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Investigation of Efficiency of using Minutiae Detection Method for Finger Vein Recognition and Matching

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ABSTRACT
Finger vein recognition is a method of biometric authentication which is a promising biometric recognition technology used to recognize the individuals, to verify their identity and is one of many famous kinds of biometrics.

With the increasing demand for fast and accurate biometric identification and matching solutions, researchers have been busy trying to develop new ways and algorithms to digitize and match biometric features of human body.

This paper will extend one of the current methods by combining it with conventional method used in fingerprint for minutiae extraction to extract the minutiae points of finger vein Based on:

1- Finger region localization
2- Miura et al. vein extraction method
3- Fingerprint Minutiae Extraction

The minutiae points are going to be used for the authentication system that requires only points to be stored on its own database.

Experimentation has been conducted to monitor each step till the minutiae points were extracted .By matching these points for each individual, authentication system will be faster and accurate.

General Terms
Finger vein detection and fingerprint minutiae detection.

Keywords
Biometric, Finger vein, Minutiae, Extraction**.**

1. INTRODUCTION
Identification and authentication are procedures applied to know the true identity of an individual [1]. In the real world users have unique identifiers (IDs) such as driving licenses or bank account numbers, etc. But these identifiers are not secure enough and without any permission, they can be used by others. Although these identifiers can have security codes as to be more secure, they can still be hacked easily and moreover, complicated passwords are difficult to be remembered. For the previous reasons, alternative authentication methods, especially those based on biometrical science have developed and are widely used. Most authentication methods suffer from two types of errors, false positive of impostors and false negative of authorized users and the challenge is to minimize the error as far as possible [1].

The popularity and reliability in accuracy of finger vein [2] can be due to the fact that the finger vein pattern is completely unique and impossible to forge. While identification cards and passwords are so easily stolen and used at once, little changes in the look such as wearing makeup, glasses, facial hair, sunglasses, hats and so on make it even more needed to keep the accuracy high. Finger vein and finger print are not permanent all the time and it is also cheatable, finger vein is an exception with any of the mentioned problems. There are some difficulties in face recognition which is avoided in finger vein recognition. While for vein recognition, there are no difficulties like this to be arise. Image is the data to be analyzed in finger vein systems, also the idea of using face recognition methods is to extract the features and classify the data has been found. [3]

Finger vein recognition method is the state of art in biometric technology recently. Many promising methods as Line Tracking (LT) [4], Maximum Curvature (MC) [5] and Wide Line detector (WL) [6] have been proposed for finger vein recognition. Between these methods, LT was very slow in each matching and feature extraction phase. Furthermore, LT, MC and WL are series dependent, and they are affected by image noise. To solve these problems, proposed feature descriptors is greatly used for several Computer Vision or Pattern Recognition (CVPR).

Such as Fourier Descriptors (FD) [7], Zernike Moments (ZM) [8], Histogram of Oriented Gradients (HOG) [9], Local Binary Patterns (LBP) [10] and Global Binary Patterns (GBP) [11].

Traditional methods are like the matched filter [12] and morphological method [13] .These methods can extract patterns which have constant widths of veins only. However, the assumed width cannot be extracted by these methods because of narrower/wider veins than the assumed widths, which affect the accuracy of the personal identification. This has been eliminated by binarising, then thinning veins image. The repeated line tracking method [4] cannot extract thin veins sufficiently from vein patterns, because the number of times that the tracking point moves on thin veins tends to be small statistically, but it can extract vein from an ambiguous image. The proposed method that solves these problems is checking the curvature of the image profiles and emphasizing only the centerlines of veins. The centerlines are detected by searching for positions where the curvatures of a cross-sectional profile of a vein image are locally maximal. Method of detecting the maximum curvature positions is robust against temporal fluctuations in vein width and brightness. The positions are connected with each other, and finally the vein pattern is obtained.

In Addition to extraction of finger veins, digitizing the minutiae made it possible to make a feasible search and match algorithm to compare an individual finger vein profile to a large number of stored data and look for a match, opening the door for countless applications like access control and personal identification.

2. PROPOSED METHOD

Input pictures used in this research were taken by a device that uses infrared illuminator and a camera to produce 8 bit grey scale images.

The system has 2 path ways

A. **Database building**:
In this section the Visual Basic program uses Mat Lab code to build a text file for each image in the image set; these files are further combined in a single database to accelerate searching and matching processes

B. Subject matching:
Following are the images obtained for each step carried out through simulation. Figure 1 shows one of the original images of finger vein taken from SDUMLA-HM database by machine learning and data mining lab. Shadong university.

These images were further analyzed using Mat Lab ® software to extract points of interest and save it into a text file that will be read by VB.NET software and compare the data in the text file with the data in a pre-built database to find a match

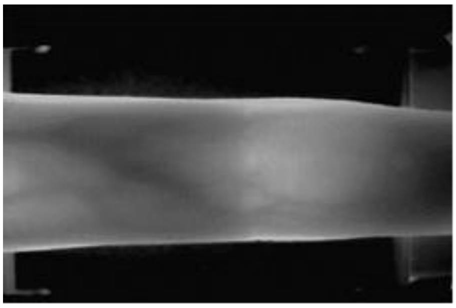

Figure 1 (Original Finger Vein image)

Figure2 (Finger Region)

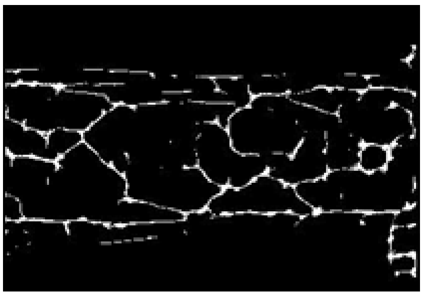

Figure 3 (Detected Veins centerlines)

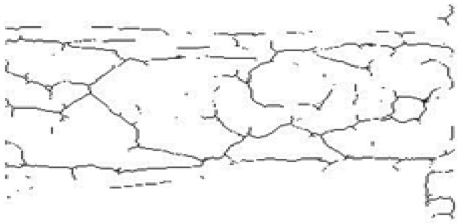

Figure 4 (Thinned Veins centerlines)

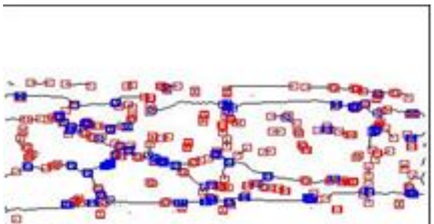

Figure 5 (Points of interest)

Since the proposed maximum curvature method was only intended for identification and extraction of vein features in the image, a matching application was built based on pixel by pixel technique in order to be used for comparison. During the testing phase the application proved itself accurate and successful yet it was very slow for practical usage.

However, taking this system one step further by reducing the 2D grey scale image to a set of points that represent key points in the finger vein image open the door to build a new application that can store the subject data in an MS Access database and do the search via SQL queries, providing lower processing time, smaller disk footprint and better hardware utilization, thus reducing matching time from several hours to seconds per operations. This application works as per the following diagram:

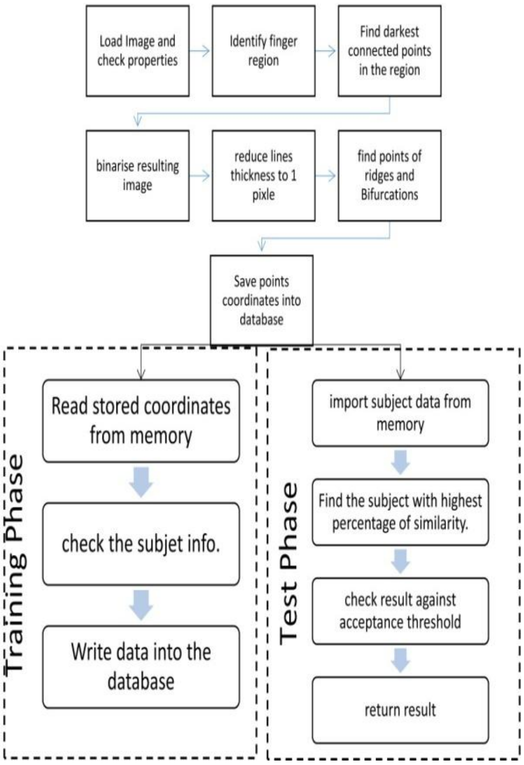

Figure 6 (Process chart)

2.1 Data Acquisition

In the Database construction part of the system, the program asks the user to provide the root folder location that contains the image set taken by the device.

These data shall be organized as follows:

Root folder\Subject number\Hand(left or right)\finger name repetition index .jpg

All of the files inside have to be 8 bit grayscale indexed images for the program to process them properly.

After verifying the bit depth and structure of the image set, the system will loop through all folders and images for processing.

2.2 Processing

In this part the program first will define the searching boundaries of the finger in order to minimize the time used for vein recognition and reduce possible noise effect of the results.
This is done by splitting the input image into two halves horizontally and filtering it, detecting the first highly lit (White) point while scanning in (x) direction of each half defining the boundaries of the finger

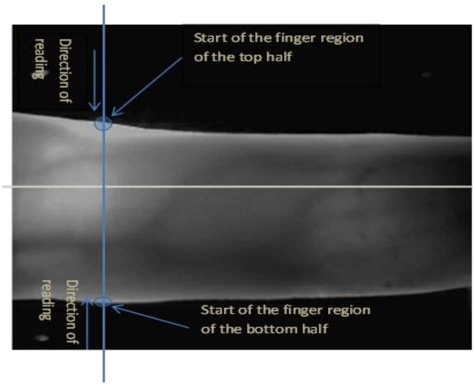

Figure 7 (Region detection)

The next step is to identify veins within the image, and this is done by using miura's maximum curvature method in this part the program detects the gradual change of brightness across vertical lines (like A and B in the figure below) where the points with the lowest brightness (darkest points) represent veins where the darkest of them represent the center lines of these veins.

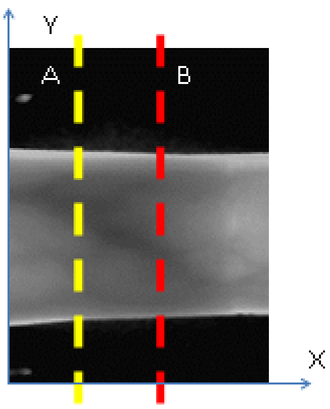

Figure 8 (Center line detection)

In this step, there is no more need for color gradient; therefore the program binarises the image into 2 bits color depth.

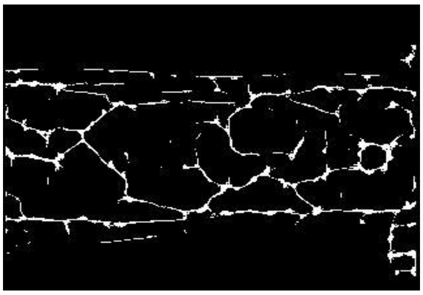

Figure 9 (Vein center lines)

The next step is to further reduce the detected veins centerlines to lines with width of 1 pixel. This helps to simplify the search for lines end points, discontinuity and splitting points, commonly used for fingerprint recognition that will be used as points of interest in the next step.

In this step, the actual coordinates of Points of Interest are detected.

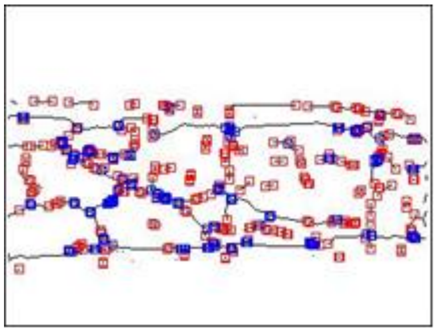

Figure 10 (Minutiae Points)

Coordinates of these points are then stored in text file in form of pairs (X,Y). The purpose of this file is to act like a bridge to transfer the data between MatLab and Visual basic program.

The text file is then loaded in memory for further usage.

If the database construction mode is selected the program will read each line, connect to the empty database file, then adds the values of X, Y and the subject number these data refer to, then loop through all images in the image set.

2.3 Matching

A. If matching mode is selected, the user will be asked to provide the complete database file and the finger vein image that the user wants to find a match for.

B. The system goes through the same first 7 steps as in database construction, until it loads the POIs file into memory.

C. The program connects to the database and creates a new temporary table with the POI data in it.

D. The program executes the a SQL query to find the similar records in between newly created table and data of each subject in the database.

E. The program then finds the user record with the highest match score and compares that score to the acceptance threshold score.

F. If the value of the match score exceeds the acceptance threshold the program will consider the match and display it to the user, otherwise it will display a message indicating that there is no match found.

Using this system, a test were made using a database of 40 subjects each have registered the vein images of 3 fingers of each hand and each hand, each finger is registered 6 different times, resulting of 720 different images, that have been processed and store into a database file through this application.

The data of the first 10 subjects has been compared to this database in order to find the match scores of correct and false matches, and determine the acceptance threshold.

3. RESULTS AND DISCUSION

Two tests were conducted to check the validity of the hypothesis as follows:

A. Test1:
The database in this test contained 40 subjects, each subject recorded 6 different images for his/her index, middle and ring fingers, for both hands, resulting in a total of 1440 image.

The data have been processed in the system and stored in the database.40 images have been chosen arbitrarily from the image set and the match scores has been obtained as follows:

The highest match score of true match: 2.854

Lowest match score of true match: 1.3795

Highest match score of false match: 0.9338

Lowest match score of false match: 0.2127

Results were found to be consistent with the assumptions, finding a clear distinction between true and false matches; however since in real life applications having an exact match for the images that built the database is very unlikely, another test was conducted to verify the results.

B. Test 2:
In this test a set of 40 subjects have been used to build a new database, using 3 fingers from each hand (index, middle, and ring fingers) and using 6 images of each finger; however in this test one image for each subject has been excluded from the database construction phase, that resulted in 40 images that have been used as a test set.

In this more practical situation, the system correctly identified 37 subjects out of the 40 with success rate of 92.5%

The Highest match score for a true match was 1.142

The lowest match score for a true match was 0.529

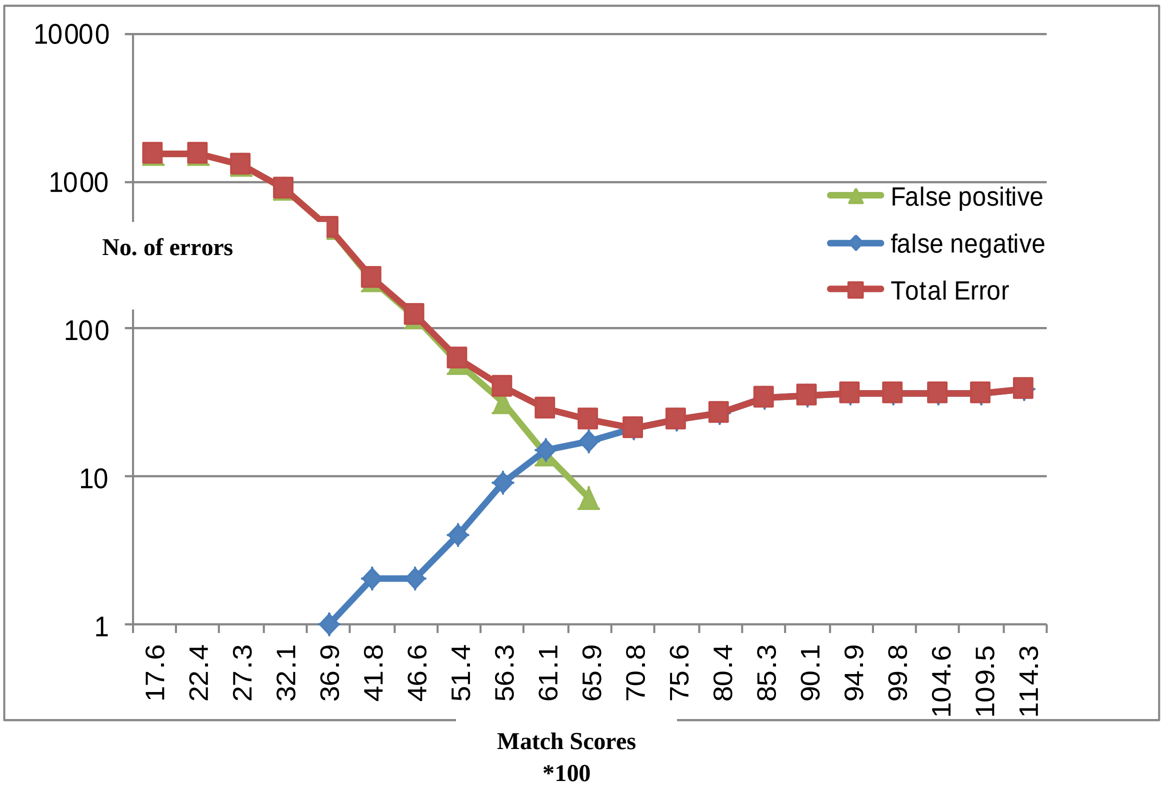

Figure 11 (Error count vs threshold)

Dashed line indicates the threshold used. Number of training samples of each individual represent 40 subjects have been used, using 3 fingers from each hand (index, middle, and ring fingers) and using 6 images of each finger

The overall number will be 36*40=1440.At the lowest threshold all the samples was false so that the false positive was at the maximum till threshold 0.369388 the first false matching appeared, which means that there was false negative began to appear as shown in the figure. At the score 0.707781 it was the first time where was the False positive at the zero and the False negative at a low matching samples so this threshold was been the indicator whether if the sample was recognized or not.

4. CONCLUTION

The proposed method is done by extracting the minutiae points of finger vein which is the result of combining two methods of maximum curvature points in image profile and the method used in extracting the minutiae points of fingerprint. The authentication system will use this robust method of storing and comparing points rather than comparing the pattern of finger vein. By merging Vein detection techniques with fingerprint minutiae detection it was possible to achieve.

Considerably faster matching technique and lower storage requirements for large quantity of data.

Comparing to traditional pixel by pixel comparison, that took hours in our test to identify and find a match for a subject in a set of image, the proposed method took only a few seconds to do the same task.

5. FUTURE WORKS

Although the proposed method does significantly improve matching speed and accuracy, however it is possible to improve it further using other techniques like Principle component analysis (PCA).

At heart, PCA removes the common image from all images forming the database, this is particularly important to remove all features added by the imaging device itself, that will greatly reduce the data needed to be stored , thus Improving accuracy and speed and further decrease the storage requirement for larger databases.

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