A New Fusion Method of Palmprint and Palmvein

Zhu Aimin, Lu Huaping, and Yao Senjie

Zhenjiang Watercraft College, Zhenjiang, China
zhuaimin001@163.com

Abstract. This paper introduces a new method for fusing palmprint and palmvein. The focus of image fusion is placed on the application of neurodynamics of vision models, and the characteristics of the bimodal cells of rattlesnakes are researched. An image acquisition device which can collect palmprint and palmvein images in the same position and at the same time is deviced, and a small palmprint and palmvein database is built by this device. Some experiments have been done to evaluate this fusion method on the palmprint and palmvein database.

Keywords: biometrics, palmprint, palmvein, receptive field, multimodal.

1 Introduction

Fusion is a promising approach that miny increase the accuracy of systems[1]. Fusion of palmprint and palmvein has been observed at score level or at representation level. This article describes a methodology to provide a fused method of palmprint and palmvein at representation level.

Recognizing that color vision evolved in animals for survival purposes, we describe in the following section a methodology, based on biological opponent-color vision, to fuse registered palmprint and palvein in real time. An apparatus which can collect palmprint and palmvein at the same time and same place is devised. Based on this apparatus, a small palmprint and palvein database is built and some experiments are done to compare our method with traditional image fusion method.

The rest of the paper is organized as follows: Section 2 descibes the fusion architecture of palmprint and palmvein.

Section 3 presents some experiments and in Section 4 we end with some conclusions.

2 Fusion Architecture of Palmprint and Palmvein

The basis of our computational approach for image fusion of palmprint and palvein derives from biological models of color vision and visible/infrared fusion. In the case of color vision in monkeys and man, retinal cone sensitivities are broad and overlapping, but the images are quickly contrast enhanced within bands by spatial opponent processing via cone-horizontal-bipolar cell interactions creating both ON and OFF center-surround response channels [2]. Fig.1 shows ON and OFF center-surround response.

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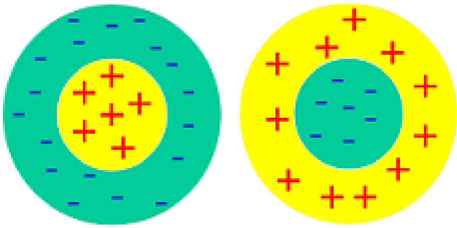

Fig. 1. ON and OFF center-surround response

Fusion of visible and thermal infrared imagery has been observed in several classes of neurons in the optic tectum of rattlesnakes, as described by E.A. Newman and P.H. Hartline [3][4]. These neurons display interactions in which one sensing modality (e.g., infrared) can enhance or depress the response to the other sensing modality (e.g., visible) in a strongly nonlinear fashion. These tectum cell responses relate to the attentional focus of the snake, as observed by its striking behavior.A.M. Waxman etc.[5] combined the visible image and thermal infrared image by using principales of biological opponent-color vision.

In this paper, we use the concept of ON and OFF center-surround response to fuse palmprint and palvein. The neurodynamics of the center-surround receptive fields is described at pixel (i,j) by the following equations.

$$\frac{dx_{ij}^{+}}{dt} = -\alpha_1 x_{ij}^{+} + (U_1 - x_{ij}^{+})C_1 - (x_{ij}^{+} + L_1)S_1$$

$$\frac{dx_{ij}^{-}}{dt} = -\alpha_1 x_{ij}^{-} + (U_1 - x_{ij}^{-})S_1 - (x_{ij}^{-} + L_1)C_1$$

$$C_1 = \sum_{(p,q)} C_{pq} I_{i+p,j+q} \qquad S_1 = \sum_{(p,q)} S_{pq} I_{i+p,j+q}$$

$$C_{pq} = A_1 (2\pi\sigma_c^2)^{-1} \exp(-\frac{1}{2}((p^2 + q^2)/\sigma_c^2))$$

$$S_{pq} = A_2 (2\pi\sigma_s^2)^{-1} \exp(-\frac{1}{2}((p^2 + q^2)/\sigma_s^2))$$

where I is the input image that excites the single pixel center of the receptive field, C is the input impulse and S is is the input image that inhibits the Gaussian surround of the receptive field.

ON and OFF center-surround response can be achived by the equation:

$$x_{ij}^{+} = \frac{\sum_{(p,q)} U_1 C_{pq} I_{i+p,j+q} - L_1 S_{pq} I_{i+p,j+q}}{\alpha_1 + \sum_{(p,q)} (C_{pq} + S_{pq}) I_{i+p,j+q}} \quad x_{ij}^{-} = \frac{\sum_{(p,q)} U_1 S_{pq} I_{i+p,j+q} - L_1 C_{pq} I_{i+p,j+q}}{\alpha_1 + \sum_{(p,q)} (C_{pq} + S_{pq}) I_{i+p,j+q}}$$

$$X_{ij}^{+} = [x_{ij}^{+} - x_{ij}^{-}]^{+} = \frac{[(U_1 + L_1)(\sum_{(p,q)} C_{pq} - S_{pq}) I_{i+p,j+q}]^{+}}{\alpha_1 + \sum_{(p,q)} (C_{pq} + S_{pq}) I_{i+p,j+q}}$$

$$X_{ij}^{-} = [x_{ij}^{-} - x_{ij}^{+}]^{+} = \frac{[(U_1 + L_1)(\sum_{(p,q)} S_{pq} - C_{pq}) I_{i+p,j+q}]^{+}}{\alpha_1 + \sum_{(p,q)} (C_{pq} + S_{pq}) I_{i+p,j+q}}$$

3 Experiments

An apparatus which can collect palmprint and palmvein at the same time and same place is devised. Based on this apparatus, a small palmprint and palvein database is built. The architecture of the apparatus and the palmprint and palvein sample images are showed in Fig.2.

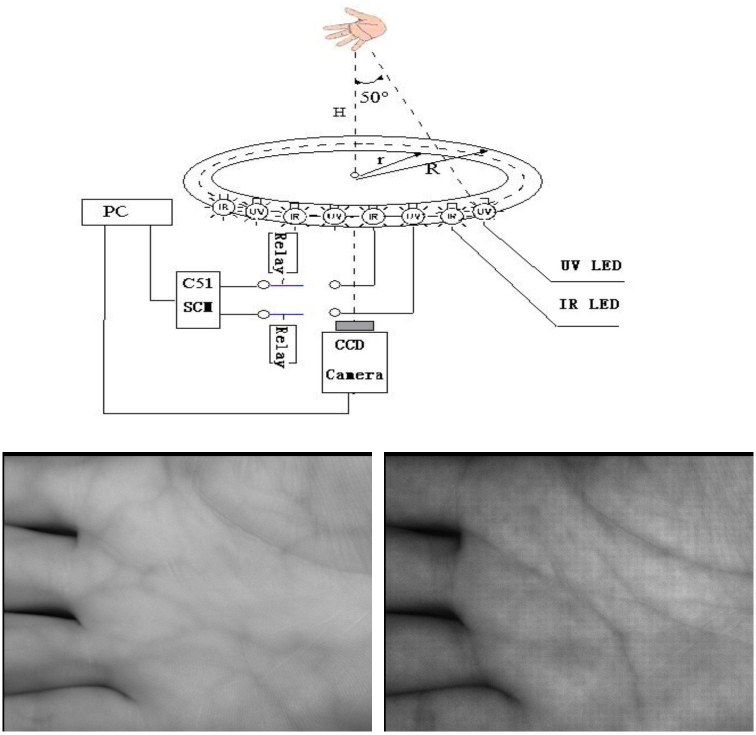

Fig. 2. The architecture of our apparatus and the palmprint and palvein sample images

With the help of ON and OFF center-surround response, the single-enhanced palmprint, single-enhanced palvein, palmprint which is enhanced by palmvein, palmvein which is enhanced by palmprint, palmprint which is restrained by palmvein, palmvein which is restrained by palmprint, and opponent-color image created by A.M. Waxman's method [5] are showed in Fig. 3.

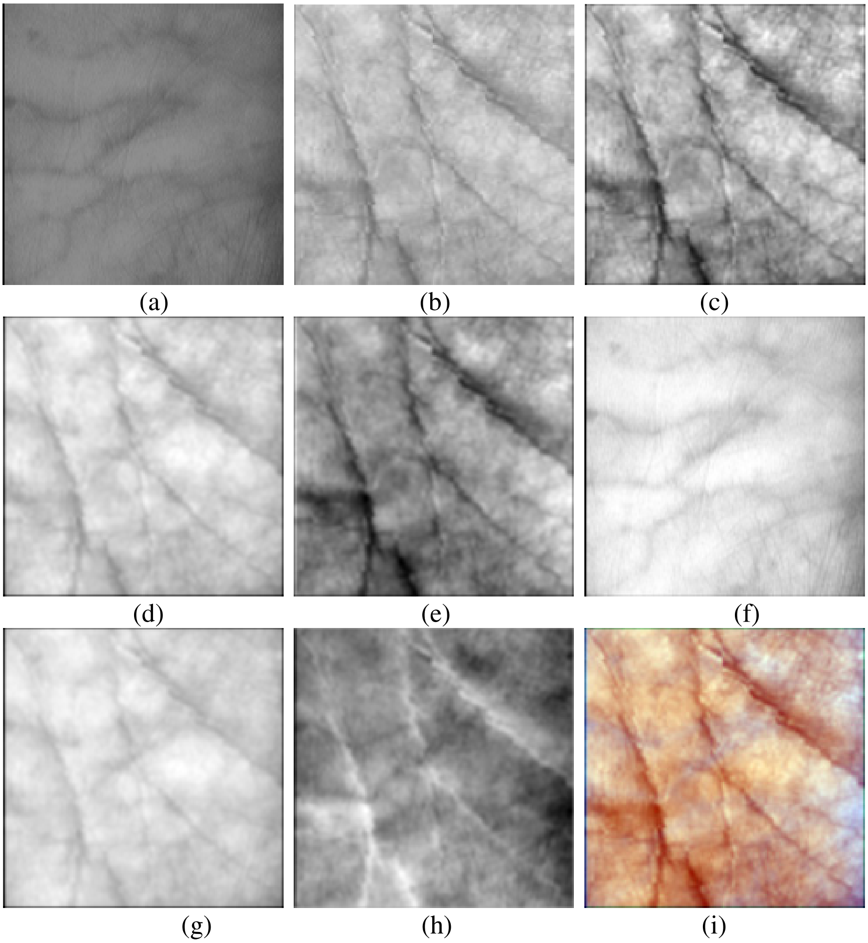

Fig. 3. (a) is the original palmvein, (b) is the original palmprint, (c) is the single-enhanced palmprint, (d) is the palmprint which is enhanced by palmvein, (e) is the palmprint which is restrained by palmvein, (f) is the single-enhanced palmvein, (g) is the palmvein which is enhanced by palmprint, (h) is the palmvein which is restrained by palmprint, (i) is the opponent-color image.

In order to compare with the conventional fusion approaches, entropy and mutal information in information theroy are introduced.

$$H = -\sum_{i=0}^{L-1} P_i \log P_i$$

where H is the entropy of the image and L is the maximum grey level.

Mutal information is defined as follows:

$$H(A) = -\sum_{i=0}^{L-1} P_i(a)\log P_i(a) \quad H(B) = -\sum_{i=0}^{L-1} P_i(b)\log P_i(b)$$

$$H(A,B) = -\sum_{i=0}^{L-1} P_i(a,b)\log P_i(a,b) \quad MI(A,B) = H(A) + H(B) - H(A,B)$$

We compare our method with the conventional image fusion method by Discrete Wavelet Transform (DWT). In the method of DWT image fusion, palmprint and palmvein are decomposed to each level respectively, and they are fused at each level by the simple score rule. The fused image is created by DWT reconstruct.

In our experiment, the original image is decomposed to 3 levels. In the stage of DWT fusion, the score rule of palmprint is chosen as 0.6 and that of palmvein is chosen as 0.4.

A small palmprint and palmvein database is built with the help of the above apparatus. The database contains 400 grayscale palmprint and palmvein which are collected from 40 individuals and 10 different images of each individual. A set of experiment is done in the database, the results are show as in Table 1.

Table 1. Comparison with DWT

Parameters \ Fusion methods	Palmvein enhanced by palmprint	Palmprint enhanced by palmvein	DWT
Entropy	6.43	6.52	6.23
Mutal information with the original palmprint	1.55	2.06	1.47
Mutal information with the original palmvein	0.83	0.78	0.74

From Table 1, we can see that our method achieved better performed than DWT in the view of information theory.

4 Conclusions

We have described a novel approach for fusion of palmprint and palmvein. Our approach to image fusion is based on biologically motivated neurocomputational models of ON-OFF receptive field. Also we deviced an apparatus to collect palmprint and palmvein. With the help of this apparatus, some experiments are done to compare our method with the conventional DWT image fusion method.

References

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