A Review on Vascular Pattern Recognition Techniques

Navjot Kaur
Mtech Scholar, University College of Engineering, Punjabi University, Patiala, Punjab

ABSTRACT
Vascular pattern recognition has been done by many researchers in last decade. Vascular pattern recognition plays an important role to improve efficiency in biometric identification due to its reliability in highly secured areas. Such as In Airport, Access Control In Laboratories And Factories traditional issue is focused on full fingerprint images matching and face detection are used for identification of humans, but Vascular pattern recognition system is more reliable and gives more accurate results for the identification. Vascular pattern recognition works on pattern recognition. In Vascular pattern recognition the signature of the new Vascular pattern is compared against the stored pattern after computing the signature of new Vascular pattern and identification is performed. This paper discusses various techniques used for Vascular pattern Recognition.

Keywords
Biometrics, hand veins ,False Accept Rate(FAR), False Reject Rate (FRR)

1. INTRODUCTION
Biometric is the term used in computer science to refer to the field of mathematical analysis of unique human features [2]. It refers to the identification of humans by their characteristics and traits.

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

1.1 Vascular Pattern Based Biometrics
Vascular pattern is the network of blood vessels beneath a person’s skin. These vascular patterns can be used to authenticate the identity of an individual. The shapes of vascular patterns are unique in each individual even in twins[8]. As blood vessels are hidden beneath the skin and are not visible to human eye, so these patterns are very hard to copy as compared to other biometric traits such as fingerprints. Vascular patterns can only be taken at live body. All these characteristics make this biometric system more secure and reliable. Following image is taken from BOSPHOROUS database.

Figure 1 Dorsal hand vein image
1.2 Modes of operation
Biometric system can operate in 2 modes that are Verification and Identification [2]. Verification means comparison of acquired biometric with a stored template to verify that the person is who he/she claims to be. All biometric systems require each authorized user to be enrolled. It involves the user to represent the characteristic trait to the system one or more times. Then a library template is formed from the acquired sample. This template may be stored in a database or it can be encoded on a smart card. When the user wants to gain access, he/she must present the characteristic trait to the system which then compares this with the stored template.

1.3 Factors affecting performance
The performance and applicability of biometric systems depends upon many factors including[1]:
(i) whether or not the client population is closed or open; e.g. a population of factory workers as opposed to the population of potential ATM users,
(ii) the false acceptance (FAR) and false rejection rates (FRR),
(iii) user reticence; e.g. objections to fingerprints because of their traditional association with criminality,
(iv) whether or not the technique is invasive; e.g. retinal scans require the back of the eye to be scanned with a laser,
(v) ease of use,
(vi) hygiene, and
(vii) Cleanliness; e.g. a clean hand is needed for palm- and fingerprints.

1.4 Uniqueness of vein patterns
A good biometric feature needs four qualities: universality, distinctiveness, collectability and permanence. With respect to these qualities, the following can be concluded about biometric recognition using hand vein patterns[2]:
(i) Universality: It is safe to say that, except in rare cases, everyone has hands and blood vessels in them. Vein patterns can thus be considered universal.
(ii) Distinctiveness: It can be concluded that the distinctiveness of the vein pattern is a valid assumption.
(iii) Collectability: With the help of NIR imaging techniques, the patterns can be extracted and the features are measured.
(iv) Permanence: The general pattern of the hand blood vessels is permanent.

1.5 Methodology
Based on this discussion, the hand blood vessel pattern can be considered a good biometric feature. Methodology of vascular pattern recognition system consists of following stages.

1.5.1 Image Acquisition & Preprocessing
The image of the hand is taken from BOSPHOROUS database or it can be captured using an ordinary webcam that is modified to allow only infrared light to reach the light sensor. After capturing the image, preprocessing is applied to the image. The purpose of this step is to improve the image quality so that vein patterns can be more easily detectable during segmentation. This is done by first cropping the image to isolate the region of interest (ROI) and then applying filters to reduce noise and enhance the contrast.

1.5.2 Segmentation & Post-Processing
Once the noise has been reduced and the contrast enhanced, segmentation permits to separate the vein pattern from the background. Indeed the vein pattern is located and isolated from the rest of the image thus binarizing it. This is the most crucial step in the entire
recognition process. If the veins are not properly detected the risk of errors increases greatly. Thus the chosen method plays a big role in the overall performance of the system. The output image of the segmentation step is a binary image with some unwanted information such as noise shadows and faint veins. Therefore it is not always a true representation of the actual vein pattern. The segmentation separates the vein pixels from the non vein ones. Due to the importance of this step in the overall performance of the system, several segmentation algorithms have been implemented here including: Repeated Line Tracking (RLT) Laplacian of Gaussian (LoG) and Direction Based Vascular Pattern Extraction (DBVPE).

1.5.3 Features Extraction & Matching

The feature extraction step aims to extract the actual features of the vein pattern from an image that they are going to be used for matching. If the image is an enrolled sample the features are saved in a database for later matching. Once the features are extracted they are compared with the ones in the database and based on that comparison a decision is taken. Thinning methods try to extract the skeleton of the vein pattern. The skeleton is a binary representation of the pattern with only one pixel wide.

2. Previous Work

A number of research studies has been conducted for person authentication using hand vein patterns. Here a brief review of some techniques is given following:

Table-1 Literature Review

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Year</th>
<th>Author</th>
<th>Title</th>
<th>Workdone</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1995</td>
<td>J.M.Cross Smith</td>
<td>Thermographic Imaging of the Subcutaneous Vascular Network of the Back of the Hand for Biometric Identification</td>
<td>Low cost automatic thermographic imaging system prototype which is used to obtain vein patterns for positive identification. 3 stages in this system are image acquisition, image preprocessing and pattern matching strategies. Grid based matching is done to match the obtained vein pattern with stored pattern.</td>
<td>By setting the minimum forward and reverse percentages to 75% and 60 % respectively for positive identification it constitutes a FRR of 7.5 % and FAR is 0 %.</td>
</tr>
<tr>
<td>2</td>
<td>2004</td>
<td>Toshiyuki Tanaka, Naohiko Kubo</td>
<td>Biometric Authentication by Hand Vein Patterns</td>
<td>System is based on both phase only correlation and template matching. The system acquires images using 2 infrared LED arrays, CCD camera and a video capture card. Then preprocessing and matching is performed.</td>
<td>At threshold 0.400 FAR is 5.818% and FRR is 16.0%.</td>
</tr>
<tr>
<td>3</td>
<td>2008</td>
<td>Mohamed Shahin et al.</td>
<td>Biometric Authentication Using Fast Correlation of Near Infrared Hand Vein Patterns</td>
<td>It is based on spatial correlation of hand vein patterns. For verification testing analysis, they used three images to represent the templates and two images is matched with the existing three templates.</td>
<td>At threshold 80 FAR is 0.02%, FRR is 3.00%, system efficiency is 99.95%, genuine accept rate is 97% and genuine reject rate is 99.98%</td>
</tr>
<tr>
<td>4</td>
<td>2009</td>
<td>Ajay Kumar, K. Venkata Prathyusha</td>
<td>Personal Authentication Using Hand Vein Triangulation and Knuckle Shape</td>
<td>Authentication system uses vein triangulation and knuckle shapes of hand. The knuckle tips are used as key points for the image normalization and extraction of region of interest. These matching scores are created in two parallel steps, (i) from the 4 topologies of triangulation in binarized vascular structures hierarchical matching score is generated, (ii) from the geometrical features which consists of knuckle point perimeter distances in the obtained image. The weighted score created from above two stages is used to authenticate an individual.</td>
<td>equal error rate is 1.14%</td>
</tr>
<tr>
<td>5</td>
<td>2009</td>
<td>Chetana Hegde et al.</td>
<td>Authentication of damaged hand vein patterns by modularization</td>
<td>To overcome the limitation of authentication due to damaged veins, it modularizes the vein images to authenticate a person.</td>
<td>FAR is 2.1% and FRR of 1.274%</td>
</tr>
<tr>
<td>6</td>
<td>2011</td>
<td>Ahmed et al.</td>
<td>Hand Vein Biometric Verification Prototype: A Testing Performance and Patterns Similarity</td>
<td>In this system, the vein tree detection stage includes four steps that are hand region segmentation, smoothing and noise reduction, local thresholding for separating veins and then the postprocessing.</td>
<td>FAR is 0.03% and FRR is 7.84%</td>
</tr>
<tr>
<td>7</td>
<td>2013</td>
<td>S.Manikandaprabu, S.N. Sivanandam</td>
<td>&quot;A Novel Biometric system for Person Recognition Using Palm vein Images</td>
<td>Palm vein based verification system with improved performance with the help of energy feature that is based on wavelet transform. Energy feature can easily reflect the wavelet energy distribution of all the veins at different resolutions, so that it can easily characterize palm veins. As wavelet is robust for</td>
<td>FAR and FRR are both less than 1% and greater than 0.7%</td>
</tr>
</tbody>
</table>
3. Strengths and Weaknesses
On the basis of literature review, strengths and weaknesses of different techniques are as follow:

**Table-2 Strengths and Weaknesses**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Approach for Vein Pattern Recognition</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Thermographic Imaging of the subcutaneous Vascular Network</td>
<td>It used low cost automatic thermographic imaging system to obtain vein patterns for positive identification.</td>
<td>A more detailed study is required using images from more people to determine more reliably estimate the FAR and FRR</td>
</tr>
<tr>
<td>2</td>
<td>Phase Only Correlation and template matching approach</td>
<td>Improvement of authentication ratio than phase only correlation approach</td>
<td>Persons with thin hand veins, it can’t perform authentication.</td>
</tr>
<tr>
<td>3</td>
<td>Fast Correlation of Near Infrared Hand Vein Patterns approach</td>
<td>Improvement of FAR</td>
<td>No good methods for persons that have hand veins with narrow blood vessels, so results are not good in that case</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>4</td>
<td>Authentication using Hand vein Triangulation and Knuckle Shape approach</td>
<td>Equal error rate is very less</td>
<td>The strong near IR component present in the sunlight also limits the usage of employed imaging setup for outdoor usage.</td>
</tr>
<tr>
<td>5</td>
<td>Authentication of damaged hand vein patterns by modularization</td>
<td>Reduces the FAR and FRR</td>
<td>for every initial rejection, the image will undergo modularization irrespective of vein damage. That is, even when the person is not genuine the result is known only after modularization</td>
</tr>
<tr>
<td>6</td>
<td>Hand vein biometric verification prototype</td>
<td>FAR is reduced and system testing performance is increased.</td>
<td>The approach used by them doesn’t considerably reduce the false reject rate, it need to be improved</td>
</tr>
<tr>
<td>7</td>
<td>Verification system using energy feature based on wavelet transform</td>
<td>Only one image is needed for enrollment, achieved higher true acceptance rate and lower false acceptance rate.</td>
<td>Test data used in the experiment is small.</td>
</tr>
<tr>
<td>8</td>
<td>Authentication by Hough Peaks</td>
<td>Improved Accuracy</td>
<td>The system needs to improve FAR,FRR</td>
</tr>
<tr>
<td>9</td>
<td>Authentication using angles and length between minutiae</td>
<td>Results better than Independent Component Analysis and Non Negative Matrix Factorization</td>
<td>They have found that out of the 20 images which are not in the database, 4 images are falsely accepted.</td>
</tr>
</tbody>
</table>

4. CONCLUSIONS
In this review paper, a brief introduction to biometrics, their classification, modes of operation, factors affecting performance and vascular pattern recognition along with its methodology is described. Here various techniques and methods of vascular pattern recognition system by different authors have been discussed followed by their results like False Acceptance Rate, False Rejection Rate, accuracy, equal error rate etc and security considerations about the security achieved. The strengths and weaknesses of various techniques is also presented.

5. FUTURE SCOPE
A more detailed study will be conducted in near future. As many techniques have been discussed which has their own strengths and weaknesses. So to improve performance, a vascular pattern recognition system will be proposed using neural network to obtain more accuracy, reduction in False Acceptance Rate and False Rejection Rate. A proposed system will use SIFT(Scale Invariant Feature Transform) algorithm for extracting features from the vein patterns. After that neural network is applied for training and then finally classification is done using neural network for authenticating the system.
REFERENCES


