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IKONOS Panchromatic 영상과 Multispectral 영상의 IHS 및 PCA 중합
IHS and PCA Merging of IKONOS Panchromatic and Multispectral Images

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Abstract

본 연구에서는 고해상도의 IKONOS panchromatic 영상과 multispectral 영상을 IHS와 PCA 방법으로 중합하고 그 결과를 비교하였다. 평가에 있어서는 중합된 영상들과 원영상간의 필셀 값에 대한 평균제곱근오차를 구하고 그 결과를 분석하였다. 분석 결과, multispectral band 1, 3, 4를 사용하는 IHS 방법, multispectral band 1, 2, 4를 사용하는 IHS 방법 및 multispectral band 1, 3, 4를 사용하는 PCA 방법이 원영상의 특성을 잘 보존하는 것으로 평가되었다.

1. Introduction

The merging of different scales or multi-sensor image data is becoming a widely used procedure of the complementary nature of various data sets. Ideally, the merging method should not distort the characteristics of the high-spatial and high-spectral resolution data used.

Several studies(Carper et al., 1990; Chavez et al., 1991; Ahn et al., 1998; Gonzalez-Audicana et al., 2004; Yun, 2006) using IHS and PCA merging methods demonstrated distinct improvements to preserve the multispectral characteristics and the high spatial characteristics of the original images.

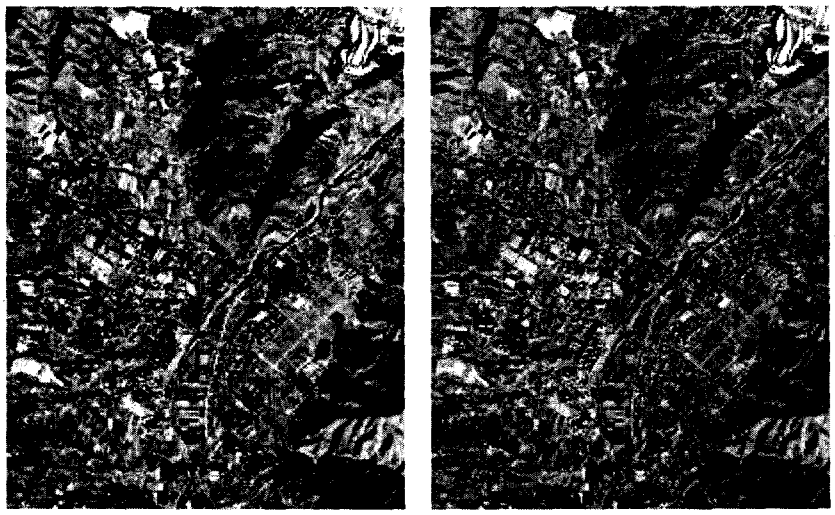
To present an effective method for merging IKONOS 1 m resolution panchromatic image and the 4 m resolution multispectral images, this paper compares the results of Intensity Hue Saturation (IHS) and Principal Component Analysis (PCA) methods. The comparison is made by statistical and visual evaluation of three-color combination images of IHS and PCA results based on spatial and spectral characteristics.

2. Data characteristics and study area

IKONOS stereo images, acquired in January 10, 2001 over Yangsan city, Gyeongsangnam-do, Republic of Korea, were used to test the proposed method (Figure 1). They are Geo-level panchromatic images of the Yangsan test field and cover an area of approximately 4×5 ㎢. The study area covers mostly an urban area, factories, forest, agricultural fields with small river and lakes, etc. These data characteristics and the study area are shown in Table 1 and Figure 1.

Table 1. The IKONOS data sets used in this study

Image	Panchromatic	Multispectral
Acquisition Date/Time	Jan. 10, 2001/02:06 GMT	Jan. 10, 2001/02:06 GMT
Image Size	4000 × 5000 pixels	1000 × 1250 pixels
Spatial Resolution	1 m	4 m
Product Level	Geo	Geo
Data Type	Unsigned 11 bits	Unsigned 11 bits
Datum/Map Projection	WGS84/UTM	WGS84/UTM
Number of Bands	1	4
Spectral Range(㎛)	0.526 ~ 0.929	Band 1 (blue) : 0.445 ~ 0.516 Band 2 (green) : 0.506 ~ 0.595 Band 3 (red) : 0.632 ~ 0.698 Band 4 (near infrared) : 0.757 ~ 0.853
Map Coordinates	Upper Left X (Easting) = 512,835.5 m Upper Left Y (Northing) = 3,921922.5 m Lower Right X (Easting) = 516,835.5 m Lower Right Y (Northing) = 3,916,922.5 m	



(a) (b)

Figure 1. Study area. (a) Panchromatic image; (b) Color composite made by using the multispectral bands 1, 2, and 3 as blue, green, and red, respectively

3. Merging by IHS and PCA methods

3.1 IHS

In this study, all possible four RGB combinations (bands 1 2 3, bands 1 2 4, bands 1 3 4 and bands 2 3 4) were tested for IHS transformations. The higher spatial resolution panchromatic image was contrast stretched by a histogram matching technique to have the approximately same variance and average as the intensity image and substituted for intensity image. The substituted panchromatic image, the remaining hue and saturation images were transformed back into the original RGB space.

Because of a problem in the IHS processing using 11 bits or two bytes 16 bits image data, another IHS processing software was used for this study.

3.2 PCA

The procedure to merge the IKONOS panchromatic image and multispectral images using the PCA method is similar to that of the IHS method. The five RGB combinations (bands 1 2 3, bands 1 2 4, bands 1 3 4, bands 2 3 4, and bands 1 2 3 4) were used as input to a PCA procedure. The panchromatic image was contrast stretched to have the approximately same variance and average as the first principal component. The substituted panchromatic image, the remaining principal components 2 and 3 were transformed back into the original RGB space.

4. Comparisons and results

The spectral and spatial characteristics in the data sets generated by using the IHS and PCA methods were compared with the original images statistically and visually.

4.1 RMSE

For the comparisons of the spectral characteristics between the corresponding bands of the merged image and the original multispectral image, the root mean square errors (RMSEs) of the pixel values between the merged images and original images were computed. Before this comparisons, reference multispectral ortho images with 1 m resolution were made using a digital elevation model. And this reference multispectral ortho images were used for the comparisons as original images. The computed RMSEs are shown in Table 2.

Table 2. The RMSEs of the pixel value differences between the merged images and original MODIS images

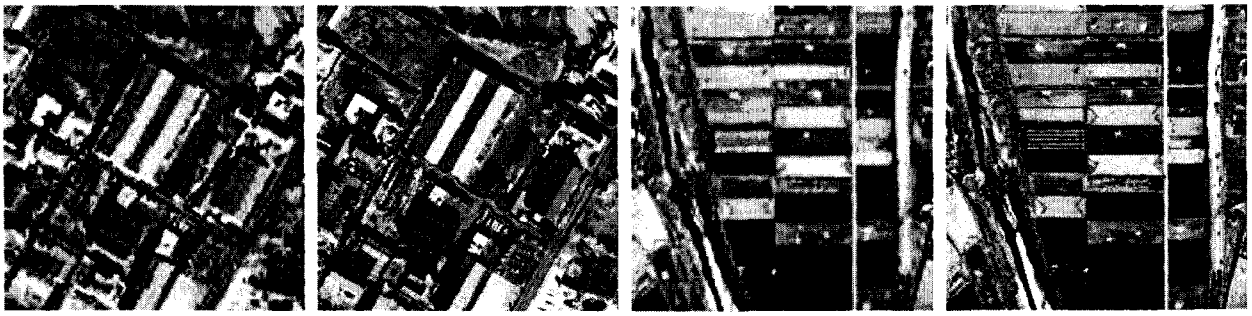
Band	IHS				PCA				
	IHS123	IHS124	IHS134	IHS234	PCA123	PCA124	PCA134	PCA234	PCA1234
1	29.00	28.87	28.45		28.60	28.21	28.32		27.66
2	36.43	36.60		46.18	41.65	36.84		46.92	41.23
3	37.95		37.38	46.23	40.07		34.97	44.36	38.19
4		33.23	32.66	42.64		37.15	37.05	44.35	39.71
RMSE	34.68	33.05	33.03	45.04	37.23	34.32	33.65	45.23	37.09

The RMSE of the pixel value differences between original multispectral images and the merged images from the three cases of the IHS using multispectral bands 1, 3, and 4, IHS using multispectral bands 1, 2, and 4, and PCA using multispectral bands 1, 3, and 4 are less than those of other six cases.

4.2 Visual inspection

To evaluate the spatial characteristics of the merged images, visual inspection was performed. It was difficult to find a distinguished differences in the spatial characteristics or resolutions. But it

shows that the overall spatial characteristics of the merged images are very good.



(a) (b) (c) (d)

Fig. 2. (a) Subset industrial area of the color composite made by using the original multispectral bands 1, 3, and 4 as blue, green, and red, respectively; (b) Subset industrial area of the color composite made by using the IHS results of the multispectral bands 1, 3, and 4 as blue, green, and red, respectively; (c) Subset vegetation area of the color composite made by using the original multispectral bands 1, 3, and 4 as blue, green, and red, respectively; (d) Subset vegetation area of the color composite made by using the IHS results of the multispectral bands 1, 3, and 4 as blue, green, and red, respectively.

5. Conclusions

To present an effective merging method of the high-resolution IKONOS panchromatic image and the multispectral images, the results of the IHS and PCA methods were compared with the spatial and spectral characteristics of the original images statically and visually.

1. The RMSE of the pixel value differences between original multispectral images and the merged images from the three cases of the IHS using multispectral bands 1, 3, and 4, IHS using multispectral bands 1, 2, and 4, and PCA using multispectral bands 1, 3, and 4 are less than those of other cases.
2. The visual comparison also indicates that all methods generate high spatial resolution images.

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