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INTELLIGENT TECHNIQUE FOR HUMAN AUTHENTICATION USING FUSION OF PALM AND FINGER VEINS

Multimodal biometric systems have been broadly behaved to realize extreme authentication correctness. This paper presents a new multimodal biometric system using intelligent technique to authenticate human by fusion of palm and finger veins pattern. We developed an image analysis technique to extract region of interest (ROI) from palm and finger veins image. After extracting ROI we design a sequence of preprocessing steps to improve palm and finger veins images using Homomorphic, 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 CASIA Multi-Spectral Palmprint Image Database V1.0 and Shandong University Machine Learning and Applications – Homologous Multi-modal Traits (SDUMLA-HMT) database. The achieved result for the fusion of both biometric traits was Correct Recognition Rate (CRR) is 97.9 %.
Key Words: Biometric systems, pattern recognition, intelligent computing, image processing, machine learning.

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ІНТЕЛЕКТУАЛЬНА ТЕХНІКА ДЛЯ АВТЕНТИКАЦІЇ ЛЮДИНИ З ВИКОРИСТАННЯМ ПАЛЬМОВИХ І ПАЛЬЧОВИХ ВЕН

Мультимодальні біометричні системи в цілому поводилися, щоб усвідомити надзвичайну правильність автентифікації. У цій статті представлена нова мультимодальна біометрична система, що використовує інтелектуальну техніку для автентифікації людини шляхом злиття візерункової та пальцевої вен. Ми розробили техніку аналізу зображення, щоб витягти область інтересу (ROI) із зображення вен вен долоні та пальця. Після вилучення ROI ми розробляємо послідовність кроків попередньої обробки для покращення зображень вен долонь і пальців, використовуючи Гомоморфний, Медіанний фільтр, Фільтр Вінера та Контрастне обмежене адаптивне вирівнювання гістограм (CLAHE) для покращення зображення вен. Наша розумна техніка базується на наступних інтелектуальних алгоритмах, а саме; алгоритм аналізу основних компонентів (PCA) для вилучення об'єктів та класифікатор k-найближчих сусідів (K-NN) для операції зіставлення. Вибраною базою даних стала база даних CASIA Multi-Spectral Palmprint Image Database V1.0 та машинне навчання та програми університету Шаньдун-гомологічні мультимодальні риси (SDUMLA-HMT). Досягнутим результатом для злиття обох біометричних ознак був коефіцієнт правильного розпізнавання (CRR) – 97,9 %.
Ключові слова: біометричні системи, розпізнавання образів, інтелектуальні обчислення, обробка зображень, машинне навчання.

1. Introduction

Recently, authentication is considered the most important objective to be satisfied whether it is physical world or the internet of things (IoT) world. Different approached and techniques exist to authenticate the user such as passwords, smart cards, and pins. Modern approaches authentication include biometrics like voice, finger prints, retina, iris, facial expressions, signatures, face and vein pattern. 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 procedure of recognizing a personality using physical or behavior characters. 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 stay the identical regardless 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. Once a user's hand is occupied above a scanner, a near-infrared beam plots the position of the veins. The red blood units state in the veins attract the beams and highlight on the plot as dark lines, while the persisting hand configure highlight as white. This vein model is then proved versus a preregistered model to verify the person. As veins are inside the body and have a variety of separating characters, tries to copy individuality are awfully complex, thus permitting a great level of safety [4].

Biometric authentication can be categorized into unimodal and multimodal biometric approaches. Unimodal approaches that operate one biometric characteristic for identification principles; and suffers some feasible troubles like non-universality, noisy sensor data, intra- session variant, confidential level of freedom, improper error rate, failure-to- register and spoof occurrences. Therefore, the implementation of unimodal approaches requires to be developed. The performances of multimodal biometric approach can present a practical technique to resolve the drawbacks coming from unimodal biometric approach. Multimodal biometric approaches forms custom of several biometric characters instantaneously to verify an individual's personality. Hardiness and extreme safety of validation can be accomplished by operating the multimodal biometric approaches [5].

The frame of the paper is structured as follows. A comprehensive analysis for the multimodal of recognition techniques and systems presents in section 2. 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 palm and finger vein system in section 4.Section 5 presents the explanation of the process of biometric system. Section 6 introduced the discussion of results. Lastly; conclusions and future work are reported in section 7.

2. Analysis of Multi-modals Recognition Techniques and Systems

There's many research used multi-model for authentication .In this section we introduced these studies divided to many fields such as modalities fused, method of feature extraction , methods of matching, level of fusion, database size and percentage of recognition to make analysis of it.

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	High FMR
[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 investigation of the above study, it can inform the following critical outcomes:

1. Most model 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 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 create vector of features that denote the maximum detailed alternative data.

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 implement greatly enhanced if wholly of the data have the alike scale, operates appropriately with a tiny amount of input variables and once the amount of inputs is extremely large, generates no expectations about the purposeful form of the trouble being resolved, estimate time is extremely small and it has great correctness.

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 ideal as it is simple to achieve and merge matching scores of separate biometrics but it is more complexity. The complexity come from matching scores cannot be consumed or merged straight; since these scores are from dissimilar modalities and based on diverse scaling techniques. Score normalization is needed, by transferring the scores into shared related area 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. The biggest problem in the phase of multimodel biometric system is there are few databases available to research. BANCA, BIOSEC, BIOMET and XM2VTS provide voice, face, ace, fingerprint hand and signature databases. SDUMLAHMT database provide many image database such as iris, fingerprint, face and gait.

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.

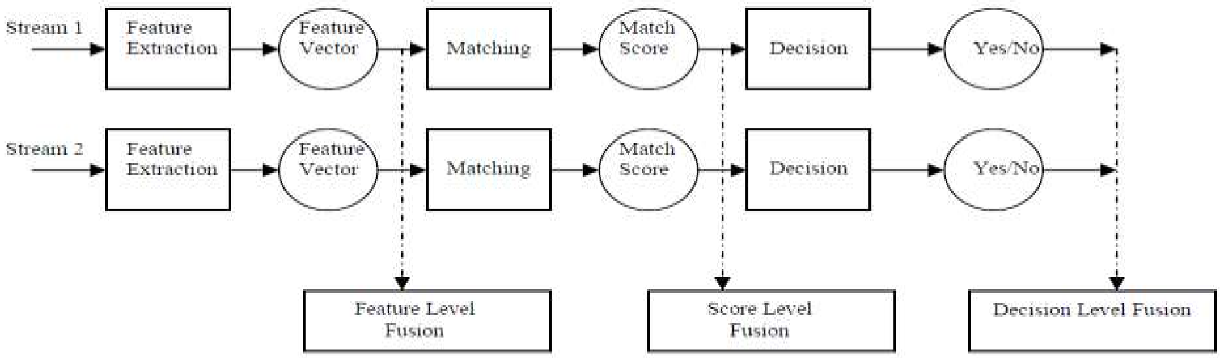

Fig. 1. Fusion levels in multimodal biometric system

A. Feature Extraction Fusion Level

The data acquired from every sensor is consumed to calculate a feature vector. As the features obtained from one biometric characteristic are independent of those isolated from the other, it is logical to concatenate the two vectors into a one novel 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. Matching Score Fusion Level

Feature vectors are generated individualistically for every sensor and are then matched to the registration patterns which are kept independently for every biometric characteristic. Each system presents a matching sore specifying the proximity of the feature vector with the original vector. These specific scores are lastly conjoined 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 discrete matchers might not be similar. For example, one matcher might 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 causes, score normalization is necessary to convert the scores of the separable matchers into a shared domain before conjoining 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. Decision Fusion Level

A separate identification decision is created for every biometric characteristic. These decisions are then merged into an ending vote. The fusion process is performed by a combination algorithm such as AND, OR, etc. Also a popular voting prototype can be used to create the final decision.

4. Proposed Methodology

In our study, we present a proposed intelligent paradigm to authenticate personal based on fusion of dorsal hand, palm and finger veins. This paradigm is used to enhance the accuracy of vein authentication. Figure 2 present the methodology of the authentication model using fusion of dorsal hand, palm and finger veins biometrics. The proposed multi-modal biometric system involves of some various submodules, each of them presenting its private functionality. There are three sensor modules for dorsal hand, palm and finger veins gain. The captured data is managed to isolate a series of features. The extracted features are compared with the templates stored in enrollment stage, specifying a matching score. The decision making modules is a last module, which can organize either in identification or verification mode.

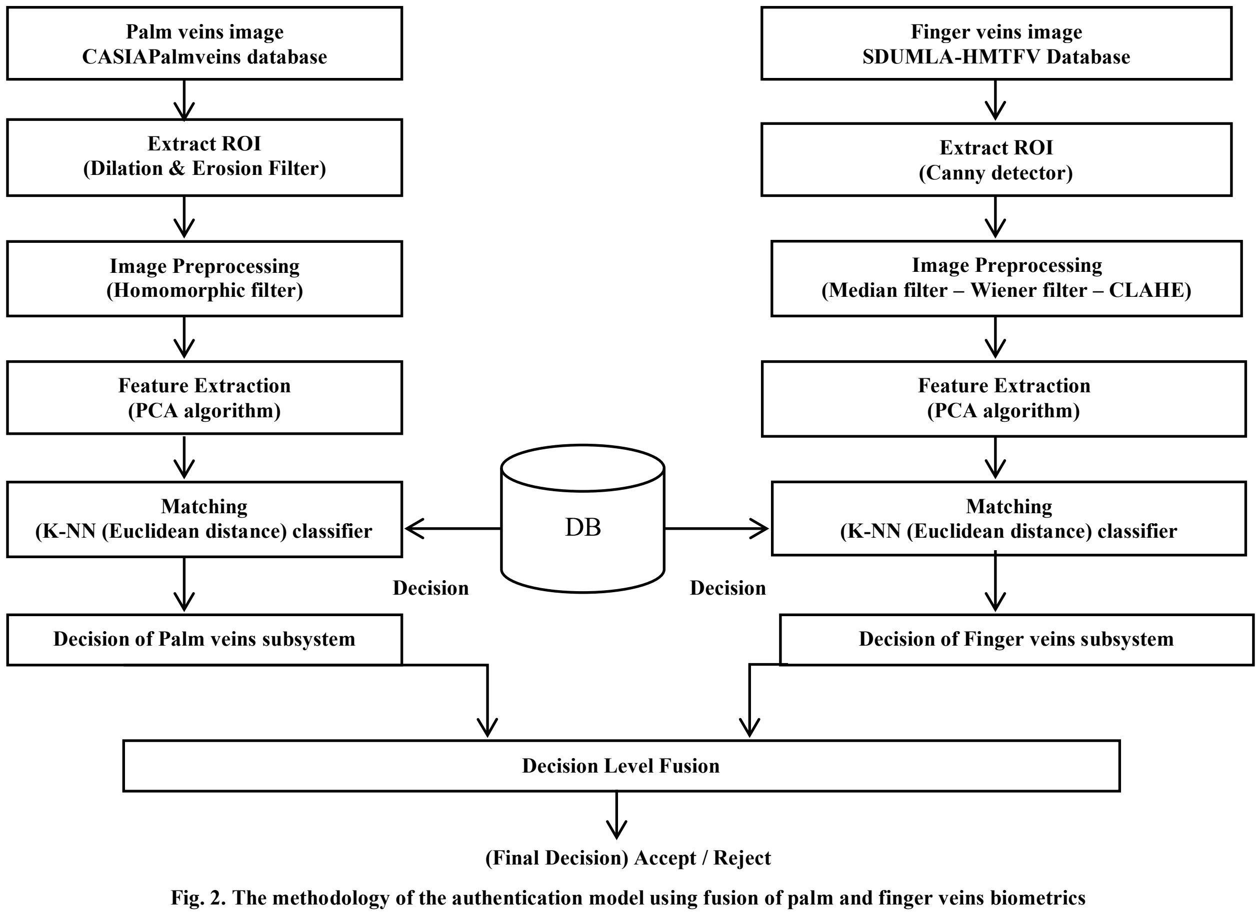

Fig. 2. The methodology of the authentication model using fusion of palm and finger veins biometrics

5. Process of Biometric System

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

5.1. Image Acquisition System

A. Palm Veins Database

The experiment reported in this paper for the palm vein authentication is CASIA Multi-Spectral Palmprint Image Database V1.0 (CASIA database) [19]. This CASIA database has been acquired using a contactless imaging device and have images from 100 users. Six images were acquired from each user and these images were acquired in two different data acquisition sessions (three images in each session) with a minimum interval of one month. Since our work is focused on palm vein identification and the vascular details are typically observed in the NIR illumination, simply the images that were gained below 850 nm and 950 nm wavelength illuminations from CASIA database were utilized in the following experiments.

B. Finger Veins Database

In our study, we used the SDUMLA-HMT Database [20].This database involves a multimodal data (finger vein, face, finger print, iris and gait) from 106 persons. The first free public access database is SDUMLA-HMT. Every field includes his/her code as ring, middle and index finger of two hands. The collection of 6 fingers is duplicated 6 times to get 6 finger vein images. Therefore, finger vein database contains 3,816 images.

5.2. Extract ROI

A. ROI of Palm Veins

To detect ROI we used Morphological operations to extract useful structural information from palm veins images. Morphological operations are applied on binary images and affecting the form, structure or shape of an object. They are used in pre or post processing (filtering, thinning, and pruning) or used for smoothing, edge detection or extraction of other features. Morphological operations offers a variety of image transformation to eliminate dark (bright) regions from binary images. The two principal morphological operations are dilation and erosion [21]. Dilation allows objects to expand, therefore possibly filling in tiny holes and joining disconnect pieces. Erosion shrinks objects by impression away (eroding) their borders. These procedures can be adapted for an application by the suitable choice of the configuring component, which establishes accurately how the objects will be expanded or eroded [22]. The proposed algorithm of ROI extraction of palm vein image includes 5 tasks, as show in figure 3.

(1) Convert image to binary.

(2) Estimates the area of the palm in binary image then apply a 201*201 square mask that could perfectly cover the whole region of palm.

(3) After then apply the dilatation filter again to get one point that is the middle point of the hand.

(4) Then apply the erosion filter on the same square mask, this time to get exact square placed at same point where the region of interest is placed in actual image.

(5) Then find xmin, ymin, length, and width of this square to crop ROI from original image.

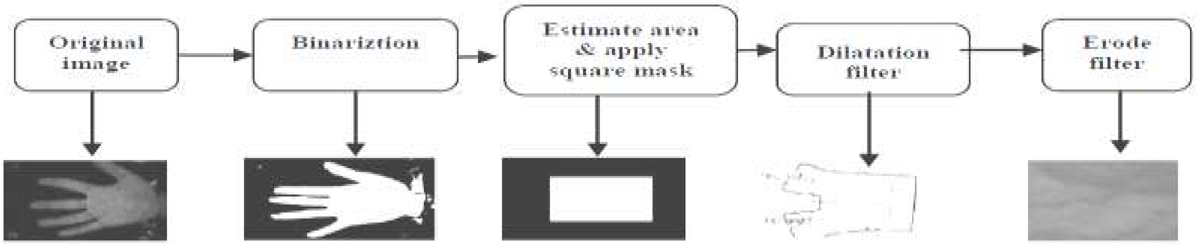

Fig. 3. The steps to detect ROI of palm veins

B. 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 [23]. The proposed algorithm of ROI extraction of finger vein image includes 3 tasks, as show in figure 4.

1 – Convert image to binary.

2 – Detect finger edge from the binary image using canny operator.

3 – A sub-image is discovered and separated as the ROI of finger vein image.

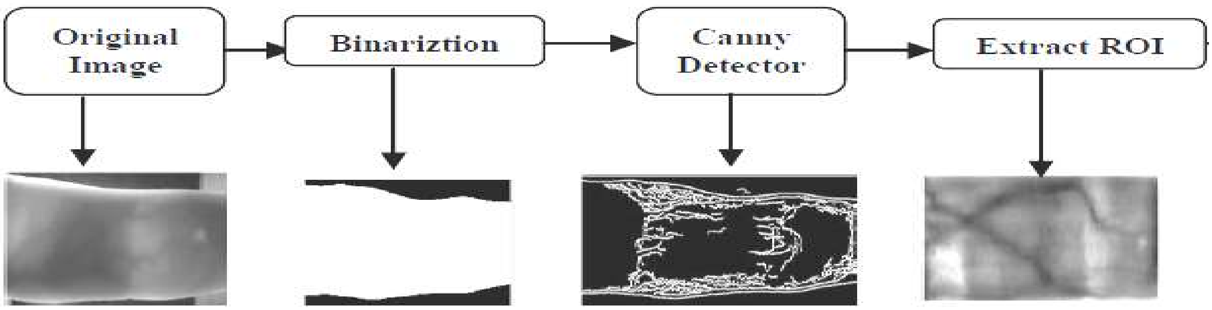

Fig. 4. The steps to detect ROI of finger veins

5.3. Image preprocessing

A. Preprocessing of Palm Veins

Homomorphic filtering is a generalized technique for image enhancement and/or correction. It separately standardizes the intensity through an image and spreads contrast. Homomorphic filter is a nonlinear enhancement method. The function of homomorphic filter is likely to decrease the low frequency and increase the high frequency.

In general, an image can be regarded as a two-dimensional function of the form I(x, y), whose value at spatial coordinates (x, y) is a positive scalar amount whose physical denoting is concluded by the basis of the image. The Homomorphic filtering can be summarized in steps show following:

1. An image I (x, y) can be stated as the product of illumination and reflectance components:

$$I(x, y) = L(x, y)\ R(x, y). \tag{1}$$

2. Because the Fourier transform of the product of two functions is not separable, we define:

$$Z(x, y) = \ln I(x, y) = \ln L(x, y) + \ln R(x, y) \tag{2}$$

Or

$$Z(u, v) = I(u, v) + R(u, v) \tag{3}$$

3. Doing the Fourier transform, as

$$S(u, v) = H(u, v)\ Z(u, v) = H(u, v)\ I(u, v) + H(u, v)\ R(u, v) \tag{4}$$

4. Taking inverse Fourier transform of S (u, v) brings the result back into natural log domain:

$$S(x,y)=F^{-1}\{S(u,v)\} = F^{-1}\{H(u,v)\ I(u,v)\} + F^{-1}\{H(u,v)R(u,v)\} \tag{5}$$

5. So the output image can be expressed by the function [24]

$$g(x,y) = e^{S(x,y)} \tag{6}$$

Figure 5 show the result of applied algorithm (a) the original image (b) the result of extract region of interest (ROI) then (c) the result of applied preprocessing step to enhance the image quality.

a b c

Fig. 5. Illustration of image enhancement: (a) The original image (b) Extraction of ROI (c) Extraction of Palm vein pattern

B. 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 6.

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.

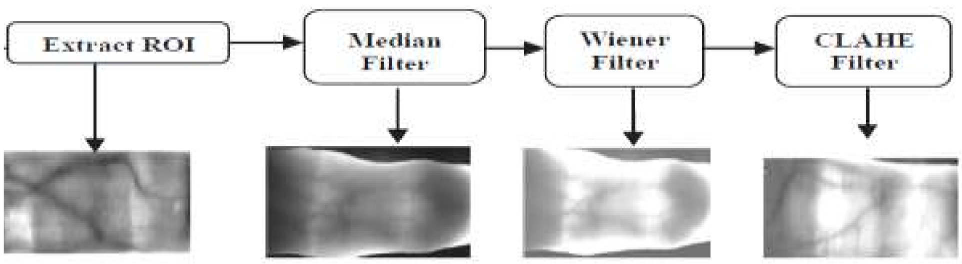

Fig. 6. The steps of preprocessing of finger veins

5.4. Feature Extraction

Feature extraction performs a vital part in pattern vein authentication since the accomplishment of feature matching is seriously affected 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 [25].This algorithm using for extracting features from palm vein images. PCA is used to create vector of features that denote the main detailed different information. A matching procedure is then utilized to realize the greatest match from the database to identify and verify the individual. 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 converts a numeral of possibly associated 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[26].

The algorithm:

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 based on the expanse of its features from the features of other images in the database. The nearest neighbor is the image which has the smallest expanse from the query image in the feature space. The distance between two features can be calculate based on one of the distance functions such as, city block distanced_1, and Euclidean distance d_2 or cosine distance d_{cos} [27].

$$d_1(x,y) = \sum_{i=1}^{N} |x_i - y_i|, \quad (7)$$

$$d_2(x,y) = \sqrt{\sum_{i=1}^{N} |x_i - y_i|}\ , \quad (8)$$

$$d_{cos}(x,y) = 1 - \frac{\vec{x}.\vec{y}}{|x|.|y|}\ . \quad (9)$$

K nearest neighbor algorithm utilizes K nearest samples to the query image. Every one of these samples fits to a identified 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 greatly associated to value of the k, the number of the samples and their topological distribution over the feature space.

5.6. Fusion decision

The suggested multi-modal biometric system depend on two dissimilar modules: the module for Palm veins and the module for finger veins authentication. The fusion method approved at the decision level is a post-classification method, and it trails the AND rule; i.e., it is appropriate that all biometric characters are identified as authentic to indicate to a positive ending decision. This sequential matching method presents the opportunity of gaining all the characters to decide if a user is authentic or a fake.

6. Results and discussion

In this section we describe the result of each system independently and the result of fusion of two traits. Palm and finger 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 result is 100% for all training cases in palm, finger veins and fusion of palm and finger 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 located in the database, and the another result is the user is approved, 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 95.20 %, 94.6 % and 97.9 %. Depended on this experimentation, it was proposed that identification based on fusing the palm and finger veins, performs better than conventional recognition technique. Hence this method can be successfully used for recognition.

Table 3

The testing results for each case

Case No.	CRR		
	Palm	Finger	Fusion Palm +Finger
1	94	93	96.8
2	94	94	97.25
3	95	95	97.8
4	96	95	98.66
5	97	96	98.8

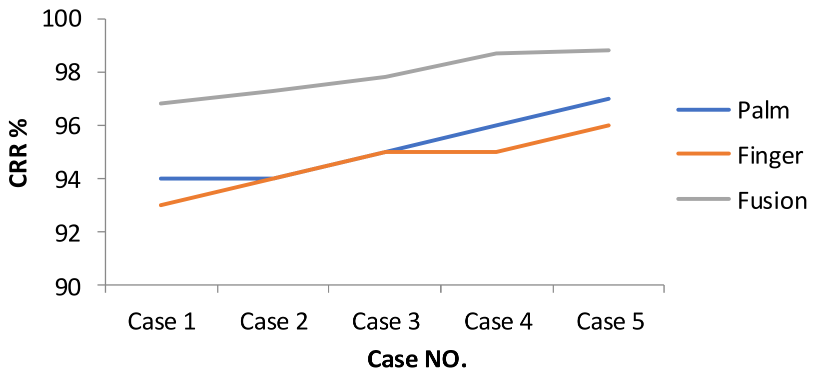

Fig. 7. Result of cases

Conclusion and Future Work

In this manuscript, we have established a new practical and intelligent technique for biometric recognition based on fusion of palm and finger veins. The technique consists of the following steps: Image acquisition, determining the region of interest and pre-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 palm and finger 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 99%.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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