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Fingervein Recognition System Using Fuzzy Score Level Fusion and Corner Detection

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Abstract: The finger vein is a unique physiological biometry to identify individuals based on the physical characteristics of vein models in humans. The technology is currently being used or developed for a wide variety of applications, including credit card authentication, automotive security, computer and network authentication, automated teller machines. The proposed technique is a fingervein recognition system based on fuzzy score level moment invariants fusion and corner detection. It is consist of two phases, enrollment phase and test phase. In the enrollment phase, several operations are implemented. Firstlly, after the preprocessing, the seven moment invariants features extracted from the input fingervein image and detect the corners locations, respectively. Second, the standard deviations of corners location of the image is calculated. Third, these features used as an input for the fuzzy rule and fuzzy membership function, respectively. Fourth, the use of a fuzzy-based method to enhance matching technique. Finally, the corner detector techniques are used for matching. The experimental results using finger-vein dataset showed that the proposed method is enhanced the accuracy of finger-vein recognition compared with previous methods.

Key words: Fingervein, biometric, fuzzy, logic, image, processing

INTRODUCTION

Recently, there has been a great deal of interest in biometrics authentication for security reasons. Biometrics or viometrics authentication (Wang *et al*., 2010) refers to automated methods of recognize a person who uses behavior or physiology characteristics such as irises, fingerprints, veins, faces, etc. Biometric characteristics are unique characteristics for an individual which is practical and safer than traditional authentication methods. For example, biometrics verification methods that are more reliable than those based on tokens (key or identity cards) and knowledge-based methods (passwords or PIN) achieving greater efficiency and better experience. Personal verification based on biometric technology widely used in access control and used in the computer forensic. However, in the circumstances biometric approaches may suffer limitations. For example, facial recognition is likely to lighting changes and rotations. Fingerprints are vulnerable to counterfeiting. In addition, the conditions of a finger like drought or sweat can also, prevent a clear pattern. The authentication system or device used here is fingerbein module. There is a lot of authenticated devices such as the biometric, etc., the most commonly used authentication devices. These modules are used to verify the authentication of a particular user or person device or system. In the same way, we are here new finger vein module that is very well insured and worthy. The recognition of the vein of the finger is a method of authentication using pattern recognition techniques on the images of the patterns of the vein of the human finger under the skin area. The recognition of the vein of the finger is one of the many forms of the biometrics used to identify individuals and verify their identity.

Literature review: The research conducted, so many on this technique shows that wide range of research in the years to come and correct them, so that, we can get a better system for use this technique. Yang *et al*. (2011) proposed a new image of the vein of chance of the fingers method based on the characteristic of the structure that describe the vein of the finger. In a practical manner, the vein skeletons are extracted and used as primitive information. Based on skeletons, a curve mapping scheme depended on the union points for extracting the curve segment. Then, the segments of the curve are coded in part by means of an including the chain of angles and the characteristic code of the structure of a vein the network is generated sequentially. Finally, a dynamic the scheme is adopted for the mapping of the structural characteristic.

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Prabhakar and Thomas (2013) present that finger vein technology is the most recent biometric technology that uses the vein model that is hidden under the human finger for identification. Like the patterns are hidden beneath the surface of the skin, enormous consideration of privacy, and therefore, extremely difficult to forge. An approach to finger vein identification based on the extraction of Minutia. The elimination of minutiae is presented in this work. Minutia extraction includes extraction of endpoints and bifurcation points of the skeletal vein patterns and elimination of false precise identification.

Qing Rao proposes a structured approach to personal identification using location and address coding of the finger vein (LDC). First, they design a finger venous imaging device with the Near Infrared (NIR) light source which establishes a database for vein images. They then perform the pre-processing of the image in which they segment the finger shape using the gradient operator to detect the vertical lines as the finger border and then use the size and normalization of the brightness to 1 extraction of features and final matching. They normalize the size by linear interpolation. In addition, LDC of the finger vein is proposed and realized which creates a characteristic structured image for each vein of the finger. The LDCs analyze the characteristics of the valley of the veins where it is considered that the point has a high probability of being in the zone of the vein when it is in the valley. Using this concept, the location of the vein is extracted in which are considered the two threshold values, according to which the position of the vein is measured. Then, the local threshold method is used to segment the ambiguous pixels finding the mean and the deviation of the neighboring pixel. After segmentation, the median filter is used to smooth the image by eliminating noise. After smoothing the location of the vein and encoding the direction is performed, overlapping the directional map in the location map of the binary vein produces the vein characteristics map with directional information. Finally, the structured entity image is used to perform personal identification in our database of images for the finger vein calculating the total number of combined points that includes 440 vein images of 220 different fingers. The same error rate of our method for this database is 0.44%.

Sujata Kulkarni, Dr. R.D. Raut proposed a recent authentication system using the finger vein. The pattern of the vein present under the skin of the finger is distinctive and stable it can be used for personal authentication which offers high security and reliability because of its positive characteristics compared to other biometric modes. It explores the IR-based finger vein capture device and a different algorithm to extract the finger vein features used for authentication. The document highlights the vein of the finger , its recognition performance parameter, i.e., the False Acceptance Rate (FAR) and the False Rejection Rate (FRR). The characteristics of finger vein authentication show that it is safer than other correlated modalities.

Park (2012) proposed new algorithms for the recognition of the finger vein. This research presents the following three advantages and contributions compared to previous work. First, they extracted the local finger vein information on the basis of an LBP (Local Binary Pattern) without segmenting the exact regions of the veins of the finger. Second, the global information was extracted from the veins of the fingers on the basis of the Wavelet transformation. Third, two LBP and Wavelet transformation score values were combined by the SVM (Support Vector Machine). As experimental results, the EER (Equal Error Rate) was 0.011% and the total treatment time was 98.2 m

Fingervein identification system

Fingervein: A biometric system is essentially a pattern recognition system that recognizes a person based on a characteristic vector derived from specific physiological or behavioral characteristics that the person possesses (Cao *et al*., 2013). A detection of fingervein patterns has been shown in the comply with definition (Crisan *et al*., 2007; Jain *et al*., 2004) and provides many important biometric features:

- The uniqueness and permanence of the pattern
- The biometric parameter is hidden from the view
- Contactless detection procedure
- Almost impossible to forge fingervein or copy
- The vein pattern is sufficiently instigating to allow sufficient criteria to positively detect different, even identical, topics

The vein detection process consists of an easy-to-implement device that takes a snapshot of the subject's fingerveins under a source of infrared radiation at a specific wavelength. The system is able to detect the fingerveins but not the arteries because of the specific absorption of infrared radiation in the blood vessels. Almost any part of the body could be analyzed in order to extract an image of the vascular pattern but the fingers are preferred. Infrared radiation is absorbed differently in different types of tissue. In order to obtain a visual penetration through the respective tissues, the illumination must be carried out under a very narrow optical window, i. e., 740-760 nm (within the infrared part close to the spectrum of electromagnetic radiation). Due to the optical properties of human tissue, a sweeping device NIR vein can not penetrate very deeply under the skin, so, the device will recognize the superficial veins and rarely the deep veins (Valavan and Kalaivani, 2014).

Preprocessing: In the images of the vein of the finger, due to non-uniform illumination caused by diffuse reflection, unnecessary data and noise exists in the background, influencing the final recognition result. Any simple but effective way to deal with specular reflection on the finger vein can be used to enhance the recognition in this approach. The image enhancement is the main operation of the preprocessing. It is used to enhance the quality of an image. It is enhance the image contrast and characteristics of the brightness. Also, it is used to reduce the noisy pixel in the fingervein image. The certain features of interest in an image is highlights by this operation.

Moment invariant: Moment invariants are common characteristics of image used in the image processing, such as classification and shape recognition. Moments are providing properties of object in image which uniquely identify its form. In wide range of applications the moments invariants associated with them detail analyzation that characterize the image models. The moment invariants were proposed firstly Hu. Hu extracted six completely orthogonal invariants and an inverse orthogonal inverse based on mathematical invariants that are not only invariant of location, size and direction but also, invariant to parallel projection. The current invariants have been established to be the appropriate evaluation to draw image models based on the translation of the images, their scaling and rotation taking into the image that has continuous functions and has no noise. Moments invariants have been widely used in image model recognition, image recording and reconstruction (Huang and Leng, 2010).

Matching: Coincidence is the key procedure for deciding whether a particular image of the finger vein is genuine or imposing using a set of appropriate algorithms. In finger vein authentication is a process of individual matching that identify the vein of the finger. In fact, the comparison of characteristics is calculation task of similarity. For authentication of the finger vein identity of the user is confirmed as authentic if the similarity is greater than a previously defined threshold value. If the similarity is less than the threshold value, the user is considered an impostor. In the case of finger vein identification, the user can be confirmed as the one whose finger vein data has a maximum similarity score. Some standard performance indicators are used to quantitatively evaluate the performance and accuracy of a vein recognition system. The False Acceptance Rate (FAR) is the probability of accepting an unauthorized person as being genuine. The False Rejection Rate (FRR) is the probability of rejecting an authorized individual by treating him as an impostor. An ideal vein recognition system will have a low FRR and FAR (Miura *et al*., 2004).

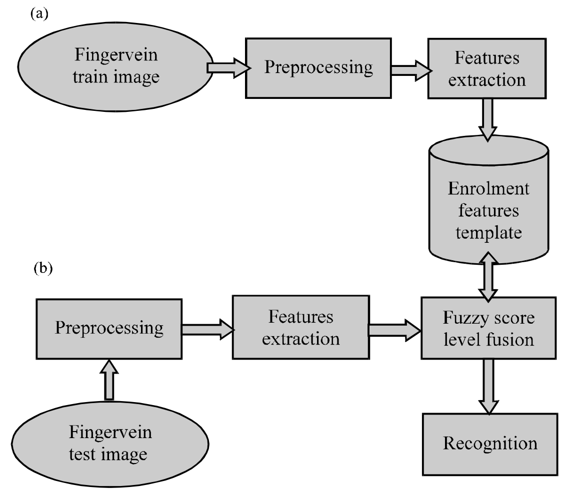

Fig. 1: The proposed fingervein recognition: a) Training phase and b) Training phase

MATERIALS AND METHODS

The development of the fingervein identification system is presented it is consist of two phases: the enrolment phase and the test phase. The image acquisition for the enrolment phase is the first step in the enrolment. Before features extraction, the preprocessing step is very important to enhance the quality of specific features and characteristics of the fingervein. Then the Region of Interest (ROI) is applied to crop the subimage of restricted fingervein area. After that the features are extracted from each image from the fingervein dataset. The features represent the moments that extracted from the grayscale image of fingervein which yields a feature vector containing scale, rotation and translation invariant moments. These features are reduced to constract the enrolment features template database. The second test phase represent the matching and recognition phase. The test image is acquires then the preprocessing operations are applied to enhance the image quality to facilitate the matching accuracy. The features of the test image, also are extracted in the same way of enrolment phase. The fuzzy logic is employed in the fuzzy score level fusion of the extracted features to build fuzzy set and rules that useful for identification matching operation. The last operation that identify the fingervein image status is the matching operation that used the Euclidian distance matching. The proposed model is illustrated in the following Fig. 1.

In the proposed system, the captured image is performed by placing a fingervein between an infrared light source and a camera. Near Infrared light (NIR) with a wavelength of 760 (850 nm) is transmitted through the back of the hand, penetrating deep into the skin while light radiation is absorbed by deoxyhemoglobin (Zharov *et al*., 2004). When hemoglobin absorbs light, ner veins appear as a shadow pattern. These vein patterns are enhanced in this stage. The original image is captured with size 320*240 pixels. Then the ROI of the image is cropped to get size around 310*120, depending of the width of the input finger. This cropped image is contain the almost veins in the central pixels of the fingervein image.this operation is performed to reduce the time consumed by the other processing.

Implementation: The fingervein identification system is implemented by Visual Studio. Net on hp labtop model ProBook 4540s with specification: Processor Intel (R) core i5 CPU 2.5 GH and RAM 6 GB. The dataset of fingervein images is applied for 25 left hand persons and 25 right hand person. Each person has the types of fengerveins index, middle and ring vein images. For each person there six images of index, six images of middle and six images of ring. Therefore, there are 900 fingervein image. Each image of size 320*240. The system is built as an image processing package contain the main image processing operation such as image cropping, enhancement filters, image normalization, histogram equalization and other operations. As shown in the model the features calculations and extraction is implemented where the system can be export or import these features template. The matching operation depend finding the nearest n-image features from the database features template by using fuzzy set concept, then the matching is applied on the nearest n-image only to reduce the execution time consuming. The following two algorithms shows the basic operation of the two main fingervein recognition phases.

Algorithm 1; Fingervein enrolment:
Input: Fingervein dataset images
Output: Extracted features template
Step 1: Fingervein dataset images acquisition
- a) Acquire train fingervein images folder
- b) Acquire training images one-by-one and apply following tasks in iterative fashion
- Step 2: Training image preprocessing
  - a) Find ROI
  - b) Convolute the median filter
  - c) Run Binary Conversion
  - d) Apply dilatation of binary image
  - e) Apply thinning

Step 3: Features extraction
- a) Find seven invariant moments
- b) Find area of fingervein image
- c) Find the corner points
- d) Computer the Standard deviation of each x and y in these points

Step 4: Compute the extracted features template

The step 2 is done for all fingervein image in the dataset. According to, the following sequence, let the input individual image is as shown in Fig. 2. Crop the ROI fingervein subimage as shown in Fig. 3. Apply the median filter as shown in Fig. 4. Convert the resulted finger vein image from Greyscale image into binary image using binary thresholding, shows Fig. 5. Apply dilation of binary image as shown the Fig. 6. The last operation of the preprocessing is the Zhang Suen Thinning operation and Invert as shown in Fig. 7. After of all the features are extracted.

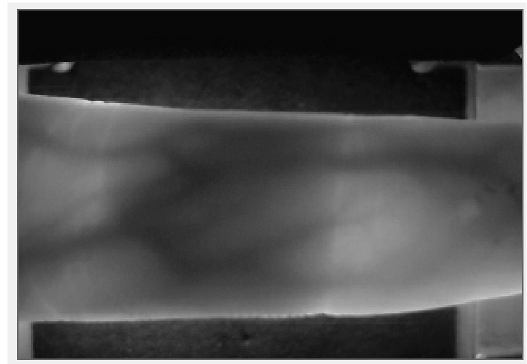

Fig. 2: The input fingervein image from NIR device

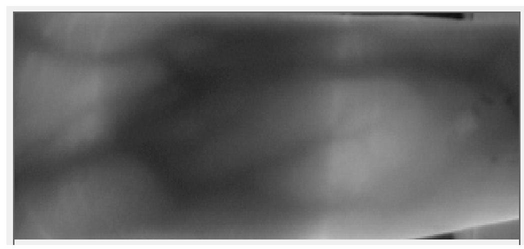

Fig. 3: The Find the ROI of fingervein

Fig. 4: Apply median filter

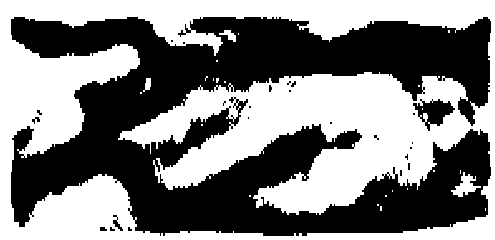

Fig. 5: Apply binary thresholdingg

Fig. 6: Apply dilatation

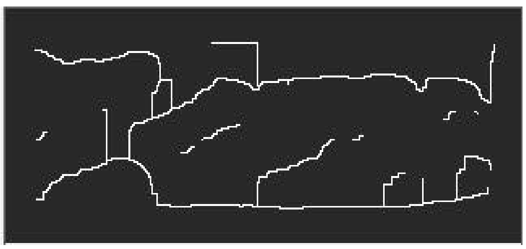

Fig. 7: Apply zhang suen thining and invert

Algorithm 2; Fingervein testing:
Input: Test fingervein image
Output: Identification
Step 1: Test image acquisition
 a) Acquire test image
Step2: Test image preprocessing
 a) Find ROI
 b) Convolute the median filter
 c) Run binary conversion
 d) Apply dilation of binary image
 e) Apply thinning
Step3: Features extraction
 a) Find seven invariant moments
 b) Find area of fingervein image
 c) Find the corner points
 d) Computer the standard deviation of each x and y in these points
Step 4: Apply fuzzy score level fusion for the extracted features
 a) Select most important features
 b) Apply fuzzy-logic to short-list the matching training samples according to the extracted features of each fingervein image
 c) Extract the most matching images according to fuzzy-sets
 d) Find shortest difference between comparison features using Euclidian distance formula
 e) Find n-most similarity matching of the test fingervein image
Step 5: Recognize fingervein as one of the n-most similar
 a) Find corner points of the test fingervein image
 b) For every n-most similar images find the corner points
 c) Find shortest distance between neighboring corner points
 d) Matching of the percentage matching greater than threshold m with shortest distance in the region and output matching
 e) Othewise, output no matching

Fuzzy score level fusion: In the recognition phase, the coincidence of the vein of the vein of finger was calculated in support of the use of Euclidean distance. If $u = (u_1, u_2, ..., u_n)$ is the characteristic vector of the fingervein image template and $v = (v_1, v_2, ..., v_n)$ is a vector characteristic of the fingervein image of the test phase, the score value of the fingervein image denited by F = d (u, v) calculated by the function of the Euclidean distance as shown in the following Eq. 1:

$$F = d(x,y) = \sqrt{\sum_{i=1}^{n}(y_i - x_i)^2} = \sqrt{(y_1-x_1)^2 + (y_2-x_2)^2 +, ..., +(yn-xn)^2} \quad (1)$$

Decision based on the diffuse merge score: after obtaining seven score values from the input images, the value of the final score must be calculated to determine whether the person is authorized or not. To combine these seven values, we used the fuzzy logic that provides the final value of the input images. Fuzzification: The corresponding score is given to the fuzzifier which converts the numerical data into linguistic values (high, medium and low) using the membership function. The membership function is a curve that describes how each entity notation is converted to an adhesion value (or degree of adhesion).

where a-c are characteristic parameters of a fuzzy set. Rule design: Definition of IF-THEN rules that are the main significant module in any fuzzy system. Here, seven input variables such as F1, F2 and F7 and an output variable are used. The rule defined in the rule base is: all seven values (F1, F2 and F7) is High (H) then the output is recognized. The extracted features parameters are:

- F1: the I1 of the image moments
- F2: the I2 of the image moments
- F3: the moments invariant
- F4: the area of the image
- F5: the number of corners in the image
- F6: the standard deviation of the X-axis of corners
- F7: the standard deviation of the Y-axis of corners

The required rules and membership functions are generated by the diffractive subtractive grouping technique. The rule extraction method first uses the subclass function to determine the number of rules and background functions and then uses the least squares linear estimate to determine the consecutive equations for each rule. The fuzzifier output is fed by the inference engine which in turn, compares this fuzzified input with the rule base. As a result, the score is determined and therefore, the output of the inference engine is one of the linguistic values of the next set {match and no match}.

RESULTS AND DISCUSSION

To examine the performance of the proposed fingervein recognition, we experimented using the method to identify a large number of models. The experiment included the evaluation False Acceptance Rate (FAR) in Eq. 2 and False Rejection Rate (FRR) in Eq. 3 for a near

Table 1: Fingervein recognition evaluation with distance 5 of fast corner detector

Distance		Matching rate	
Fast	Harris	FAR	FRR
5	11	0.06	0.04
5	9	0.04	0.06
5	7	0.02	0.06
5	5	0.02	0.08
5	3	0.20	0.12

infrared fingervein imaging dataset is computed. The results obtained from the proposed fingervein recognition with fuzzy score level fusion of the features attracted from moments and corner algorithm:

$$\text{FAR} = \frac{\text{Number of false accept}}{\text{Total number of taste between classes}} * 100 \quad (2)$$

$$\text{FAR} = \frac{\text{Number of false reject}}{\text{Total number of taste in same classes}} * 100 \quad (3)$$

The dataset contained 900 different infrared images of the fingerveins with six images per finger. The FAR was obtained by calculating the de-admission ratios using the five images of each finger and the FRR was obtained by calculating the mismatch ratios between the different finger images for all combinations. The classical method was evaluated independently in the same way. Each distribution was normalized by its maximum frequency. Most values in distributions for the same people were low, although, some were high due to a finger change. The distributions for identical and different fingers were almost completely separated from one another, demonstrating that personal identification can be performed using finger vein models. The proposed method produced a smaller region of overlap between the distributions for the same and for different fingers than the conventional method. In order to quantitatively evaluate these results, the FAR is calculated. Then, the rate of FRR which is defined as the ratio between the number of data in different fingers for which the mismatch ratio corresponding the total number of data in different fingers is calculated for all fingers. That is the error rate in personal identification was lower for the proposed method than for the conventional method. Therefore, the proposed methodology is more effective which means that the recognition of the fingervein with the proposed method is very effective.

Table 1 shows that the results of the proposed system where the fuzzy score level fusion give as the nearest match fingervein images. The corner point detector is used as a comparison technique to get the identical fingervein matching. In this phase two corner detectors are used and Harris techniques. The distance is the score of matching it has very effectiveness of matching rate and accuracy. The following results show that if we take a large distance the FAR is increase while FRR decrease. If the distance is decrease the FAR is decrease while the FRR is increase Table 2.

Tabel 2: Fingervein recognition evaluation with distance 5 of harris corner detector

Distance		Matching Rate	
Fast	Harris	FAR	FRR
11	5	0.06	0.00
9	5	0.04	0.02
7	5	0.02	0.02
5	5	0.02	0.08
3	5	0.00	0.12

The best result appear when distance of Fast corner detector is 7 and the Harris corner detector is 5. The threshold value of matching, also, effect the matching rate. Experimentally the best value of the threshold value for Fast corner detector is 75 while the best value of threshold value for Harris corner detector is 78.5. Finally, the accuracy of the proposed system is 98%. Therefore, the proposed methodology is more effective which means that the recognition of the fingervein.

CONCLUSION

The fingervein recognition technique is developed using the fuzzy algorithm based on diffuse images to improve the quality of the fingervein images which can be degraded by various factors such as the diffusion of the skin and the thickness of the finger. The seven Moment Invariant and the corner location is used for the fuzzy fusion method were determined using the STD in the local fingervein features template to pick up the neares n-fingervein images. Two techniques of corner detector are used for matching. Experimental results have shown that the accuracy of finger vein recognition has been improved using the proposed method compared to other imaging methods based on the fingervein dataset. The matching technique give accuracy 98%.

RECOMMENDATIONS

In future research, a vein of palm can be applied the proposed method. In addition, also can be test the possibility of applying this method to other biometric modalities such as face, iris and fingerprint images.

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