Palm Vein Identification Using Radon Transform: RBF Approach

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Abstract:

In this paper, a new biometric method based on palm veins recognition is developed. The main goal is to study the possibility of a contactless identification of individuals by using a sequence of palm veins images captured by a camera in the near infrared. This method is based on radon transform for features extraction and radial basis function RBF for classification and identification. This approach shows that the palm veins pattern is unique for each individual and encouraged results shown the good performance of the radon transform and the RBF network for classification.

Keywords: Palm Vein, Radon Transform, Neural Network, RBF.

1. INTRODUCTION

Personal identification systems are becoming more important and used in our daily life, whenever you want to access internet, withdraw money, enter a private region, etc... you are asked to prove or identify yourself by IDs, cards, and passwords. But such technology is not safe because cards, IDs, and passwords can be easily stolen or forgotten. The solution was the biometric technologies which passes the mentioned disadvantages. Biometric technology is the use of behavioral or physiological characteristics of an individual to identify him. Nowadays there are many biometric methods that are in use or under study, such as ECG, fingerprint, iris, retinal, hand geometry, finger-vein [1].

In this paper, a new biometric feature authentication technology using palm-vein patterns is proposed. Unlike other biometric identification technology, palm-vein identification method is more safe and hard to replicate since veins are internal to the human body. Moreover, palm-vein identification does not involve touching the sensor, and it is detected by a CCD camera through near-infra-red filter. The infra-red LED light with 760–1000 nm can pass through the skin of the finger while the hemoglobin in the vein can absorb the infra-red light. Because the reflections of the veins are less than their surroundings, the palm-vein pattern can be observed with an infra-red sensitive CCD camera.

The palm-vein identification has some advantages compared to other biometric authentication techniques. The advantages of this method are: (1) Non-contact: are not influenced by skin conditions. (2) Live body identification: Identification of the palm-vein pattern can be taken on a live body. (3) High security: the vein pattern is an internal feature and difficult to forge.

The palm vein identification system consists of image preprocessing, feature extraction and classifier. In our research, radon transform is used for feature extraction and image classification using artificial neural network and especially the RBF. The radon transform concentrates the information in a few high valued coefficients in the transformed domain [6]. Artificial neural network are widely used in pattern recognition and image classification. Radial Basis Function (RBF) is used in our study for image classification and identification.

The block diagram of our system shown in the figure will be described in the following sections.

Figure 1: General Block Diagram of Our Study.

2. IMAGE ACQUISITION AND PREPROCESSING

PS3 camera was converted into infra-red camera by replacing its infra-red filter by a negative album. The camera implanted inside a closed box with an array of infra-red led (wavelength: 850 nm) surrounded it. The images were taken by the reflection of the infra-red rays from the hand to the cam (figure2). Acquisition was done for the right hand at 25cm far from the cam in the horizontal position and the size of a vein image captured is 640×480 pixels (figure3).
The acquired images by the PS3 camera are converted to grey images for the processing. Our interest is to obtain the palm region, so it must be cut from the hand by using a rectangle which has a start point A, length \((A \rightarrow B)\), and width \((B \rightarrow C)\) (figure 4). First of all get the contour of the image then detect the three points (A, B, and C).

By detection these points, the palm is cropped and we obtain the total region of interest in order to detect only the palm veins. (figure 5).

The image is then adjusted for better contrast and intelligibility of veins (figure 6).

To remove noise, an anisotropic diffusion filter is used. It has been shown that diffusion filters can be used to enhance and detect object edges within images [2, 3]. The use of nonlinear diffusion equations in image processing was introduced by Malik and Perona in 1990 [2]. The idea of the diffusion filter consists of applying the physical process of diffusion to an image where the concentration balance between the molecules depends on the density gradient. In other words, the anisotropic diffusion filters smoothen more over homogenous region and lessen or stop when it falls on a discontinuity on an edge. It is given by:

\[
\frac{\partial u}{\partial t} = \text{div}(g(\|\nabla u\|)\nabla u)
\]  

(1)

The diffusivity becomes a decreasing function of the modulus of the gradient, called diffusion function. The functions \(g\) proposed by Perona and Malik are:

- The Gaussian function:
  \[
  g(\|\nabla u\|) = \exp(-[\|\nabla u\|/k]^2)
  \]  
  (2)

- The lorentzian function:
  \[
  g(\|\nabla u\|) = 1/(1 + ([\|\nabla u\|/k]^2))
  \]  
  (3)

With \(k\) the gradient modulus threshold that controls the conduction, it serves to draw the line between the gradients corresponding to transitions to maintain, and low gradients corresponding to the noise. In our approach, we used the Gaussian function (figure 7).

Once the image is filtered, a line detection mask is applied to extract the palm veins. We use a “convolution kernel” to detect lines of width \(n\) and orientation \(\theta\). The kernel filter is applied in four directions. The figure below presents the vein segmentation for 2 different individuals. (figure 8).
4. FEATURE EXTRACTION USING RADON TRANSFORM

Once palm veins are detected, we select the ROI and we apply the radon transform in order to extract the features for classification. The Radon transform is used to detect straight lines in an image. It is the projection of the image intensity along a radial line oriented at a specific angle (figure 9) \([4]\). Let \(f(x,y)\) the ROI of the palm vein image and \(R_f(\rho, \theta)\) its radon transform given by:
\[
R_f(\rho, \theta) = \iint f(x,y) \delta(\rho - x\cos \theta - y\sin \theta) \, dx \, dy \quad (4)
\]
where \(\theta \in [0, \pi]\), \(\rho \in [-\infty, +\infty]\) and \(\delta(.)\) is the Dirac function defined by \(\delta(t) = 1\) if \(t = 0\) and \(\delta(t) = 0\) otherwise.

The Radon transform of \(f(x,y)\) is the line integral of \(f\) parallel to the \(y'\) axis. Thus equation (4) can be expressed as:
\[
R_\theta(x') = \int_{-\infty}^{+\infty} f(x'\cos \theta - y'\sin \theta, x'\sin \theta + y'\cos \theta) \, dy' \quad (5)
\]
where
\[
\begin{bmatrix}
  x' \\
  y'
\end{bmatrix}
= \begin{bmatrix}
  \cos \theta & \sin \theta \\
  -\sin \theta & \cos \theta
\end{bmatrix}
\begin{bmatrix}
  x \\
  y
\end{bmatrix}
\]
(6)

5. NEURAL NETWORK APPROACH: RBF

The Radial Basis Function (RBF) neural network is used to classify individuals. The RBF neural network, a class of supervised neural networks, consists of three layers: input layer, non linear hidden layer and linear output layer \([5]\). The figure 10 shows the architecture of the RBF network, which is similar to a traditional back propagation neural network (BPNN).

The input layer in our neural network corresponds to the parameters extracted from the radon transform applied to the images. The activation function often used in this type of network is a symmetric and radial function. In our approach, the activation function used in the hidden layer is the Gaussian function.

6. RESULTS AND DISCUSSIONS

Radon transform is applied to the different images acquired by the PS3 camera for feature extraction. Figure 11 shows the application of the radon transform for 2 different images corresponding to two different individuals. The figure shows the different of the position of the strong peaks energy, which are corresponding to the straight lines in the original images.

Experimentally the maximum 15 coefficients from the radon transform application are used as the inputs of the neural network. 100 images are used in our classification correspond to 10 different individuals. We took 10 images from each individual, 5 images for the training set and the other 5 images for the test.

The table below shows the performance of the RBF network in the individual classification.
The results showed the performance of this biometry method with identification rate equal to 90%. Palm veins pattern is unique among people even twins don’t have same pattern which makes from palm veins biometry a new involve in the world of security. It can be applied in the most security places over the world with no fear of any penetration would happen.

### 7. CONCLUSION

In this paper, we have developed a new biometric method based on palm veins pattern. This approach required three stages: image preprocessing involving contrast enhancement, smoothing and segmentation, feature extraction using Radon transform and finally classification with RBF neural network. The coefficients of Radon transform images are indeed the inputs of the neural network. The proposed method provides high performance. As a future outlook, the effect of rotation of the geometry of the hand and the effect of dynamic identification accuracy must be study.

### REFERENCES:


