The Best Fusion Method for ALOS Image in Karst Mountainous Area

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Abstract—**GuiZhou is a typical karst region, the ecological environment background there is complex with sharp cutting surface, steep slope and the cloudy and rainy weather. It is difficult to get high-quality image data. In this paper, the best karst mountainous areas ALOS image fusion method will be searched by the new high resolution ALOS data. The methods are IHS, Wavelet, Brovey and IHS & Wavelet transformation. Based on the evaluation of comparing tests, it is proved that the method of IHS&Wavelet transformation could overcome some problems to achieve high-quality image in the karst mountainous areas and preserve multi-spectral information exactly as well as strengthening spatial resolution of ALOS images effectively.**

Keywords-component; image fusion; karst mountainous area; ALOS; evaluation

I. INTRODUCTION

In the typical vulnerable mountainous areas of south China Karst, the karst area has reached 10.9 km^2 in GuiZhou, which accounting for 73.8% of the whole provincial area. The natural condition of GuiZhou is complex, the surface is broken and cutting deeply, accessibility poor, the environment differences obvious. That caused a few serious difficulties for local development, management and protect. It is necessary to researching to present situation and environment evolution trend based on remote sensing technology. High quality image data can provide us the foundation and basis in the field of resources optimization and environmental protection [1-2].

ALOS (Advanced Land Observing Satellite) adopted the advanced technology of land observation which can get the global high resolution data, surveying, mapping, regional environment observation, disaster monitoring and resource survey are the main application field of the satellite [3-4].

There are some better fusion methods: the fusion processing method based on pixel weighted IHS transformation, PCA method, wavelet transformation, and the IHS&Wavelet transformation[5-8].With the ALOS spectral data (AVNIR-2) and panchromatic data (PRISM) as the research object, we have tried to discovery the best fusion method, and evaluating them by the subjective evaluation and objective quantitative method. The purpose is to obtain the high-quality image data, with high resolution, extensive scope of application, less influenced by weather and limited of terrain in karst mountainous area.

II. IMAGE PREPROCESSING AND FUSION METHOD

A. Image preprocessing

The key of image fusion is the geometric correction and method selected. geometric correction is the high resolution image correction the panchromatic data, and the corrected point is the easier positioning of the surface features (such as road, river lies at the intersection ,etc),the control points are required to have uniform distribution of space, and the tolerance allow half a pixel as well.

B. Image fusion method

- Image fusion based on IHS algorithm

  In colorimetry, the red (R), green (G), blue (B) of color image transform into the intensity (I), hue(H), saturation (S), which called IHS transformation. The IHS transformed into RGB called inverse transformation. Under the IHS transformation method, the information of merging becomes possible between kinds of remote sensing image source. As shown in figure 1:

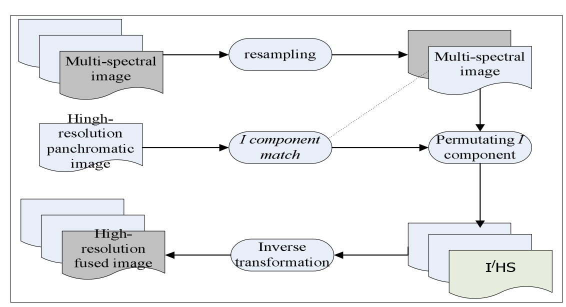

Fig.1 Image fusion based on IHS algorithm

- Image fusion based on the wavelet transformation

  Wavelet transformation is image fusion between the reconstruction fast algorithm and the analysis thought of

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wavelet multi-resolution. Firstly, the resampling of staying fusion image is necessary, and converting them into the same image of scale and size. Then, they will be decomposed into some different resolution sub-image by wavelet forward transformation. The fusion will be processing in high frequency sub-image which is decomposed[9-10]. as shown in figure 2:

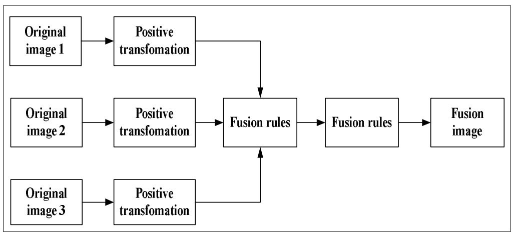

Fig.2 Image fusion based on wavelet transformation

- Image fusion based on the Brovey algorithm

Ratio transformation (Brovey) usually is called transformation fusion of color standardization, that normalizing the color of multi-spectral image, then that will be fusion by the panchromatic data with multiply themselves. Formula is as follows:

$$DN_f = \frac{DN_1}{DN_1+DN_2+DN_3} DN_h$$

DN_f is the fusion d image data value; DN_a and DN_b is panchromatic and multi-spectral image value[11].

- Image fusion based on IHS&Wavelet transformation

Wavelet fusion processing is that the high resolution and multi-spectral image is decomposed and reconstructed directly by using wavelet transformation. IHS transform method is transforming and merging in different color space, which is increasing the space information.It could enhance the space details expression of multi-spectral image effectively [9].The process is as follows:

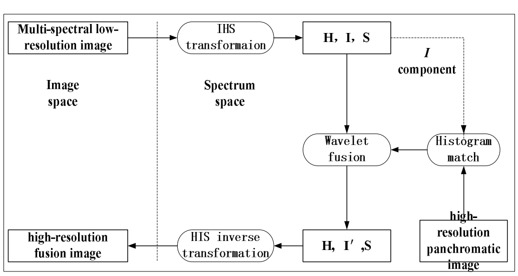

Fig.3 Image fusion based on IHS&Wavelet transformation

III. AN EXAMPLE OF FUSION IMAGE EVALUATION

The tested data is in the suburb of north Duyun city of Guizhou. It locate in the mountainous and winding rivers, the terrain is northwest high, southeast low, slope gentle. There are some types of land: paddy fields, dry land, forest land, residential areas, land for traffic, water area and so on. The time of ALOS multi-spectral (figure4) and panchromatic image (figure5) is in March of 2009.

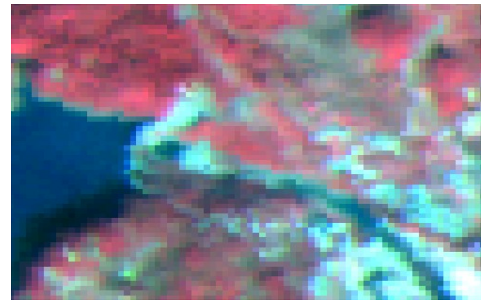

Fig.4 ALOS multi-spectral image

Fig.5 ALOS panchromatic image

A. *Qualitative evaluation of subjective*

From the point of appearance, four kind of fusion method are underlines effectively the space feature details of high resolution image. (1) The fusion image of IHS algorithm. The tonal of cultivated land, grassland, residential areas have distortion, and the performance is not natural, the expression and texture details of water body and forest land are good, as shown in figure 6; (2) The fusion image of wavelet transformation. The tonal of the ground feature are not balanced and the fuzzy degrees higher, as shown in figure 7; (3) The fusion image of Brovey algorithm. water is deep blue, the tonal of the whole image is light, texture details is better, as shown in figure 8; (4) The fusion image of IHS and wavelet algorithm. The tonal of features is nature, the texture details and clarity is better than others, but there were a few noise appeared, influenced the quality of image in a certain degree, as shown in figure 9.

The four different fusion methods is compared as follows: Brovey algorithm > IHS and wavelet transform method combined > IHS algorithm > wavelet transformation.

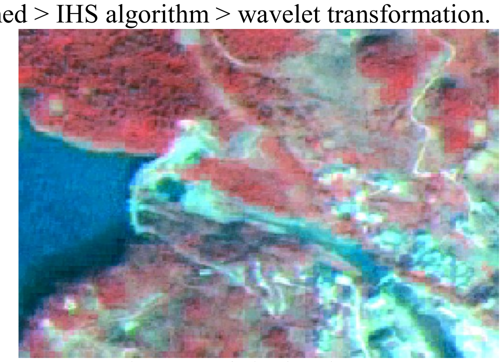

Fig.6 Image fusion based on IHS

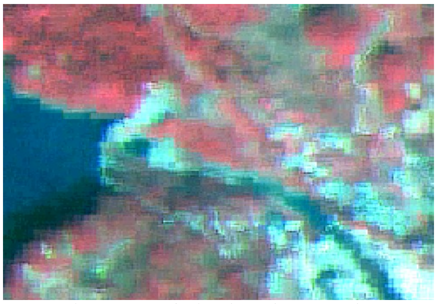

Fig.7 Image fusion based on wavelet

Fig.8 Image fusion based on Brovey

Fig.9 Image fusion based on IHS&Wavelet

B. *Quantitative evaluation of objective*

(1) Mean. The mean is the average of pixel grey scale in the image, or is the brightness in vision. Through out the in the comparison of the images, the mean is the reaction of similarity between the fusion image and the original. The smaller of the grey value, the better of the image in the spectral fidelity[12].

$$\overline{G(X)} = \frac{1}{M * N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} G(X_{i,j})$$

X is the image of M × N; G ($X_{i,j}$) is the grey value of (i, j) in X.

(2) Standard deviation. The standard deviation is the discrete degree of mean.

The bigger the standard deviation of an image, the scatter the grey degrees, which means the image contain more information of features. The mathematical expression of standard deviation is:

$$\sigma = \sqrt{\sum_{i=1}^{M} \sum_{j=1}^{N} [F(x_i, y_j) - \mu^2] / (M \times N)}$$

M and N are numbers and columns of the image; F (X_i, Y_j) is the grey value of pixel; X is the grey mean of image.

(3) Related coefficient. the relativity of multi-spectral image is usually expressed by the related coefficient of bands. The bigger the coefficient between the original and the fusion image, more information the multi-spectral image contains. The mathematical expression is[11]:

$$r = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} [F(x_i, y_j) - f][A(x_i, y_j) - a]}{\sqrt{\sum_{i=1}^{M} \sum_{j=1}^{N} [F(x_i, y_j) - f]^2 [A(x_i, y_j) - a]^2}}$$

F is the grey value of fusion image, f is the grey average of fusion image, A is the grey value of original image, and “a” is the grey average of original value.

(4) Comentropy. The average information of the fusion image is the reaction of the entropy value of the image. The entropy of image information could be expressed as follows:

$$E = -\sum_{i=0}^{L-1} p_i \log_2 P_i$$

E is the entropy of image; L is the general grey level of image; Pi is the ratio between the pixel level (Ni) and the numbers of pixel (N) that is the relative frequency of grey appearance.

Tab.1 Index statistics of objective evaluation

Image types	band	mean	Standard deviation	Correlation coefficient	Comentropy
ALOS multi-spectral image	1	79.657	8.144	1	3.289
	2	57.944	10.965	1	3.609
	3	46.026	13.345	1	3.746
	4	41.895	11.024	1	3.722
Image fusion (IHS)	2	41.348	9.695	0.501	3.562
	3	46.090	14.385	0.942	3.834
	4	57.939	12.623	0.174	3.788
Image fusion (wavelet)	2	41.572	11.094	0.396	4.142
	3	45.641	13.399	0.975	3.750
	4	57.474	11.124	0.390	3.643
Image fusion (Brovey)	2	14.055	4.50	0.401	2.951
	3	15.314	5.031	0.950	2.940
	4	19.232	4.477	0.573	2.883
Image fusion (IHS& wavelet)	2	51.414	18.549	0.384	4.231
	3	34.245	13.708	0.956	3.789
	4	49.949	13.270	0.408	3.810

The analysis results are as follows:

(1) The best fusion method about mean: IHS > wavelet > IHS & wavelet > Brovey;

(2) The best fusion method about standard deviation: IHS & wavelet > IHS > wavelet > Brovey;

(3) The best fusion method about related coefficient: Brovey > IHS & wavelet > wavelet > IHS；

(4) The best fusion method about comentropy: IHS & wavelet > wavelet > Brovey > IHS;

It is difficult to get better and high image that contains much information of features in karst mountainous areas, which is mainly influenced by the complex terrain and bad weather, such as the cloudy, rain, fog and so on. It is proved that the combined transformation of IHS&wavelet is the best fusion method.

IV. CONCLUSION AND DISCUSSION

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar. The special and typical terrain, landscape and climate conditions in karst mountainous regions are complex and changeable, the above four methods were used to fuse the ALOS multi-spectral and panchromatic image, adopting the means of subjective and objective evaluation as well. The research shows that fusion image based on IHS&wavelet contains a lot of detail information of features, and fidelity is very good. All of the advantages are more useful and helpful for the difficulty to get better image in the karst mountainous areas, and that providing the technology support about data processing in the field of resource survey, environment monitoring, the situation change in agriculture, etc.

The IHS&wavelet is the best one in the four kind of fusion method, but in order to improve the image quality, there are still some difficulties we need to solve and overcome as the noise existing in image. The image preprocessing and the noise eliminating later is becoming necessary. At the same time, in the view of the special background of karst mountainous areas, the radar technology will also be serving actively in the field of resource investigation, environmental monitoring and other related geological research. It will be achieved that the remote sensing data of high quality is easily gaining in any time, any conditions of weather and environment.

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