International Journal of Multimedia and Ubiquitous Engineering
Vol.11, No.8 (2016), pp.37-44
http://dx.doi.org/10.14257/ijmue.2016.11.8.04

# Based on the Improved Fusion Algorithm of Wavelet Image Contrast and Canny Operator

Liying Yuan and Xue Xu

*College of Automation, Harbin University of Science and Technology, Harbin, China*
*huazi90927@163.com*

***Abstract***

*Aiming at the visual effect and the fusion quality is poor of the traditional image fusion algorithm, the new fusion algorithm is adopted that combining the Canny operator with taking big window contrast. The algorithm uses wavelet transform to the original images are decomposed firstly, the process will be based on the frequency characteristics of the image information to form two pieces of information, low frequency and high frequency information. Low frequency subband uses weighted average fusion algorithm, while high frequency subband uses the algorithm which combines Canny operator with taking big window contrast, the last fusion image is got from the wavelet reconstruction in contrast to the principle of wavelet decomposition . The corresponding simulation analysis was carried out on the fusion algorithm, and the visual effect is more clear. Also the object evaluation standard increased significantly.*

***Keywords****: image fusion; wavelet decomposition; Canny operator*

## 1. Introduction

In recent years, image fusion technology has been developed widely, important information of target image is fused according to the different demand of various fields. Stability and availability of target tracking, recognition and detection have been improved greatly from image processing. By extracting multiple sensor device at the same time or different time to collect useful image information, image fusion technology are used to get the one from a single sensor is unable to get the new information about image scene description [1-2]. Image fusion application information redundancy of source images that can improve the SNR and complementarity that obtain more specific, more comprehensive information. Image fusion technology played an indispensable role in meteorological forecast, medical diagnostic imaging and military target recognition fields due to these advantages. Image fusion based on the process phase is divided into three fundamental levels: the pixel level fusion on basic data layer, feature level fusion on the middle layer and decision level fusion at the highest layer [3-4]. Image fusion at pixel level is in the most basic level of information fusion, which can keep the scene of the original information as much as possible due to fusion process using the original data directly. Additionally, image fusion at pixel level has the highest accuracy and , providing detail information that feature level and decision level image fusion does not have , comparing feature level fusion and decision level fusion ,so the pixel level image fusion is one of the most popular direction in the field of image processing [5]. Pixel level image fusion need to source image preprocessing, including image enhancement, noise reduction and registration, in order to improve the quality of fused image. The pixel level image applies the multi–resolution structure in multiple gray level image fusion process. This paper uses multi-resolution structure of the images processed by wavelet transform, and Canny operator to detect edge, then image is fused based on the characteristics of human

ISSN: 1975-0080 IJMUE

visual features is sensitive to neighborhood contrast in different resolution on edges. Finally, fusion image is got through the principle of wavelet reconstruction.

## 2. The Theoretical Basis of Image Wavelet Decomposition

Wavelet transform was proposed by the French earth physicist J. Morlet in 1948, which develops as a new mathematics branch rapidly. The useful information of the signal can be extracted accurately after wavelet transform. Wavelet transform has the ability to focus on the object, which can realize the signal multi-scale refinement, make the signal to the time domain and frequency domain unified pace, and keep frequency domain by orthogonal decomposition [6]. That the relationship between time domain and frequency domain can be reflected fully in the wavelet transform, and the fusion image can obtain good effect. So wavelet transform is very important in image fusion, and it is extended to other fields.

Image is treated as a two-dimensional function processing in spectrum analysis, space from $L^2(R)$ to $L^2(RXR)$, feet function from $\phi(x)$ to $\phi(x,y)$. If $\{V_j\}_{j\in z}$ is a multi-resolution analysis of $L^2(R)$, tensor space $\{V_j^2\}_{j\in z}$ is expressed as

$$V^2{}_j = V_j \otimes V_j \tag{1}$$

The three directions of the wavelet function are expressed as:

$$\psi^1(x,y) = \phi(x)\psi(y) \tag{2}$$

$$\psi^2(x,y) = \psi(x)\phi(y) \tag{3}$$

$$\psi^3(x,y) = \psi(x)\psi(y) \tag{4}$$

If $\psi(x)$ is orthogonal wavelet of one dimensional multi-scale analysis $\{V_j\}_{j\in z}$ in $L^2(R)$, the multi-scale analysis of two-dimensional horizontal, vertical and diagonal direction of integer wavelet function of translation respectively, $\{\psi_{j,n}\phi_{j,m}\}$, $\{\phi_{j,n}\psi_{j,m}\}$, $\{\psi_{j,n}\psi_{j,m}\}$, which constitute orthogonal wavelet basis orthogonal wavelet base of $L^2(RXR)$ [7.8]. Integer translation system of horizontal, vertical and diagonal directions wavelet functions of two dimensional multi-scale analysis is $\{\psi_{j,n}\phi_{j,m}\}$, $\{\phi_{j,n}\psi_{j,m}\}$, $\{\psi_{j,n}\psi_{j,m}\}$ respectively.

Wavelet transform can change adaptively the time-frequency window and refine the image each local information. Wavelet transform is more ideal than the previous Fourier transform in the image processing field [9]. The image is decomposed by wavelet transform into $N$ layers, the result contains $(3N+1)$ different bands, including a low frequency component $(LL)$ and $3N$ high frequency component ($LH, HL, HH$).Figure 1 is the image secondary wavelet decomposition （$N$ =2, than seven different frequency band is obtained.

 

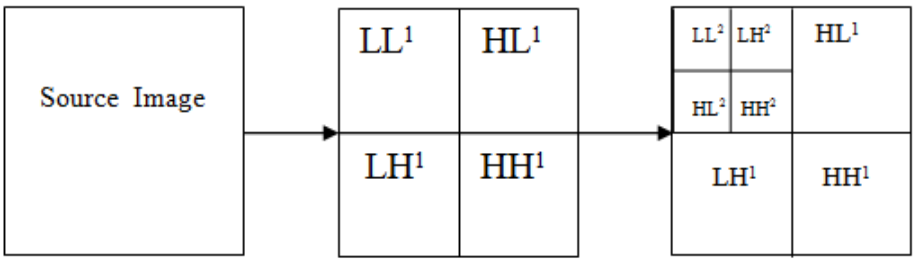


**Figure 1. Secondary Image Wavelet Decomposition**

## 3. Fusion Method

### 3.1. The Direction of Contrast

Image contrast $C$ is defined as [10]:

$$C = (L - L_B) / L_B = L_H / L_B \tag{5}$$

$L$ represents the local brightness of the image, $L_B$ represents the image of local background luminance (the equivalent of low frequency component).The meaning of $L_H = L - L_B$ is the high frequency component in type (5). According to the above formula (5) and the advantages of wavelet transform, more detailed direction contrast expression is got:

$$\begin{aligned} &\text{Vertical contrast:} && C_{l-1}^{v} = D_{l-1}^{1} / A_{l-1} \\ &\text{Horizontal contrast:} && C_{l-1}^{H} = D_{l-1}^{2} / A_{l-1} \\ &\text{Diagonal contrast:} && C_{l-1}^{D} = D_{l-1}^{3} / A_{l-1} \end{aligned} \tag{6}$$

Type (6) is more specific than (5) about the form of contrast definition. Subband signals $A_{l-1}$, $D_{l-1}^{1}$, $D_{l-1}^{2}$ and $D_{l-1}^{3}$ constitute the orthogonal complement $2^{l-1}$, $A_l$ is the straight summation of $A_{l-1}$ and $D_{l-1}^{d}$ (d = 1, 2, 3):

$$A_l = A_{l-1} \oplus \sum_{d=1}^{3} D_{l-1}^{d} \tag{7}$$

### 3.2. Canny Operator

Canny [11] proposed the optimal edge detection operator Canny edge detection operator in 1986.Canny operator has very good detection effect. So far, Canny operator is still the main method of edge detection. Canny edge detection is mainly divided into 4 parts, the specific steps as described below:

#### 3.2.1 Image Smoothing Filtering

Canny algorithm chooses appropriate one dimensional gaussian function, and the image have smoothing denoising according to the row and column respectively, which is equivalent to convolution of image signal. The gaussian function selected as:

$$G(x) = \frac{1}{\sqrt{2\pi\sigma}} e^{\frac{-x^2}{2\sigma^2}} \tag{8}$$

$\sigma$ standards deviation of the Gauss curve ,and it controls the smooth process.

### 3.2.2. Calculate the Amplitude and Direction of the Gradient

Usually, gradient calculation uses the method of partial derivatives, the Canny algorithm adopts finite difference of first order partial derivatives from 2x2 neighborhood to calculate gradient amplitude and gradient direction of the smoothing data array $I(x, y)$ [12-13]. Among them, the two arrays $P_x(i, j)$ and $P_y(i, j)$ from partial derivative of the $x$ and $y$ direction as:

$$P_x[i, j] = (I[i, j+1] - I[i, j] + I[i+1, j+1] - I[i+1, j]) / 2 \quad (9)$$

$$P_y[i, j] = (I[i, j] - I[i+1, j]) + I(i, j+1) - I[i+1, j+1]) / 2 \quad (10)$$

The pixel gradient amplitude and gradient direction using the coordinate transformation formula of rectangular coordinates to polar coordinates, the gradient amplitude is calculated by two order norm.

$$M(i, j) = \sqrt{(P_x[i, j])^2 + (P_y[i, j])^2} \quad (11)$$

The gradient direction as:

$$\theta[i, j] = \arctan(P_y[i, j] / P_x[i, j]) \quad (12)$$

### 3.2.3. With Non-Maximum Suppression of the Gradient Amplitude, Retain Local Gradient Value Maximum Points

In order to extract single pixel and wide edge, gradient amplitude diagram must be specified. In a gradient amplitude image .Ridge belt is produced near the maximum value of $M(i, j)$ .The edge position is determined refining accurately by refining these ridge. Only keep amplitude local maximal changes point, which is non maximum suppression.

### 3.2.4. The Edge is Detected and Connected with Hysteresis Threshold. The Threshold Selection Affects the Quality of Edge Detection

The sub image $N[i, j]$ through the non-maximum suppression and gradient histogram classification uses the high and low threshold $H_{Th}$ , $H_{Tl}$ . The pixel gray level of gradient is less than the threshold value is set to 0, and image is divided into 2 threshold edge image $T_h[i, j]$ and $T_l[i, j]$. Image is got by high threshold value, so image contain seldom false edge. $T_l[i, j]$keeps edge information comprehensively, but also contains some false edge. The comprehensive edges are got by basis of image $T_h[i, j]$, supplement of image $T_l[i, j]$.

### 3.3. Based on the Wavelet Image Fusion Algorithm of Improved Contrast and Canny Operator

Two parts frequency information are got by decomposition of the image. The low frequency part reflects the image overview and average characteristics, and the high frequency part expresses the detail information of image, such as the edge, definition and so on. These detail features can be represented with contrast parameter. This article adopts the method of the local contrast, considering the relationship of image and neighborhood pixels, which can descript completely regional features of the image. The specific of fusion steps are as follows:

(1) The pretreatment of the image

 

(a)Image filtering: Preprocessing operation of the original image for eliminating noise. or to contain the noise image directly fusion will inevitably lead to image noise affect the final fusion result. Otherwise, fusing noisy images will affect inevitably the final fusion results.

(b)Image registration: In order to get more extensive information, information provided by the various imaging modes can not meet the needs. Its defect can be offset by multi focus, because them have complementarity.

(2) Wavelet decomposition. The two source images is performed by 3 layer wavelet decomposition , then get the low frequency sub band coefficients $L_{A,N}(x,y)$, $L_{B,N}(x,y)$ ( $N$ =3) and a number of high frequency sub band coefficients $D_{l-1}^1$, $D_{l-1}^2$ and $D_{l-1}^3$ are got.

(3) Low frequency fusion。Low frequency part of images reflects the overall outline, the overall information, and low frequency is fused by weighted average method, which can be represented as:

$$L_{F,N}(x,y) = \alpha_1 L_{A,N}(x,y) + \alpha_2 L_{B,N}(x,y) \tag{13}$$

Among them, $\alpha_1$ , $\alpha_2$ shows weighting coefficient, and $\alpha_1$ + $\alpha_2$ = 1, here $\alpha_1 = \alpha_2 = 0.5$ .Because the gap of two source image information is not very big, $\alpha_1 = \alpha_2$ making fusion efficiency improved significantly.

(4) The high frequency fusion. The source image is extracted edge, and $3\times 3$ neighborhood window is established on edge. Judging how much of the fusion image detail information by comparing the size of the area direction contrast. Fusion images of the color, brightness, clarity, detail performance will have a very significant advantage, with the direction contrast becomes great. According to formula (6), each pixel point is processed according to the above take big window contrast algorithm:

$$\begin{cases} D_{l,A}^d(i,j) \ , & C_{l-1,A}^d(i,j) > C_{l-1,B}^d(i,j) \\ D_{l,B}^d(i,j) \ , & \text{ot her} \end{cases} \tag{14}$$

$D_{l,F}^d(i,j)$ stands a high frequency sub band coefficients that is handled with Canny operator after $l$ layer decomposition. $C_{l-1,T}^d(i,j)$ （ $d = H,V,D \quad T = A,B$ ） stand horizontal, vertical and diagonal direction contrast respectively.

(5) The wavelet reconstruction. Based on the first three steps, the wanted image information extracted, the redundant part is filtered out. Then the fusion image is got by wavelet reconstruction.

## 4. Evaluation of the Quality from Fusion Image

Image fusion quality evaluation is an important part in the image field. Evaluation methods are different, with the different practical applications and purpose of image fusion. On the whole, the method of evaluating the quality of image fusion can be divided into two categories: subjective evaluation and objective evaluation. Subjective evaluation method that the observer relies on their own feeling and experience to assess the quality of fusion image directly, which is affected by people's knowledge, ability and so on. Another objective evaluation method is that judge the performance of the algorithm by comparing the size of some parameters.

This article uses the objective standard to evaluate the quality of different algorithms fusion image, such as information entropy, the standard deviation and average gradient. These parameters can select which algorithm performance has more significant advantages.

Image information entropy is defined as how much average information contained in the image, which is a kind of statistical characteristics of image information form. As the main basis of measuring the image information, thus the greater the information entropy means contains more information. The definition of information entropy as follows:

$$H=-\sum_{i=0}^{L-1} p(i)\log_2 p(i) \tag{15}$$

$p_i$ means distribution probability of gray level $i$, and $L$ means image total grayscale in the type.

The average gradient can show the details of the image and the gray level change rate sensitively. The average gradient expression is as follows:

$$\nabla G=\frac{1}{(M-1)\times(N-1)}\sum_{i=1}^{M-1}\sum_{j=1}^{N-1}\sqrt{(\nabla xF(i,j))^2+(\nabla yF(i,j))^2} \tag{16}$$

$\nabla xF(i,j)$ means difference of $F(i,j)$ along the $x$ direction, and $\nabla yF(i,j)$ means difference of $F(i,j)$ along the $y$ direction. The m layer type on the value, the greater the representative image, the edge information more eye-catching, the higher the relative resolution, the final image visual more satisfactory. The difference have higher value means the more image layers, the more prominent the, edge information, the higher the resolution. The final image vision is more satisfactory.

Standard deviation is an important index to measure the distribution of the image gray value. The greater the standard deviation indicates the degree of grayscale distribution deviation from the mean value, contenting the more useful image. The smaller the standard deviation means image grayscale distribution focus, carrying the less information. The standard deviation expression is:

$$\sigma=\sqrt{\frac{1}{M\times N}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(F(x_{i,}y_i)-\overline{f})^2} \tag{17}$$

$\overline{f}$ means fusion image grayscale average.

## 5. The Experimental Results

Two face the left and right focus image focus image simulation experiment is conducted through MATLAB to illustrate this paper based on the improved contrast and Canny operator performance of wavelet image fusion algorithm. This paper selects db4 wavelet, the wavelet significant advantages compared with other evaluation parameters of wavelet base. Figure a) is the right image, Figure b) is the left image, and Figure c) is image is got by the method of literature, namely, the experimental results of image fusion based on the gradient method. The image is got by literature in Figure d), namely, the experimental results of image fusion based on the contrast method. The image is got by this paper in Figure e), namely, based on the improved contrast and Canny operator image fusion method. The edge is blur , some ghosting in hat place, Mosaic around the eyes in Figure c); The edge fuzzy phenomenon has eased, still have shadow in the hat, overall effect has improved in Figure d);The boundary is clear, no fuzzy and shadow phenomenon in Figure e). This paper algorithm advantages is saw through objective evaluation parameters in Table 1.

 


a) The Right Focus Image b) The Left Focus Image



c) Gradient Method d) Variance Method e) Contrast and Canny Operator Method

**Figure 2. Comparison of Different Fusion Image Effect**

Table 1 lists the objective evaluation parameters in order to compare the algorithm fusion quality:

**Table 1. Comparison of Objective Evaluation Index of each Algorithm**

| Algorithm | standard deviation | information entropy | average gradient |
|---|---|---|---|
| Gradient in solution | 50.6211 | 7.3636 | 5.0564 |
| Variance method | 50.7134 | 7.3705 | 4.9612 |
| Contrast and canny operator method | 50.7678 | 7.5802 | 5.0794 |

## References

[1] L. Yuan and L. Sun, "Infrared image denoising based on wavelet linear minimum mean square error", Journal of Harbin University of Commerce (NATURAL SCIENCE EDITION), vol. 4, **(2012)**, pp. 439-443
[2] T. Bai and C. Deng, "Image edge detection method based on wavelet transform and Canny operator fusion", Journal of Harbin University of Science and Technology, vol. 1, **(2010)**, pp. 44-47,51.
[3] H. Liu and Y. Shi, "New method of image fusion based on wavelet analysis", computer engineering and application, vol. 6, **(2013)**, pp. 205-208.
[4] W. Liu, "Image information fusion and recognition", Beijing: Electronic Industry Press, **(2008)**.
[5] Z. Qin and F. Bao, "Digital image fusion", Xi'an Jiao Tong University press, **(2004)**, pp. 1-6.
[6] H. Li and Z. Ning, "Based on regional energy and inter layer correlation weighted image fusion algorithm", Harbin University of Technology, vol. 5, **(2014)**, pp. 99-102.
[7] Y. Bingkun, "The Study on Information Fusion algorithm of Multi-sensor remote sensing image", Hubei: Wuhan University of Science and Technology, **(2007)**.
[8] D. M. Bulanon, T. F. Burks and V. Alchanatis, "Image fusion of visible and thermal images for fruit detection", Biosystems Engineering, vol. 103, no. 1, **(2009)**, pp. 12-22.
[9] J. W. Roberts, A. J. Van and F. B. Ahmed, "Medium resolution image fusion, does it enhance forest structure assessment, in: International Archives of the Photogrammetry", Remote Sensing and Spatial Information Sciences, Beijing, China, vol. XXXVII, no. 8, **(2008)**, pp. 3-11.
[10] L. Wang, "A multi focus image fusion method based on wavelet direction contrast" Chinese Journal of image and graphics, vol. 1, **(2008)**, pp. 145-150.
[11] J. Canny, "A computational approach to edge detection", IEEE Trans Pattern Analysis and Machine Intelligence, vol. 8, no. 6, **(1986)**, pp. 679-698.

 

[12] J. Lin and X. Zhao, "A gradient based image fusion algorithm for multi focus image", Fujian computer, vol. 5, **(2007)**, pp. 92-93.
[13] T. Pu and G. Ni, "Based on the multi resolution image fusion", Electronic journal, vol. 28, no. 12, **(2000)**, pp. 116-118.

 