Finger vein image enhancement using U-Net

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Abstract

As the need for privacy protection is emphasized, interest in biometric recognition increases. Among them, the security system using internal features such as using blood vessel is considered as a sanitary and highly secure biometric technology, which is impossible to be forged or tampered with. Unlike most external characteristics, internal characteristics cannot be obtained with a visible light camera and a near-infrared camera must be used. However, during this process, scattering and smudging of light results in inaccurate biometric characteristics. Therefore, in this paper, we propose a method of improving the quality of finger vein images in internal features. The method includes preprocessing the original finger vein image by localization and stretching. Vein emphasis, binarization, U-Net algorithm, thinning, bifurcation detection procedure is performed respectively to improve the visibility of the image.

Keywords: vein recognition, U-Net, vein pattern, image enhancement, bifurcation

1. Introduction

Due to the increased importance of security systems, biometric recognition has become one of the most significant and challenging tasks in the field of security. The security system by internal information has gained the spotlight in biometric technology for its difficulty to be forged. Unlike other biometric methods, finger vein cannot be obtained with a visible light camera, and instead, a near-infrared camera should be used [1].

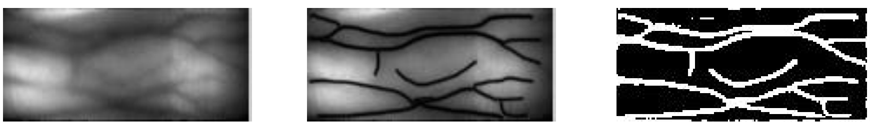
However, light scattering and blur problems occur in the captured near-infrared image due to the unclearness of the boundary between the finger vein and the skin [2]. Consequently, many studies for new methods on finger vein recognition were performed.

2. Literature review

Research on vein identification system method using 2D Gabor filter [3] and Biological Optical Model (BOM) method [4] have been conducted to improve the features of vein. Unlike previous studies, this paper proposes a method of improving the quality of finger vein images through deep learning U-Net algorithm which is appropriate for biometric image segmentation.

3. Proposed Work

In this paper, acquired finger vein images were localized and stretched to 152 X 60 pixels [5], as shown in Figure 1(a). Data augmentation was performed to obtain various data in order to prevent overfitting during the training process. Without altering the biometric properties of finger vein, using only brightness and contrast control, train and test datasets consist of 1880 images and 600 images. To increase training efficiency of deep learning, after emphasizing the vein area shown as Figure 1(b), they were constructed by binarization with adaptive threshold, as shown in Figure 1(c).



(a) (b) (c)

Figure 1. Training image generation. (a) Original. (b) Manually drawn vein region (black solid line). (c) Binarization result of (b).

U-Net is an end-to-end model based on Fully Convolutional Network (FCN), which shows outstanding performance in various biomedical fields with very few training images and yielding more precise segmentations. The architecture consists of a contracting path to capture context and a symmetric expanding path that enables precise localization [6]. Using U-Net structure, the model was trained with Adam optimizer and learning rate of 1×10^{-3}.

To extract feature points from finger vein, thinning and bifurcation was done on postprocessing. Because the thinning process makes it easier to extract bifurcation, in this study, the Zhang-Suen algorithm was used for thinning. After thinning, bifurcation points can be obtained by counting the number of foreground pixels of eight-directional neighbor pixels on each finger vein line. 4 pixels around the detected bifurcation point was colored as red pixels for clarity.

4. Result

Figure 2 is the result representing the process of predicting and postprocessing the original finger vein image. The average number of bifurcation points detected in the original image was 7.7, while the average number of bifurcation points detected through U-Net algorithm has improved to 10.7. Comparing Figure 2 (a) with Figure 2 (d), we can notice the proposed method displays a more explicit vein image.

(a) (b) (c) (d)

Figure 2. Result of finger vein image enhancement. (a) Original. (b) Prediction result of (a) using U-Net. (c) Thinning result of (b). (d) Bifurcation detection result (red dots) of (c).

5. Conclusion

In this paper, enhancing the quality of finger vein images using U-Net algorithm was proposed. With our method, improved performance was shown at detecting features in finger vein. Furthermore, in the future, techniques based on this study can be applied to security systems in finance, access control, medical care, quarantine, and entertainment for higher accuracy.

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