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# Subject Review: Hand Vascular Pattern Technology

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## ABSTRACT

*Vein recognition systems are a form of biometric recognition that can distinguish people according to their vascular structure. Identification from hand-wrist vein pattern is one of these systems. In this study, hand-wrist vein images taken from people using an infrared light source with a wavelength of 850 nm were segmented by passing through various image processing algorithms. Scale-independent feature transformation (SURF) method was used for key point extraction from segmented images. The features obtained by the SURF method are rotation, camera angle, ambient light intensity, etc. This method has been preferred because it is invariant against situations. In the identification process, the Euclidean distance method was used by making use of the extracted key points. The accuracy rate was determined as 97% as a result of the matching processes using the hand-wrist vein patterns in the database.*

**Keywords**: Hand-wrist, Authentication, Infrared vein imaging, Feature extraction, Surf.

## 1. INTRODUCTION

Biometrics; It allows to identify people according to various human physiological and behavioral characteristics such as fingerprints, iris, gait and movement patterns. While physiological features such as fingerprint, palm print, iris are related to the shape of the body, behavioral features such as voice, handwriting signature and gait are related to the individual's behavioral pattern. [1-2]

Among the various biometric features, vascular biometry has rapidly gained popularity as it has advantages such as the uniqueness of the vein pattern from person to person, difficult to replicate due to its presence in the skin, and non-contact verification. This fact has enabled the deployment of the vascular biometric system, especially in banking applications. In banking applications, especially palm authentication processes are used. In these systems, the palm is placed on a platform and identification is performed from the vein pattern of the person. Contact with the surface area can cause the platform to become dirty over time and the vein pattern cannot be detected by the camera. Therefore, it is predicted that the widespread use of contactless authentication systems will be both more sterile and minimize the errors in authentication due to contamination due to surface area over time.

The vascular network structure is determined as a result of the absorption of the near-infrared wavelength by the hemoglobin in the blood and the darker imaging of the vascular regions close to the skin in the infrared camera [3].

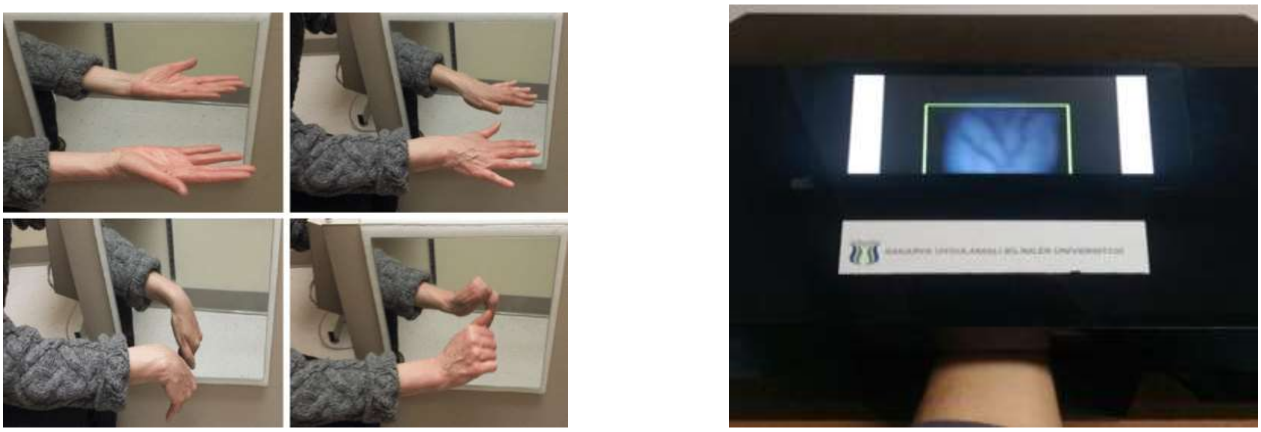
Identification from the vein pattern; hand vein pattern [4], finger vein pattern [5], palm vein pattern [6] and wrist vein pattern [7]. Among the four different types of vein patterns, the hand-wrist vascular network structure provides a clear image because it is located very close to the outer skin and is densely located.

Wrist vein biometry has not been investigated much in the literature. In their study, Akhloufi et al. obtained the vascular network structures in the forearm wrist region by means of a CCD infrared camera. To improve the contrast of the images obtained, anisotropic diffusion process was applied and then they segmented the vascular network structures using morphological processes [8]. Pascual et al. collected hand-wrist vein images thanks to the illumination system and infrared camera platform they designed and showed that these images were clear enough to be used in identification [9]. In their study, Kurban et al. collected three hand-wrist vein images from 14 female and 20 male volunteers at different times of the day using a mobile phone camera with 5 MP resolution. In order to increase the visibility of the vascular regions, various image processing steps were applied to the images, respectively. First, an FFT-based low-pass filter is applied to the images, thereby eliminating background noise. Afterwards, the vascular regions were clarified by applying the sharpen filter and histogram equalization processes. Finally, the images were resized by 1/5 to reduce processing time. The accuracy rate of the system, which was trained using various neural networks, was determined as 96.07% by the SVM (Support Vector Machine) method. [10]

Commonly, vessel recognition technology includes the following steps, in order; image acquisition, vessel image preprocessing, vessel image feature extraction and representation, classifier design and recognition. The most important and difficult part in practice is the development of an effective feature extraction method.

It is a low cost near infrared based identification system proposed in this study. In the identification study from wrist vein images, firstly, the vascular network structure was segmented using various image processing methods. Afterwards, the SURF method was used for feature extraction on the processed images. Then, in the matching step, the similarity between the extracted features was determined using the Euclidean distance.

Right and left wrist vein images taken from 20 female and 30 male total 50 volunteers used in the study were collected by the mechanism shown in figure 1. People were asked to place their wrists on the hand placement platform illuminated by infrared power LEDs with a wavelength of 850 nm, and images were taken by means of an infrared camera from a height of 15 cm. The procedures did not cause any harm to the participants.



(a) (b)

**Figure 1. (a) Installation architecture of the system [11] (b) Collection phase of hand-wrist images**

The obtained images were transferred to the digital environment on the microcomputer and inserted into the image processing and feature extraction algorithms, respectively. The extracted features were then stored in the database in the microcomputer environment for near-real-time authentication.

## 2. METHOD

The flowchart of the authentication system from local feature-based hand-wrist images is shown in Figure 2. During the recording phase of the system, the hand-wrist vein images taken with the help of infrared camera were entered into the SURF algorithm by going through gray level conversion, contrast limited adaptive histogram thresholding, median filtering, adaptive thresholding and morphological processes, respectively. Key points are extracted from the images entering the SURF algorithm and saved in the database.

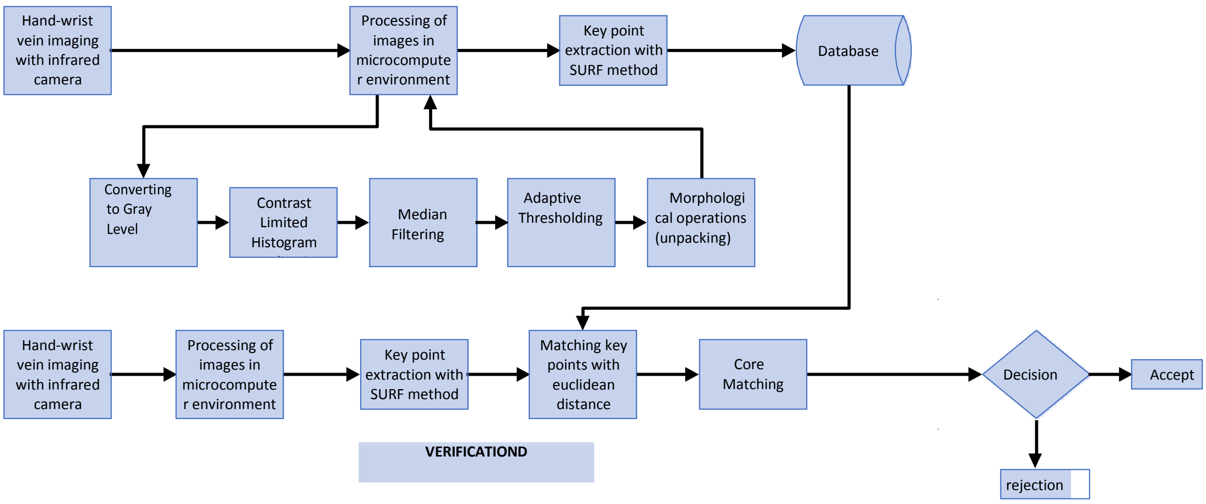



**Figure 2. The general framework of the identification system from the Hand-Wrist Vein pattern**



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In the validation step, the real-time hand-wrist vein image taken by the camera is passed through the image processing steps again, and then key point extraction is performed on the processed image. Then, the key points of the previously saved images in the database are matched with the key points of the new image. As a result of the operations, the two images with the most matching points were accepted as the same. The operations in the block diagram shown in Figure 2 are explained in the following sections, respectively.

### 2.2.1 Segmentation of Vessel Regions with Image Processing Algorithms

In the first preprocessing step, gray level conversion, contrast limited adaptive histogram equalization (KSAHE), median filtering and adaptive thresholding are applied on the images. Then, KSAHE was applied to the images after gray level conversion to increase the visibility of the vascular region.

Contrast enhancement in the hand-wrist vein causes noise in people with hairy areas. To overcome this problem, the median filter has been applied. After median filtering, vessel images were converted to 1-bit with adaptive thresholding. Finally, morphological operations were applied on the 1-bit converted images, eliminating the noise and then segmenting the vascular regions. All image processing steps are shown in Figure 3.

Figure 3.a shows the raw image and Figure 3.f shows the morphologically processed vessel region converted to 1-bit.

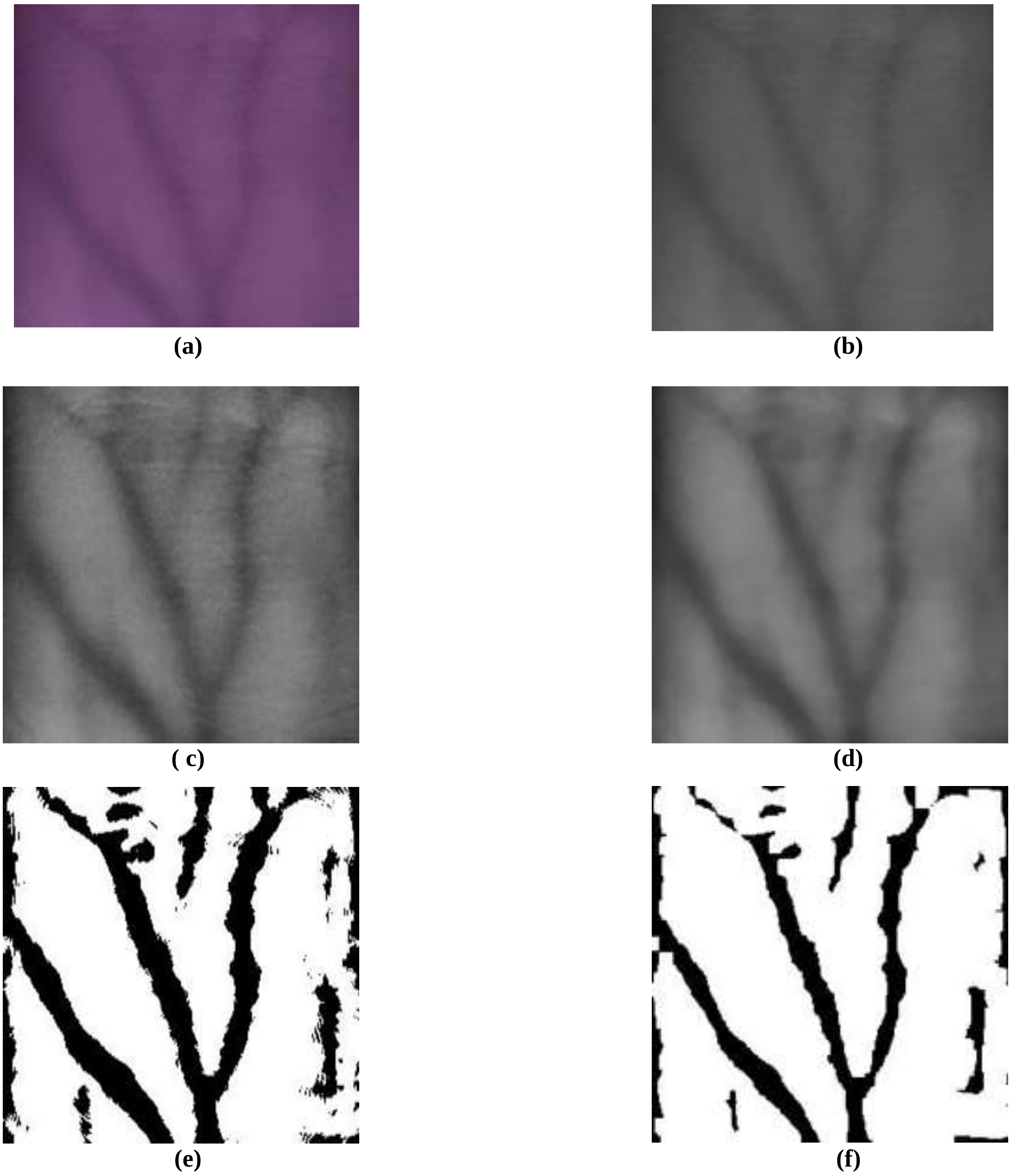


**Figure 3. (a) Raw image (b) Gray level (c) KSAHE (d) Median (e) Adaptive thresholding (f) After morphological manipulations**



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### 2.2.2 SURF Algorithms

SURF, (Speeded-up Robust Features) Hessian matrisinin determinantını kullanarak özellik noktalarını tespit eder [12].

$$H(x,\sigma)= \begin{pmatrix} Lxx\ (x,\sigma) & Lxy\ (x,\sigma) \\ Lyx\ (x,\sigma) & Lyy\ (x,\sigma) \end{pmatrix} \quad (1)$$

Here L is the derivation of the scale at X (x, y) of the Gaussian second order in terms of σ and similarity for Lxy and Lxy. The maximum and minimum discriminant value of the function is used for classification. Identification begins with the creation of the window around the detected feature point. The feature vector resulting from the pixel in this region is calculated. In Figure 4, the key point extraction process is shown using the SURF method from the vascular region segmented and morphologically processed hand-wrist vein image.

**Figure 4. Key point extraction with SURF**

## 3. RESULTS

With the help of the SURF method, the key points on the hand-wrist images and the descriptors of these points are determined. The same process is applied to all elements that come to the camera during the subsequent identification process. Matching is made by comparing the key points of the images in the database with the images in front of the camera. An example matching process is shown in Figure 5. The matching process is done using the Euclidean distance method between key points.

$$mesafe = \sqrt{(x(i) - (sütun + x_2(i)))^2 + (y(i) - y_2(i))^2} \quad (2)$$

The process of finding the pre-matching distances between two images in Equation(2) is done. seen in the equation x(i) and y(i) key on image in database shows the point position of the points on the x-ye axes.

An example matching process is shown in Figure 5. Figure 5 (a) shows the processed image of the real-time image for the matching process, while (b) shows the wrist vein image of the same person recorded in the database. The hand-wrist images of the person are successfully matched

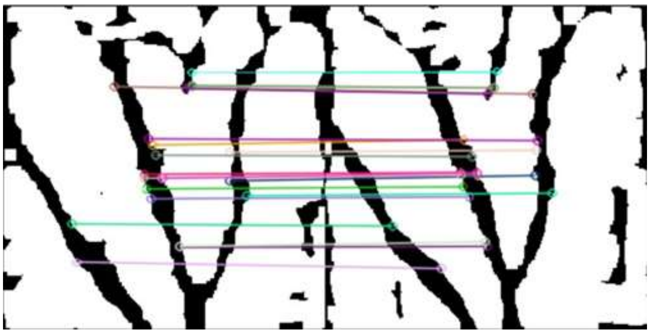

**Figure 5. Matching process with the SURF method (a) Real-time image taken from the camera (b) Image in the database**



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As a result of the study, the accuracy rate was determined as 97% as a result of the matching made on the segmented hand-wrist images. The matching process took about 4 seconds for each subject in the database of 100 people.

## 4. DISCUSSION

In the study, identification process was performed from microcomputer-based hand-wrist vein images. As a result of the study using Raspberry Pi infrared camera and 3 B+ microcomputer, hand-wrist vein images collected from 100 people were transferred to the microcomputer environment and vascular regions were segmented by passing through various image processing algorithms. Images with visible vessel regions were inserted into the SURF algorithm for local feature extraction. The images whose key points were extracted were stored in the database and then the matching process was performed with the vein images in front of the camera.

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