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A New Technology of Remote Sensing Image Fusion

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Abstrak

Transformasi paket Wavelet menonjol di bidang fusi citra karena karakteristik frekuensinya yang baik, dan jaringan syaraf berpasangan pulsa (PCNN) memiliki keunggulan yang unik dalam pengolahan citra. Untuk mengatasi masalah fusi citra penginderaan jauh spektrum jamak, dalam makalah ini, kami mengajukan sebuah algoritma mengkombinasikan paket wavelet dan PCNN berdasarkan algoritma transformasi. Algoritma ini akan dilakukan sebagai berikut. Pertama, gambar TM akan diubah menjadi ruang HIS, dan kemudian komponen pencahayaan dan gambar resolusi tinggi akan dipecah menjadi skala jamak oleh paket wavelet. Kedua, sesuai dengan karakteristik domain frekuensi dari dekomposisi paket wavelet, kami masing-masing menggunakan metode rata-rata tertimbang dalam domain frekuensi rendah dan metode PCNN dalam domain frekuensi tinggi untuk memilih koefisien rekonstruksi. komponen luminasi bisa didapatkan menyatu dengan mengambil invers transformasi paket wavelet untuk dibangun kembali. Akhirnya, kita dapat memperoleh citra fusi dengan mengambil invers transformasi HIS. Hasil eksperimen menunjukkan bahwa algoritma tidak hanya dapat menyimpan informasi spektral, tetapi juga sangat meningkatkan resolusi spasial dari citra spektrum jamak dengan memiliki efek fusi baik

Kata kunci: fusi citra, HIS; jaringan syaraf berpasangan pulsa, paket wavelet

Abstract

Wavelet packet transform stands out in the field of image fusion for its good frequency characteristics, and pulse coupled neural network (PCNN) has a unique advantage in image processing. To resolve the problem of multi-spectral remote sensing image fusion, in this paper, we put forward an algorithm combined the wavelet packet and PCNN based on HIS transform.The algorithm will be carried out as follows. Firstly, the TM images will be converted into HIS space, and then the luminance component and the high-resolution image will be broken into multi-scale by wavelet packet. Secondly, according to the frequency domain characteristics of the wavelet packet decomposition, we respectively use a method of weighted average in the low-frequency domain and a method of PCNN in the high frequency domain to select reconstruction coefficient.We can get a fused luminance component by taking inverse wavelet packet transform to be reconstructed. Finally, we can obtain the fusion image by taking inverse HIS transform. The experimental results show that the algorithm can be not only to retain the spectral information, but also greatly improve the spatial resolution of multispectral images, has a good fusion effect

***Keywords**: HIS, image fusion, pulse coupled neural networks, wavelet packe*

1. Introduction

The purpose of remote sensing image fusion is to obtain the fusion image with high spectral resolution and high spatial resolution at the same time, and improve the capabilities of analysis and extraction of image information,and solve the lake of a single source of information content of remote sensing image. With the continuous development of remote sensing technology, many scholars at home and abroad used pixel level fusion such as HSV transform, the weighted average method and brovey in research of Multispectral and high resolution remote sensing images fusion. Nowadays, image fusion technique based on wavelet transform image fusion has become a hot topic of today's research. The pulse coupled neural network is the neuron model proposed by Eckhorn and other sync pulse on the cat's visual cortex neurons issued phenomenon.It is a new neural network different from the traditional artificial neural network.It has been successfully applied in image segmentation, image enhancement, pattern recognition and other fields.The fusion algorithm proposed in Literature 6, combining wavelet packet and PCNN simply, got the fusion image of serious edge shift . This algorithm develops a novel image fusion ideas. Experiments show that this algorithm is a

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feasible and effective method of integration. It is not only to solve the problem of edge shift, but also good to retain the spectral information and to improve the spatial resolution .

2. The Proposed Method

2.1. Principle of Wavelet Packet Transform

Wavelet packet transform is based on the wavelet transform of further development, and has more flexibility. It will divide bands for multi-level and decompose high frequency pare further to raise the time-frequency resolution , the following are the algorithms of wavelet packet decomposition and reconstruction.

Set $g_j^n(t) \in U_j^n$, g_j^n can be expressed as in (1):

$$g_j^n(t) = \sum_l d_l^{j,n} u_n(2^j t - l) . \quad (1)$$

Wavelet packet decomposition algorithm:

Solve $\{d_l^{j,2n}\}$ and $\{d_l^{j,2n+1}\}$ by $\{d_l^{j+1,n}\}$, as in (2) and (3).

$$d_l^{j,2n} = \sum_k a_{k-2l} d_k^{j+1,n} . \quad (2)$$

$$d_l^{j,2n+1} = \sum_k b_{k-2l} d_k^{j+1} . \quad (3)$$

Wavelet packet reconstruction algorithm:

Solve $\{d_l^{j+1,n}\}$ by $\{d_l^{j,2n}\}$ and $\{d_l^{j,2n+1}\}$, as in (4).

$$d_l^{j+1,n} = \sum_k [h_{l-2k} d_k^{j,2n} + g_{l-2k} d_k^{j,2n+1}] . \quad (4)$$

2.2. Principle of PCNN model design

PCNN (PCNN -Pulse Coupled Neural Network) , put forward in the 1900s by Eckhorn, is a simplified neural network model based on the cat's visual principle. It consists of a number of neural element which can interconnect to form a feedback neural network. PCNN in the Digital imaging applications is a single-layer two-dimensional horizontal connection of pulse-coupled neurons. A PCNN neuron consists of three parts: receiving part, modulation part and pulse generator. The basic model as Figure 1:

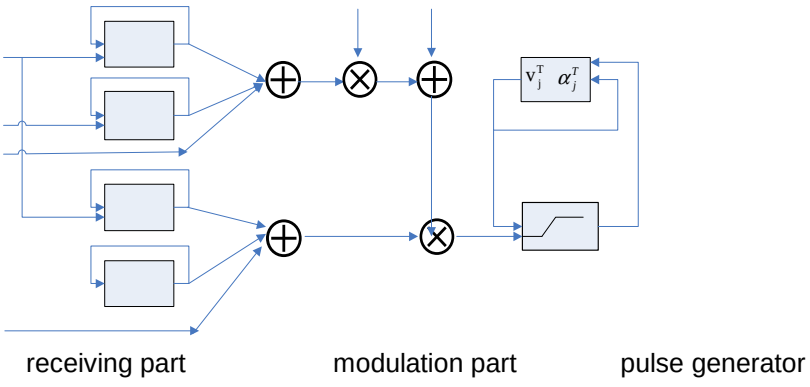

Figure 1. Pulse Coupled Neuron Model.

Mathematical expression of PCNN model in image fusion can be expressed ,as in (5):

$$\begin{cases} F_{ij}(n) = I_{ij} \\ L_{ij}(n) = \exp(-\alpha_L) L_{ij}(n-1) + V_L \sum_{m,n} W_{ij,mn} Y_{mn} Y_{MN}(n-1) \\ U_{ij}(n) = F_{ij}(n) * (1 + \beta L_{ij}(n)) \\ \theta_{ij}(n) = \exp(-\alpha_\theta) \theta_{ij}(n-1) + V_\theta Y_{ij}(n-1) \\ Y_{ij}(n) = \begin{cases} 1, if: U_{ij}(n) \rangle \theta_{ij}(n) \\ 0, otherwise \end{cases} \end{cases} \quad (5)$$

Subscript (i, j) is the (i, j) element of the wavelet packet decomposition coefficients, m and n are the range of neurons connected with the surrounding. External stimuli F_{ij} enters the network, the thresholds of neighboring neurons increase through the feedback rapidly and output pulse signal Y_{ij} .Modulation domain modulates the information which come from the input field and the signal of links domain, and outputs modulation results U_{ij} .Because the pulse generator is comprised of the variable threshold characteristics , leakage capacitor integrator to the network output signal and the hard limiter function, it can compare U_{ij} with the dynamic threshold θ_{ij} , then output the formation from the neuron and produce of the pulse signal (also known as ignition).

Wavelet packet transform is based on the wavelet transform of further development. It has a strong suitability. It can make bands for multi-level division, and improve the time-frequency resolution. Compared with BP neural network, PCNN will be able to extract useful information from the complex background without learning curve or training .It has sync pulse issued and global coupling characteristics. The signal form and the processing mechanism is more in line with the physiological basis of human visual nervous system. Wavelet packets combined with PCNN algorithm get a more clearer integration of results with the image edge dislocation. the algorithm remotes more detailed information at the same time to solve the image edge dislocation of fusion image.

3. Research Method

3.1. The Article Fusion Algorithm

This fusion algorithm first transforms multi-spectral image to HIS space, and uses wavelet packet for decomposition of I component and high resolution image. In the high part and low frequency part it uses different fusion rules to select the wavelet packet reconstruction coefficient. Finally, we obtain the final fusion image by taking the wavelet packet reconstruction and inverse HIS transform. This method not only keeps the spectra of the multi image information but also obtains good high resolution image details. Specific steps are as follows:

- Pretreatment of two images by geometric correction, filtering, contrast enhancement and so on;
- Transform multi-spectral image into the HSI color space and extract the luminance component I , and use histogram matching for the I and the high-resolution image, then use wavelet packet decomposition for the matched luminance component and high-resolution images to get high-frequency coefficient and low-frequency coefficients in the same scale;
- Construct PCNN model, then initialization PCNN parameters; the high frequency coefficients after normalization will enter into the model in turn as an incentive ;
- Select the high-frequency and low-frequency reconstruction coefficient;
- Get the brightness component $I^{"}$ by taking wavelet packet reconstruction;

- Taking H, S and $I^{"}$ reverse conversion to the RGB color space to obtain the final fusion image.

This paper fusion process is shown in Figure 2:

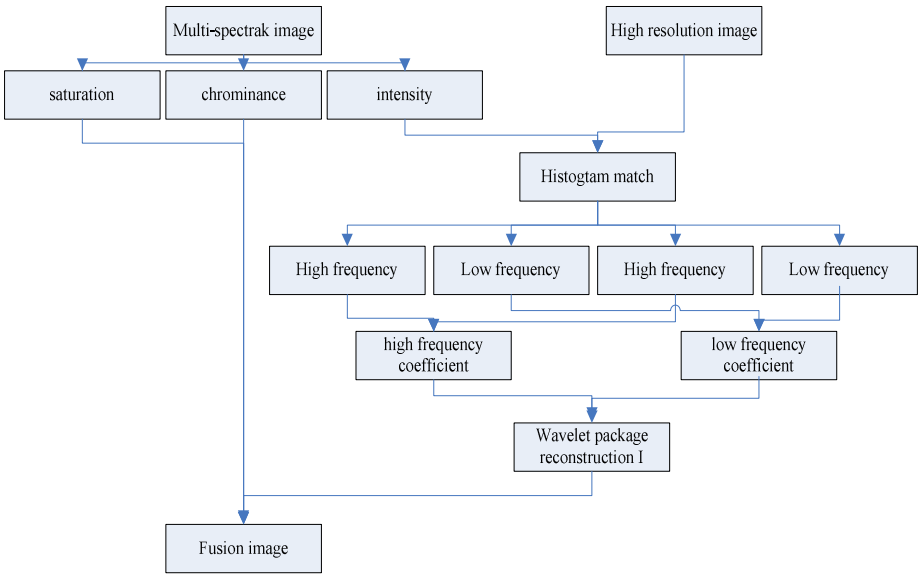

Figure 2. This paper implementation steps

3.2. Fusion Rules

The fusion rule of Low-frequency part uses the weighted average to select low-frequency coefficient, and high-frequency part uses the PCNN method to select high-frequency coefficients. Extraction high-frequency coefficients of I and high-resolution images of multi-layer two-dimensional wavelet decomposition and normalize them between [0, 1].The resulting value as an incentive enters the PCNN network. Set the maximum number of iterations is N, calculate the total number M of the (x, y) neurons during the nth iteration after the pulse, and select the most pulse total number of pulses (ignition number of times) as the ultimate high-frequency fusion coefficient.

4. Experimental Results and Evaluation Research Method

The experimental data uses 4、5、3 bands of TM resolution multi-spectral image and high-resolution images of Sand Lake of Ningxia province in 2010. These bands can be good at determining the boundaries of land/water and highlighting the linear features of water bodies, cities and mountains. The fusion images of variety of methods are shown in Figure 3.

First, from the subjective visual on look, the fusion image by HSV algorithm has dim brightness and lost more detailed information; the definition of (d) and (e) is a little bit higher, but the details information of (d) are still missing, and (e) has more serious local distortion and obvious phenomenon of edge shift. This algorithm is better visual effect and improves the spatial resolution and the clarity at the same time. It retains more detailed features to high frequency decomposition. Secondly, this paper used definition, information entropy, average gradient and correlation coefficient as objective evaluation to compare and judge the pros and cons of the fusion results of various fusion method. Among them: the information entropy and clarity reflect the image spatial quality of the information, the greater the information entropy shows that the spatial information of the image is more abundant; the greater definition shows that the image is more clear.The greater the average gray reflects the more brightness information of the image. Average gradient can reflect the image contrast of small details and texture transform features sensitively.The data is shown in Table 1.

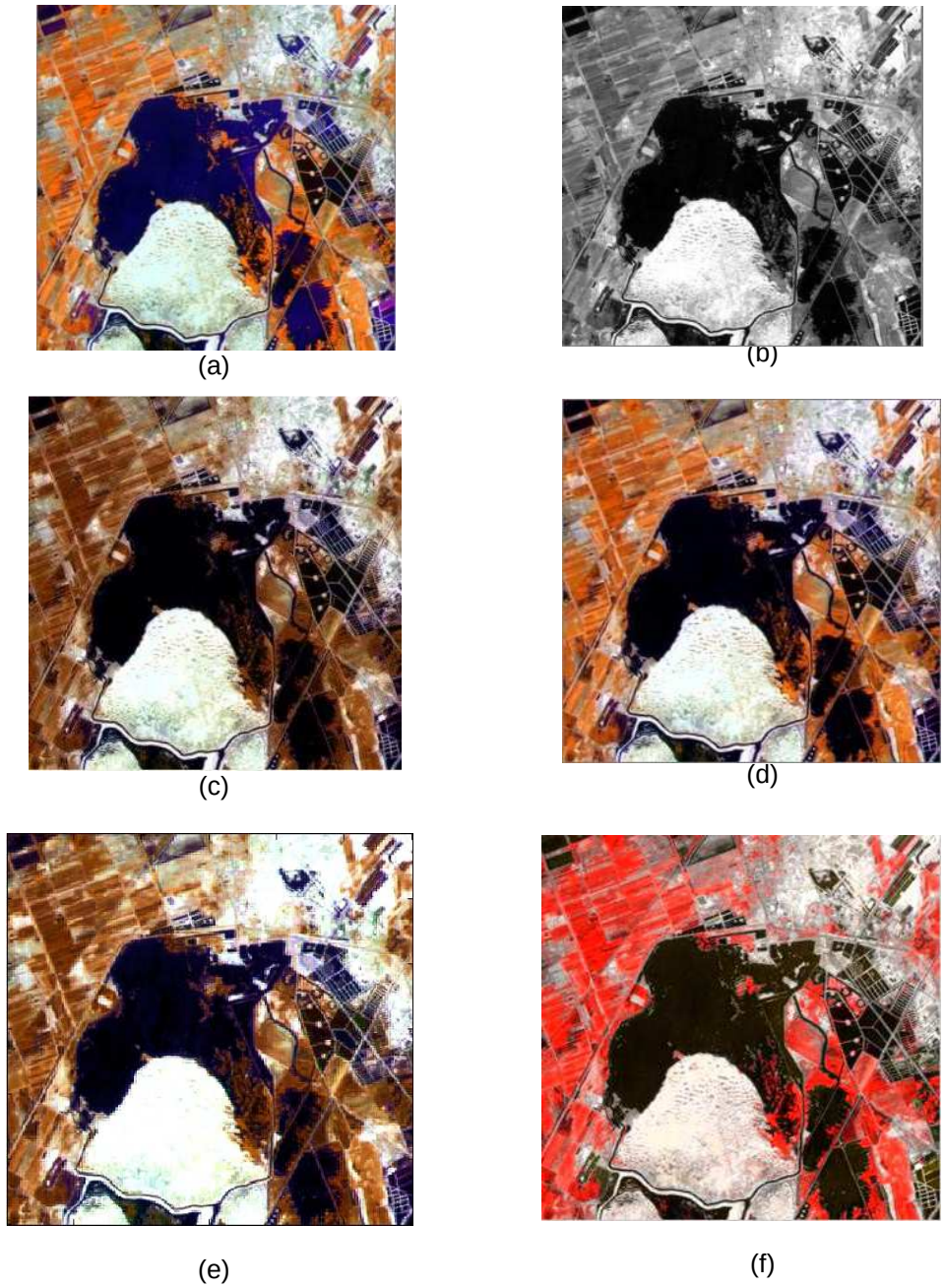

Figure 3. The fusion images of various algorithms:(a) TM image;(b) High Resolution image;(c) HSV;(d) brovey;(e) wavelet packet and PCNN;(f) the algorithm

Table 1. Objective evaluation form of the image fusion

	R	G	B	Mean value	entropy	Average gradient
HSV	15.1341	14.9066	15.0226	122.5212	7.5472	16.4701
brovey	16.2762	15.5474	15.8748	116.6986	7.6251	16.2762
waveletpacket and PCNN	15.7431	14.978	15.3582	118.1299	7.1450	15.7405
the algorithm	17.8876	16.3992	16.0196	119.0212	7.8046	17.8959

From table 1 of the experimental data we can see ,the definition, mean gray, information entropy and average gradient of brovey and wavelet packet and PCNN methods inferior to this algorithm.It shows that the spatial information quality and spectral quality of the fusion image by

the algorithm are better than these of the fusion image based on brovey and wavelet packet and PCNN method.Compare with HSV method, the effect of the proposed method in maintaining the image brightness information is not as good as HSV, however, the information entropy, the definition and the average gradient of the mothod are better than HSV method ,so the effect of this method in improving spatial resolution is better than that of HSV method. All in all, this algorithm not only retains the spectral information, but also greatly improve the spatial resolution of multispectral images, so it has a good fusion effect.

5. Conclusion

This paper presents a fusion method in the HSI color space, combined with the advantage of high-frequency decomposition of wavelet packet and advantage of the human visual nervous system of PCNN. The experimental results shows that both subjective and objective evaluation this algorithm has obtained the good fusion effect. It not only makes the details of the image space richer, but also get a better visual effect. The experiment proved that this method is feasible.

Acknolegment

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