Hand vein authentication based wavelet feature extraction

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Abstract.
Biometrics is a growing scientific field. It aims to identify, through technological systems, an individual, using biological characteristics (eg details of hand, iris, ear, hand lines, fingerprints, gait, posture,). The Using of this technique is now generalized worldwide and takes an important place in everyday life. In the coming years, biometrics will probably be one of the techniques used, first to identify or authenticate individuals and also to control and manage access to material resources, particularly in the following sectors: banking, airports, bus and railway stations, hospitals, private and public institutions, homes, smart cars, museums, ...). The aim of our study is to build a dorsal hand vein database and test our approach on it. Just like any recognition system this last is composed of four steps: the acquisition, enhancement, feature extraction and classification. This paper presents the building protocol of a new database SAB11 BIOM14. Applying some enhancement on the database's image was required to get it ready for a real biometric's application. To validate our tests we proposed a new adaptive feature extraction method for the dorsal hand vein biometrics; which is the discrete wavelet transform.

Keywords: Hand vein pattern, wavelet transform, feature extraction, database, authentication.

1 Introduction
For getting a biometric system authentication; the user or the data has a long way before arriving to the final decision which authenticate or not. From the sensor data acquisition, image enhancement, hand vein pattern extraction and matching; these are the steps to be achieved to get the final decision. Each of them is essential for the good result of the authentication process.

Good recognition should have a good classification and a good classification should be above a perfect feature extraction phase this is where lies the strength of the biometric system, our work is focused on the dorsal hand veins feature extraction step, but the question asked is which method used to ensures a better feature extraction?

In this paper, we used our built database; which contains hand vein pattern in gray level image. The main objective of this work is to validate tests on our built databases SAB11 and BIOM14 by providing a method which allows feature extraction of veins pattern from low quality images.

They are several works about feature extraction of hand veins pattern; among them there is the Gabor filter, the Hough transform, discrete Curvelet transform, triangulation of minutiae ... etc. most of his method are preceded by a preprocessing step where in the Gabor filter [2] and the Hough transform [3] they use the Median filter, Wiener in Gabor [2] and SIFT method [5], the Mexican hat in triangulation minutiae [6], The following table summarizes some methods with their phases preprocessing, database size and performance. The table 1 summarizes most of this works.
<table>
<thead>
<tr>
<th>Method</th>
<th>Enhancement</th>
<th>Size of DB</th>
<th>Time Processing</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gabor filter[2]</td>
<td>Median and Wiener</td>
<td>/</td>
<td>0.3631</td>
<td>EER=1.41% FRR=2.278%</td>
</tr>
<tr>
<td>Hough-transform[3]</td>
<td>Median &amp; Gaussian filter</td>
<td>400</td>
<td>/</td>
<td>FRR=0.0025%</td>
</tr>
<tr>
<td>Discrete curvelet-transform [4]</td>
<td>Gaussian &amp; high pass filter</td>
<td>400</td>
<td>/</td>
<td>EER=1.17%</td>
</tr>
<tr>
<td>SIFT [5]</td>
<td>high pass &amp; Wiener filter</td>
<td>1020</td>
<td>/</td>
<td>RR=97.95%</td>
</tr>
<tr>
<td>Minutie triangulation [6]</td>
<td>Mexican Hat</td>
<td>300</td>
<td>/</td>
<td>FRR=1.14% FAR=1.14%</td>
</tr>
<tr>
<td>Across point and black box aproach [7]</td>
<td>/</td>
<td>100</td>
<td>/</td>
<td>FAR=0.1%</td>
</tr>
<tr>
<td>Ridgelet-transform [8]</td>
<td>/</td>
<td>128</td>
<td>/</td>
<td>ERR=0.13%</td>
</tr>
<tr>
<td>Invariant moment [9]</td>
<td>/</td>
<td>0.2</td>
<td>500</td>
<td>FAR=1.48%</td>
</tr>
</tbody>
</table>

Table 1: works on feature extraction hand vein

2 PRIOR WORK

Extracting features from hand vein images have involved the attention of many researchers. Indeed, representing vein images by their skeletons was among the most published work [3] [4] [5] but sometimes it is difficult to extract these features due to acquisition complexities and lead to the high False Acceptance Rates (FAR>1%) [6]. To solve a problem like this, some used integration of multiples features based on some fusion rules [6] [7] [8]. Meanwhile the dorsal hand veins are different in visibility, structure and noise [8], several pre-processing methods and enhancement were applied. First, we describe these methods in next section.

![Figure 1 Dorsal hand vein biometric identification](image)

3 DATABASE ACQUISITION SYSTEM

It was very difficult for us to find a database of dorsal hand veins. Knowing that there is no database directly available on the net; we decided to design a low-cost sensor to be able to build our own one using SAB11 device [1]. And have a hand vein images on which to test our approach. The figures below show some samples of each Database SAB11 and BIOM14.

For getting good quality of the images, we note that our hardware system needs a number of conditions:
- The day light impact on the quality of the image obtained except in the absence of IR filter.
- The temperature of the environment also influences the quality of the image must be room neither too hot nor too cold at about the temperature of the human body.
- The distance between the sensor and the object should be sufficient for good acquisition.

The following figures show nine different samples of SAB 11 vs BIOM14.
4 PREPROCESSING IMAGE

4.1 ROI extraction

For extracting the ROI, was made a small algorithm that allows an automatic extraction of the region of interest by calculating the mean of each row (column) and compared to the threshold as follows.

For each row do
  If (average (oldpic(row)) >= threshold)
  Pic = oldpic(row:end)
Oldpic = pic
For each row do
  If (average (row) <= threshold)
  Pic = oldpic(row:line)
For each column do
  If (average (oldpic(column)) >= threshold)
  Pic = oldpic(fist:column)
Oldpic = pic

The thresholds are calculating as:

\[
Threshold_{c} = \left( \frac{\text{max img (larg img)}}{\sum_{i=1}^{\text{row}} \sum_{j=1}^{\text{col}} \text{img}(i,j)} \right) \times \text{Percentage}.
\]

After applying the algorithm to our image we obtain result of the Figure 2.

4.2 ENHANCEMENT

To enhance the contrast accentuations of the image, we applied a double adaptive equalization; the vein contrast the result is in the following figure. It differs from ordinary histogram equalization in the respect that the adaptive method computes several histograms, each corresponding to a distinct section of the image, and uses them to redistribute the lightness values of the image. It is therefore suitable for improving the local contrast. AHE has a tendency to overamplify noise in relatively homogeneous regions of an image. A variant of adaptive histogram equalization called contrast limited adaptive histogram equalization (CLAHE) prevents this by limiting the amplification.
Adaptive histogram equalization dual is applied twice to the algorithm proposed by [10], the following algorithm:

Algorithm AHE

For every pixel $i$ (with grey level $l$) in image do
Initialize array $Hist$ to zero;
For every contextual pixel $j$ do
  $Hist[g(j)] = Hist[g(j)] + 1$
  Sum: $CHist = \sum_{k=0}^{l} Hist(k)$
  $l' = CHist \times l/W$

is gray level of pixel $j$, $l$ and $l'$ are original and new gray level of center pixel $i$, $l$ is the cumulative histogram function value in gray level. The result obtained is as follows

4.3 FEATURE EXTRATION

The main objective of the wavelet transform is data compression, it is used for signal analysis, image compression, sound processing and geology are the main application areas for wavelet in our works we will refrain to the application images.

The integral wavelet transform is the integral transform defined as

$$[W_{\psi}f](a,b) = \frac{1}{\sqrt{|a|}} \int_{-\infty}^{\infty} \psi(\frac{x-b}{a}) f(x) dx$$

The wavelet coefficients $c_{jk}$ are then given by

$$c_{jk} = [W_{\psi}f]\left(2^{-j}, k 2^{-j}\right)$$

Here, $a = 2^{-j}$ is called the binary dilation or dyadic dilation, and $b = k 2^{-j}$ is the binary or dyadic position.

To extract dorsal hand vein pattern we have used a single 2 dimensional wavelet transform, a discrete wavelet transform in two dimensions can be achieved by running two separate one-dimensional transforms. First, the image (2D signal) is filtered horizontally (along the x axis) and divided by two. Thereafter the filtered subimage is vertically (along the y axis) and divided by two.

We then obtain an image composed of four bands after decomposition at a single level.

How is the compression of an image?

The compression is achieved by successive approximations of the initial information from the
coarsest to the finest. Then it reduces the size of the information by selecting a level of detail.

It exist many categories of wavelet. The most suitable for our database is the bi-orthogonal reverse wavelet family with wavelet bio 3.1. It gives us good results; which are shown in Figure 5.

![Fig.7. discret Bi-orthogonal wavelet transform](image)

For improving the result obtained, We test an adaptive equalization on the vertical and horizontal details image for improved contours veins as in this figure7.

We used a binarization of each image to keep the pattern of the veins with using vertical threshold SV=0.12 and horizontal threshold SH=0.25 the result is in the following figure.

![Fig.8. adaptive equalization of detail images and the binarization](image)

The most important is to keep just the pattern of veins and eliminates noise, after a series of tests we could find a morphological operation that allows this processing called morphologically open image.

The opening of A by B is obtained by the erosion of A by B, followed by dilation of the resulting image by B:

\[ A \circ B = (A \ominus B) \oplus B \]

The opening is also given by \( \beta B = \bigcup_{\beta B \subseteq A} Bx \), which means that it is the locus of translations of the structuring element B inside the image A. In the case of the square of side 10, and a disc of radius 2 as the structuring element, the opening is a square of side 10 with rounded corners, where the corner radius is 2.

Example application: Let's assume someone has written a note on a non-soaking paper and that the writing looks as if it is growing tiny hairy roots all over. Opening essentially removes the outer tiny "hairline" leaks and restores the text. The side effect is that it rounds off things. The sharp edges start to disappear.

Where B is composition of erosion and dilatation this method is used with two parameters 4 connectivity of neighborhood and
PV=40 pixels in vertical
PH=30 pixels in horizontal

PH and PV denote the maximum size of objects to delete in a binary image.

**Fig. 9.** Morphologically open image

After having superimpose the two results and proceed to the deletion of noise pattern by applying morphological opening operation of the binary image on the image of the negative result with 40 pixels as the minimum object size kept, the result is in the following figure.

**Figure 10.** the result to merge two images

**4.4 Authentication**

Authentication uses several technics of classification. In our case we opted for the classification based on the binary image as a feature vector.

Which seem to be more appropriate is the Euclidean distance:

$$D(I,J) = \left( \sum _ { i } \left| f_i(I) - f_i(J) \right| ^2 \right)^{\frac{1}{2}}$$

Euclidean distance is to be applied in calculating the distance between two matrices (binary image) of fixed size which is not the case of all images in the ROI of each image extraction of different size with respect to another, luted to be against problem we had to do a normalization step image this step helps to make all the images in a standard size template given the choice.

According to the results we find that identification with calibration performed on detailed image provides a low error rate compared to other approaches tested.

**5 EXPERIMENTAL RESULT**

Our work has been tested on a database of 34 individuals for each individual there are 5 taken for each hand which make 3400 image database, the results of different approaches are summarized in the following:
Fig. 12. Four sample hand vein and extracts pattern

We see here that with automatic threshold with translation operation provides better results; Table 2, 3:

Table 2 FRR with a static threshold

<table>
<thead>
<tr>
<th>Operation</th>
<th>Vertical detail</th>
<th>ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotat &amp; Transl</td>
<td>31.74 %</td>
<td>48.24 %</td>
</tr>
<tr>
<td>Translation</td>
<td>13.43 %</td>
<td>19.41%</td>
</tr>
</tbody>
</table>

Table 3 FRR with automatic threshold

<table>
<thead>
<tr>
<th>Operation</th>
<th>Vertical detail</th>
<th>ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotat &amp; Transl</td>
<td>30</td>
<td>42.65</td>
</tr>
<tr>
<td>Translation</td>
<td>10.29</td>
<td>21.18</td>
</tr>
</tbody>
</table>

This result is obtained by applying the method mentioned above, the pattern is satisfactory for use to make a classification.

The figure below allows you to see the histogram for each pattern extracted correspondence is by number.

6 DISCUSSION OF THE RESULTS

Based on the results obtained, we see that the sequential time was very large (about 6 second) against parallel time. Since with our approach with Akka actors, the parallel time was always smaller than the sequential time, but we found that increasing the number actors to binarize one image, speedup decreases, so we were limited to two actors who handles a single picture.

In this work, we have worked with two databases: the previously acquired and NCUT of hand dorsa vein images which contains 2000 images from 100 individuals, 10 images of the right hand and 10 images of the left.

The figure below show the images of dorsal hand vein biometric of several persons used in this experiment with:

We have obtained the same output image in sequential version and parallel version.

7 CONCLUSION

The conception of our database was very interesting in the way that we got a dorsal hand vein database to share and test on it our actual and
future approach. This was our principal contribution with the use of the wavelet transform for the vein extraction phase. After this research, we conclude that the wavelet transform gives good results for such kind of imaging. The wavelet gives us access to the multi-resolution; it allows the manipulation and extraction of contours which helps us during the feature extraction step. Even in the case where the quality of the images is a bad.

The two built database are very efficient for future study and specially for testing some new approaches as ridglet and contourlet. Within the aspects which can be considered for future works, we note; Generalization of the system for any acquisition system, Optimization time processing for the classification phase and method for distinguishing right from left hand.

8 REFERENCES


