Korean Journal of Geomatics
Vol. 3, No. 1 / June 2003
pp. 59~65

Merging of KOMPSAT-1 EOC Image and MODIS Images to Survey Reclaimed Land

Ki-Won AHN*, Seok-Hyo SHIN, Sang-Cheol KIM*** and Doo-Chun SEO******

Abstract

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. To present an effective merging method for survey of reclaimed land using the high-resolution (6.6 m) Electro-Optical Camera (EOC) panchromatic image of the first Korea Multi-Purpose Satellite 1 (KOMPSAT-1) and the multispectral Moderate Resolution Imaging Spectroradiometer (MODIS) image data, 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. The use of MODIS bands 1, 2, and 3 with a contrast stretched EOC panchromatic image as a substitute for intensity was found to be particularly effective in this study.

Keywords : Merging, KOMPSAT-1 EOC, MODIS, Reclaimed Land, IHS, PCA

1. Introduction

In South Korea, it is necessary to survey reclaimed land areas and crop yields of North Korea for a unification policy. The KOMPSAT-1 EOC panchromatic image data and multispectral MODIS image data are acquired in real-time from the Korea Aerospace Research Institute (KARI). To survey reclaimed land of North Korea using these image data, a study on effective merging method is needed.

The images merged by this method will enhance the classification or survey capabilities of reclaimed lands. The merging method should not distort the characteristics of the high-spatial and high-spectral resolution data used. Applied IHS transformations for merging SPOT panchromatic and multispectral image data (Carper et al. 1990). Compared the results of three different IHS, PCA, and high-pass filter (HPF) methods to merge Landsat TM and SPOT panchromatic data (Chavez et al. 1991). Compared the results of IHS, PCA, HPF, and radiometric method for merging SPOT panchromatic and multispectral image data (Shih and Hsieh, 1997). Applied IHS, PCA, HPF, ratio enhancement, and look-up-table methods to merge IRS-1C PAN and Landsat TM data (Ahn and Seo, 1998). To present an effective merging method for survey of reclaimed land, this paper compares the results of IHS and PCA methods to merge the information contents of the high-resolution (6.6 m) KOMPSAT-1 EOC panchromatic image and the multispectral MODIS image data.

2. Data Characteristics and Study Area

The MODIS mutispectral data were collected on 26 July 2002 by TERRA and the EOC panchromatic

*Member, Professor, Dept. of Civil Eng., College of Eng., Gyeongsang National University, Researcher, Research Institute of Industrial Technology, Gyeongsang National University, Chinju, Gyeongnam, Korea (E-mail : kwahn@nongae.gsnu.ac.kr)
**Member, Corresponding Author, Ph. D., Dept. of Civil Eng., College of Eng., Gyeongsang National University, Chinju, Gyeongnam, Korea (E-mail : s_shshin@gshp.gsnu.ac.kr)
***Member, Ph.D. Candidate, Dept. of Civil Eng., College of Eng., Gyeongsang National University, Chinju, Gyeongnam, Korea (E-mail : sangcholyi@hanmail.net)
****Member, Ph.D., Senior Researcher Satellite Mission Operation Department, Korea Aerospace Research Institute, Yusung, Daejon, Korea (E-mail : dcivil@kari.re.kr)

The manuscript for this paper was received on June 26, 2003 / accepted on June 30, 2003.

Table 1. Data characteristics

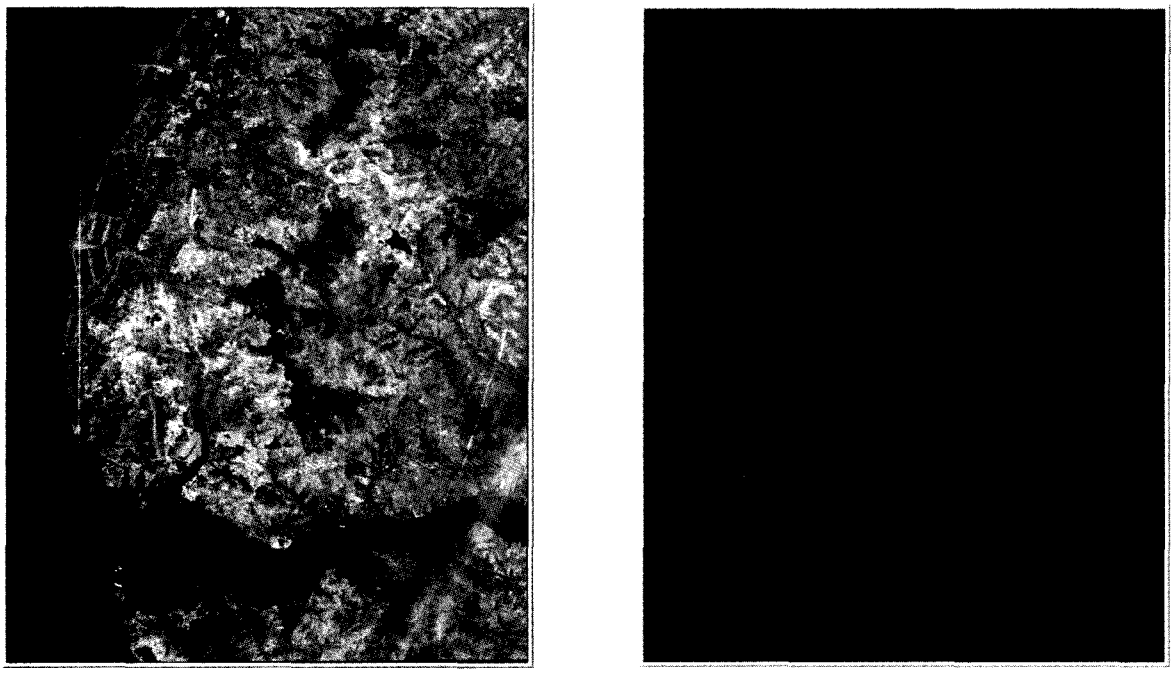
Satellite	KOMPSAT-1		TERRA
	Left Orbit Image	Right Orbit Image	
Sensor	EOC	EOC	MODIS
Spatial Resolution	6.6 m	6.6 m	250 m ~ 1 km
Date of Acquisition	June 29, 2002	June 3, 2002	July 26, 2002
Number of Bands	1 (PAN)	1 (PAN)	36
Clouds	0%	0%	0%
Wavelet Length(μm) of Used Bands	0.51 ~ 0.73	0.51 ~ 0.73	band 1: 0.620 ~ 0.670 band 2: 0.841 ~ 0.876 band 3: 0.459 ~ 0.479 band 4: 0.545 ~ 0.565

data were collected on 3 June 2002 by KOMPSAT-1. MODIS has seven reflective bands for land studies, two 250 m spatial resolution bands and five 500 m spatial resolution bands, and twenty-nine 1 km spatial resolution bands for studies of ocean, cloud, water vapor, etc. In this study, only two 250 m bands (band 1 and 2) and two 500 m bands (band 3 and 4) were used as shown in Table 1. These data characteristics are shown in Table 1.

The study area is approximately 40 km south west of Pyeongyang, North Korea and covers mostly an agricultural reclaimed lands with a small forest area, salt field, river and sea, etc.

3. Merging by IHS and PCA Methods

For geometric registrations of the two EOC panchromatic images, each 12 and 11 ground control points (GCPs) were selected. The ground coordinates for GCPs were captured by CAD system from 1:50,000-



(a) The KOMPSAT-1 EOC panchromatic image mosaicked from the left and right orbit images of 43.8 km × 34.6 km ground sized study area. The area is approximately 40 km southwest of Pyeongyang, North Korea.

(b) The true color composited TERRA MODIS multispectral image from bands 1, 4, and 3 as red, green, and blue.

Fig. 1. The study area and data used.

scale topographic maps. The two panchromatic images were then resampled into the 6.6 m panchromatic coordinate system using a first order polynomial. And these two resampled panchromatic images were mosaicked for the entire study area.

The multispectral MODIS images were geometric registered using a "image to image" tool of ERDAS IMAGINE software system and were also resampled with 6.6 m pixel resolution.

The resampled study area is the size of 6,646 rows by 5,241 columns or about 43.8 km × 34.6 km ground size as shown in Figure 1.

The two methods used to merge the information contents of both data sets were the IHS and PCA methods.

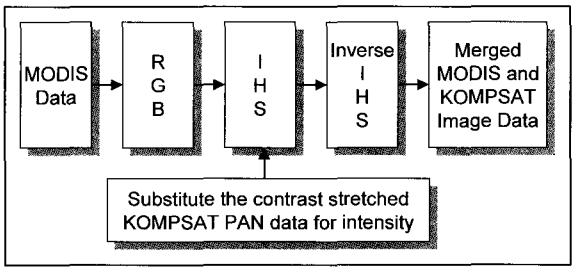


Fig. 2. Procedure for IHS method.

3.1 IHS

In this study, two RGB combinations (MODIS bands 1, 2, and 3 and bands 1, 2, and 4) were tested for IHS transformations. The higher spatial resolution image, EOC panchromatic data were 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. The overall IHS procedure used in this study are shown as Figure 2. Figure 3 shows color composit made by using the IHS results of EOC panchromatic image and MODIS bands 1, 2, and 3 as blue, green, and red only.

3.2 PCA

The procedure to merge the EOC panchromatic image and MODIS multispectral images using the PCA method is similar to that of the IHS method. The only two combinations of MODIS bands 1, 2, and 3 and 1, 2, and 4 were used as input to a PCA procedure. The panchromatic data were contrast stretched to have the approximately same variance and average as the first principal component.

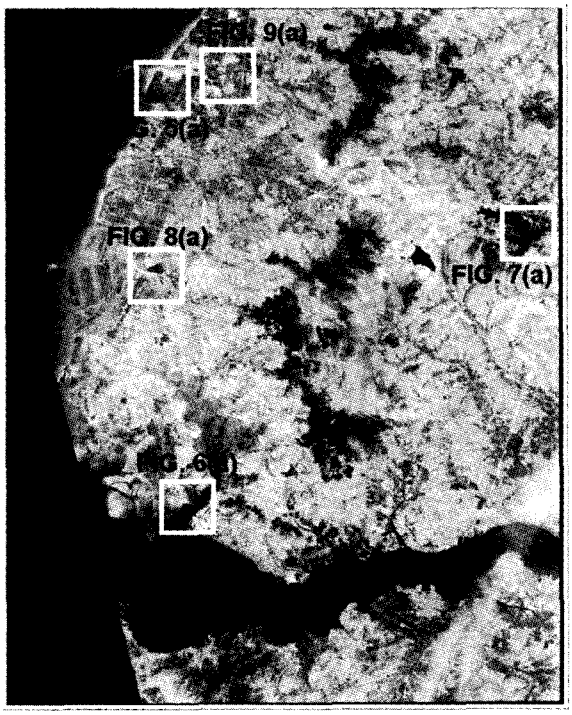


Fig. 3. Color composit made by using the IHS results of EOC panchromatic image and MODIS bands 1, 2, and 3 as blue, green, and red.

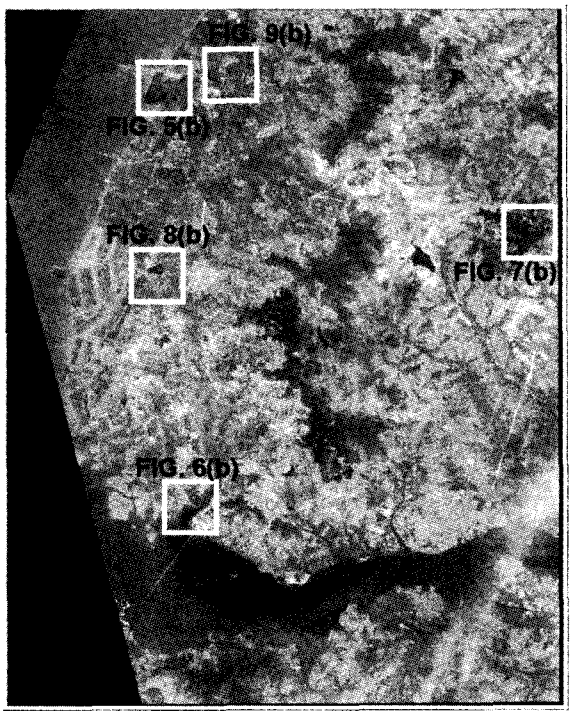


Fig. 4. Color composit made by using the PCA results of EOC panchromatic image and MODIS bands 1, 2, and 3 as blue, green, and red.

The substituted panchromatic image, the remaining principal components 2 and 3 were transformed back into the original RGB space. Figure 4 shows color composit made by using the PCA result of EOC panchromatic image and MODIS bands 1, 2, and 3 as blue, green, and red only.

4. Comparisons and Results

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

4.1 Mean and Standard Deviations

For the comparisons of spectral characteristics between the corresponding bands of the merged image and the original multispectral MODIS image, the mean and standard deviations were calculated as shown in Table 2. Table 2 shows that the mean and standard deviations of the merged image generated from the IHS bands 1, 2, and 3 have similar values with the corresponding original MODIS images.

4.2 RMSE

The RMSE of the pixel values between the merged images and original MODIS images were computed by Eq.(1) The computed RMSEs are shown in Table 3.

$$RMSE_j = \sqrt{\frac{\sum_{j=1}^{N}(DN_{mj} - DN_{aj})^2}{N}} \quad (1)$$

where,

DN_{mj} : pixel value of merged image
DN_{aj} : pixel value of MODIS image
N : total number of pixels for i band
$RMSE_4$: root mean square errors for i band

The RMSE of the pixel value differences between the merged image from the IHS bands 1, 2 and 3 and original MODIS images is less than those of other 3 cases.

4.3 Visual Inspection

To evaluate the spatial characteristics of the merged images, the grading is made based on the image viewing quality visually for the features of reclaimed farming facilities. Three persons who have image interpretation experience performed visual inspection of the images. Each merged image was graded between one and five. The gradings are listed in Table 4. From the grading results, the IHS bands 1, 2, and 3 shows the best visual inspection results.

The figure 5 ~ 9 are samples of subset merged images used for visual inspections.

Table 2. Differences of mean and standard deviations between the merged images and original MODIS images

		MODIS Value	IHS123		IHS124		PCA123		PCA124	
			Value	Diff.	Value	Diff.	Value	Diff.	Value	Diff.
Mean	1	24.65	25.15	-0.50	25.30	-0.65	23.45	1.20	23.62	1.03
	2	57.94	56.96	0.98	56.85	1.09	54.20	3.74	54.89	3.05
	3	40.82	41.59	-0.77			39.23	1.59		
	4	36.57			37.39	-0.82			35.24	1.33
S.D.	1	8.77	10.45	-1.68	10.95	-2.18	9.06	-0.29	9.16	-0.39
	2	30.93	29.21	1.72	29.19	1.74	21.89	9.04	21.81	9.12
	3	14.24	16.94	-2.70			14.98	-0.74		
	4	12.88			15.70	-2.82			13.27	-0.39

Table 3. The RMSEs of the pixel value differences between the merged images and original MODIS images

MODIS Band	IHS123	IHS124	PCA123	PCA124
1	5.04	5.9	4	3.98
2	11.86	13.17	17.06	17.41
3	8.36		5.97	
4		9.04		7.49
Total RMSE	8.87	9.83	10.69	11.18

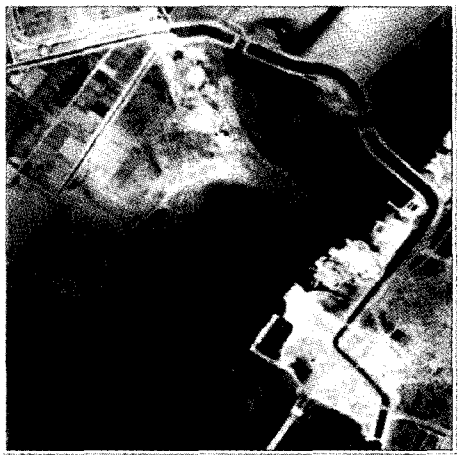
Table 4. The grading results from the visual inspection

	IHS123				IHS124				PCA123				PCA124			
	1	2	3	Ave.	1	2	3	Ave.	1	2	3	Ave.	1	2	3	Ave.
Reclaimed Farming Land and Road	4	5	5	4.7	4	4	5	4.3	4	4	4	4.0	4	4	4	4.0
Tide Embankment	5	4	5	4.7	5	4	4	4.3	5	4	5	4.7	5	4	5	4.7
Reservoir	5	5	4	4.7	5	5	5	5.0	5	4	4	4.3	5	4	5	4.7
Water Pumping Facility	5	5	5	5.0	4	5	4	4.3	4	5	4	4.3	4	5	4	4.3
Flume	5	5	5	5.0	5	4	5	4.7	5	5	5	5.0	4	4	4	4.0
Others	5	5	5	5.0	4	5	5	4.7	4	4	4	4.0	4	4	4	4.0
Total Average				4.8				4.6				4.5				4.3

(a) Subset merged image made from IHS bands 1, 2, and 3 for visual inspection of reclaimed farming land and road (500 rows by 500 columns).

(b) Subset merged image made from PCA bands 1, 2, and 3 for visual inspection of reclaimed farming land and road (500 rows by 500 columns).

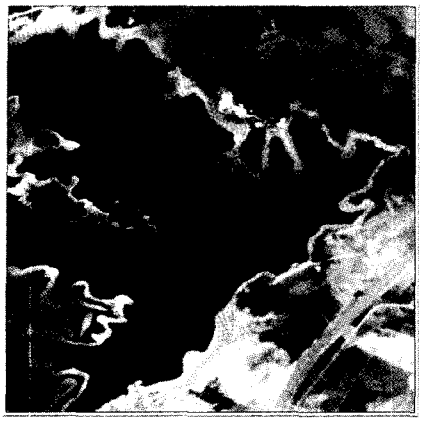
Fig. 5. The subset merged images for visual inspection of reclaimed farming land and road.



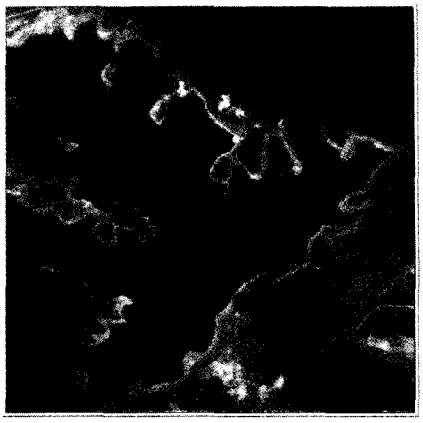
(a) Subset merged image made from IHS bands 1, 2, and 3 for visual inspection of tide embankment (500 rows by 500 columns).

(b) Subset merged image made from PCA bands 1, 2, and 3 for visual inspection of tide embankment (500 rows by 500 columns).

Fig. 6. The subset merged images for visual inspection of tide embankment.



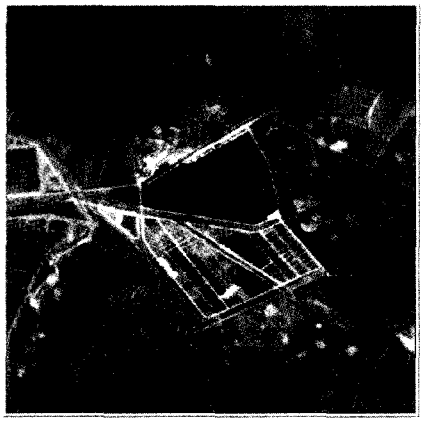
(a) Subset merged image made from IHS bands 1, 2, and 3 for visual inspection of reservoir (500 rows by 500 columns).



(b) Subset merged image made from PCA bands 1, 2, and 3 for visual inspection of reservoir (500 rows by 500 columns).

Fig. 7. The subset merged images for visual inspection of reservoir.

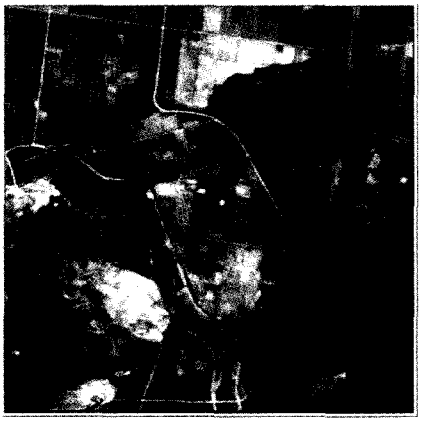
(a) Subset merged image made from IHS bands 1, 2, and 3 for visual inspection of water pumping facility (500 rows by 500 columns).



(b) Subset merged image made from PCA bands 1, 2, and 3 for visual inspection of water pumping facility (500 rows by 500 columns).

Fig. 8. The subset merged images for visual inspection of water pumping facility.

(a) Subset merged image made from IHS bands 1, 2, and 3 for visual inspection of flume (500 rows by 500 columns).



(b) Subset merged image made from PCA bands 1, 2, and 3 for visual inspection of flume (500 rows by 500 columns).

Fig. 9. The subset merged images for visual inspection of flume.

5. Conclusions

To present an effective merging method of the high-resolution KOMPSAT-1 EOC panchromatic image and the multi-spectral MODIS images for survey of reclaimed land, the results of the IHS and PCA methods were compared with the spatial and spectral characteristics of the original MODIS images statically and visually.

1. The statistical comparisons for the spectral characteristics of the merged images indicate that the results generated with the IHS method using MODIS bands 1, 2, and 3 are less distorted than the results generated by the IHS method using MODIS bands 1, 2, and 4, PCA method using MODIS bands 1, 2, and 3, or PCA method using MODIS bands 1, 2, and 4.

2. The visual comparison also indicates that the IHS method using MODIS bands 1, 2, and 3 generates with as good a spatial resolution as do other three methods.

Acknowledgement

The financial support of this study by the Korea Aerospace Research Institute (Research Title : A study on technique for survey of reclaimed land of North Korea using KOMPSAT-1 EOC image and MODIS image) is gratefully acknowledged.

References

1. AHN, K.W., and SEO, D.C., (1998). "Comparison of five different methods to merge IRS-1C PAN and Landsat TM data." Journal of the Korean Society of Remote Sensing, Vol. 14, No. 2, pp. 149-164.
2. CARPER, W.J., LILLESAND, T.M., and KIEFER, R.W., (1990). "The use of intensity-hue-saturation transformations for merging SPOT panchromatic and multispectral image data." PE & RS, Vol. 56, No. 4, pp.459-467.
3. CHAVEZ, P.S., Jr., SIDES, S.C., and ANDERSON, J.A., (1991). "Comparison of three different methods to merge multiresolution and multispectral data: Landsat TM and SPOT Panchromatic." PE & RS, Vol. 57, No. 3, pp. 295-303.
4. SHIH, T.Y., and HSIEH, C.S., (1997). "A comparative study on the techniques for merging spot panchromatic and multispectral image data." ACSM/ASPRS Annual Convention & Exposition Technical Papers Vol. 3: Remote Sensing & Photogrammetry, pp. 64-73.
5. Chavez, P.S., Jr. and Bowell J.A. (1988). "Comparison of the spectral information content of Landsat Thematic Mapper and SPOT for three different sites in the Phoenix, Arizona region." PE & RS. Vol. 54. No. 12. pp. 1699-1708.