ANALYSIS OF HAND VEINS AND MULTIMODAL PATTERN RECOGNITION ALGORITHMS AND SYSTEMS

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***Abstract**: Recently, many researchers investigated the palm, hand, and finger vein recognition for automated personal authentication. The aim of this paper is to review the ideas published earlier and presents an analysis of palm, hand, and finger vein pattern recognition and the fusion of modalities. This model is used to improve the accuracy and response time of vein pattern authentication. The steps of pattern vein system are extensively analyzed. The main result of this paper is the comparison of the results of various researches preprocessing, feature extraction and matching algorithms.*

***Keywords:** Biometric, vein pattern, multimodal, feature extraction, matching, fusion level, intelligent algorithms, soft computing.*

Introduction

Identity verification (authentication) in computer systems has been traditionally based on something that one has (key, magnetic or chip card) or one knows (PIN, password). Things like keys or cards, however, tend to get stolen or lost and passwords are often forgotten or disclosed. To achieve more reliable verification or identification we should use something that really characterizes the given person [Marcos, 2006].Biometrics is automated methods of recognizing a person based on a physiological or behavioral characteristic. An example of or behavioral characteristic are face recognition, fingerprints, hand geometry, signature verification, iris, retinal, finger/hand/palm vein recognition, ear recognition, and voice recognition. In biometric applications, a relatively new technology is emerging, namely the optical scanning of superficial vein patterns. In order to be viable, a biometric parameter has to be easily identifiable but hidden from view so that it cannot be reproduced or simulated. It can be observed that the veins of the human body do not leave external marks like fingerprints, are not easily falsifiable like the voice, cannot be disguised like face traits, and are extremely hard to covertly extract during and after the lifetime of an individual in order to be reused by an impostor. In the same time, the technology used to acquire the vein pattern has reduced costs and is not invasive, requires minimal cooperation from a person, and is largely a noncontact procedure that allows it to be used where hygienic concerns are an issue [Crisan, 2008].

A biometric recognition system consists of the following steps: Image acquisition from the database and pre-processing, finding of region of interest, extraction of pattern features and recognition as showed in figure 1. 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[Sarkar,2010]. After image capture, a small area of a hand image is located as the region of interest (ROI) to extract the features and to compare different hands. Using the features within ROI for recognition can improve the computation efficiency significantly [Soliman,2012].In the image-based biometric systems there is a number of processing tasks used to produce a better quality of image that will be used on the later stage as an input image and assuring that relevant information can be detected. Normally, the captured vein pattern is grayscale and subject to noise. Noise reduction and contrast enhancement are crucial to ensure the quality of the subsequent steps of feature extraction [Soliman, 2012].Also, the vein pattern extracted from infrared-ray images is represented as dark lines. To extract these lines many researcher used edge detection and morphological operators [luo, 2010].Feature extraction plays an important role in pattern vein recognition because the performance of feature matching is greatly influenced by its output. Matching is the key procedure of deciding whether a particular vein pattern image is genuine or imposter using a set of appropriate matching algorithms. In vein pattern authentication it is a one to one matching process where as in vein pattern identification it is one too many. In effect feature matching is nothing but a task of similarity computation [Ezhilmaran, 2015].

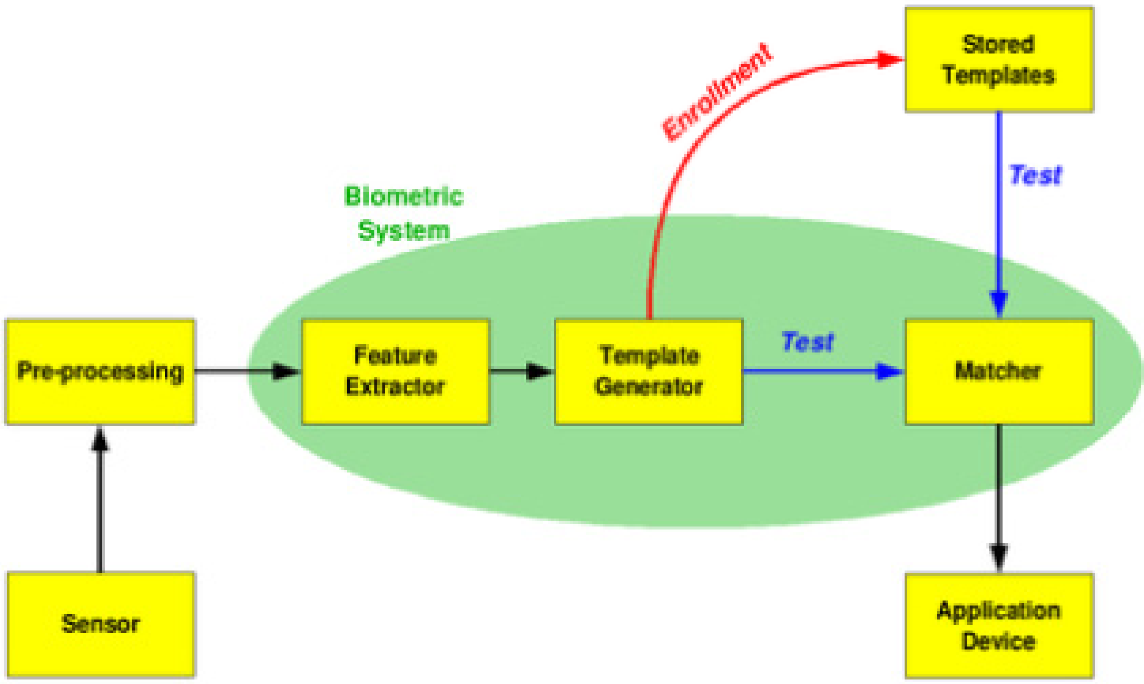

Figure 1.The basic block diagram of a biometric system

For some security systems, one method of authentication is not enough. Any single modal biometric has limitations. For example, iris recognition suffers from some problems like camera distance, eyelids and eyelashes occlusion, lenses, and reflections [Gad, 2011]. Face changes overages and unstable, and twins may have similar face features. Also, fake faces from mobiles as example, and masks used to attack the system. Fake fingers made from gelatin and/or silicon has ability to attack the fingerprint-based recognition system. Cold leads to voice problems and tape recordings may be used to hack the system [Gad, 2015]. The DNA needs several hours to be obtained. Besides, DNA includes sensitive information related to genetic of individuals and the test is expensive to perform. Hand geometry is not distinctive enough to be applied to a large population. Thus, it is not suitable for purpose of identification. Gait is sensitive to body weight and not stable; it is not used for large population and not reliable enough. Signature is not universal and changes with time. Offline ones are forgery while, Online signature cannot applied for documents verification. None of above traits alone can ensure perfect recognition performance.

Nevertheless, the biometric system can also be attacked by the outsider or unauthorized person at various points [Bhatia, 2013]. Combining multiple modalities is a good idea to decrease these conditions.

Palm Veins Pattern Techniques

Palm vein recognition is a part of physiological biometric uses blood vessel structure for the identification. The blood transfusion from body parts to heart is made by the blood vein. The blood vein carries de-oxygenated hemoglobin that can be sensed under near infrared light. The pattern classification proposes a design cycle to build a system for recognition [Shriram, 2015].Table 1 provides a detailed analysis of the existing feature extraction techniques and image enhancement algorithms for palm vein recognition.

Table 1 analysis of palm veins recognition techniques

Author(s)	Method of preprocessing	Method of feature extraction	Method of matching	Database size	Accuracy
Sasikala et al. [2016]	DWT	Sobal filter	-	-	-
Smorawa et al. [2015]	Histogram equalization	Proposed filters	Hamming distance Hidden Markov	800 images	99.62% & 99.76%
Raut et al. [2015]	Gabor filter	canny edge detector	Euclidean distance	100 images	-
bikoye et al [2016]	Histogram equalization & Zhang Suen	k-means	Euclidean distance	800 images	-
Gayathri et al.[2015]	WEF	canny edge detector & ACO	SVM	6000 images	98%
Pooja et al.[2016]	Gabor filter	LBP & PCA	ANN	500 images	99.5%
Dere et al.[2017]	Histogram equalization	canny edge detector	-	-	-
Sayed [2015]	2-D Gabor filter, Median filter & morphological	LLBP	Coset decomposition algorithm	250 images	99.8%

Author(s)	Method of preprocessing	Method of feature extraction	Method of matching	Database size	Accuracy
	operations				
Villariña et al.[2015]	Gamma correction & LRE	Sobel Directional Coding	BPNN	400 images	98%
Singh et al.[2015]	Gabor filter	Laplacian	k- nearest neighbor classifier	10 images	95.6%
Bayoumi et al.[2015]	Morphological operations	PCA	Euclidean distance	25 images	70%
Ali et al[2017]	Median filter	DoG	degree of similarity	6000 images	99.67%
Wang et al.[2014]	Retinex method &	-	-	-	-
Raut et al.[2018]	Gabor filter	Harris-Stephens Corner Point Detector	BPNN	250 images	95.8%

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

a) [Sasikala, 2016] preprocessed images used sobal filter to detect edges which is shape features and historically, structural and statistical approaches have been adopted for texture feature extraction.
b) [Smorawa, 2015] studies included two ways of verification. The first one is based on comparing feature vectors using a Hamming distance. The second method takes into account the verification of identity, based on Hidden Markov Models.
c) [Shriram, 2015] used the Gabor filter to process the image matrices and extract the blood vessel structure. The computed distance is stored in the form of feature vector set. The binary vector from the set is to be extracted and further will lead to classify the sample set of one subject with another.
d) [Bikoye, 2016] proposed a technique for palm vein biometric verification enhancement and accuracy using statistical and data mining tools. The

work brings to light a faster system with high efficiency for good experience when addressing security.

e) [Gayathri, 2015] proposed system to accommodate the rotational, potential deformations and translational changes by encoding the orientation conserving features. Compared to the previous methodologies.
f) [Pooja, 2016] proposed an approach for person's authentication, which can be more reliable and achieve higher identification rate accuracy.
g) [Dere, 2017] proposed biometric system implemented for improving the security and authentication biometric system. The experimental result shows that it takes minimal time that is only 0.5 seconds to verify one input palm vein sample image. This system consumes low power and has less computational complexity.
h) [Sayed, 2015] developed an algorithm which merges the biometrics and cryptography. The model which is fit for matching user palm veins is, to the best of my knowledge, entirely new.
i) [Villariña, 2015] proposed an effective palm vein recognition system used directional coding scheme to extract the feature of the palm veins. They propose three verification neural network mechanisms to verify the palm vein images.
j) [Singh, 2015] proposed new method for human authentication, this approach performs very well even with the minimum number of enrollment images.
k) [Bayoumi, 2015] proposed a system for attendance using palm vein as a biomedical features based on Principal Component Analysis (PCA) to discriminate the variances between the image features instead of between the whole training set.
l) [Ali, 2017] introduced an approach of personal recognition system based on centerline of palm vein. The features were extracted from vein's centerline by finding keypoints locations depending on scales of difference-of Gaussian (DoG) function. Comparing with other results of palm vein recognition algorithms, this algorithm gets the highest recognition performance.
m) [Wang, 2014] proposed a Retinex based method to reduce the bad influence caused by shadow. The experiment results show that the

proposed method is robust to shadow effect and can better enhance the palm vein image.

n) [Raut, 2018] introduced an abstract way to do image processing operations to result edge extraction and detection, classification and assessment of the results by computing recognition rate. This paper put fourth scheme for classifier validation using neural pattern recognition model.

Dorsal Hand Veins Pattern Techniques

The dorsal hand vein pattern is unique biometric identity of the human beings. The dorsal hand vein recognition is a recent biometric technique which is used for authentication purposes in various applications. Different techniques used for designing the system has discussed here. Table 2 provides a detailed analysis of the existing feature extraction techniques and image enhancement algorithms for hand vein recognition.

Table 2 analysis of dorsal hand vein recognition techniques

Author(s)	Method of preprocessing	Method of feature extraction	Method of matching	Database size	Accuracy
Naidile et al.[2015]	Morphological operations	Gaussian shaped filter	Simple correlation method	-	75%
Belean et al. [2017]	Hough transform	mathematic morphology	BPNN	360 images	99.17%
Sree et al. [2016]	Histogram equalization	BPNN	SVM	-	99.76%
Premavathi et al.[2018]	Morphological operations	CB IN TP	K-nearest neighbor	2040 images	95.10%
Rajalakshmi et al.[2015]	Median filter& Morphological operations	CNN	Logistic Regression	403 images	96.77%
Raghavendra et al. [2018]	Histogram equalization	HoG-SRC, LBP-SRC, LG-SRC and LPQ-SRC	SRC	100 images	99.3%

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

(a) [Naidile, 2015] proposed a system using the infrared camera to acquire the hand image. Experimental results show that this method can be successfully used for identification.

(b) [Belean, 2017] proposed a novel user authentication approach based on dorsal hand vein pattern analysis and multi-layer perceptron neural network. For image processing two different techniques are employed: rotation invariant Hough transform and clustering based segmentation and mathematic morphology. Both approaches lead to binary images containing the vein patterns.

(c) [Sree, 2016] proposed a new approach for personal verification, explained the function effectively locates the hand vein speedily by using edge detection. SVM approach avoids the challenge of dealing with the change of intensities for different NIR image slices.

(d) [Premavathi, 2018] proposed feature descriptor and classification method for an efficient recognition system. A new minimum distance classification is proposed with dataset and the results are checked for accuracy and reliability.

(e) [Rajalakshmi, 2015] proposed work combined multiple models together to form an ensemble, with minimal use of resources and computational power while ensuring appreciable scalability.

(f) [Raghavendra, 2018] presented a new dorsal hand vein sensor that can capture a good quality of hand vein images based on a NIR illumination that can emit light in a spectrum of 940nm.The sensor proposed use pegs allow users to directly capture ROI rather than whole dorsal hand vein image.

Finger Veins Pattern Techniques

Recently finger vein biometric has attracted increasing interest from many researchers and thus considerable development is seen in the past decade. Hitachi Ltd. of Japan has been exploring the finger vein technology since 1997 and was the first to commercialize the finger vein authentication into product form which was released in 2002. Hitachi developed ATM applications in 2004 and commercialized them in 2005 [Charaya, 2018].Table 3 provides a detailed analysis of the existing feature extraction techniques and image enhancement algorithms for finger vein recognition.

Table 3 analysis of finger vein recognition techniques

Author(s)	Method of preprocessing	Method of feature extraction	Method of matching	Database size	Accuracy
Mulyono et al. [2008]	Median filter	CCL	Rm threshold	1000 images	100%
Pham et al.[2015]	Gabor filter	LBP	HD	1200 images 1980 images 3816 images	96.35%
Meng [2018]	Morphological operations	SIFT	proposed method	1872 images 3816 images	99.68% 99.70%
Ayappan et al. [2017]	median filter, Gaussian low pass filter& Morphological operations	CN	MHD	150 images	100%
Ali et al. [2017]	DWT	GLCM	Euclidean distance	3816 images	92.4%
Bader et al. [2018]	Median filter & Zhang-thinning	FAST &Harris	Manhattan distance	636 images	99.71%
Janney et al. [2017]	Median filter	DWT	Manhattan distance	-	-
Qin et al. [2013]	Morphological operations	SIFT	SVM	4260 images 7120 images	95.04%
Das et al. [2019]	histogram equalization & Morphological operations	Gabor filters	CNN	3132 images 5904 images 3816 images 1440 images	95%
Kaur et al. [2015]	Repeated Line tracking	Gabor filters	SVM	-	-

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

a) [Mulyono, 2008] introduced preliminary process to enhance the image quality worsened by light effect and noise produced by the web camera.

b) [Pham, 2015] proposed a finger-vein recognition system using a near infrared (NIR) image sensor. The experimental results obtained with three databases showed that their system can be operated in real applications with high accuracy.
c) [Meng, 2018] proposed technique based on that regular deformation, which corresponds to posture change, can only exist in genuine vein patterns.
d) [Ayappan, 2017] proposed new algorithm with high performance and optimum accuracy. The proposed image preprocessing method comprises of 8 sub-blocks. Seen from the experimental result the method is very effective as a biometric personal identification system.
e) [Ali, 2017] presented a robust method for finger vein recognition based on the discrete wavelet transform. The simulation results show that this method is robust and fast for feature extraction and classification.
f) [Bader, 2018] used computer vision algorithms (FAST and Harris) proved that use of two algorithms together produce a reliable system of finger vein identification.
g) [Janney, 2017] proposed method aims to implement the secured patient database in hospitals using a finger vein pattern.
h) [Qin, 2013] proposed a new approach which can extract two different types of finger-vein features and achieves a most promising performance. The experimental results suggest the superiority of the proposed scheme.
i) [Das, 2019] propose a convolution-neural-network-based finger vein identification system and investigate the capabilities of the designed network over four publicly-available databases. The main purpose of this work is to propose a deep-learning method for finger-vein identification, able to achieve stable and highly accurate performance when dealing with finger-vein images of different quality.
j) [Kaur, 2015] proposed a newly developed method. An enhanced Human Identification algorithm is developed using finger vein which based on Automatic Trimap Generation, Repeated Line Tracking, Gabor and SVM. This algorithm is fast and more accurate with respect to other finger vein identification technique and also takes less time as comparison to other technique.

Multimodal Patterns Techniques

Biometric is an automated authentication technique for identifying or verifying an individual based on one's physiological or behavioral characteristics [Down, 2012]. Biometric systems can be classified into two types namely, unimodal and multi-modal systems. A unimodal biometric system is one in which, only a single type of the constituent components is present, whereas in multi-modal system more than one type of the component is present.

[Ross, 2007] establishes six advantages of a multi-modal system. Multiple modalities address the issues of non-universality encountered by unimodal systems. For example, a person who has lost his hands cannot be authenticated by a fingerprint authentication system. Unlike the process of detecting any objects, detecting human face poses many challenges due to the dynamics of skin color and facial expression. The illumination conditions, occlusion, background structure and camera positions add complexities on to the existing challenges. So the system needs multiple sensors to acquire multimodal information to authenticate a person. Multi-biometric systems helps in reducing false match and false non-match errors compared to a single biometric device.

In multimodal biometric recognition systems, the fusion of various traits can be carried out at different levels: Sensor Level Fusion, Feature Level Fusion, Score Level Fusion and Decision Level Fusion. The first two approaches are known as pre-matching fusion whereas the last two approaches are known as post-matching fusion. In sensor level fusion, the raw data acquired from either the samples of the same modality with compatible sensors or multiple instances of the sample modality and the same sensor are fused together. In feature level fusion, the extracted features are fused together. When the feature sets are homogeneous, a single resultant feature set can be calculated as a weighted average of the individual feature sets. When the feature sets are non-homogeneous, we can concatenate them to form a single feature set. In score level fusion, the output matching scores of different biometric matchers are fused together to produce a final fused score. The decision is made using the fused score. Examples of score level fusion are weighted sum, weighted product or post-classifier approaches. In decision level fusion, the matching score of each biometric system is converted into a hard decision by comparing it with the threshold tuned for that matcher. The output decisions are then fused together to make the final decision. Examples of decision level fusion are majority vote, Borda count, Behavioral Knowledge Space, Bayes fusion or the AND and OR rule [Merati, 2011].

Table 4 Analysis of multimodal recognition techniques

Author(s)	**Method of preprocessing**	**Method of feature extraction**	**Method of matching**	**Fusion levels**	**Database size**	**Accuracy**
Bharathi et al. [2016]	palm vein + dorsal hand vein	Proposed filter	Euclidean distance	Feature level	2400 images 250 images	high accuracy
Stefani et al. [2016]	Face + iris	LBP Daughman's	LBPH Hamming Distance	decision level	400 images 200 images	77%
Shruthi et al. [2013]	finger vein + fingerprint	Gabor filters	Hamming distance	decision level	6264 images	98.78%
Christo et al. [2017]	Hand geometry + palm veins	proposed algorithm HOG	SVM	Feature level	7.200 images	98.7%
Raghavendra et al. [2014]	Finger Vein + Fingerprint	SMR	weighted sum rule	decision level	1500 images	99.22%
Trabelsi et al. [2013]	Finger Vein + Hand Vein	MLBP	IGMF	decision level	3916 images 4846 images	98%
Dhameliy et al. [2013]	Palmprint and Fingerprint	Gabor filters	Euclidean-distance	Feature level	250 images	87%
Siddharth et al. [2017]	Palm Print + Palm Vein	Gray scale Gabor filter	Euclidean-distance	Feature level	28 images	100%
Park et al. [2013]	Hand geometry + Hand Vein	median filter	Euclidean-distance	decision level	300 images	99.94%
Author(s)	Method of preprocessing	Method of feature extraction	Method of matching	Fusion levels	Database size	Accuracy
Usharani et al. [2014]	Palm Print + Palm Vein	Wavelet packet tree	K NN Naive Bayes	Feature level	2400 images	95.95%
Faris et al. [2014]	Finger Vein + Iris	Current tracking point	Hamming Distance Matcher	decision level	120 images 140 images	92.40%

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

a) [Bharathi, 2016] developed hand vein-based multi-modal biometric technique using palm and dorsal hand vein images as two modalities for biometric recognition. Based on the threshold value, decided whether the image of the corresponding person is presented in the database or not.
b) [Stefani, 2016] designed, implemented, and deployment a multi-modal biometric system to grant access to a company structure and to internal zones in the company itself.
c) [Shruthi,2013] employed a new approach 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.
d) [Christo,2017] 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 fusion was done on feature level.
e) [Raghavendra, 2014] 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.
f) [Trabelsi, 2013] proposed a new multimodal biometric system based on fusion of both hand vein and finger vein modalities. Experimental results confirm that the proposed multimodal biometric process achieves excellent recognition performance compared to unimodal biometric system.
g) [Dhameliya, 2013] developed Multimodal biometric identification system based on palm print and 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. The experimental results demonstrated that the proposed multimodal improving system accuracy and reliability.

h) [Siddharth, 2017] proposed biometric system uses two modalities, palm print and palm vein. The encrypted data of both modalities are fused using advanced biohashing algorithm.
i) [Park, 2013] proposed a hand biometric authentication method based on measurements of the user's hand geometry and vascular pattern. The proposed multimodal biometric system uses only one image to extract the feature points. This system can be configured for low-cost devices.
j) [Usharani, 2014] proposed a multimodal biometric system using palm vein and palmprint. The proposed fused feature technique improves the recognition rate in the range of 5.05% to 7.65%.
k) [Faris, 2014] proposed system fuse personal finger vein and iris which utilizes a vein feature matcher for finger vein and Hamming Distance Matcher for iris. It has been more secure than a framework used a single identification of personal feature.

Conclusion

This paper presents a detailed review on palm veins, dorsal hand vein, finger vein and multibiometric recognition algorithms. Such tools include image acquisition, preprocessing, feature extraction and matching methods to extract and analyze object patterns. Multi-biometrics topic has attracted more interest in recent research. It is used to identify individuals based on their physiological and behavioral characteristics for security purposes. Overview of biometrics showed that it is impossible to find the best single biometric suitable for all applications, populations, technologies and administration policies. Also, integration of biometric modalities can solve unimodal system limitations to achieve higher performance. Benefits and limitations of multi-biometrics discussed as we introduced it as a solution. In this paper, a state of the art survey of integration strategies, and fusion levels prior to matching and after matching are discussed design and finally, evaluate the multi-biometric systems raises many issues and trends.

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