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MULTISPECTRAL PALMPRINT RECOGNITION USING ANT COLONY OPTIMIZATION

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ABSTRACT

Biometric authentication is an effective method for automatically recognizing a person's identity with high confidence in which feature extraction and classification are key considerations. Palm vein pattern biometric technology is a promising feature for use in forensic and access control application. It uses the unique patterns of palm veins to authenticate personals at a high level of accuracy. Our proposed work is to accommodate the rotational, potential deformations and translational changes by encoding the orientation conserving features. The proposed system analyses the palm-vein authentication on two different databases that are acquired with the contactless CASIA and touch-based imaging setup collected from PolyU palmprint database.

Keywords: palm vein, biometric, contactless method, ant colony, wavelet energy.

INTRODUCTION

Personal authentication and identification using palm vein has been the recent research area of interest [1]. Basically biometric authentication provides a non-transferable means of identifying people, i.e., the credentials used cannot be given or lent to another individual so nobody can get around the system- they personally have to go through the control point. Spoofing becomes very easy to perform when we use hand-geometry for authentication. Whereas vascular biometric like palm dorsal vein are extremely difficult to forge and at the same time have high user acceptance.

Palm vein authentication uses an infrared beam to penetrate the user's hand as it is held over the sensor; the veins within the palm of the user are returned as black lines, as only the deoxygenated blood would absorb the infrared radiation. From the studies made previously it is seen that every individual possess a unique pattern of palm vein, which is true even in case of twins. Hence this method provides a high degree of accuracy. And also because the palm vein patterns are internal to the body, this becomes a difficult method to forge.

RELATED WORK

The palm-vein imaging typically requires infrared illumination which is one component of multispectral illumination for the multispectral palm print imaging. Therefore, the multispectral palm print images inherently acquire palm-vein details. Prior work in the literature suggests the lack of any study to systematically compare the suitability of different feature representations for the palm-vein over different imaging setup protocols, such as contact free and constrained. In addition, the prior efforts have been more focused on the multispectral palm images, rather than on single (near-infrared) spectrum palm-vein images. Having studied the previous work on palm vein identification we invited ourselves to explore more and provide a better authentication system for real-world applications and ascertain the best possible performance from the near-infrared-based palm-vein identification.

In [2] researcher proposed a new technique using Palm-Vein Images and features are extracted using Gabor Filter. The performance of palm vein based identification system using the Gabor filter is improved by presenting two new approaches. The potential deformations, rotational and translational change are effectively accommodated with this approach by encoding the orientation preserving the features and utilizing a novel region-based matching scheme. In [3] the researcher studied contactless biometric system using palm print and palm vein features. It shows that the properties of uniqueness, stability and spoof-resilient are the reasons because of which hand vein has become potentially a good biometrics for personal authentication.

In [4] researcher presented a novel biometric system for person recognition using palm vein images. Here improvement in the performance of the verification system based on palm vein is done using an energy feature. Effective characterization of palm is done because the energy feature reflects the distribution of wavelet energy of all veins at various resolutions. In [5] researcher presented biologically inspired optimization can be transferred into an algorithm for discrete optimization. The application of ant colony optimization to continuous optimization is demonstrated. Also variants of ant colony optimization are discussed. In [6] researcher discussed palm vein recognition with local binary patterns and local derivative patterns. Effective descriptors are identified by investigating the operators and histograms of multi-scale Local Binary Patterns (LBPs). This approach is compared with Local Derivative Pattern (LDP) and is evaluated in the framework of verification and identification tasks.

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In [7] researcher explained the Mexican hat wavelet family application to point source detection in cosmic microwave background maps", here a detection technique in 2D images is proposed based on an isotropic wavelet family which is naturally constructed as an extension of the Gauss- Mexican Hat Wavelet pair. Here performance of these wavelets for dealing with the detection of point extragalactic sources in the cosmic microwave background (CMB) maps: a very important issue within the more general problem of the component separation of the microwave sky.

In [8] researcher presented edge detection of images using ant colony optimization and fisher ratio. Here the researcher proposes edge detection which is inspired from Ant Colonies, is fulfilled by Ant Colony Optimization (ACO). For the determination of threshold calculation, a novel technique of Fisher ratio (F-ratio) is used.

MATERIALS AND METHOD

Studying the previous works in the field of palm vein authentication, it is seen that extraction of feature is the important process. Previous works using either single feature extraction or multiple feature extraction with which further processing and computations become complicated and moderately accurate. In this paper, we propose to calculate the energy levels of the vein and form a pattern based on the output. It is highly accurate because the energy level of the vein varies even with respect to its blobs. And so the pattern extracted for each individual will be highly distinctive. Also, since we use multiple images for a single person the problem of rotation, stability and invariance are greatly reduced. This means that the false acceptance ratio and false rejection ratio are very less. Thus the identification of individuals is highly accurate.

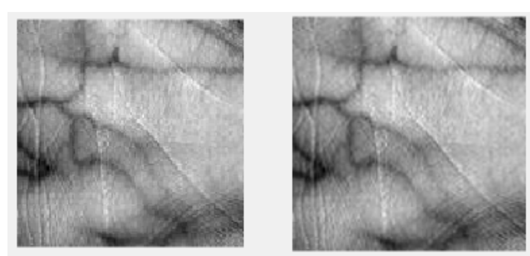
Wavelet energy allows complex information such as images and patterns to be decomposed into elementary forms at different positions and scales and subsequently reconstructed with high precision [6]. The optimization is done by using Ant Colony Optimization technique which is one of the biologically inspired optimization techniques. ACO algorithms have the advantage that it can be run continuously and adapt to changes in real time [7] even if the graph tends to change dynamically. The greatest characteristic of SIFT algorithm is scale invariance [8]. The procedure of SIFT mainly includes three steps: key point detection, descriptor establishing, and image feature matching. The performance of SIFT by adjusting these steps.

The classification is done by using Support Vector Machine (SVM) technique. There are four main advantages: Firstly, it has a regularization parameter, which makes the user think about avoiding over-fitting. Secondly, the kernel trick is used that builds an expert knowledge about the problem via engineering the kernel. Thirdly an SVM is defined by a convex optimization problems (no local minima) for which there are efficient methods (e.g. SMO). Lastly, it provides an approximation to the test error rate.

Pre-processing

The images captured are more often prone to many variations in position, direction and stretching degree. Even the image of a same person may have deviations when acquired at different times. In order to establish a standard dimension for computing the varied size of images are aligned to particular scale and the region of interest is extracted. In this research the dimension chosen is 300 x 300.

Once the image is acquired it requires some processing to be done so that it becomes suitable for computation. Pre-processing includes resizing of the image, which is necessary because we need a standard dimension for calculations. This is followed by extraction of the desired segment of the image. Hence we need to crop the image for the ROI (region of interest). The selected ROI is subjected to a filtering process remove any of the noises, basically distortion, present in the image. The filtering technique used is the averaging neighborhood pixel filter. The input image is resized from 128x128 to 300x300 which is shown below Figure-1. The resized image is selected for the region of interest which is enhanced by sing an average neighborhood filter which is shown in Figure-2.



(i) (ii)

Figure-1. Preprocessed multispectral palm print image, (i) input image 128x128, (ii) resized image 300x300.

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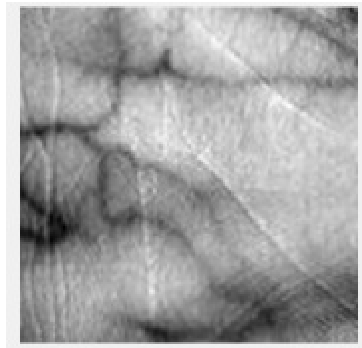

Figure-2. Enhanced image (output of average neighborhood filter).

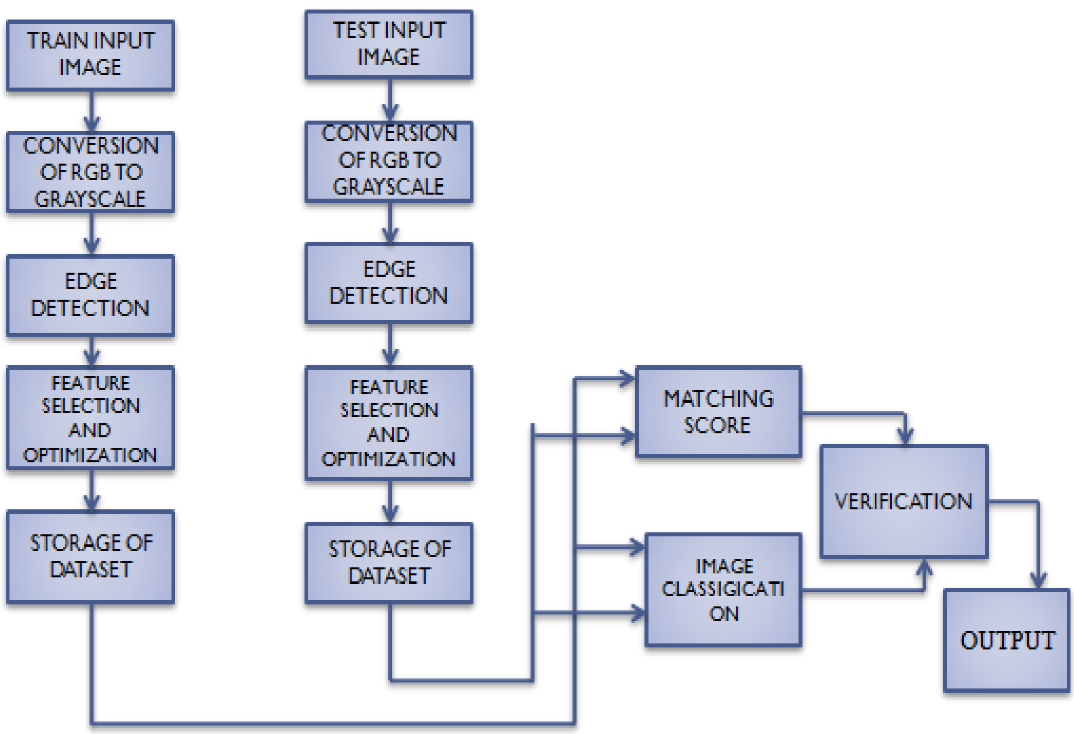

Figure-3. Proposed multispectral palm print image based recognition.

The image is acquired from palmprint sensor. If the acquired image is a color image it is converted to grayscale image for ease of processing. Edge detection is performed on the image by using Canny Edge detector. Selection of feature and optimization is done by the Ant Colony Optimization technique. Resizing of the selected feature is done using filters. The above mentioned steps are carried out for each of the training image and test images. Separate dataset is created where the information is stored. Comparing the training image and test image is done by calculating the Euclidean distance between them. The Result is obtained as a percentage of similarity, False Acceptance Ratio (FAR), False Rejection Ratio (FRR). The test is to be found to which class (person) it belongs to. This classification is done by using Support Vector Machine (SVM) technique. This entire process is shown as a flow chart in the Figure-3.

Wavelet energy calculation

Palm veins are lined structures with changing width, whose gray level values differ from the background. They have basic features like principle lines and ridges that differ in resolution. Wavelet energy is the novel feature that reflects the energy distribution of these principle lines [9] [10]. This ensures efficient characterization of the palm vein pattern. These are

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powerful tools of multi-resolution analysis which have been used widely. The principle lines of the palm vein pattern are non-oscillation pattern and so the amplitudes of wavelet coefficients increase when the scale of wavelet decomposition increases.

The complete process to compute WEF of a palm vein pattern is as follows:

- Orientate the palm vein image.
- Crop an NxN rectangular sub-image from the center of the palm.
- Decompose this sub-image to the Jth scale by a 2D wavelet transform.
- Divide each detail image into SxS non-overlapping blocks.
- Compute the energy of each block and construct the feature vector.
- Normalize this vector to form the WEF.

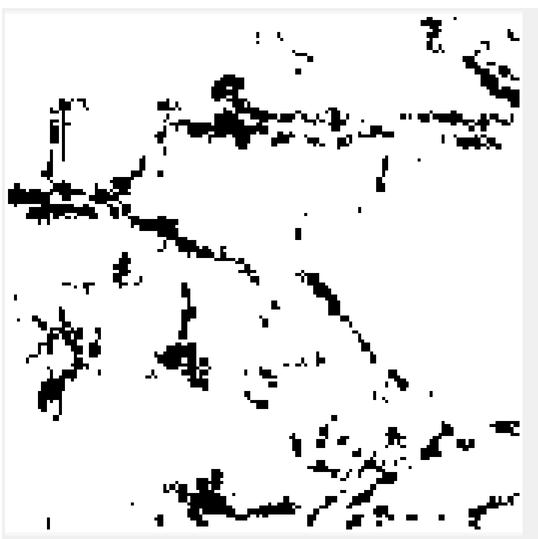

Figure-4. Output of ACO Edge detection.

SIFT algorithm

A common requirement for feature extraction and representation techniques is that the features used to represent and the image must be invariant to Rotation, Scaling and Translation collectively called as RST. The invariance of RST ensures that a machine vision system will still be able to recognize objects even when they appear at different sizes, different positions within the image and angle. To achieve this we use the Scale Invariant Feature Transform. It generates one of the features of image called “key points” [11] that are invariant to image rotation and scaling, and partially invariant to change in illumination. Any number of key points can be extracted from typical images and these are highly distinctive [11].

$$L(x,y,\sigma) = G(x,y,\sigma) * I(x,y) \quad (1)$$

where, $G(x,y,\sigma) = \frac{1}{2\pi\sigma^2} e^{-(x^2-y^2)/2\sigma^2}$

Key points are detected using scale-space extreme in difference-of-Gaussian function D.

D definition:

$$D(x,y,\sigma) = (G(x,y,k\sigma) - G(x,y,k\sigma)) * I(x,y) \quad (2)$$

$$= L(x,y,k\sigma) - L(x,y,\sigma)$$

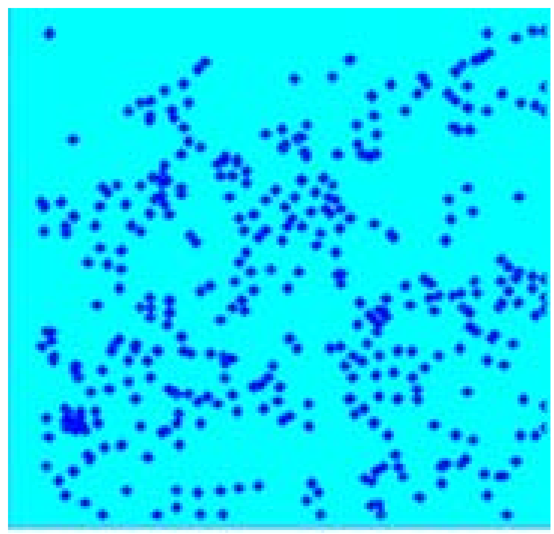

Figure-5. Key point mark on the ROI image.

In the phase of descriptor establishing, SIFT only describes local information and does not make use of global information. E. N. Mortensen [12] introduced a SIFT descriptor with global context (called GSIFT), which adds a global texture vector to the basis of SIFT. In the phase of key point detection, SIFT only uses grayscale information of an image. A lot of color information is discarded for color images. A. A. Farag [13] proposed CSIFT, which adds color invariance to the basis of SIFT and intends to overcome the shortcoming of SIFT for color images. For the edge detected output, which is shown in Figure-2, the key points are detected using SIFT algorithm. These key points are depicted in the form of graphs which is shown in Figure-5. The corresponding magnitude and orientations are depicted in the Figure-6.

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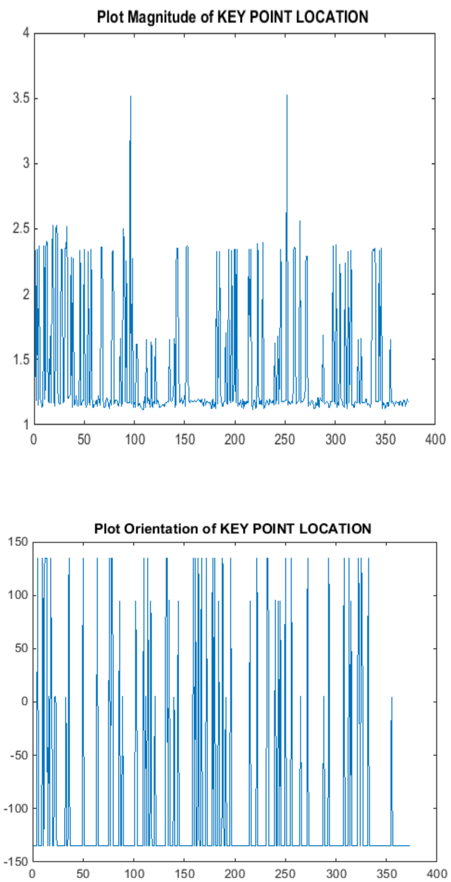

Figure-6. Key point mark for magnitude and orientation.

Optimization using Ant Colony

Feature extraction and reduction of pattern dimensionality is the most important step in a pattern recognition system. Ant colony optimization is a paradigm for designing a meta- heuristic [14] algorithm for the combinational optimization problem. Classifier performance and the length of the selected feature vector are adopted as heuristic information for ACO. Because of which the selection of the optimal feature subset is possible without prior information. It is easy to implement this approach and computational complexity is made low because of using the simple classifier. It has the advantage of distributed computing. It is also robust and easy to accommodate with other algorithms.

Classification using SVM

The Support Vector Machine (SVM) was first proposed by Vapnik and has since attracted a high degree of interest in the machine learning research community [15]. SVMs provide a learning technique for pattern recognition and regression estimation [16]. SVM provides the solution which is theoretically elegant, computationally efficient and very effective in many large practical problems. It has a simple geometrical interpretation in a high dimensional feature space that is nonlinearly related to input space. By using kernels all computations keep simple.

A bound on the Generalization Performance of Learning Machine
Expected Risk

$$R(\alpha) = \int \frac{1}{2} \left| y - f(\vec{x}, \alpha) \right| dP(\vec{x}, y)$$

Empirical Risk

$$R_{emp}(\alpha) = \frac{1}{2l} \sum_{i=1}^{l} \left| y_i - f(\vec{x}_i, \alpha) \right|$$

$$R(\alpha) \le R_{emp}(\alpha) + \sqrt{\left(\frac{h(\log(2l/h)+1) - \log(\eta/4)}{l} \right)}$$

The VC dimension is a property of a set of functions, and can be defined for various classes of function. The dimension of VC for the set of functions is defined as the maximum number of training points that can be shattered by VC dimension gives concreteness to the notion of the capacity of a given set of functions. The number of parameters of Learning Machines is not proportional to the VC dimension. The decision boundary hyper plane should be as far away from the data of both classes as possible.
The optimization problem is as follows:

1. Let {x1, ..., xn} be our data set
2. And let $y_i = \hat{I}\{1,-1\}$ be the class label of x_i
3. The decision boundary should classify all points correctly Þ $y_i(w^T x_i + b) \ge 1, \forall i$
4. A constrained optimization problem

$$Minimize \frac{1}{2} \|w\|^2$$

Subject to $y_i(w^T x_i + b) \ge 1, \forall i$

(The numbers inside the brackets denote which particular sample among the four samples of the subject has been taken for computation.)

Table-1. Comparison of images by fixing various threshold values.

Person	**Images**	**Threshold** (85%)	**Threshold** (90%)	**Threshold** (95%)
1	1-4	87 (1st)	92 (3rd)	97 (4th)
2	5-8	86 (6th)	95 (8th)	94 (7th)
3	9-12	89 (9th)	93 (11th)	93* (11th)
4	13-16	92 (13th)	90 (15th)	96 (16th)
5	17-20	83* (17th)	95 (18th)	97 (19th)
6	21-24	93 (21th)	92 (23rd)	93*(21st)
7	25-28	92 (26th)	86* (27th)	94*(28th)
8	29-32	89 (29th)	90 (30th)	96 (32nd)
9	33-36	90 (33rd)	90 (33rd)	96 (35th)
10	37-40	95 (37th)	94 (38th)	98 (40th)

*Similarity doesn't match

In the above tabulation (Table-1) we show the various threshold values. For every individual four samples are taken and are computed by fixing low, moderate and high threshold values. The images for which the similarity values are above the threshold value are only accepted. Even the input test image that belongs to the particular person fails to get selected if its similarity value falls below the threshold value. In the same way, when an image that doesn't belong to the particular person is input, it might get accepted because of its falsely generated similarity value that exceeds the threshold value. This is known as a false acceptance ratio (FAR). Hence fixing of threshold becomes a difficult job. If it is too, low then FAR will be more. On the other hand, if the value is too high then FRR will be more

Database

The PolyU database consists of 6000 images of palm vein, captured from 500 subjects. Images from this database undergo ROI extraction. The ROI extracted images are then processed to extract multiple features of palm vein. Matching is done to check for the accuracy of the proposed method.

CONCLUSIONS

This paper investigates a novel approach for personal authentication using palm vein images. After preprocessing of the vein images, edge detection and optimization is done using an ant colony method. Since we use multiple images for training the accuracy is high compared to the earlier methods. Compared to the previous methodologies we achieve accuracy of about 98%. Since we calculate the energy pattern of the vein it is highly distinctive for every individual. So wavelet energy is calculated for every image which will ensure the accuracy of the proposed method.

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