STUDY OF REMOTE SENSING IMAGE FUSION AND ITS APPLICATION IN IMAGE CLASSIFICATION

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Commission VII , WG VII /6

KEY WORDS: Landsat image, data fusion, spectral Distortion, Classification accuracy, Algorithms evaluation

ABSTRACT:

Data fusion is a formal framework in which is expressed means and tools for the alliance of data originating from different sources. It aims at obtaining information of greater quality; the exact definition of 'greater quality' will depend upon the application. Satellites remote sensing image fusion has been a hot research topic of remote sensing image processing. Make Multispectral images matching with TM panchromatic image, and the error control in 0.3 pixels within. Use Smoothing Filter-based Intensity Modulation (SFIM), High Pass Filter (HPF), Modified Brovery, Multiplication, IHS, Principle component analysis Transform (PCA) methods for the fusion experiment. Use some parameters to evaluate the quality of fused images. Select representative features from the fused and original images and analysis the impact of fusion method. The result reveals that all the six methods have spectral distortion, HPF and SFIM are the best two in retaining spectral information of original images, but the PCA is the worst. In the process of remote sensing image data fusion, different method has different impact on the fused images. Use supervised classification and unsupervised classification method to make image classification experiments, the study reveals that all the fused images have higher spatial frequency information than the original images, and SFIM transform is the best method in retaining spectral information of original image.

1. INTRODUCTION

The specific objectives of image fusion are to improve the spatial resolution, improve the geometric precision, enhanced the capabilities of features display, improve classification accuracy, enhance the capability of the change detection and replace or repair the defect of image data [1].

But for a long time, remote sensing image fusion is mainly used to enhance the visual interpretation, and it not usually used in the research of improving the image classification, the main reasons are shown as follows [2]: ① Image fusion is mostly based on the fusion of different satellite. Because of the difference of the various parameters and phase between different sensors, as well as the inevitably registration error, led to the fusion classification results unsatisfactory;② Although the same sensor system provided different spatial resolution images, because of its low spatial resolution, resulting in poor classification effect; ③Because of the unreasonable fusion algorithm or classification method make the failure of classification.

In this paper, using Landsat ETM + images panchromatic bands and multi-spectral bands to fuse, to research the fusion technology of different spatial resolution based on the same sensor system and the classification technology, evaluate the infection of each fusion method with the land use classification.

2. THE CHOICE OF DATA SOURCES AND SUMMARIZE OF THE PRETREATMENT

In this paper, using the image data of Landsat 7 ETM + panchromatic and multispectral images of August 2001,the study area is Shenyang.There are many types of feature in this area ,the main features include rice, dry land, forest, water bodies, residents of villages and towns and so on.

2.1 Bands Selection

Bands combination is a key step of fusion technique, bands combination optimization must be followed by two principles: firstly, the physical significance of the selected bands are good and they are in different light area, that is to say the relevance of each bands are small; secondly, we should choose the bands with the largest information [3].In this paper calculate the correlation coefficient matrix and OIF index, select the bands combinations in turn (table1 and table 2).

In the table of OIF index we can see that, the OIF index of the combination of bands ETM+3,4,5 is the biggest, and the correlation coefficient of bands3,4,5 is the smallest, so choose bands 3,4,5 as a fusion experiment.

2.2 Image Registration

The essence of image registration is according to the geometric correction of the remote sensing images; adopt a geometric transform to make the image unified to a same coordinate

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system [4]. Image registration include relative registration and is call for the error control within a single pixel in the high-resolution images, or within the pixel size of 10% ~ 20% in the low-resolution multispectral image [5].

In this study, use the relative registration method, take the panchromatic band of ETM + images for the reference image, select forty-six control points to make geometric correction absolute registration [8],the general requirements of registration with the multispectral images, in order to reduce loss of spectrum by resample, use the nearest neighbour method to resample, the accuracy of registration is controlled within 0.3 pixel, which can meet the need of registrations accuracy.

	ETM+1	ETM+2	ETM+3	ETM+4	ETM+5	ETM+7
ETM+1	1					
ETM+2	0.952	1				
ETM+3	0.846	0.927	1			
ETM+4	0.626	0.611	0.436	1		
ETM+5	0.645	0.719	0.712	0.690	1	
ETM+7	0.678	0.780	0.864	0.465	0.891	1

Table1 Correlation coefficient matrix table

Bands combination	OIF index	Range order	Bands combination	OIF index	Range order
123	12.832	1	134	22.605	11
127	16.739	2	157	22.724	12
124	17.229	3	357	22.840	13
237	18.043	4	245	23.918	14
125	18.359	5	145	24.316	15
137	19.160	6	247	24.858	16
135	19.693	7	147	25.724	17
235	20.596	8	457	27.442	18
257	21.314	9	347	29.209	19
234	22.169	10	345	29.230	20

Table 2. The OIF index of different bands combination（according to the order from small to big）

3. COMMON FUSION METHODS

In this study, the fusion methods are all based on pixel-level fusion method, pixel-level image fusion method is a process to analysis the original information, this fusion method loss the least information, so the accuracy of the pixel-level fusion is the highest, but the data transmission and processing is the largest. [6].

3.1 Fusion Methods

3.1.1 High-pass Filter Fusion Method: High-pass filter fusion method a method that make the high frequency components of high-resolution panchromatic image superimposed on low-resolution multispectral image, to obtain the enhanced spatial resolution multispectral image. The formula is as follows:

$$F_k(i,j) = M_k(i,j) + HPH(i,j) \tag{1}$$

In the formula, $F_k(i,j)$ is the fusion value of the band k pixel (i,j), $M_k(i,j)$ the value of multi-special of band k pixel (i,j), $HPH(i,j)$ show the high frequency information of the high-resolution panchromatic image.

3.1.2 SFIM Fusion Method: The full name of SFIM transform is called Smoothing Filter-based Intensity Modulation[8],which is a brightness transformation based on the smoothing filter. The formula of this arithmetic is as follows:

$$B_{SFIM_i} = \sum_j \sum_k \frac{B_{low_{ijk}} \times B_{high_{jk}}}{B_{mean_{jk}}} \quad i = 1,2,3 \tag{2}$$

In the formula B_{SFIM} is the fusion image generated by this arithmetic, i is the value of the band, j and k is the value of row and line; B_{low} is the Low-resolution images, here denote the multi-spectral band of ETM+; B_{low} is the high-resolution images, which is the panchromatic bands of ETM+; B_{mean} is simulate low-resolution images, which can be

obtained by low-pass filter with the pan-band, this study use the low-pass filter operator of 5*5 of ERDAS8.7.

3.1.3 Brovery Change Fusion Method

Brovery fusion formula as follows:

$$B_{MB_i} = \frac{\sum_j \sum_k B_{low_{ijk}} \times B_{high_{jk}}}{\sum_{i=1}^{n} \sum_j \sum_k B_{low_{ijk}}} \quad (3)$$

In the formula, B_{MB} is the fusion image, n is bands numbers, denominator denote the summation of the three ETM+ multi-spectral bands.

3.1.4 The Product Transform Fusion Method

The product fusion method is a simple algebra operation, multiply the pixel of the two images to obtain the fusion image. In this paper, take extraction with the product of the pixel to obtain the fusion image pixel value, the fusion algorithm formula as follows:

$$ML_{ijk} = \left(XS_{ijk} \times PN_{ij} \right)^{1/2} \quad (4)$$

In the formula, ML_{ijk} is the fusion image pixel value, XS_{ijk} is the pixel value of multi-spectral image, PN_{ij} is the pixel value of panchromatic.

3.1.5 IHS Transform Fusion Method

At present, IHS transform model mainly contains spherical transform, cylinder transform, triangular transform and six pyramid transform. On the image fusion, the differences between the four models are not obvious, but sphere transform is the best in compare [9].

In this study use IHS transform method for the fusion experiment, and programming in Matlab to achieve the fusion algorithm.

3.1.6 Principal Component Fusion Method

The image after fusion contains the character of high spatial resolution image and high spectral resolution of the original image, reserve the high frequency of the original image. The individual part character of the aim of the fusion image is more clear, and the spectral information is more richer, and PCA transform conquer the localization of the HIS transform which can only at the same time do fusion with three bands, it can do fusion with more than two multi-spectral image.

3.2 Fusion Image Evaluation Parameters

The common used image fusion quality evaluation parameters are: the mean, standard deviation, average gradient, information entropy, and the correlation coefficient.

4. EXPERIMENTS AND ANALYSIS

Programming the various fusion algorithm with Erdas Model module and matlab, fused images are displayed: 5, 4 and 3 bands in accordance with the R, G, B, fusion results are shown as follows(figure1-6):

Figure1.HPF fused image 543 bands Figure2.SFIM fused image 543bands Figure3. Brovery fused image 543bands

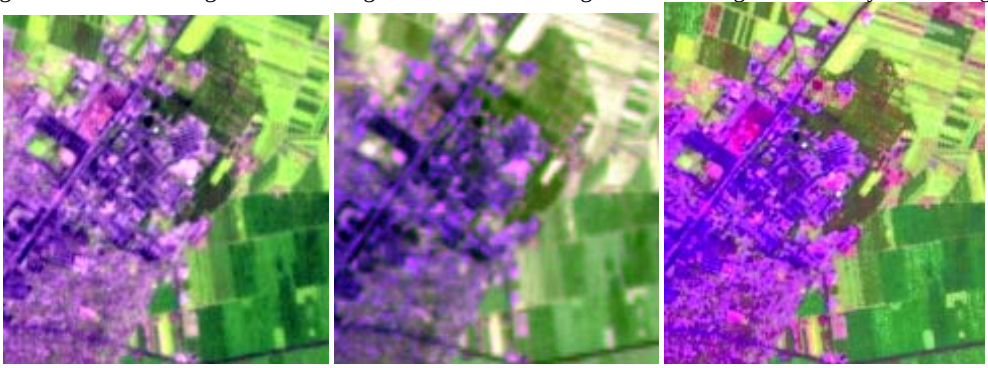

Figure4.ML fused image 543bands Figure5.PCA fused image 543bands Figure6. HIS fused image 543bands

image	band	mean	standard deviation	entropy	Correlation coefficient with XS image	average gradient	Correlation coefficient with Pan image
XS image	5	75.183	21.675	6.0952	1	4.0176	0.6541
	4	71.941	15.599	6.0627	1	2.8171	0.7284
	3	66.227	18.682	6.0598	1	3.2773	0.1661
HPF fused image	5	75.113	22.141	6.3509	0.9455	6.6193	0.7214
	4	71.871	15.884	6.2881	0.9636	6.5239	0.7956
	3	66.157	21.041	6.2971	0.9843	5.6477	0.2985
SFIM fused image	5	75.161	22.966	6.291	0.9548	8.0911	0.7365
	4	71.810	17.516	6.2199	0.9603	7.3351	0.8139
	3	65.971	19.383	6.2274	0.9537	7.2359	0.3127
ML fused image	5	100.228	23.161	6.2391	0.9277	8.1029	0.8883
	4	98.153	19.267	6.2595	0.9433	7.6337	0.9140
	3	93.150	19.167	6.0762	0.8425	7.952	0.6674
Brovery fused image	5	47.925	15.982	5.6371	0.7847	9.9214	0.9543
	4	47.965	21.041	6.2393	0.9732	9.1894	0.6699
	3	40.908	9.767	5.1429	0.7844	9.266	0.7208
IHS fused image	5	73.574	14.842	5.9055	0.8231	6.5412	0.8970
	4	71.761	22.728	6.4812	0.8786	6.8252	0.7000
	3	64.028	21.48	5.8278	0.8157	6.5109	0.4894
PCA fused image	5	136.353	28.614	6.9469	0.6441	10.3735	0.9613
	4	134.02	13.613	6.9428	0.9546	9.396	0.7738
	3	137.837	17.966	5.9238	0.2372	9.6198	0.9734

Table 3. Table of evaluate parameters

4.1 Parameters Statistics of Fused Image

The original multi-spectral images using XS to replace，and panchromatic images with PAN replaced, evaluate parameters are shown in the table3：

From the parameters of table 3, we can see that:

(1) All fusion method in accordance with the definition in descending order, the order is: PCA>Brovery>ML> SFIM>MIHS>IHS>HPF;

(2) All fusion method in accordance with the Spectra maintains degrees in descending order, the order is: HPF>SFIM> Brovery>MIHS>ML>IHS>PCA;

(3) All fusion method in accordance with the entropy in descending order, the order is: PCA>MIHS>HPF>IHS>SFIM> ML>Brovery.

4.2 Feature Identification Accuracy of Fused Image

Different fusion methods have different impacts on image. Image Recognition is the application of spectral characteristics and structural characteristics of different features to identify information; therefore spectra and texture information on the objectives of the interpretation are important significance [10].
In order to verify the influence of various fusion methods on the classification accuracy, in this paper, the image data of different experiments using the same processes to deal with unsupervised classification; and make classification accuracy
test, select high precision fused image to make supervised classification.

4.2.1 Research Methods: Make classification with maximum likelihood classification; using random method to select 256 ground inspection points, make accuracy test for thematic maps of XS image and fused image, obtain total accuracy and Kappa index.

4.2.2 Accuracy Test of Unsupervised Classification

From the comparative data table 4, we find that: PCA fusion image, in addition to other fusion image classification accuracy are significantly higher than those without fused image classification accuracy, the reason maybe that: PCA fused image has the worst spectrum distortion, and it leads to the lower classification accuracy. Descending order of the classification accuracy is: SFIM> HPF >ML>Brovery > XS>IHS>PCA.

type	XS image	HPF fused image	ML fused image	Brovery fused image	PCA fused image	SFIM fused image	IHS fused image
Total accuracy	77.34%	81.25%	80.47%	78.52%	67.97%	84.38%	76.95%
Kappa index	0.6799	0.7468	0.7298	0.6809	0.5271	0.7810	0.6454

Table 4. Comparative data of image unsupervised classification accuracy

4.2.3 Supervised Classification Accuracy Evaluation: Do supervised classification with the original image and the SFIM fusion image choosing 5,4,3bands after the bands selection, and evaluate the accuracy of the classification, the classification accuracy of the results are showed in table 5

type	XS image	SFIM fusion image
Total accuracy	82.81%	90.23%
Kappa index	0.7668	0.8673

Table 5.Comparative data of image supervised classification accuracy

By comparing the total accuracy and Kappa index of the two, we can see that: the accuracy and Kappa index of the supervised classification of SFIM fusion image are much higher than the XS images.

Through the accuracy analysis of the unsupervised classification and supervised classification, can generally know the character of the above five algorithm, on the basis of ETM+ classification, select SFIM fusion image as the basic image; Brovery fusion image as the small information leading to the lower classification accuracy; HPF fusion image owing to the better spectral fidelity and more high-frequency information can be used as the auxiliary image of the visual interpretation; PCA, ML fusion image has high integration of high frequency information, which has a certain value in the extraction of the city internal structure.

5. CONCLUSIONS AND OUTLOOK

This paper introduces the basic concepts and theory of image fusion, and discussed a variety of fusion method. Summarize the quantitative evaluation criteria of the mean, standard deviation, correlation coefficient, entropy, the average grads and so on, measure and compare each fusion algorithm and obtained many useful conclusion.

But this study make fusion analysis with the panchromatic image and multispectral images in the same satellite system of Landsat-7 ETM+, as different types of sensors have different data types, it should be more complex in the process of fusion and the evaluation, yet has to do further studies with specific issues.

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Appendix

Supported by the Ministry of Education of Doctor Spot Foundation (20050147002);
College of Liaoning Province Emphasis Laboratory Item (20060370)