A METHOD TO DETERMINE SPATIAL RESOLUTION OF REMOTE SENSING FUSED IMAGE QUANTITATIVELY

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ABSTRACT:

Spatial resolution of remote sensing fused image is usually the spatial resolution of high spatial resolution image which is not the real spatial resolution of the fused image. A method of determining spatial resolution of remote sensing fused image quantitatively is presented in this paper, based on correlation coefficients and bias indexes between different spatial resolution image aggregation which resolution is 11m, 12m, till 20m obtained by the resample of SPOT pan image which resolution is 10m and fused images obtained by the fusion methods of HIS, PCA, and Brovey. The experiments have been done on the fused image from SPOT pan image(10m) and TM multi-spectral image(30m), and the spatial resolution of the fused image is closer to 17m.

1. INTRODUCTIONS

In the recent years, remote sensing image fusing is one of hot points of research in home and overseas. With the appearance of kinds of fused methods, remote sensing image fusing technology is developed fast. All of the purpose of the methods is to keep spectrum information and enhance spatial resolution[Liu CH.P., 2002]. Spatial resolution is one of the criterions of evaluating image quality, and which is also an important parameter in image application[Hao P.W., 1998].

In the preprocess course of remote sensing image fusing, bad accuracy of geometric-rectification and image matching will decrease the spatial resolution of remote sensing fused image[Yang J., 2003], which is also effected by different methods. Considering frequency field[Hao P.W. et al, 1999], high frequency of pan image will be lost in the fused course, which will also cause resolution decrease. Spatial resolution of remote sensing fused image mentioned is generally the resolution of the pan image which is not the real resolution. How to determine quantitatively the real resolution of remote sensing fused image is one of the different problems in the remote sensing image process field at all times and there is no uniform method to resolve now[Ji T.K. et al, 2005].

Through constituting image aggregation of different spatial resolution and comparing the correlation coefficient and bias index between different spatial resolution image aggregation and fused image, the real resolution of remote sensing fused image is determined quantitatively in this paper.

2. EXPERIMENT DATA

Figure 1 is a SPOT pan image which resolution is 10 meter(m), and Figure 2 is a TM multi-spectral image which resolution is 30 meter(m). The two images are the same area, which have been geometric-rectified and matched. Figure 3 is the information of the images.


Figure 1. SPOT image

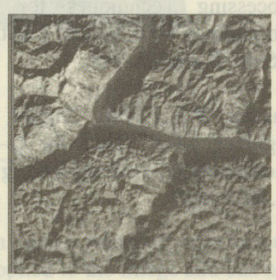
Figure 2. TM image

3. EXPERIMENT METHOD

3.1 Constituting Image Aggregation of Different Spatial Resolution

The images which resolution are 11m, 12m, till 20m are obtained through the resample of SPOT pan image. The resolution of the fused image is high than 20 m. Figure 4 is the image aggregation.

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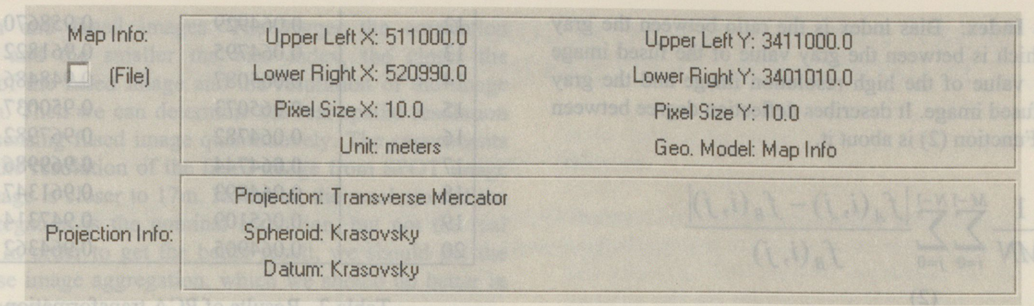

Figure 3. Imageinformation

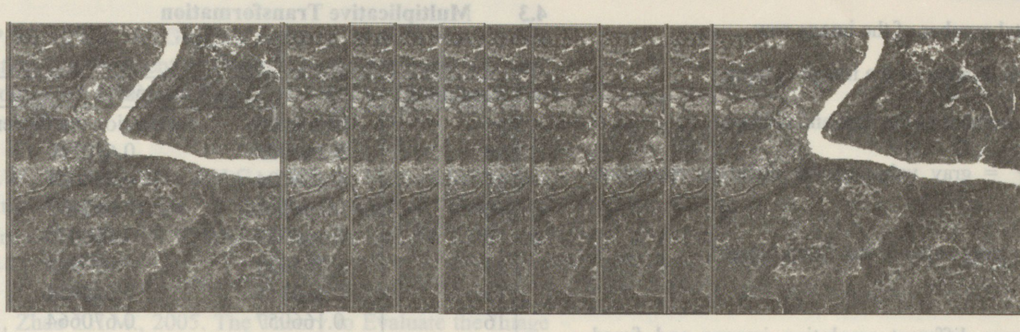

Figure 4. Image aggregation of differentspatial resolution

3.2 Fused Images Obtained by Different Fusion Method

Image fusing methods are mainly Color Model Method (Hue Intensity Saturation, HIS), Principal Component Analysis Method(PCA), Multiplicative Method, Brovey Method and so on. The effect to spatial resolution is different from different fusing methods.

Figure 1 and Figure 2 are fused by the methods mentioned above. And then, the fused images are obtained, which are Figure 5, Figure 6, Figure 7 and Figure 8.

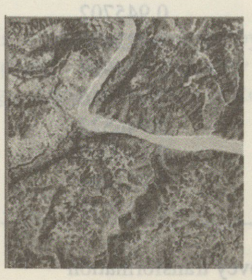

Figure 5. HIS

Figure 6. PCA

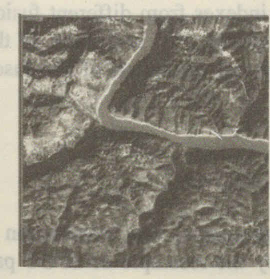

Figure 7. Multiplicative

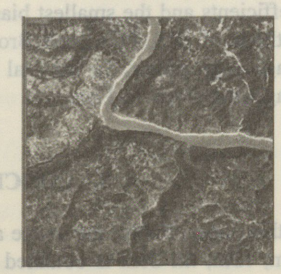

Figure 8. Brovey

3.3 Criterions of Determining Fused Image Quantitatively

3.3.1 Correlation Coefficient: Correlation Coefficient describes similarity degree of two images[Sun J.B., 2003]. Function (1) is about it.

$$r = \frac{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(f_A(i,j)-\bar{f}_A)(f_B(i,j)-\bar{f}_B)}{[\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(f_A(i,j)-\bar{f}_A)^2\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(f_B(i,j)-\bar{f}_B)]^{1/2}} \tag{1}$$

where r = correlation coefficient

M = total number of the image row

N = total number of the image column

(i, j) = number of the row and column

$f_A(i, j)$ = gray value of the different resolution image

$f_B(i, j)$ = gray value of the fused image

$\bar{f}_A$, $\bar{f}_B$ = average gray value of images

Correlation coefficients between different resolution images and fused image can be computed by Function (1). The bigger the correlation coefficient is, the closer the resolution of the fused image and the resolution of the high resolution is.

3.3.2 Bias Index

Bias Index: Bias index is the ratio between the gray difference which is between the gray value of the fused image and the gray value of the high resolution image and the gray value of the fused image. It describes deflection degree between two images. Function (2) is about it.

$$D=\frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}\frac{|f_A(i,j)-f_B(i,j)|}{f_B(i,j)} \tag{2}$$

where D = bias index

M = total number of the image row

N = total number of the image column

(i,j) = number of the row and column

$f_A(i,j)$ = gray value of the different resolution image

$f_B(i,j)$ = gray value of the fused image

Bias indexes between different resolution images and fused image can be computed by Function (2). The smaller the bias index, the closer the resolution of the fused image and the resolution of the high resolution.

4. EXPERIMENT RESULTS

Correlation coefficient and bias index between fused image and image aggregation of different spatial resolution was acquired and evaluated, and then spatial resolution of remote sensing fused image was determined quantitatively.

4.1 IHS Transformation

Resolution	Criterions	
m	bias index	correlation coefficient
10	0.019391	0.780013
11	0.019501	0.783598
12	0.019666	0.770825
13	0.019786	0.782763
14	0.019941	0.760863
15	0.019889	0.763048
16	0.019345	0.781943
17	**0.019302**	**0.783749**
18	0.019543	0.775115
19	0.019974	0.759841
20	0.019518	0.776331

Table 1. Results of IHS transformation

4.2 PCA Transformation

Resolution	Criterions	
m	bias index	correlation coefficient
10	0.064791	0.967980
11	0.064767	0.960864
12	0.064929	0.958670
13	0.064795	0.961822
14	0.065087	0.948486
15	0.065073	0.950037
16	0.064782	0.967982
17	**0.064744**	**0.969986**
18	0.064893	0.961347
19	0.065109	0.947314
20	0.064905	0.964362

Table 2. Results of PCA transformation

4.3 Multiplicative Transformation

Resolution	Criterions	
m	bias index	correlation coefficient
10	0.166083	0.670760
11	0.166104	0.670031
12	0.166192	0.665437
13	0.166057	0.670076
14	0.166323	0.660959
15	0.166315	0.662954
16	0.166057	0.670664
17	**0.166030**	**0.670942**
18	0.166165	0.667535
19	0.166367	0.659890
20	0.166935	0.650448

Table 3. Results of Multiplicative transformation

4.4 Brovey Transformation

Resolution	Criterions	
m	bias index	correlation coefficient
10	0.108042	0.945704
11	0.108078	0.945791
12	0.108242	0.933972
13	0.108052	0.945702
14	0.108413	0.922659
15	0.108398	0.924924
16	0.108076	0.944646
17	**0.108038**	**0.946523**
18	0.108204	0.937007
19	0.108443	0.921004
20	0.108334	0.932918

Table 4. Results of Brovey transformation

From table 1 to table 4, we can see that the biggest correlation coefficients and the smallest bias indexes from different fusion methods of HIS, PCA, and Brovey are 17m resolution of the image aggregation. So the real spatial resolution of the fused images are closer to 17m.

5. CONCLUSIONS

In this paper, firstly, the image aggregation which resolution is 11m, 12m, till 20m is obtained by the resample of SPOT pan image which resolution is 10m. Secondly, the fused images are obtained by different fusion methods. Thirdly, the correlation coefficients and bias indexes are computed between the image aggregation and fused images. The bigger the correlation coefficient and the smaller the bias index, the closer the resolution of the fused image and the resolution of the image aggregation. Then we can determine the real spatial resolution of remote sensing fused image quantitatively. The experiments show that the resolution of the fused image from SPOT image and TM image is closer to 17m. However, the resolution of the image aggregation is the nominal resolution, but not the real resolution. In order to get the better result, we should get the more precise image aggregation, which we should do better in the later research.

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