Directional Adaptive WSSG Filter

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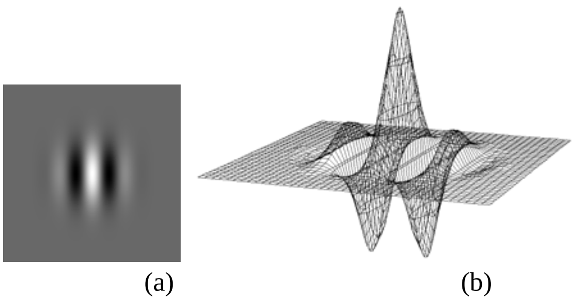
Abstract: The image recognition performance depends on the quality of images. In this paper, we propose a method which applies a directional adaptive Weight Separable Symmetrical Gabor filter for vein recognition. The proposed filter is the improved 2D Gabor filter. It has the attributes including separation, symmetry, weight and directional adaptation. In feature of this, our method contributes to the short time and the small cost for image recognition.
Keyword: biometric, vein identification, preprocessing

1. Introduction

The first step of the image recognition is based on image pre-processing using the filtering. Therefore, it is important for selecting and using filter. Among them, Gabor filter is arguably the best filter.

Though LoG(Laplacian of Gaussian) and DoG(Difference of Gaussian) are useful filter, they are no-direction filter. On the other hand, 2D Gabor filter is a filter for direction. And then, 2D Gabor filter acts as local band-pass filter with certain optimal joint localization properties in both the spatial domain and the spatial frequency domain. (1), [1], [2]. Fig. 1. So 2D Gabor filter is used in many fields.

$$G(x,y,\theta,f) = \exp\left\{\left(\frac{x_\theta^2+\gamma^2 y_\theta^2}{-2\sigma^2}\right)\right\}\cos(2\pi\ f_0 x_\theta),$$
$$x_\theta = x\cos\theta + y\sin\theta \quad (1)$$
$$y_\theta = -x\sin\theta + y\cos\theta$$



(a) (b)

Figure 1. 2D Gabor filter Image (a) wavelet (b) 2D

The scheme which uses a set of 16 Gabor filters is used to capture the ridge strength at equally spaced orientations. So it demands lots of computational time. In order to overcome this disadvantage, after 2D Gabor filter split into two wavelet of 1D, each 1D wavelet act in sequential convolution. This method is called Separable Gabor Filter. (2), [3], [8]

$$G_{BP}(x,f_0) = \exp\left\{-\frac{1}{2}\left(\frac{x_\theta^2}{\sigma_x^2}\right)\right\}\cos(2\pi f_0 x_\theta)$$
$$G_{LP}(y) = \exp\left\{-\frac{1}{2}\left(\frac{y_\theta^2}{\sigma_y^2}\right)\right\} \quad (2)$$

The Separable Gabor Filter considerably decreases operation time while it shows significantly consequences like 2D Gabor Filter, and reduces computational complexity. However, it require index operation about pixel in addition which is generated to 1D wavelet rotated for diagonal adapted filter such as 22.5, 45, 67.5, 72.5, 112.5, 135, and 157.5 degree except 0 and 90 degree. This degree was quantitated to each 22.5 degree which is got by dividing 180 degree by 8 for directional filter operation. Furthermore, This is not used suitably in general because the larger image is implemented, the more operation time is required. Specially, as large image, the vein image is not suitable against fingerprint image. In order to overcome the disadvantage, Separable Symmetric Gabor Filter is proposed. This filter pre-prepare rotated 1D wavelet that is made by 2D Gabor rotated filter. This filter is made by each direction implement for convolution.

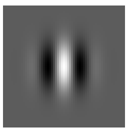
When 1D wavelet of the Separable Symmetric filter is convolved, it doesn't need to be rotated. This point results in reduced computational complexity and simpled implementation. Moreover, This filter has symmetric feature whose enhancement corresponds to direction about diagonal simultaneously. However, 1D wavelet made by direction filter for diagonal has disadvantage that bandpass feature is weaker than that of Gabor filter. In order to overcome this disadvantage, Weighted Separable Symmetrical Gabor filter is proposed. [4]

Weighted Separable Symmetrical Gabor(WSSG) filter has Symmetrical feature. Thus, 1D wavelet of diagonal direction , such as 22.5, 45, and 67.5 degree expect 0 and 90 degree, has to be added by appropriate value. One more point, the value of 22.5 and 67.5 degree surely different from the value of 45 degree, because each degree has different rotated degree. The added value effects to complement decreased bandpass feature of Gabor. consequently, the result of this method shows similar with the result of Gabor filter.

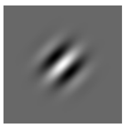
2. Directional Adaptive WSSG filter

2. 1 Weighted Separable Symmetrical Gabor filter

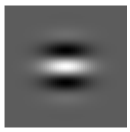
We separate all of image into small block, and then filter them. The filter is two 1D wavelet extracted from 2D Gabor. For each direction of pixel, vertical and horizontal 1D wavelet extract from rotated 2D Gabor.



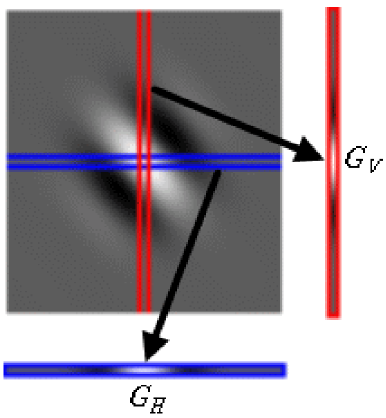
(a) 90



(b) 45



(c) 0



(d)

Figure 2. (a), (b), (c) 2D Gabor filter image rotated (d) two 1D filter extracted from 45 degree 2D Gabor filter image.

We convolute each block image with 1D Gabor filter. (3)

$$I_1(x,y) = \sum_{i=-n}^{n} I_0(x+i,y) \times G_H(n+i)$$
$$I_2(x,y) = \sum_{i=-n}^{n} I_0(x,y+i) \times G_V(n+i) \quad (3)$$

But, This method has disadvantage that edge feature is weaker than 0 and 90 degree in diagonal filtering. For a directional view for enhancement edge feature, we consider eight direction in block image.

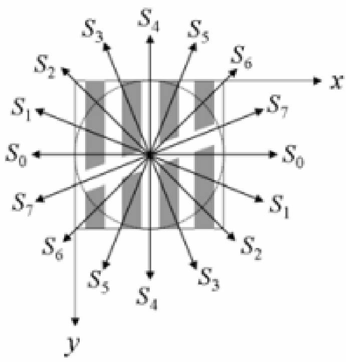
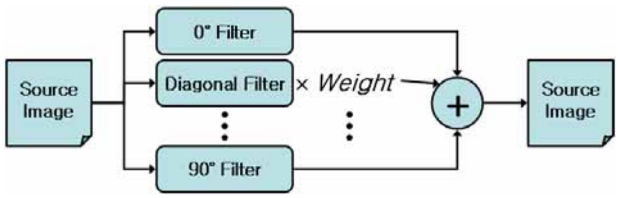
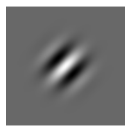


Figure 3. 8 direction divided by each 22.5 degree

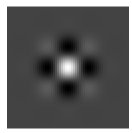
2D Gabor filter take weak of its feature as much as image rotated. Because this reason, Gabor filter feature add to 22.5, 45, and 67.5 degree. This is weight separable symmetrical Gabor filter. Fig. 3, [9]



(a) Diagram of weighted filter function



(b) normal



(b) weighted

Figure 3. (a) Diagram of weighted filter function

(b) 45 degree filter of normal 2d Gabor

(c) weighted 45 degree filter of normal 2d Gabor

2.2 Directional Adaptive WSSG filter

Generally, WSSG filter consider all of direction about each block image. It is stand a good chance of optimizing .

For the cost and time make to decrease, we have to work suitable filter on a block. And then, consider information between pixels about a block.

We preprocessed image P by computing an M x N directional image V. We compute the direction at each pixel P(i, j) by sliding the 13 x 13 mask in Fig. 4 over P where c is the center pixel P(i, j). A number of d, e, f, g and h is correspond to 0, 22.5, 45, 67.5 and 90 degree, respectively. [5], [6], [7]

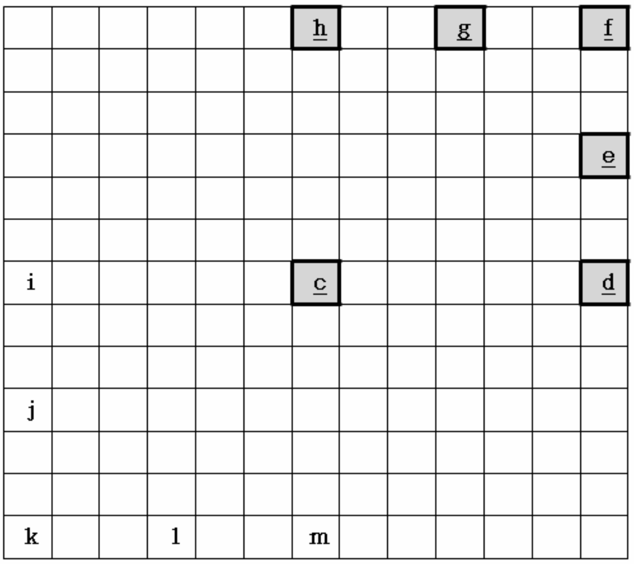


Figure 4. 13 x 13 direction mask

We compute difference between P(i, j) and P(i_m, j_m) for m = d, e, f, g, h (directional point). Next step, the c value has to be acquired over minimum of its difference. (4) The mean of difference value is not simply pixel value but directional mean of 13 x 13 block filter.

$$V(i, j) = \min_m || P(i, j) - P(i_{m,} j_m) | \quad (4)$$

For example if we obtain minimum value over P(i, j) minus P(i_m, j_m) as 45 degree direction, this block image has to be adapted two 1D wavelet extracted from rotated 2D Gabor filter 45 degree.

This method used is to reduce computational complexity, because it does not need to convolve with other direction wavelet.

Also, we present one more technique for accurate detection about direction. Only center one pixel is not enough, If pixel about edge is not put in the center, direction about block probably has be to another direction. For the case that edge feature is not passed to center, we consider not a pixel of center but a group of center pixels. So, The area of center point is 3 x 3 area.

$$V(i, j) = \min_m | \text{average}(P(i, j)) - P(i_{m,} j_m) | \quad (5)$$

where P(i, j) is from 0 to mask size divided by four around center pixel. A group of pixels as center is average, and then we compute between average and P(i_m, j_m). (5)

Though this method is improved than first method, when edge is not acrossed in center location, we have the wrong information, too. Because the reason which average a group of pixels as center value is for improved detection of direction, if a group of P(i_m, j_m) pixels has to be averaged, It will had better result. (6)

$$V(i, j) = \min_m | \text{average}(P(i, j)) - \text{average}(P(i_{m,} j_m)) | \quad (6)$$

That is, minimum of difference averaged P(i, j) and P(i_m, j_m) result in improved directional filter deteced. For averaging compute, we have to make a group of directional point area. We define average area to mask size divided by 4 around directional point. So, The area of directional point is 3 x 3 area. Fig. 5

For it is so fast function, when we average a group of pixels except pixels out of image block.

Next, we add weight to the center and direction pixel. As average percentage of original center and direction pixel is increased help domiant direction. (7)

$$\text{average}(P(i, j)) = (c \times 0.5) + (c_0 \times 0.5) \quad (7)$$

where c and c_0 is changed to d, e, f, g, and h direction pixel. This added function is not a lot of computational time and complexity implement.

We present a directional adaptive weighted separable Symmetrical Gabor filter which utilizes not only combination of convolution about considering every direction, but also convolution of suitable direction about a group of pixel. For example, a group of pixel which has vertical edge feature is convolved with 1D wavelet of 90 degree.

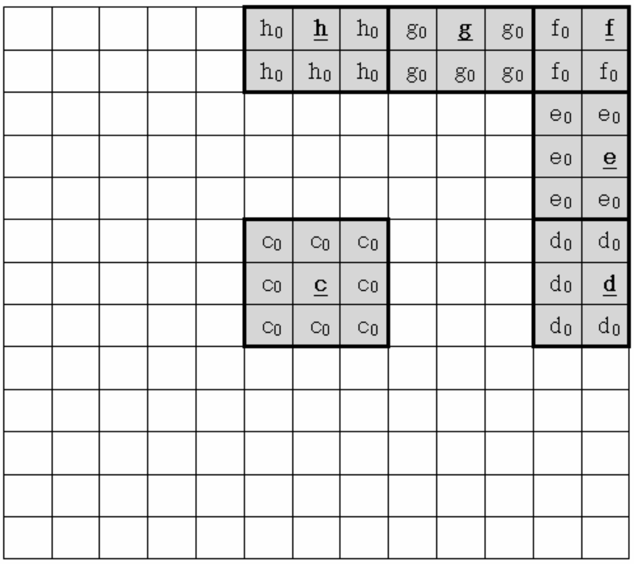


Figure 5. each 3 x 3 averaged area of pixel

4. Conclusion

Well-known steerable filter is generally considered the cornerstone of edge detection in image processing. We introduce a directional adaptive WSSG filter technique using difference of averaged pixels for vein recognition. Our method reduces processing time by removing the need for all directional filtering. Also, the method used is to reduce computational complexity, because it does not need to convolve with other direction wavelet.

Our method performs similar filter that consider all direction. We believe that it can be used as the basis for other image processing.

5. Future work

Our method is fast filter function. However, there are a number of parts that remain to be improved for capability. Direction pixel of i, j, k, l, and m in Fig. 4 is also able to be considered.. To reach a fuller improvement, we need to resarch more closely at image processing.

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