WSSG Filter using LUT for Vein Identification

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Abstract: The problem of 2D-Gabor filter is very slow. So some filters are proposed such as Separable Gabor fitler and WSSG filter. However, these filters are alos slow in the embedded systems that have no floating-point unit. So we propose using LUT for WSSG filter instead of multiplication operations with floating point numbers. This filtering consumes approximately 25 time faster than the normal WSSG fitlering with compareble enhancement results.

1. Introduction

Recently, the identification methods using biometric are getting more interest. Because, general methods for identification such as key, smart card and password are exposed to some problems such as still, loss and copy. There are many methods for the biometric identification system such as fingerprint, iris, vein and face. The fingerprint and the iris are the most general methods. Specially, the fingerprint system is generally used, because the fingerprint system can be made into small size. When using the fingerprint for identification, however, the input image form sensor can have bad quality, because sensor can be polluted by sweat, hand cream and dust. This image that has bad quality can make false result. In case of iris identification system, when getting iris image from scanner, many people have rejection. So vein identification is getting more interest. So, we study the method to enhance the result of vein identification.

There are some methods for vein identification system such as palm vein identification system by FUSITSU, finger vein identification system by HITACHI, and vein of back of hand identification system by Techsphere, and ID-One [1][2]. In this paper, we use vein of back of hand.

In this paper, we focus on WSSG filter that is preprocessing to enhance features of vein image. This filter is based on 2D-Gabor filter and Separable Gabor filter. And WSSG filter enhance process time. However, this filter is not suitable with embedded system, because this filter has too many arithmetic operations with floating-point number and most of embedded system have no floating-point unit. In this paper, we study about enhancing process speed of this filter in the embedded system.

2. 2D Gabor and Separable Gabor Filter

The 2D-Gabor filter is a very good filter to enhance directional features [3][4]. However, the problem of this filter is very slow, because it requests too many arithmetic operations. The Separable Gabor filter was researched to solve this problem by V. Areekul, U. Watchareeruetai and S. Tantaratana [3]. This filter uses two equations which are separated from the 2D-Gabor filter equation with 0 degree as the parameter for the orientation. The equation (1) is for 2D-Gabor filter. And the equation (2) is for Separable Gabor filter.

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

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

This two equations are used to make two 1D-wavelets for the x-axis and the y-axis respectively [5]. And then, this two 1D-wavelets are rotated by the orientation to enhance directional features of the image. Each rotated 1D-wavelets are used for convolution as masks. As a result, the operation is much faster though the result image is very similar with the image which is convoluted with 2D-Gabor filter. However, when the orientation of a wavelet is diagonal, the computing the offset for each pixel in an image need many arithmetic operations. So effect of this filter is reduced. This is a big problem, especially when the size of wavelet is too wide.

2. WSSG Filter

Weighted Separable Symmetric Gabor (WSSG) filter can cover the reduced effect that is described in previous section effectively [6]. In case of the WSSG filter, the rotated 2D-Gabor wavelet is used to extract two 1D-wavelets for filter instead of 2D-Gabor wavelet with 0 degree. So, rotation of wavelets is not needed during the process of convolution. As a result, the convolution of filter is faster than Seaparable Gabor filter because computing of indices for each pixel of a image become more simple. In addition, diagonal wavelets of WSSG filter have a characteristic that can enhance a symmetrical orientation with the y-axis. So, WSSG filter can reduce the number of filter for diagonal orientation. This characteristic also reduces operating time.

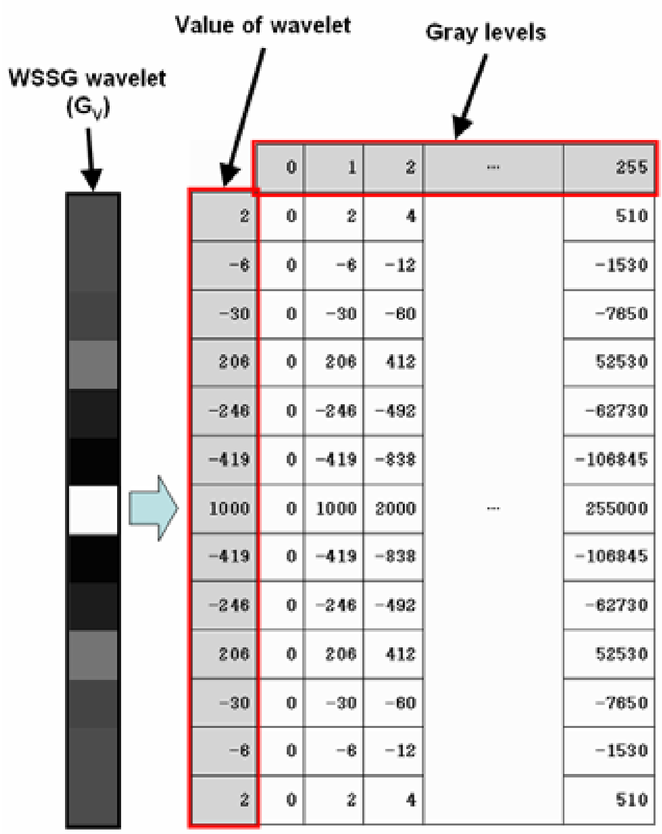
3. WSSG Filter in Embedded System

Many biometric identification systems use the processor for embedded system without floating point unit. There are also some processors for embedded system also without multiplication unit. However, the filters based on 2D-Gabor such as Separable Gabor filter and WSSG filter request too many multiplication operations with floating point numbers. This is a big overhead for embedded system. So, in this paper, we propose using Look-Up Table (LUT) for convolutions of WSSG filter.

4. WSSG Filter using LUT

To make the LUT for WSSG filter, 1D-wavelets are changed into arrays of integer numbers. When 1D-wavelets are changed into arrays of integer numbers, a scale constant is multiplyed by each values of 1D-wavelet. This scale constant decide the detail of LUT. And we make a table that has the values calculated by multiplying the integer number in the array and each value of gray-level between 0 and 255. <Table 1> is a sample of LUT with 1000 as the scale constant.

Table 1 - The LUT for WSSG filter



	0	1	2	...	255
2	0	2	4		510
-6	0	-6	-12		-1530
-30	0	-30	-60		-7650
206	0	206	412		52530
-246	0	-246	-492		-62730
-419	0	-419	-838		-106845
1000	0	1000	2000	...	255000
-419	0	-419	-838		-106845
-246	0	-246	-492		-62730
206	0	206	412		52530
-30	0	-30	-60		-7650
-6	0	-6	-12		-1530
2	0	2	4		510

This table is LUT for vertical 1D-wavelet of WSSG filter with 13 pixels as width and 90 degrees as orientation. As you can see, this table is completely symmetrical to middle line. So, just half of this table is needed for LUT. [Table 2] is LUT without bottom half.

Table 2 - LUT without bottom half

	0	1	2	...	255
2	0	2	4		510
-6	0	-6	-12		-1530
-30	0	-30	-60		-7650
206	0	206	412	...	52530
-246	0	-246	-492		-62730
-419	0	-419	-838		-106845
1000	0	1000	2000		255000

And the LUTs for G_H and G_V are completely symmetrical to 45 dgrees as orientation. So, if you have LUTs for G_H, you don't need LUTs for G_V. If you save LUTs for each orientation and use LUTs for convolution of WSSG, you can compute convolution operation easily without multiplication of floating point numbers. At first in convolution for each orientation, value for each pixels in the image is computed using horizontal LUT. In this operation, the index for value of the mask and the value of pixel are used as indices of LUT. [Figure 1] is show this operation.

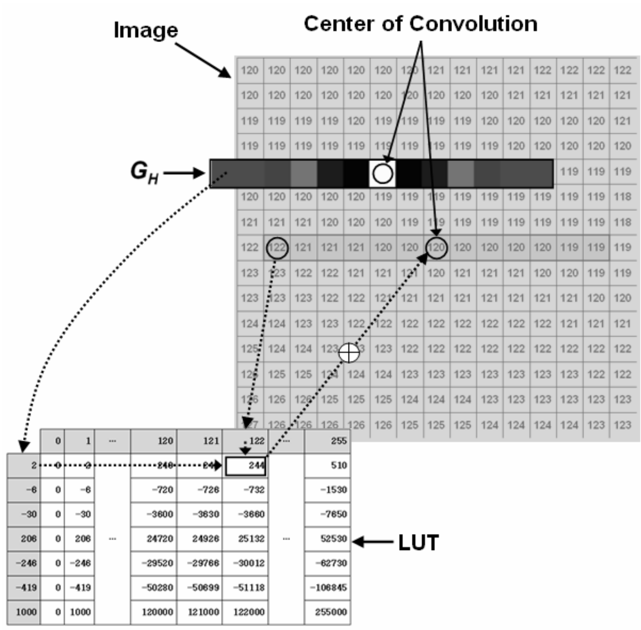


Figure 1 - Convolution of WSSG using LUT

These values are not a number between 0 and 255. So, these values have to be divided by the weight of LUT. The weight of LUT can be computed by the sum of numbers in second column of LUT. In <Table 1>, the weight of LUT is 15 which is 2-6-30+206-246-419+1000-419-248+206-30-6+2. Also, these values have to be clipped between -255 and 255. In the convolution using vertical LUT, the signs of those numbers have to be considered.

5. Experimental

We compare the process time of WSSG with LUT and without LUT in both PC and embedded system. And we compare result image of 2D-Gabor as source image and the other result images using the PSNR (Peak Signal-to-Noise Ratio). The PSNR is most commonly used as a measure of quality of image of reconstruction in image compression etc. If this value is more than about 30db, finding noise from the target image is very hard for the human. In this experimental, if the PSNR value is higher, that image is more similar with result image of 2D-Gabor filter. Equation (3) is for PSNR.

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\{I(i,j) - K(i,j)\}^2$$

$$PSNR = 10 \times \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \quad (3)$$

Here, I and K are images for sourse and target that have m×n pixels as the size. And MAX_I is the maximum possible pixel value of the image.

In this experiment, we use one PC and two evaluation boards based on ARM processor. PC have a Intel Pentium 4 processor that is operated on 1.5Ghz clock. And 256Mbytes SDRAM is used for main memory. Operating system of PC is Ferora 7 (kernel version 2.6.21), and compiler is gcc (version 4.1.2). For the embedded system, SA-1110 (206MHz) and PXA255 (400MHz) are used as the processor. Two embedded systems have 64 Mbytes and 128 Mbytes SDRAM as main memory respectively. And both system use linux kernel (version 2.4.0 and 2.4.19 are used) as operating system. Cross-compiler for both embedded systems is arm-linux-gcc (version 2.95.3). Both the number of orientations for 2D-Gabor and Separable Gabor are 8 (0 , 22.5 , 45 , 67.5 , 90 , 112.5 , 135 and 157.5) degrees. And both the number of orientation for WSSG with and without LUT are 5 (0 , 22.5 , 45 , 67.5 , 90) degrees, because the filter based on WSSG can reduce filtering for diagonal orientation by half. As the optimization level for an option of compiler, level 2 is used. The size of an image is 180×140 pixels, and the size of the 2D-mask for 2D-Gabor filter is 61×61 pixels, and the size of the 1D-mask for the other fitlers is 61 pixels.

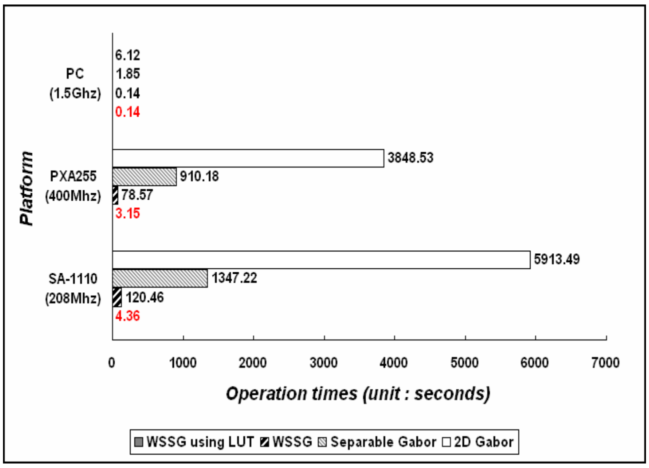


Figure 2 - Evaluate process time

[Figure 2] is the result about process time. In the result, when using LUT, the process time on the PC is very similar, but the process times on the embedded systems are reduced by about 96% and 96.4% respectively.

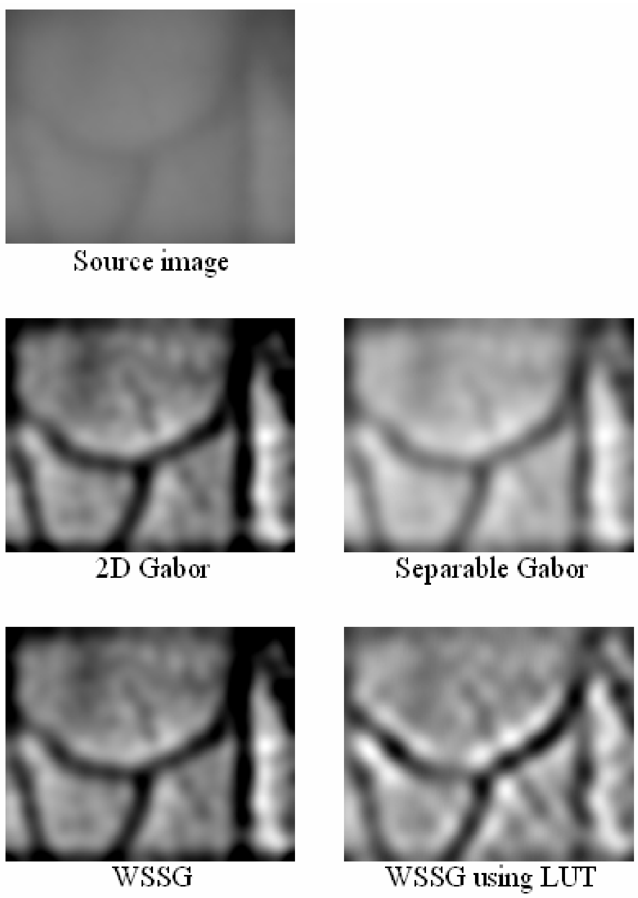


Figure 3 - Result images

[Figure 3] is input and result images. As you can see, result images are very similar.

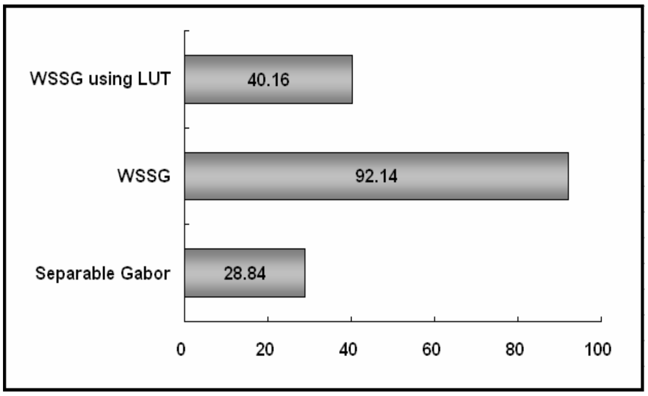


Figure 4 - PSNR result

[Figure 4] is PSNR result against result image of 2D-Gabor filter. PSNR In this result, PSNR of WSSG using LUT is 40.16db.

6. Result

In this paper, we use LUT on process of convolution for WSSG filter to reduce the process time. In the result on the embedded system, process time is reduced by about 96.0~96.4% with comparable enhancement result.

References

[1] http://hitachi.com/rev/archive/2004/2006642_12604.html

[2] http://www.fujitsu.com/downloads/GLOBAL/labs/papers/palmvein.pdf

[3] Hyun-Bo Shim, Young-Bae Park, "Fingerprint Recognition using Gabor Filter," *The KIPS transaction*, Part B, Vol. B9, Issue 5, pp.653-662, 2002.

[4] http://matlabserver.cs.rug.nl/

[5] Vutipong Areekul, Ukrit Watchareeruetai, and Sawasd Tantaratana, "Fast Separable Gabor Filter for Fingerprint Enhancement," *Proceeding International Conference on Biometric Authentication (ICBA2004)*, LNCS3072, Springer, pp. 403-409, 2004.

[6] Sang-Woo Sin, Kyung-Sik Jang, "Weighted Separable Symmetrical Gabor Filter for Vein Identification," *The institute of electronics engineers of korea*, CICS 2007, Vol. 30-2.

[7] Choi Hwan-Soo, "A Biometric Technology Utilizing Hand Blood Vessel Pattern," *KIPS*, Vol. 19, No. 7, 2001. 7, pp. 45-50.

[8] B. G. Sherlock, D. M. Monro, and K. Millard, "Fingerprint enhancement by directional Furier filtering," Vision, Image and Signal Processing, *IEEE Proceedings*, Vol. 141, pp.87-94, Apr. 1994.

[9] J. G. Daugman, "Uncertainty relations for resolution in space, spatial frequency, and orientation optimized by two-dimensional visual cortical filters," *Journal of the Optical Society of America A*, vol. 2, pp. 1160-1169, 1985.