

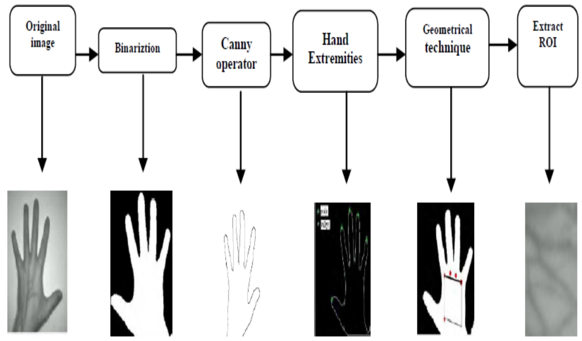

Figure 4The steps to detect ROI of dorsal hand veins

5.3 Image preprocessing

A) Preprocessing of Finger Veins

In this process, a number of preprocessing techniques are typically required for the purpose of reducing the effect of noise and enhancing the targeted finger veins. The proposed algorithm of preprocessing finger vein image includes the following steps done as show in figure 5.

1- Apply the median filter to reduce the black noise between vein pattern lines
2- Apply the wiener filter to remove effect of high frequency noises.
3- Apply the CLAHE filter to enhance contrast of vein image.

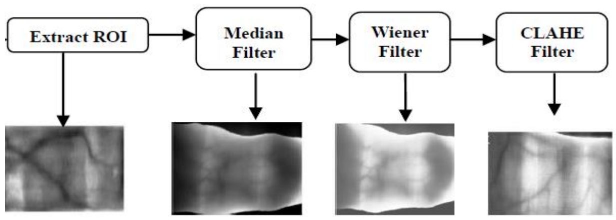

Figure 5 The steps of preprocessing of finger veins

B) Preprocessing of Dorsal Hand Veins

In this process, a number of preprocessing techniques are typically required for the purpose of reducing the effect of noise and enhancing the targeted hand veins. The proposed algorithm of preprocessing hand vein image includes the following steps done as show in figure 6.
1- The median filter is applied to the original hand vein image for denoising.
2- 2D Wiener filter “Gaussian white noise” is applied to remove the effect of high level frequency noise.
3- Applied Contrast Limited Adaptive Histogram Equalization (CLAHE) filter to enhance hand vein image.

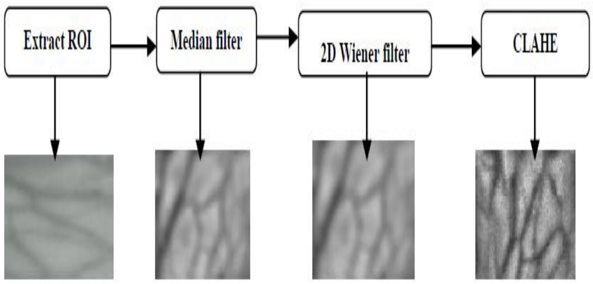

Figure 6 the steps of preprocessing of dorsal hand veins

5.4 Feature Extraction

Feature extraction plays an important role in palm vein recognition because the performance of feature matching is greatly influenced by its output**.** We use principal component analysis (PCA) algorithm to extract features from images. Principal component analysis (PCA) is among the most popular algorithm in machine learning, statistics, and data analysis more generally. PCA is the basis of many techniques in data mining and information retrieval, including the latent semantic analysis of large databases of text and HTML documents described in [23].This algorithm using for extracting features from palm vein images. PCA is applied to generate vector of features that represent the highest detailed variant information. A matching process is then applied to find the best match from the data base to recognize and authenticate the person. It is one of the most widely implemented tools for dimensionality reduction or data exploration used in a variety of scientific and engineering disciplines. It transforms a number of possibly correlated variables into a smaller number of new variables, known as principal components. Since a digital image can be regarded as a two – or more – dimensional function of pixel values and represented as a 2D (grayscale image) or 3D (color image) data array, PCA can be performed on such an m x n matrix[24].

<u>The algorithm:</u>
1- Assume data matrix is B of size m x n. Compute mean μ_i for each dimension.
2- Subtract the mean from each column to get A
3- Compute covariance matrix C of size n x n which C= A^T A
4- Calculate the eigenvalues and eigenvectors (E, V) of the covariance matrix C
5- Project the data step by step onto the principle components$\vec{v_1}$,$\vec{v_2}$,……, etc
6- Select n eigenvectors that correspond to the largest n eigenvalues to be the new basis.

5.5 Matching

In our technique, we use the K-NN classifier. The nearest neighbor classifier works depended on a simple nonparametric decision. Every query image *I*q is inspected depended on the distance of its features from the features of other images in the database. The nearest neighbor is the image which has the minimum distance from the query image in the feature space. The distance between two features can be compute depended on one of the distance functions such as, city block distance d_1 , and Euclidean distance d_2 or cosine distance d_{cos} [25].

$$d_1(x,y) = \sum_{i=1}^{N} |x_i - y_i| \qquad (1)$$

$$d_2(x,y) = \sqrt{\sum_{i=1}^{N} |x_i - y_i|} \qquad (2)$$

$$d_{cos}(x,y) = 1 - \frac{\vec{x}.\vec{y}}{|x|.|y|} \qquad (3)$$

K nearest neighbor algorithm utilizes K nearest samples to the query image. Every one of these samples belongs to a known class Ci. The query image Iq is arranged to the class CM which has the most of events among the K samples. The presentation of the KNN classifiers highly related to value of the k, the number of the samples and their topological distribution over the feature space.

5.6 Fusion decision

The proposed multi-modal biometric system relies on two different modules: the module for Palm veins and the module for dorsal hand veins authentication. The fusion methodology adopted at the decision level is a post-classification method, and it follows the AND rule; i.e., it is sufficient that all biometric traits are recognized as genuine to lead to a positive final decision. This serial matching approach gives the possibility of acquiring all the traits to determine if a user is genuine or an impostor. From a numeric value (generally normalized between 0 and 1) that represents the confidence of the matching, each decision module is given two possible different outputs {YES, NO}, depending on the comparison of that value with some predefined thresholds that divide the interval [0,1] .A decision module outputs the YES value if the obtained score is the interval [1, 1] and the user is recognized as one of the enrolled users (in identification mode) or their claimed identity has been confirmed (in verification mode). The output value NO is produced if the obtained score is one of intervals [0, 1] or [1, 0] or [0, 0] and the user is rejected as if they were impostors.

6. Results and discussion

In this section we describe the result of each system independently and the result of fusion of two traits.Finger and dorsal hand vein recognition includes training and recognition phases. In training phase, features of the training samples are calculated and stored in a database template. In the recognition phase, features of the input vein are determined and then matched by using K-NN matching classifier. After this, these features are compared with the stored template to obtain the recognition result. We do our experiment by divided the database to 5 Cases as table 2 shows:

Table 2 Data base for 5 cases

Case No.	Training	Testing
1	One image for every person(100 images)	Five images for every person (500 images)
2	Two images for every person (200 images)	Four images for every person(400 images)
3	Three images for every person(300 images)	Three images for every person(300 images)
4	Four images for every person(400 images)	Two images for every person (200 images)
5	Five images for every person(500 images)	One image for every person(100 images)

By applying the PCA algorithm with K-NN (Euclidean distance) the results are 100%, 98.5% and 100% for all training cases in finger, dorsal hand veins and fusion of finger and dorsal hand veins. Testing result of every case showed in table 3 and figure 7. We have two potential results, the first result is where the user that is unauthorized which means that his/her template is not found in the database, and the other result is the user is authorized, i.e. a template similar to his/her is found in the database. The experimental results show that the results of recognition Correct Recognition Rate (CRR) are 94.6%, 91.2 % and 96.8%.Based on this experiment, it was suggested that recognition based on authentication by fusing the finger and dorsal hand veins, performs better than conventional recognition technique. Hence this method can be successfully used for recognition.

Table 3The testing results for each case

Case No.	CRR		
	Finger	Dorsal hand	Fusion Finger +Dorsal Hand
1	93	89	95
2	94	90	96.3
3	95	92	97.2
4	95	92	97.2
5	96	93	98.5

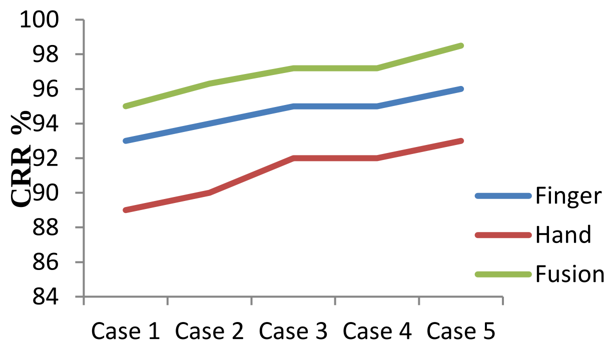

Figure 7 Result of cases

7. Conclusion and Future Work

In this paper, we have developed a new practical and intelligent technique for biometric recognition based on fusion of finger and dorsal hand veins. The technique consists of the following steps: Image acquisition, determining the region of interest andpre-processing, extracting the vein pattern features and recognition. We proposed an original method based on the principal component analysis (PCA) algorithm to extract features and using K-NN (Euclidean distance) matching classifier in matching. In addition, this smart technique has many advantages and characteristics of flexibility of the former approaches; such as it can overcome the problem of rotation and shift, accurate, simple, practical and fast. In this paper, a complete biometric system based fusion of finger and dorsal hand veins has been developed. We proposed an original method based on the PCA algorithm to extract features and using KNN classifier in matching. The experimental results show that the result of recognition CRR is 96.8%.Hence this method can be successfully used for recognition. The vein pattern identification can proceeded in a perfect way using the method proposed in this paper which is accurate, simple, practical and fast.

In our opinion, this developed improvement increases the usefulness and usability of this efficient technique, especially as regards its application in all security tasks and domains. Future work may involve applying additional/ alternative pattern recognition algorithms or turning it into a multimodal system where other additional biometrics traits are considered and making the system more invariant to illumination conditions.

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