Hand Vein Infrared Image Segmentation for Biometric Recognition

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Abstract. In this paper we propose a technique for extracting vein regions from infrared hand images; this technique analyzes the geometry of the hand to get the vein patterns for being used in recognition. Commonly, the vein points extracted are used as geometric representation of the vein patterns which are matched with the representation of the images in a database. This paper also presents a preprocessing technique to obtain the Region of Interest (ROI) from low contrast images.

Keywords: Biometry, Hand vein recognition, Infrared image segmentation

1 Introduction

In Computer Science, Biometric Recognition is the science of identifying a person based on the physiological and/or behavioral characteristics; these characteristics are known as biometrics and for every person, they have special features such as: Universality, Uniqueness, Permanence and Measurability [1]. Some examples (Fig. 1) of typical biometrics are: Iris, face, palm print, signature, finger print, ear, among others [2, 3, 4].

Biometric Recognition is commonly an automatic technique used in our digital age; in this context, a computer system designed for person identification is named biometric system. Some biometric systems consist of the following phases:

-Capture. This stage is related to the acquirement of the biometric through a digital capture device or sensor (e.g. camera, scanner, microphone).

-Pre-processing. This module respects to the steps for preparing the information to be analyzed from the biometric. When the biometric is stored as a digital image, the pre-processing steps are: cleaning (of noise), contrast enhancement, sharpen, equalization, among other processes. Pre-processing is an important phase since the better quality of information provided to the biometric system the higher recognition rate is achieved.

-Feature extraction. This stage extracts the most relevant descriptive components (minutiae) that describe to the biometric. The main processes involved in feature extraction are the Region Of Interest (ROI) extraction and segmentation; the goal of both processes is the isolation of the region where there exists relevant and descriptive information about the biometric.

-Recognition. This is the last phase in a Biometric Recognition system and uses the features extracted to analyze and determine the person's identity. Commonly, classifiers (supervised, non supervised) are used in this recognition stage.

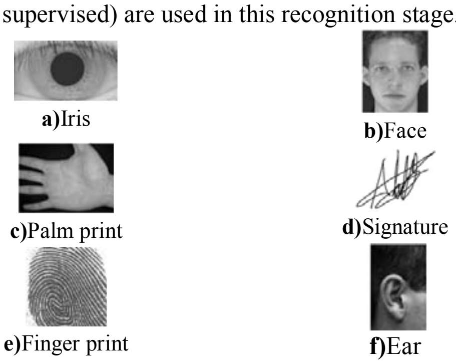


Fig. 1. Biometrics commonly used for person recognition **a)**Iris, **b)**Face, **c)**Palm print, **d)**Signature, **e)**Finger print, **f)**Ear

In this work, we focused in the pre-processing stage and the ROI extraction for a Biometric Recognition system based on dorsal hand vein as biometric.

Compared to typical biometrics, vein recognition is a new member of the biometric family. This technology started in the 1990s, but it did not attract much attention in that decade. Since 2000 year, few papers on this topic have been published and nowadays, there is not a vein pattern database for free access; as a result, each researcher has to collect and create the vein images dataset.

Hand vein are commonly captured by digital cameras operating in the visible range (400-700nm wavelength) of the electromagnetic spectrum i.e. illuminating the region to capture using visible light. In the captured images it is difficult to discern the veins since in some cases the person's veins are not superficially visible. Fortunately, the Infrared (IR) light (2.5-50μm wavelength) could help us. IR light is a non visible light that penetrates into the skin about 3mm. Due to the hemoglobin properties in the veins, it absorbs the infrared radiation and as consequence, the veins are contrasted in a dark color. When IR light is used to capture dorsal vein images, it is necessary to capture via IR cameras which are named thermal cameras and the captured images are named thermal images [5].

One of the main problems using thermal image recognition is the low contrast, because in the image it is not easy to distinguish components that could be simple to recognize for the human eye. Unfortunately there is not a global solution to this problem, but there are useful methods for specific cases.

It is important to have a special mention about the vein pattern, which is a vast network of blood vessels underneath a person's skin. Like fingerprints, the shape of vascular patterns is believed to be distinct among different people [6-8], and very stable over a long period of time. In addition, as the blood vessels are hidden underneath the skin and they are mostly invisible to the human eye, vein patterns are more difficult to copy by intruders (in comparison to other biometrics such as signature).

A key part of hand dorsal vein biometric is the difference with other similar biometrics because its recognition requires analyzing alive people, putting special attention that when person is not alive the vein pattern would change, also pressure, temperature, color and other similar characteristics. Hand veins can prevent a possible misuse that could occur affecting the user, considering that there are several myths about the misuse with the fingerprints when they do not require vitality by the biometric(e.g. mutilations by intruders that would damage both the users' integrity and users' body).

The properties of hand vein make it a potentially good biometric which offers secure and reliable features for person's identity verification.

2 Hand vein IR image pre-processing

As it was mentioned before, it is not easy to obtain a pattern from a raw hand vein IR image. For this reason, the ROI extraction, segmentation and contrast enhancement are necessary for the recognition face in a Biometric Recognition system. In the following sections, we present an approach for extracting ROI and segmenting hand vein IR images.

2.1 ROI extraction and segmentation

In Fig. 2, a couple of hand vein IR images with low contrast are shown. In order to locate the ROI in these low-contrast cases, it is necessary to isolate the hand in the scene, so we need to get a mask in order to delimit the hand.

As initial step, we propose to use a 3x3 Median filter to eliminate the possible noise of the image. After that, to get the position of the hand, we use a Sobel Filter to find the area with most edges. After edges are obtained, we apply a horizontal white filling (6px) that is a simple process which take every white pixel and look at the 6 neighbor pixels left (in this case), and if it finds a white pixel then it fills the pixels to white until that pixel; then a vertical white filling process is applied, which takes every white pixel and fills in white every pixel above (Fig. 3b).

For each column, the mean is calculated to create a histogram and find the valley points, see Fig. 4a where:

P1 is originally the valley point between the small finger and the ring finger.

P2 is originally the valley point between the index finger and the thumb.

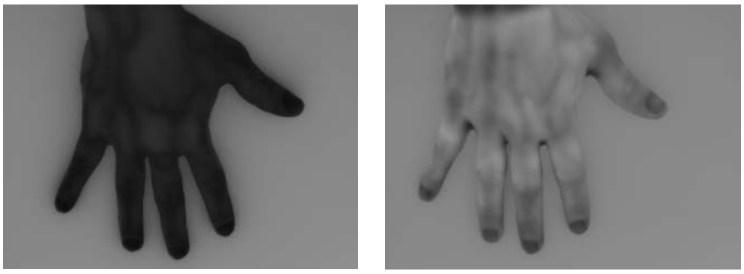


Fig.2. IR hand vein images of two hands captured in different environments

a) **b)**

Fig.3. Creating the Mask. **a)** IR hand vein image. **b)** Hand Mask obtained from **a)**

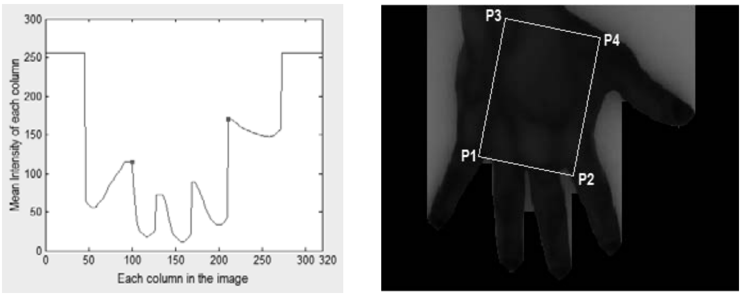
The Euclidean Distance *D* between *P1* and *P2* is calculated to be used as a reference of the hand dimensions. Then point *P2* is adjusted to estimate the position of the valley point between the middle finger and the index finger (*X* position is *D*4/7* from *P1* and *Y* position is at the same height than *P1-D/7*). *P1* is adjusted to estimate the actual position of the valley point between the middle finger and the index finger (*Y* position is *Y+D/14*).

The ROI is therefore defined as a rectangular region $R_{P1P2P3P4}$ (Fig. 4b). Where $\overline{P1P3} = 1.4 * \overline{P1P2}$. The process of defining the ROI is shown in Fig. 3 and Fig. 4. The reason for extracting the ROI in this manner is because it ensures all the ROIs reference to the same region in the hand image, and it is irrelevant to the size of the hands; in addition, extracting ROI based on hand landmark will increase the tolerance of the system against hand rotation and low contrast.

The image depicted in Fig. 4b shows the result of the extracted ROI from the hand image in Fig. 3a.

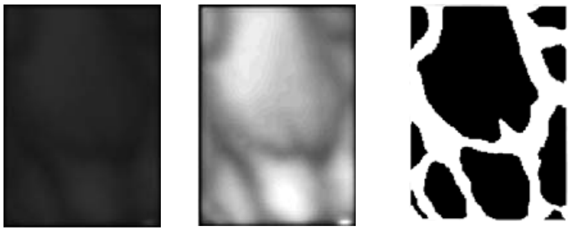
2.2 Image Enhancement

The vein pattern show different clearness among different images. That is why it is necessary to enhance the contrast in the images, for this purpose, we propose to apply a 5x5 Median Filter to remove the speckling noise in the images. Then a 2-D Weiner filter as suggested by Hong et. al. [9] was applied to the ROI in order to eliminate the high frequency noise. The intensity of the image is normalized and later thresholded as suggested in [10]. Fig.5b shows the vein region image after ROI enhancement with noise reduction and normalization. Fig. 5c shows the enhanced ROI after applying the local thresholding binarization.



a) **b)**

Fig.4. Defining the ROI. **a)** Intensity Histogram. **b)** Locating the ROI



a) **b)** **c)**

Fig.5. Preprocessing of IR vein pattern images. **a)**ROI for the hand image in Fig. 2a). **b)** After noise reduction and normalization. **c)** After local thresholding with global reduction.

Table 1. Features of the **ETIP**- 7320 P-Series Infrared Camera Highlight used in our experiments

Detector	Microbolometer 320 x 240 UFPA VOX
Spectral Response	7 to 14 microns
Video Update Rate	50-60Hz (16bit digital)
Accuracy	±1°C or ±1%
Thermal Sensitivity	27 mk
Operating Temperature	-20C to 50C

2.3 Experimental Results

For applying our approach, we captured IR hand vein images in different environment temperature conditions. For capturing the images we used the ETIP 7320 P-Series Infrared Camera described in Table 1.

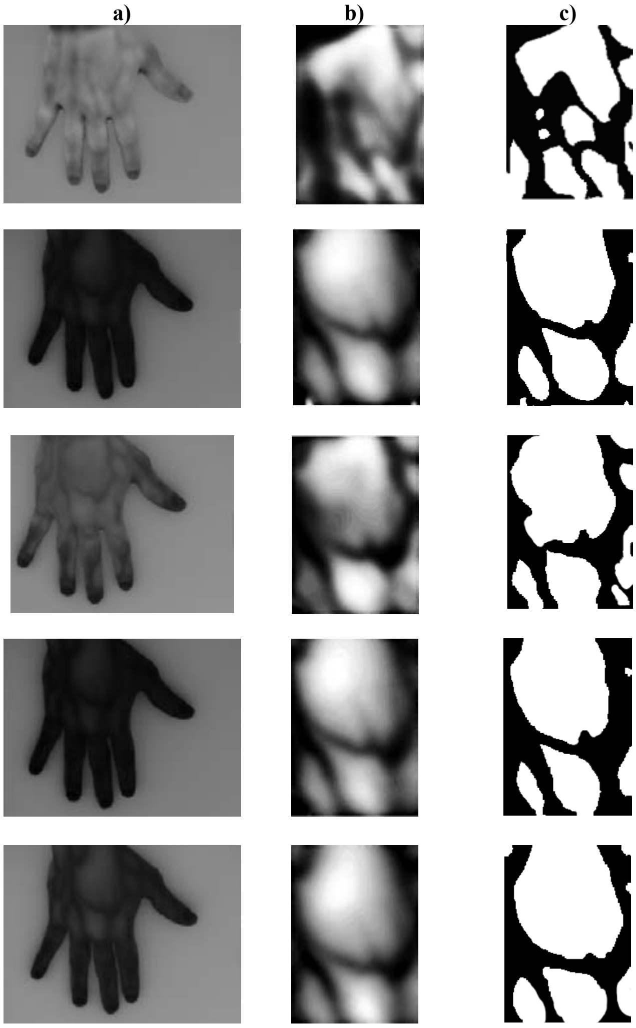


Fig.6. Results obtained for segmenting IR hand vein images. **a)** Original IR hand vein image. **b)** After ROI extraction, noise reduction an normalization. **c)** After local thresholding.

Some results obtained by our approach are shown in figure 6, where it can be noticed that our approach is able to segment and isolate the ROI related to dorsal hand vein IR images with low contrast which is the main problem to face when trying to analyze biometric digital images.

The proposed method can be used to segment images in low contrast and variable gray-level intensity in IR hand vein images. This technique allows being implemented in variable temperature environments.

3 Conclusions

This paper shows a technique to segment the vein patterns in the human hand, with the purpose of recognize and get the minutiae points. This technique may be used to process low contrast images, even when it is not a global solution because it can be affected by motion or rotation; it is enough to be used in several cases. It is very important to highlight that with this approach is possible to recognize a person in different environments. Hand vein biometric has a special characteristic because for recognizing a person through this biometric it is necessary that the person stays alive.

As it was mentioned in the introduction, this initial research work is related to the pre-processing and feature extraction (ROI extraction) stages in a biometric system. Then, as future work we will apply morphological operators for thinning the hand vein segmented and then extract the features like bifurcation regions which will be the input of some classifiers (Neural Networks, Support Vector Machines) for the recognition stage.

Acknowledgment. This work was supported by the projects OLLJ-ING14-I VIEP-BUAP (Puebla, Mexico) and PROMEP/103.5/12/7954 UPSIN-PTC-015 (Sinaloa, Mexico).

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