# An Improved Palm Vein Based Recognition System

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**Abstract**

Though biometrics techniques has been recording high level of security when compared with other forms of authentication, it still come with challenges of speed and accuracy of the technique been used. In this paper an improved palm vein based recognition system was developed and implemented. The development procedure was divided into four stages which are Image enhancement, Image segmentation, Image thinning and Pattern Matching. The Image was enhanced using Histogram Equalization, after which it was passed for Segmentation by K-Means algorithm. The binarized image from K-Means was then thinned using the Zhang Suen's algorithm. The Pattern Matching section of the project was done using the Euclidean Distance. Inter-distances of the intersections from the thinned image were stored in a database for subsequent matching. Results from the various test carried out showed that the system has high speed and accuracy.

**Keywords: Palm vein verification, enhancement, segmentation, thinning, pattern matching**

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## 1. Introduction

According to Chowdary, Verma and Monga (2014), authentication in use today comes in three forms: something you know, something you have and something you are. Where the first refers to authentication that utilizes tools such as passwords, and PIN (Personal Identification Number), it has been in the world scene for decades. The second refers to smart cards or tokens, these items have to be carried along. While the third type of authentication is biometrics. Biometrics has a higher level of security when compared the other forms of authentication as it cannot be lost, borrowed, stolen or forgotten.

Chowdary, Verma and Monga (2014), defined Biometric technology as a pattern recognition system which depends on physical or behavioral features for the person identification. Biometrics systems have been researched and tested for a few decades, but have only recently entered into the public consciousness because of high profile application, usage in entertainment media and increased usage by the public in day-to-day activities. Many companies are also implementing biometric technologies to secure areas, maintain time records, and enhance user convenience. Before now commonly implemented biometric modalities include fingerprint, face, iris, voice, signature, and hand geometry.

As technology advances, humans try to use these technological tools to achieve things that seemed impossible at a given time. Previously used biometric systems were based on outward physical or behavioral characteristics of an individual, but this has led to issues of porous security in terms of increased high impersonation rate as regards these technologies.

Recently, many personal authentication methods have proposed the vein patterns such as palm veins and finger veins have been used in security applications. In palm vein recognition, vital information is extracted from the internal part of an individual body- the vein, this information is thus used for authentication purposes. Palm vein authentication has high level of authentication accuracy due to the singularity and intricacy of vein patterns of the palm (Aj-juboori, Bu, Wu, and Zhao, 2014). Unlike other biometric approaches, the palm vein patterns are difficult methods to forge because it is internal in the body.

This paper work proposes a technique for palm vein biometric verification enhancement and accuracy using statistical and data mining tools.

## 2. System Overview

Although, there are numerous methods already in existence for addressing the issues of palm vein recognition, the following algorithms are used are used for the system development.

- Histogram Equalization
- K-means
- Zhang Suen
- Euclidean distance

In handling image enhancement, Histogram Equalization is used while for image segmentation, K-means algorithm. Zhang Suen's algorithm is employed for thinning while Euclidean distance is used for inter-distance calculation of intersections hence handling the pattern matching aspect of the system. Microsoft C# programming language and SQL server is also used at the front and back end respectively for the implementation.

## 3. Related Works

In (Ahmed, Ebied, El-Horbaty, Salem, 2014), authors focused on the utilization of Homomorphic filtering for the preprocessing step which is a generalized technique for image enhancement and/or correction. The pattern matching was done using the canny edge detection filter images was gotten from CASIA Multi-Spectral Palmprint Image

In the reported work by (Kumar and Gayathri, 2014) for feature extraction and classification, the subspace learning approach using kernel principal component analysis (KPCA) was used to extracts the vessel structures by analyzing the eigenvalues of the normalized palm-vein images and also the Local mean based k-nearest centroid neighbor (LMKNCN) approach achieves the palm-vein authentication.

Aj-juboori, et.al, 2014 reported on Gabor filter for the extraction and feature reduction dimensional and matching for Palm Vein Verification.

Manocha and Kaur, 2013 discussed on using neural network palm vein recognition. The back propagation algorithm was used for the neural network implementation. The project simultaneously utilized the palm surface and palm subsurface features for identification.

In the work by Saravanan and Prabhu, 2013. The authors presented the juncture point approach and hand geometry for recognition. The junction point approach extracts palm-vein features by analyzing the junction point of the palm image.

Deepamalar and Madheswaran, 2010 used Multi-level Fusion of Multimodal Features and Adaptive Resonance Theory. Multiple Feature extraction technique was used to extracts hand shape features, Adaptive sequential floating forward search (ASFFS) was then applied for feature optimization after which pattern matching which was carried out using k-Nearest Neighbor classifier.

## 4. Methodology

Different algorithms have been implemented over the years for palm vein pattern recognition which have been successful. The developed system improves on the efficiency of existing system by using a simple and more efficient algorithm, paying attention to time taken for the algorithm completion and also accuracy in matching patterns.

Essential components for the system development are listed below:

a) Image Acquisition
b) Image Enhancement
c) Image Segmentation
d) Image Thinning
e) Inter-Distance Computation

### 4.1 Image Acquisition

Dataset used for the development and implementation were collected from the CASIA Multi-Spectral Palmprint Image Database V1.0 (CASIA database).

The Near Infrared Imaging is more tolerant to changes in environment and body condition and hence is employed in the data acquisition of palm dataset by CASIA database which is utilized in this project.

### 4.2 Image Enhancement

A region of Interest (ROI) of 100 * 100 is extracted from the collected dataset. The palm images collected are often blur. The image firstly has to be enhanced to increase its contrast, and make the patterns more visible. Histogram equalization is used for Image enhancement.

In histogram equalization, the input pixel intensity, x is transformed to new intensity value, $x^t$ by T. The transform function, T is the product of a cumulative histogram and a scale factor.

$$x^t = T(x) = \sum_{i=0}^{x} n_i \frac{max\ intensity}{N} \qquad 4.1$$

*where* $n_i$ *is the number of pixels at intensity i*

*N is the total number of pixels in the image*

### 4.3 Image Segmentation

The K-means algorithm is used for the segmentation stage after successful image enhancement with the histogram equalization.

The algorithm is composed of the following steps:

Let X = $\{x_1,x_2,x_3,\ldots\ldots,x_n\}$ be the set of data points and

V = $\{v_1,v_2,\ldots\ldots,v_c\}$ be the set of centers.

a) Select *'c'* cluster points randomly.
b) Compute the distance between each data point and cluster centers.
c) Assign the data point to the cluster center whose distance from the cluster centre is minimum of all the cluster centers.
d) Re-compute the new cluster center using:

$$J = \sum_{j=1}^{k} \sum_{i=1}^{x} \left|\left| x_i^{(j)} - c_j \right|\right|^2 \qquad 4.2$$

*where, '$c_i$' represents the number of data points in $i^{th}$ cluster.*

e) Re compute the distance between each data point and new obtained cluster centers.
f) Stop if no data point was reassigned, else repeat from step c.

### 4.4 Image Thinning

After segmentation is completed, the binary images obtained are now thinned to single pixel width vein patterns. This is done by using the Zhang Suen algorithm.

The algorithm operates on all black pixels P1 that can have eight neighbors. The neighbors are, in order, arranged as:

| | | |
|---|---|---|
| P9 | P2 | P3 |
| P8 | P1 | P4 |
| P7 | P6 | P5 |

Define A (P1) = the number of transitions from white to black, in the sequence P2,P3,P4,P5,P6,P7,P8,P9,P2. (Note the extra P2 at the end- it is circular)

Define B (P1) = the number of black pixel neighbors of P1. (= sum (P2…P9))

The algorithm based on [25] is given below

*i) Step 1*

All pixels are tested and pixels satisfying all the following conditions are just noted at this stage

- the pixel is black and has eight neighbors
- (1) 2 <= B(P1) < = 6
- (2) A(P1) = 1
- At least one of P2 and P4 and P6 is white
- At least one of P4 and P6 and P8 is white

After iterating over the image and collecting all the pixels satisfying all step 1 conditions, all these condition satisfying pixels are set to white.

*ii) Step 2*

All pixels are again tested and pixels satisfying all the following conditions are just noted at this stage

- the pixel is black and has eight neighbors
- (1) 2 <= B(P1) < = 6
- (2) A(P1) = 1
- At least one of P2 and P4 and P8 is white
- At least one of P2 and P6 and P8 is white

After iterating over the image and collecting all the pixels satisfying all step 2 conditions, all these condition satisfying pixels are again set to white.

*iii) Iteration*

If any pixel were set in this round of either step 1 or step 2 then all steps are repeated until no image pixels are so changed.

## 4.5 Inter-Distance Computation

Euclidean distance is employed for inter-distance computation of cross through intersections. Cross through intersection were used to reduce time taken for inter distance computation. The intersections are gotten by the following method:

| | | |
|---|---|---|
| 1 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |

| | | |
|---|---|---|
| 0 | 1 | 0 |
| 1 | 1 | 1 |
| 0 | 1 | 0 |

For any nine pixels arranged in any of the two forms above, the coordinate of the central pixel is taken as the intersection points. The intersections are used in the computation of the inter-distance using the Euclidean distance formula.

$$D = \sqrt{(x_1-x_0)^2 + (y_1-y_0)^2} \qquad 4.3$$

*where* $x_0, y_0$ *are coordinates of the first intersection*

$x_1, y_1$ *are coordinates of the second intersection*

The computed inter-distances are stored in the created database.

When a test sample is brought to the system, all the previously analyzed process performed for the training set is as well performed on the test image, after which the stored inter-distances is matched with the trained one retrieved from the database to verify if it is the same palm sample.

## 4.6 Threshold Estimation

A threshold value of 0.7 is chosen for the matching process. This value is computed based on the pseudo code below:

```
START Process
    GET the length of the array holding the data to match with and place in A.
    GET the length of the array holding the data to verify and place in B
    COMPARE both arrays for identical elements.
    GET the number of the identical elements and place in x.
DIVIDE x by A and B
    IF the result of any division is greater than 0.7 THEN
    Return it is a Match
    ELSE
    Return it is not a match
END Process
```

A threshold value of 0.7 was choosing due to the inconsistencies present in the extraction of the Region of Interest (ROI).

## 5. Result and Discussion

After the training and testing images were acquired, the ROI was firstly extracted. A region of 100 * 100 was used in the development and a K-value of 5. The essence of the ROI is to separate the part that possess more feature from the image, which is then forwarded as the actual input to the system. The irregularities present in the extraction of the ROI did not affect the result since inter-distances of 2 point are the same even when read from different locations (i.e. different coordinates).

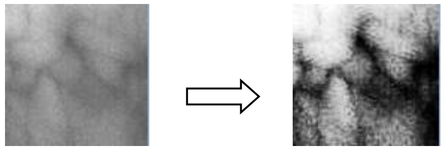

**Figure 1: The image enhancement stage**

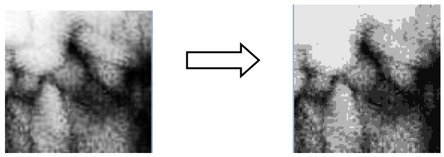

**Figure 2: The segmentation stage successfully separated the image from the background.**

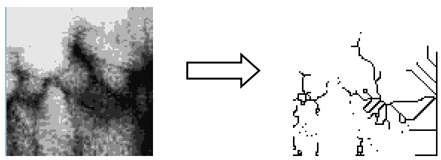

**Figure 3: The binarized image which was also successfully thinned**

## 5.1 Feature Extraction

Features of the palm vein patterns were extracted and the distance values between cross through intersection. As shown in figure

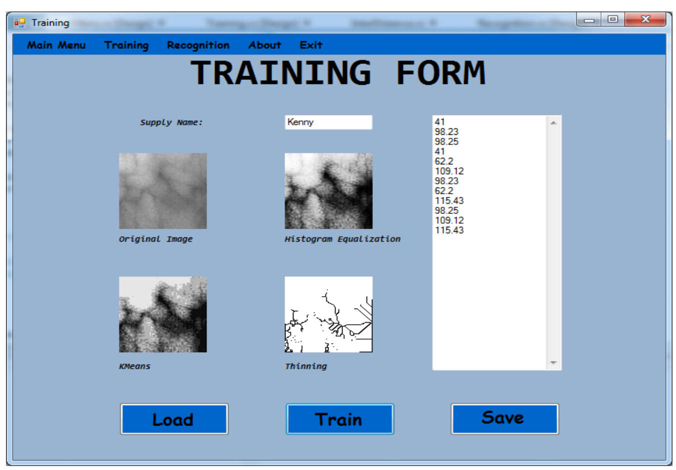


**Figure 4: Interface for the Training Form**

For verification, a threshold value of 0.7 is set for match due to inconsistencies in extraction of the ROI. If value is 0.7 and above a match is registered, else a mismatch.

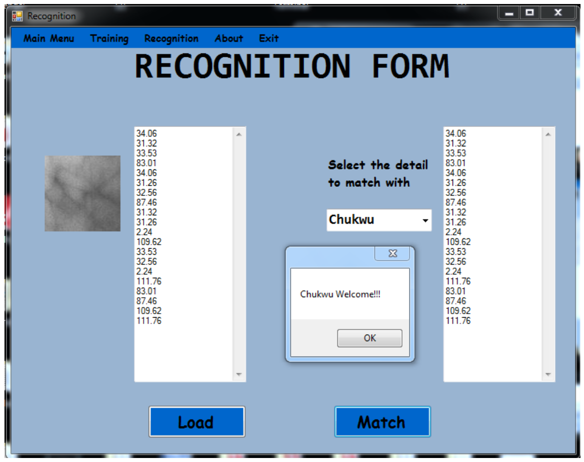


**Figure 5 (a): Interface for Recognition match**

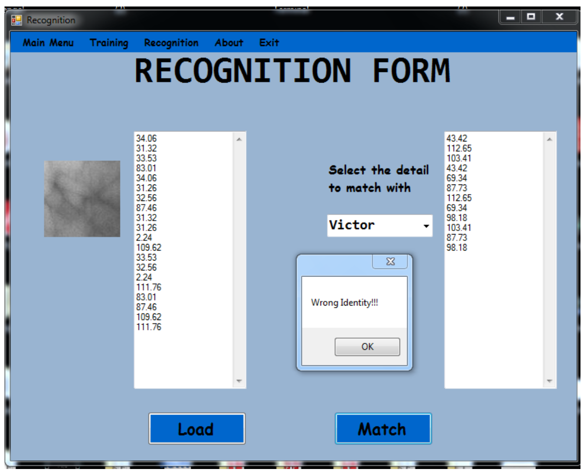


**Figure 5 (b): Interface for Recognition mismatch**

## 6. Conclusion

Biometrics system is now becoming a normal norm for enhanced security measures due to the fact that it is part of us hence cannot be forgotten or stolen. Despite its high security among other approaches, there is still a need to enhance its speed and accuracy.

The developed application was successfully tested using the CASIA database and has shown high accuracy and speed in recognition. The system has a very low dependency rate with the ROI size extracted. The system was tested with an ROI of 100 * 100 but has shown to have an increased accuracy when the region is between 150 and 220.

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

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