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A Novel Image Fusion Algorithm Combining with Classification in NCST Domain

Jitao Zhang, Aili Wang and Jiaying Zhao

Higher Education Key Lab for Measuring & Control Technology and Instrumentations of Heilongjiang, Harbin University of Science and Technology, Harbin, China
zhangjitao1978@sina.com

Abstract

Image fusion is an important branch of information fusion, which is widely used in various fields. At present, the image fusion method is mainly aimed at the different frequency information of the images, the images are fused in transform domain. But in practical application, image fusion is used to improve the credibility of the target information and the demand of background information of is not high. Therefore, this paper puts forward an image fusion method combining with image classification. Firstly, the NSCT transform is used to transform the source images, and the K-Means method is used to realize the classification of the target and the background, and the different fusion criteria are used to get the target and the background. The experimental results show that the image fusion based classification method has a better effect on the subjective visual effect and objective evaluation index.

Keywords: *Image fusion; image classification; NSCT; K-Means*

1. Introduction

Image fusion is to refer to obtain images of the same scene from the images of different sensors of the same scene, or different sensors in different modes or different imaging time, using fusion technology to merge into a more abundant rich image [1-3]. Image fusion as the basis for human or machine to carry out further image analysis, the main objective is to improve object clarity and information content [4-5]. Thus in the process of the image fusion, target information uses fusion criterion with relatively high computational complexity, the background information uses fusion rule which computational complexity is relatively low In this way, it can not only guarantee the fusion effect of the target information, but also reduce the computational complexity [6-7].

Image classification divides the image pixels into different categories according to certain attributes of the image. In recent years, image classification has been widely studied as the basis of tracking and detection. Image classification can be classified according to the background samples and the target samples in advance [8-9]. In 2010, Yang Yi *et. al.*, proposed image fusion method based on classification using principal component analysis(PCA), and the practice proved the superiority of the method. 2012; Zhao Chunhui *et. al.*, proposed image classification based on wavelet transform, and applied the method to hyperspectral image classification successfully. Therefore, this paper proposes an image fusion algorithm based on NSCT transform and K-Means classification.

2. K-Means

Clustering task is to assign all instances into some clusters, the clusters in the same instance gather around a cluster center, and the distance between them is near; However,

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the distance between different clusters instances is relatively far. Common clustering analysis methods are KNN, K-means, K-Center, FCM, *etc.*, the following part focuses on the K-Means method used in this paper [10-11].

K-Means algorithm is one of the most widely used clustering algorithms. It divides the data set into different categories through an iterative process. Algorithms are described: (1) initialize k seeds for center vector $c_1, c_2, \ldots c_k$ (2) packet: assign samples to each of the nearest center vector, these samples construct disjoint clustering; (3) determine the center and a clustering center vector is regarded as a new center; (4) duplicate the steps of packet and determination of the center , until convergence [12-13].

Firstly, input the number of clusters K and database which contains n objects, determine an initial cluster center for each cluster, thus K initial cluster centers are obtained; Secondly, samples of the counterfeiting of according to the distribution principle of the minimum distance to the nearest neighbor clustering; again in each cluster sample mean as a new cluster center, repeated 2.3 know clustering center does not change; at the end of the last, get the K clustering and output K clusters, the square error criterion is minimized. The functions used are as follows:

Minimum value of the function:

$$\sum_{i=1}^{n} \min_{j\in\{1,2\ldots k\}} \| x_i - p_i \|^2 \tag{1}$$

Update cluster average value:

$$Z_j(I) = \frac{1}{n}\sum_{i=1}^{n_j} x_i^{(j)} \tag{2}$$

Calculate criterion function J_c:

$$J_c(I) = \sum_{j=1}^{k}\sum_{k=1}^{n_j} \| x_k^{(j)} - Z_j(I) \|^2 \tag{3}$$

The distance of each data object to the cluster center $D(x_i, Z_j(I)), i = 1,2,\ldots n;\ j = 1,2,3\ldots k$:

$$D(x_i, Z_k(I)) = \min\{D(x_i, Z_k(I)), j = 1,2,3\ldots n\} \tag{4}$$

Figure 1, is a flow chart of the K-Means algorithm.

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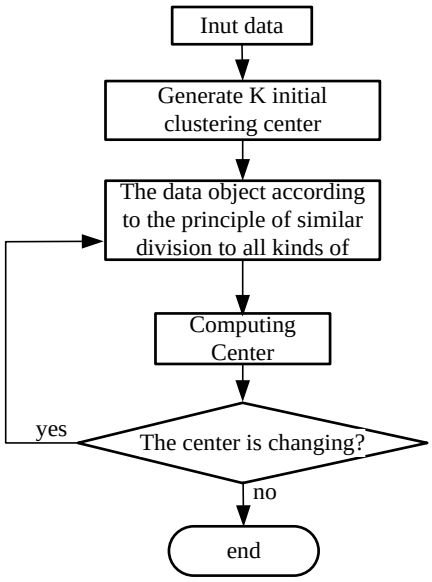

Figure 1. The Flow Chart of K-Means Algorithm

3. Introduction of PCNN Theory

PCNN is a new neural network different from the traditional artificial neural network, which is composed of a plurality of neurons interconnected feedback neural network. Each neuron Nij is composed of receiving part, modulation and pulse generating part three parts, as shown in Figure 1, [14-15].

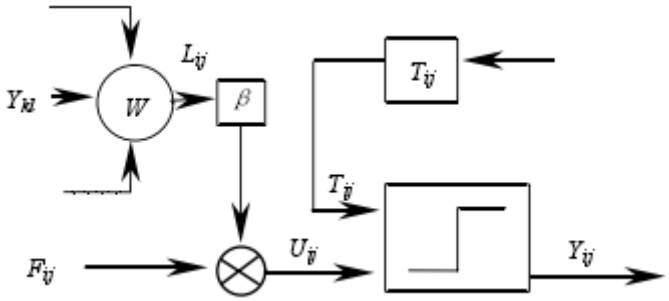

Figure 2. Single Neural Cell Model

When image size of M*N is processed by PCNN, the gray value of each pixel should be used as the input of each neuron, so the image matrix of M*N is composed of M*N neurons belong to PCNN neuron network, and the activity of each neuron can be described by the following formula [16-18]:

$$F_{ij}[n] = e^{-\alpha F} F_{ij}[n-1] + S_{ij} + V_F \sum_{kl} M_{ijkl}\, Y_{kl}[n-1] \tag{5}$$

$$L_{ij}[n] = e^{-\alpha L} L_{ij}[n-1] + V_L \sum_{kl} M_{ijkl}\, Y_{kl}[n-1] \tag{6}$$

$$L_{ij}[n] = e^{-\alpha L} L_{ij}[n-1] + V_L \sum_{kl} M_{ijkl}\, Y^1_{kl}[n-1] + V_N \sum_{kl} M_{ijkl}\, Y^2_{kl}[n-1] \tag{7}$$

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$$U_{ij}[n] = F_{ij}[n]\left(1 + \beta L_{ij}[n]\right) \tag{8}$$

$$T_{ij}[n] = e^{-\alpha T} T_{ij}[n-1] + V_T Y_{ij}[n] \tag{9}$$

$$Y_{ij}[n] = \begin{cases} 1 & U_{ij}[n] \geq T_{ij}[n] \\ 0 & \text{otherwize} \end{cases} \tag{10}$$

Where $S_{ij,}$ Y_{ij} and U_{ij} are respectively stimulate input, internal behavior and output of neuron N_{ij}. L_{ij} and F_{ij} are respectively neurons linked domain and feedback to the domain of the two input channels, M and W are weight coefficient matrix for connection between neurons. V_F and $V_l(V_N)$ are amplification coefficients of feedback and link domain. T_{ij} and V_T are amplification coefficients of parametric threshold function output power and threshold. α_L, α_F and α_T are time constants of links domain, feedback domain and variable threshold function [19-20].

4. Image Fusion Method Based on Image Classification and PCNN

4.1. Image Classification Based on K-Means in NSCT Domain

In this paper, an image fusion method based on image classification and PCNN is proposed, which assumes that the source images are A and B, and the fusion result is F. The classification method in NSCT domain is explained as following:

(1) From the image A, B, extract a number of samples belong to background and objects and the total sum is K.

(2) Apply NSCT transform to the samples and get the transform coefficients of different levels.

(3) The mean of different levels of the transform coefficients is extracted as a feature vector, which is used as an element in the feature vector. Thus, the feature points for the target and the background are extracted completely.

(4) Apply NSCT transform to the whole image A and B. Decomposition level and the number of direction are the same as step (2).

(5) The K group transform coefficients which are obtained in step (3) are used as the initial cluster centers, the K-Means method is used to the transform coefficients of the images for classification.

(6) According to the classification results obtained from step (5), the region belongs to the background is marked with black, the object region is marked with white.

Figure 3, gives the classification results based on K-Means in wavelet domain and Nonsubsampled contourlet transform(NSCT) domain. The experimental images are selected as the right and left focus image Clock_A and Clock_B. For the excellent decomposition performance of NSCT, the classification result in NSCT domain is better than the one in wavelet domain. Thus the fusion steps are processed in NSCT domain too.

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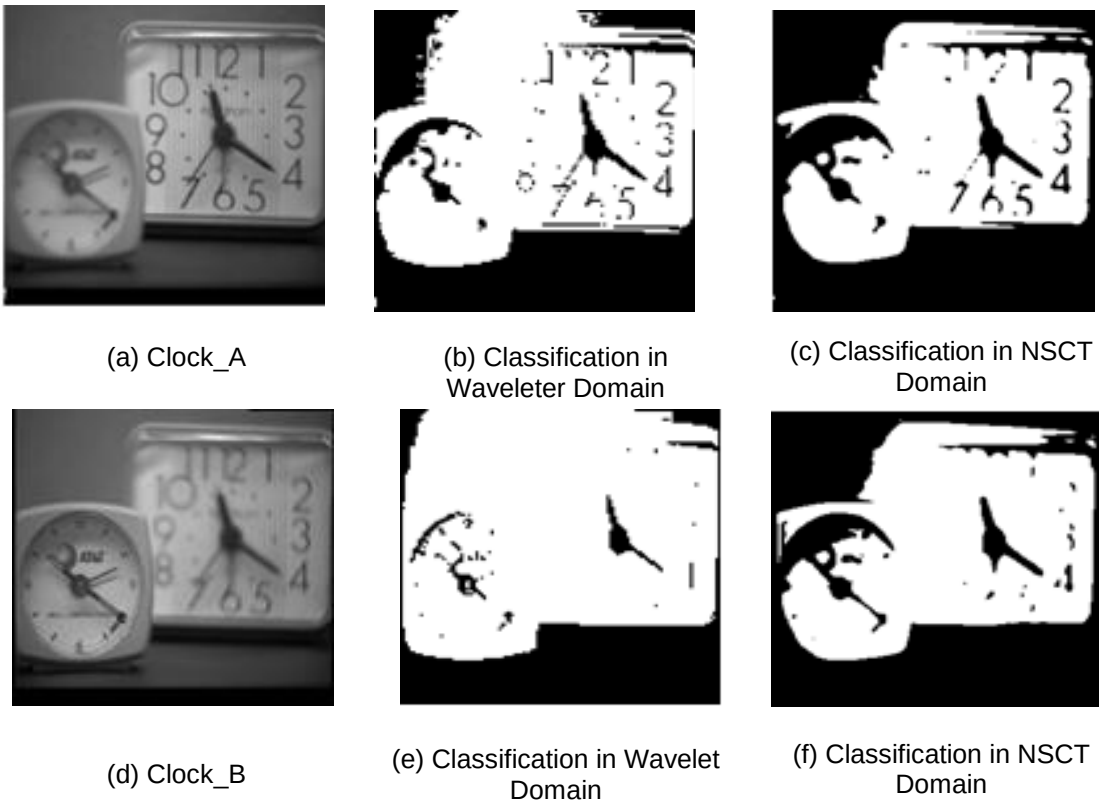

(a) Clock_A

(b) Classification in Waveleter Domain

(c) Classification in NSCT Domain

(d) Clock_B

(e) Classification in Wavelet Domain

(f) Classification in NSCT Domain

Figure 3. Classification Results in Different Transform Domain

4.2. Background Information Fusion Criterion

Because the purpose of the fusion is to improve the definition of the target information, the requirement for the background information is not high, so mean rule is applied to background fusion. Set $F_b(i,j)$ as the fused pixel value of the background image at the pixel (i,j), $A_b(i,j)$ and $B_b(i,j)$ are background pixel values of the source image A and image B. The mean fusion rule is shown as following:

$$F_b = \frac{A_b(i,j) + B_b(i,j)}{2} \tag{11}$$

4.3. Target Information Fusion Criterion

The NSCT transform coefficients can be divided into two parts, the low frequency and high frequency coefficients. The low frequency information is the overall image intensity information and overall trend information, so for low frequency information belong to the target are fused by mean fusion criterion too. $F_{ol}^K(i,j)$ is the fused value of target's low-frequency decomposition coefficients at (i,j), $A_{ol}^K(i,j)$ is the low-frequency coefficient of image A in K-level NSCT decomposition, $B_{ol}^K(i,j)$ is the low-frequency coefficient of image B in K-level NSCT decomposition, the low-frequency fusion rule is shown as follows:

$$F_{ol}^K(i,j) = \frac{A_{ol}^K(i,j) + B_{ol}^K(i,j)}{2} \tag{12}$$

Due to the high frequency part reflects the details of the image information, and each pixel point is not independent and relevant to the neighbor pixels, so a global fusion

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method can be considered for the high frequency part fusion. PCNN can extract useful information from complex background, with a synchronous pulse distribution and global coupling characteristics, and its signal form and mechanism more are in line with human visual neural system for physiological basis. So in the part of high frequency coefficients, we adopt the PCNN neural network for fusion.

In the PCNN method, the attenuation coefficient is 1 in the formula (4), the amplitude gain equals 0.2, the internal connection matrix is $\frac{1}{(i-m)^2+(j-n)^2}$. The attenuation coefficient equals 2 in the formula (6); the amplitude gain is 20; the connection strength in the formula (5) is computed as following:

$$\beta = \sum_{i,j\in M}(A_{obj}(x,y) - A_{obj}(x+1,y))^2 + (A_{obj}(x,y) - A_{obj}(x,y+1))^2 \quad (13)$$

Set $F_{high-obj}(x,y)$ as the fused pixel value of the background image at the pixel (i,j), $A_{obj}(x,y), B_{obj}(x,y)$ are object coefficients of the source image A and image B in high frequency subband. For fusion results, when $Y_{ij}^k = 1$, $F_{high-obj}(x,y) = w * A_{obj}(x,y) + (1-w) * A_{obj}(x,y)$, when $Y_{ij}^k = 0$, $F_{high-obj}(x,y) = (A_{obj}(x,y) + B_{obj}(x,y))/2$,

where $w = abs(A_{obj})/(abs(A_{obj}) + abs(B_{obj}))$.

4. Experimental Results and Analysis

In order to validate the fusion algorithm, select the two groups of multifocus images. Experiments have been carried out on the basis of MATLAB2012. NSCT+PCNN+Classification is the proposed method in this paper, and compared to NSCT+PCNN and Wavelet+PCNN+Classification two methods. Figure 4, and Figure 5, give the fusions results of Clock and Lab images.

(a) NSCT+PCNN (b)Wavelet+PCNN+Classifica (c)NSCT+PCNN+Classificatio

Figure 4. Image Fusion Results of Clock

(a) Lab_A (b) Lab_B

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(c)NSCT+PCNN (d)Wavelet+PCNN+Classification (e)NSCT+PCNN+Classification

Figure 5. Image Fusion Results of Lab

Figure 4, and Figure 5, show fusion results obtained by our proposed method get more bettern subjective visual effect comparing to the other methods, especially in image texture information. To further validate the advantages of the method, the following results for a fusion of an objective evaluation conducted a statistical analysis. Among them, PSNR is the Power Signal-to-Noise Ratio of image, MI is the mutual information which shows the fusion result from the source image information, QABF is according to keep edge information, H expresses the information content in the image, SF is the overall image spatial domain activity, AVE shows the clarity of the image. CERF is the Cross Entropy showing the gray difference between images. Fusion results by different methods are given in Table 1.

Through the above table, we can see that the method proposed in this paper is superior to other methods in terms of objective evaluation index. Compared with the NSCT+PCNN method, characteristics of human vision is considered in the process of image fusion. In order to get the target information and background information for human, adopt different fusion rules using the weighted coefficient criterion in the fusion information of the target, the simple weighted average in the background, which reduces the amount of calculation at the same time and improves the fusion efficiency and image clarity. Compared with Wavelet+PCNN+Classification method, the use of NSCT transform for image decomposition with multi-direction and shift invariance, so this method demonstrate the superiority in the classification process.

Table 1. Image Fusion Performance Comparison by Different Methods

Images	method	PSNR	CERF	MI	QABF	H	SF	AVE
Clock	NSCT+PCNN	54.988	0.0563	17.1228	0.5042	7.3544	8.9595	0.0249
	Wavelet+PCNN +Classification	55.537	0.070	18.264	0.482	7.2795	12.1567	0.0338
	NSCT+PCNN +Classification	58.5167	0.0601	19.503	0.528	7.3501	12.5856	0.0350
Lab	NSCT+PCNN	48.624	1.3139	12.6345	0.2939	7.0325	8.8043	0.0113
	Wavelet+PCNN +Classification	42.8448	2.7208	12.5346	0.2820	6.9167	8.7302	0.0114
	NSCT+PCNN +Classification	57.261	0.9108	13.044	0.4097	7.2160	8.9302	0.0112

5. Conclusion

Image classification is the base of pattern recognition and target tracking. The image is classified according to the different characteristics and divided into target and background two parts with the human brain rules of image processing, so the image fusion combined with image classification has a certain theoretical basis. In this paper, image fusion

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method called NSCT+PCNN+Classification is proposed, and the experimental results show that the proposed method is superior to both subjective and objective evaluation indicators.

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