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# Palm vein recognition using adaptive Gabor filter

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ABSTRACT

Vein pattern recognition is one of the newest biometric techniques researched today. One of the reliable and robust personal identification authentication approaches using palm vein patterns is presented in this paper. In our work, we consider the palm vein as a piece of texture and apply texture-based feature extraction techniques to palm vein authentication. A Gabor filter provides the optimized resolution in both the spatial and frequency domains, thus it is a basis for extracting local features in the palm vein recognition. However, Gabor filter has many potential parameter combinations to use, and it is a common practice now to use multiple Gabor filters or to determine desired single combination by experience. The overall aim of this work is to discuss the optimization algorithm that determines the best parameter values of a single Gabor filter for palm vein recognition. In order to obtain effective pattern of palm vascular, we proposed an innovative and robust adaptive Gabor filter method to encode the palm vein features in bit string representation. The bit string representation, called VeinCode, offers speedy template matching and enables more effective template storage and retrieval. The similarity of two VeinCodes is measured by normalized Hamming distance. A total of 4140 palm vein images were collected form 207 persons to verify the validity of the proposed palm vein recognition approach. High accuracy has been obtained by the proposed method and the speed of this method is rapid enough for real-time palm vein recognition. Experimental results demonstrate that our proposed approach is feasible and effective in palm vein recognition.



## 1. Introduction

In this age of digital impersonation, biometric techniques are being used increasingly as a hedge against identity theft. The premise is that a biometric—a measurable physical characteristic or behavioral trait—is a more reliable indicator of identity than traditional methods. Traditional personal verification methods rely heavily on the use of passwords, personal identification numbers (PINs), magnetic swipe cards, keys, smart cards, etc. No matter which method is employed, it offers only limited security. Many biometric recognition systems dealing with various human physiological features or behavior including facial images, hand geometry, fingerprints, palm prints, retina, handwriting signature, and gait (Jain, Bolle, & Pankanti, 1999) have been proposed to improve the security of personal verification. Each of these systems has merits and demerits. In the case of fingerprints, direct contact of the finger with the fingerprint-image-extracting sensor causes degradation in performance, especially in factory construction sites where good-quality fingerprints are hard to obtain due to oil from the finger, moisture, dirt, etc. In the case of iris/retina scanners, users must place the eye close to the scanner, causing an uncomfortable feeling or privacy-infringing feeling. In the case of hand-shape recognizers, problems may arise with users who suffer from arthritis or rheumatism, so they are rarely used due to their poor performance. Compared with the other physical characteristics, palm vein authentication has been developed to resolve the problems stated above. Since it acquires a palm vein pattern image without direct contact with the palm or with the vein pattern-extracting sensor, there exists no contamination. Both user comfort and performance are improved, and stable operation is also expected. It appeared in 1990s (MacGregor & Welford, 1991), and becomes popular from 2000 because special advantages. For example, a vein pattern is the vast network of blood vessels underneath a person's skin. Like fingerprints, though it has never been proven in a strict scientific sense, the shape of vascular patterns in the same part of the body is believed to be distinct from each other (Hawkes & Clayden, 1993; MacGregor & Welford, 1991), and very stable over a long period of time. In addition, the palm vein is an ideal part of the body for biometrics; it normally does not have hair which can be an obstacle for photographing the blood vessel pattern, and it is less susceptible to a change in skin color, unlike a finger or the dorsal hand. The properties of uniqueness, stability and strong immunity to forgery of the vein pattern make it a potentially good biometric which offers secure and reliable features for person identity verification. As a result of the

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Fujitsu research (Laboratories Ltd, 2003) using data from 140,000 palms (70,000 individuals), Fujitsu has confirmed that the FAR (false acceptance rate) is 0.00008% and the FRR (false rejection rate) is 0.01%, with the following condition: a person must hold the palm over the sensor for three scans during registration, and then only one final scan is permitted to confirm authentication.

In general, palm veins consist of some significant textures and a lot of minutiae similar to the ridges and branches of palmprint. In addition, there are many different features existing in palm vein images, such as the geometry, the principal line, the delta point, etc. These features offer stable, unique and reliable biometric for personal identification. In this paper, we consider the palm vein as a piece of texture and apply texture-based feature extraction techniques to palm vein authentication. Gabor filter works as a bandpass filter for the local spatial frequency distribution, achieving an optimal resolution in both spatial and frequency domains. Therefore, the method of adaptive Gabor filter (AGF) is proposed to extract local vein patterns for palm vein recognition. Experimental results on our own Near-Infrared (NIR) palm vein image database, including more than 200 classes, have demonstrated that the proposed method is highly feasible and effective for personal identification. The palm vein identification system based on adaptive Gabor filter consists of two parts: a palm vein collection device for palm vein image acquisition and an algorithm for real-time palm vein authentication. There are three main issues to be considered in the system:

(1) The palm vein images are captured by a NIR camera as the input data. Then, a median filter is employed on the palm vein images to remove some noises and an Otsu's method is applied to select a suitable threshold to segment the palm region. Finally, the two datum points are found automatically and a square region of interest (ROI) of vein pattern is obtained.
(2) A Gabor filter was used on the palm vein pattern to extract features. To obtain useful representation of the palm vein modalities, we propose an innovative and robust AGF method to set the best parameter values of a single Gabor filter and encode the palm vein features in bit string representation.
(3) The Hamming distance is employed to measure the similarity of two VeinCodes and verify whether the template and testing samples are captured from the same person or not.

The rest of this paper is organized as follows. Section 2 briefly summarizes related works. We will briefly introduce the palm vein image collection device and process in Section 3. A detailed description of the proposed method for palm vein recognition is given in Section 4. Experimental results are demonstrated and discussed in Section 5, prior to conclusions in Section 6.

## 2. Related works

Analyzing palm vein patterns for recognizing a certain individual belongs to a biometric approach for personal identification and verification. In this paper, we present a novel palm vein recognition method for personal identification. Many verification technologies using biometric features of hand vein were developed over the past decade. Lin and Fan (2004) present person verification results using palm dorsal images acquired from the thermal infrared (IR) camera operating in 3.4–5 μm range. Their approach is based on the combination of multi-resolution images obtained from the pre-processed thermal vein images. Wang, Leedham, and Cho (2007) present another approach for personal authentication using hand vein images acquired from the thermal imaging. Wang et al. (2007), Wang, Leedham, and Cho (2008) have employed Hausdorff distance to generate matching scores between the extracted line patterns and illustrated promising results. Wang, Yau, and Suwandy (2008) proposed a multimodal person identification system where palmprint and palm vein modalities were combined in a single image. Locality Preserving Projection (LPP) was used to extract features of the fused images and they called this "Laplacianpalm". Wang, Kefeng, Cui, Shark, and Varley (2010) proposed hand-dorsa vein recognition method based on Partition Local Binary Pattern and assessed using a similarity measure obtained by calculating the Chi square statistic between the feature vectors of the tested sample and the target sample. Crisan, Tarnovan, and Crisan (2010) has focused on improving the two essential parts of a vein-scanning device: the hardware lighting system and the feature extraction algorithms. However, there are rarely published papers about the palm vein recognition. Most of the papers are white papers published by Fujitsu Company (Laboratories Ltd., 2003; Palm Vein Authentication Technology, 2007; Sasaki, Kawai, & Wakabayashi, 2005). Fujitsu's palm vein verification product has high accuracy, but to the best of our knowledge, the features used are not disclosed in any published research articles. Zhou and Kumar (in press) employed the Hessian phase approach to feature extraction and presented a matching approach that can effectively accommodate the potential image deformations, translational and rotational variations by matching to the neighborhood of the corresponding regions and generate more reliable matching scores. Chen, Lu, and Wang (2009) proposed an efficient refinement method for palm vein matching by adopting the iterative closest point (ICP) algorithm, which can accurately align the rotation and shift variations introduced in data acquisition. Zhang, Li, You, and Bhattacharya (2007) used a low cost CCD camera to capture the infrared palm images and extracted the palm vein features by multi-scale filtering. The experimental results demonstrate that the recognition rate of their system is fine but not good enough to be a real system. Michael, Tee, and Jin (2010) presented an innovative contactless palm print and palm vein recognition system. The proposed system offers several advantages like low-cost, accuracy, flexibility, and user-friendliness. Although these authors claim the features they use to recognize the vein patterns can reach a high level of accuracy, most of them only used small datasets to evaluate the performance of the vein recognition. The final results are doubted because of the feasibility of these algorithms. Up to now, there is currently no publicly available palm vein pattern database available to the research community. To demonstrate the robustness of the proposed approach, we constructed our own Near-Infrared (NIR) palm vein pattern image database, which has 207 distinct participants and contains 4140 palm vein pattern images. It provides a contactless, non-invasive data acquisition method and requires no injection of any agents into the blood vessels. Therefore, it is by far the best known non-invasive option to acquire palm vein pattern images.

Gabor transform is first brought forward by Dennis Gabor in 1946 (Gabor, 1946). Daugman (1980) explains how 2-D Gabor filter can attain the combined optimized resolution in space and frequency. Namely, it can adjust the direction and frequency band width when doing space localization. This characteristic is very useful for analyzing the texture of images. The method has been successfully used in texture segmentation and classification (Dunn, Higgins, & Wakeley, 1994), fingerprint recognition (Lee & Wang, 1999), face recognition (Liu & Wechsler, 2003), palmprint recognition (Zhang, Kong, You, & Wong, 2003), iris recognition (Daugman, 1993) and so on. For example, Zhang et al. (2003) proposed an approach utilizing 2-D Gabor filter to extract features, and used Hamming distance to measure the similarity between palmprints.

Because the palm vein image consists of many lines, it has stable and obvious direction which makes it suitable to be viewed as a texture image. However, 2-D Gabor filter is a widely adopted