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Spectral Signatures of Tombs and their Classification*

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묘지의 분광적 특성과 통계적 분류*

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Abstract : More than 0.5 percent of land in Korea is used for cemetery and the rate is growing in spite of the increase in cremation these days. The systematic management of tombs may be possible through the 'Feature Extraction' method which is applied to the high-resolution satellite imagery. For this reason, this research focused on finding out the radiometric characteristics of tombs and the classification of them. An IKONOS image of northwest areas of Seoul with 8km x 10km dimension was analyzed. After sampling 24 tombs in the study area, the statistical radiometric characteristics of tombs are analyzed. And tombs were classified based on the criteria such as landscape, NDVI, and cluster analysis. In addition, it was investigated if the aspect or slope of the terrain influenced to the classification of tombs. As a result of this research, authors find that there is similarity between the classification by NDVI and the classification through cluster analysis. And aspect or slope didn't have much influence on the classification of tombs.

Key Words : tomb, feature extraction, statistical radiometric characteristic, classification of tomb, aspect, slope

요 약 : 화장의 증가에도 불구하고 묘지의 면적증가는 계속되고 있고 이로 인해 국토공간 가운데 산지를 효율적으로 활용하지 못하고 있는 것이 현실이다. 위성영상을 이용한 사상추출(feature extraction) 방법은 이러한 문제점을 해결하고 묘지의 체계적인 관리를 가능하게 할 것으로 기대할 수 있다. 이에 본 연구에서는 묘지의 반자동 혹은 자동추출을 위한 기초연구로서 묘지의 통계적인 분광특성과 유형분류에 관한 연구를 수행하였다. 연구를 위해 고해상도 위성영상인 IKONOS 영상을 이용하였다. 연구지역 내에서 24개의 대상묘지를 선정하여 해당 묘지의 통계적 분광특성을 조사하고, 경관 식생지수 군집분석 등에 의한 분류를 시도하였다. 그리고 사면이나 경사도가 묘지의 유형구분에 미치는 영향을 연구하였다. 연구결과, 식생지수와 군집분석에 의한 유형구분이 유사하게 나타났고 사면이나 경사도는 묘지의 유형구분에 큰 영향을 미치지 않는 것으로 나타났다.

주요어 : 묘지, 사상추출, 통계적 분광특성, 유형분류, 사면, 경사도

1. Introduction

1) Backgrounds

The burial of corps is an important ritual process under the influence of Confucius culture, more than 0.5 percent of land in Korea has been used for cemetery. In these days, some changes can be noticed in this phenomenon, partly because young generation began to recognize the problem, partly because local governments established new cremation facility. According to statistics, the rate of cremation increased from 23.2% in 1997 to 33.7% in 2000[1]. But most Koreans still prefer burial to cremation, which results in the increase in cemetery areas.

Amendment of law on the burial includes new

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section for more strict management of burial procedure. According to the law, those who want to bury their relatives should submit tomb registry and attachments which has information on cadastre, forest map or maps and photography to show the location of the tomb. According to the regal part of 17109 on the president' enforcement regulation amended in 2001, new private tomb shall not be larger than $80m^2$. If the law is observed strictly, the management of mountainous areas can be under control. In reality, the registration process is not known to public and the larger size tombs are prevalent. According to a report, 75 percent of tombs are not registered to administration unit (Kim, 1996).

Even though the collection of registry and management is the duty of local governments; it is not carried out effectively due to the lack of time, money and man-power[3]. This study investigates the potential use of remotely sensed data for the tomb management. Statistical radiometric characteristic has not been investigated yet, even though high resolution data is available since 2000. Based on the spectral characteristics, semi-automatic or automatic feature extraction could be possible.

2) Current Status of Burial Culture and Study Purposes

(1) Current status of burial culture

Burial is the very important process for the country under the tradition of Confucius. Fengsui idea enforced the tradition and expanded the space for the dead ancestors, which resulted in inefficient land use for the whole country.

A study estimated that the number of tombs in the end of 1995 was 19,612,000 and about 200,000 tombs are added every year (Kim, 1996). At that time, number of public cemeteries was 132 and that of private cemeteries was 110. However, the number of public cemetery increased to 286, and the number of private cemeteries was 125 in the end of 2001[4]. With the increase in burial space, the cremation rate also has increased significantly, which reflects the changes in burial culture. Table 1 showed that the rate of cremation from 1954 to 2001 increased noticeably[5].

According to the Ministry of Healthy and Social Welfare, the death toll in 2001 reached 243,730 and the cremation rate of that year was 38.5%.

In spite of this change, the total area for the cemeteries increased due to the preference of burial. The amended regulation is observed fairly by both public and private group cemeteries, as it is mandatory to submit the papers on the locations of new tombs. As for the private tombs, public do not follow the government regulations due to various reasons.

Only one study has been made so far. Ministry of Health and Social Welfare funded a research on a mapping project to find suitable places for cemeteries and depots for corpse ashes for City of Osan, Gyeongi Province. The field survey was done for each tomb with GPS (Global Positioning System) and heads of each village (ri-jang) (Park 2003). As we mentioned before, the shortage of budget and manpower, each and every new tomb can not be monitored. Therefore, the new practical methods should be designed to manage and monitor tombs, especially for detecting wood-surrounded luxurious ones which can not be found by the roadside field survey. Therefore, remotely sensed data with high spatial resolution were analyzed to prove potential use of local governments.

(2) Reviews and Study Purposes

Many researches have been done to extract features on earth surface semi-automatically or automatically from the aerial photographs and satellite

Table 1. *Trend of Cremation Rate*[6]

(unit: %)

year	1954	1970	1981	1991	1996	1999	2000	2001
cremation	3.6	10.7	13.7	17.8	23.0	30.3	33.7	38.5

images.

Franklin(2001) did texture analysis to delineate age group of Douglas fir trees with IKONOS panchromatic images. The digital number (DN values) of different age groups was significantly different. Kiema(2002) did automatic feature extraction for the built-up area with SPOT and Landsat TM images. The texture of SPOT panchromatic image were analyzed first and fused with Landsat TM data into new merged images. Kiema emphasized homogeneity of pixel values of built-up areas for the SPOT image. Then built-up areas were classified into six categories such as settlement, vegetation, industry, water, forest, and road.

Smith(2002) extracted fire scars in southern Sudan based on the texture analysis. Near Infrared band from ASTER-2 images was separated for the texture analysis and compared with the results of GLCM(Grey Level Co-occurrence Matrices)[7] and that of traditional unsupervised method such as ISODATA.

Feature extraction from the image has been in various algorithms to consider the continuity of pixel values and directions of the pixel value within variation. Traditional unsupervised classification may be one of the extraction methods. With a very high resolution image, it is possible to distinguish tombs with bare eyes, even though the interpretation depends on the size of tombs. But it takes too much time to distinguish all the tombs, so image processing software is required. In addition, expert or trained personnel should perform the monitoring jobs. Therefore, semi-automatic or automatic extraction methods are necessary to ease the situation. Before developing feature extraction algorithms for the tombs, the spectral signature should be investigated with some verification of field work. The accuracy of position should be checked, which will be discussed in another article. So the main purpose of this article is to find out the spectral characteristics of tombs and classify the types based on field work and the statistics.

3) Material and Site

(1) Material

Remotely sensed data can be obtained from the

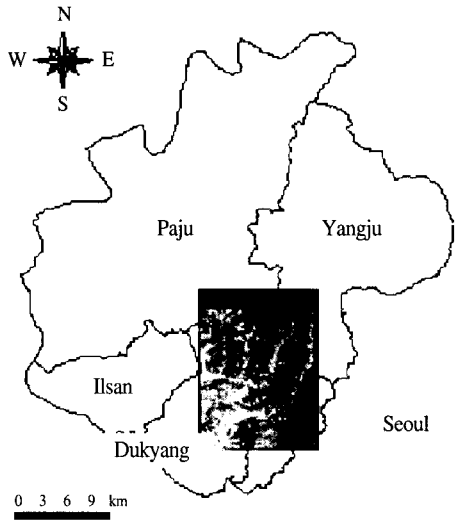

Figure 1. Study area with administration boundaries

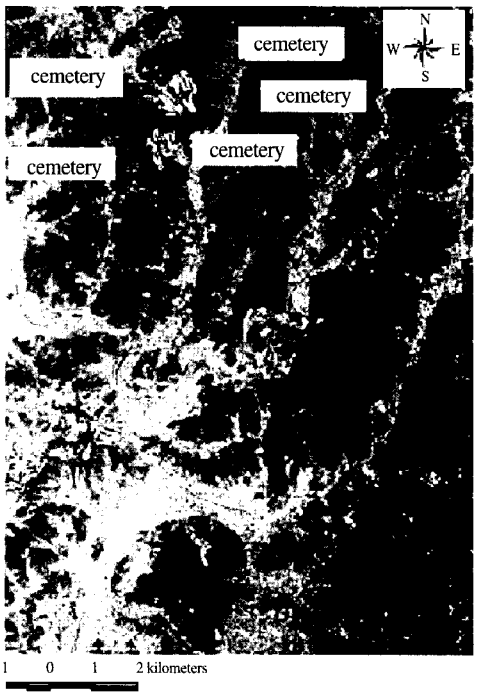

Figure 2. IKONOS image of study area

various platforms from airplane to satellite. Korean government has invested a great amount of money to build Satellites and KOMPSAT-2 (KOrean Multi Purpose SATellite-2) is supposed to launch in 2004. Since IKONOS image has almost identical bands to KOMPSAT-2, the application of KOMPSAT-2 image can be simulated with IKONOS data. IKONOS image with one meter spatial resolution was chosen to test the potential applicability of KOMPSAT-2 for the public administration. The IKONOS image is geo-level pan-sharpened one which is fused with panchromatic band and multi-spectral bands (Blue, Green, Red, NIR band). Original image was taken on March 28th, 2001 and manufactured on June 3rd, 2001. The image was rectified with UTM coordinates in the zone of 52, and radiometric resolution per pixel was 11bits.

(2) Study area

Dukyanggu Goyangsi and Yangju, Gyeongido areas, located in northwestern part of Seoul, were selected as a study area, since there are private and public cemeteries. Also Yongmiri of Pajusi has municipal cemetery of Seoul Metropolitan City. Not only various cemetery types but also private tombs can be observed in the site.

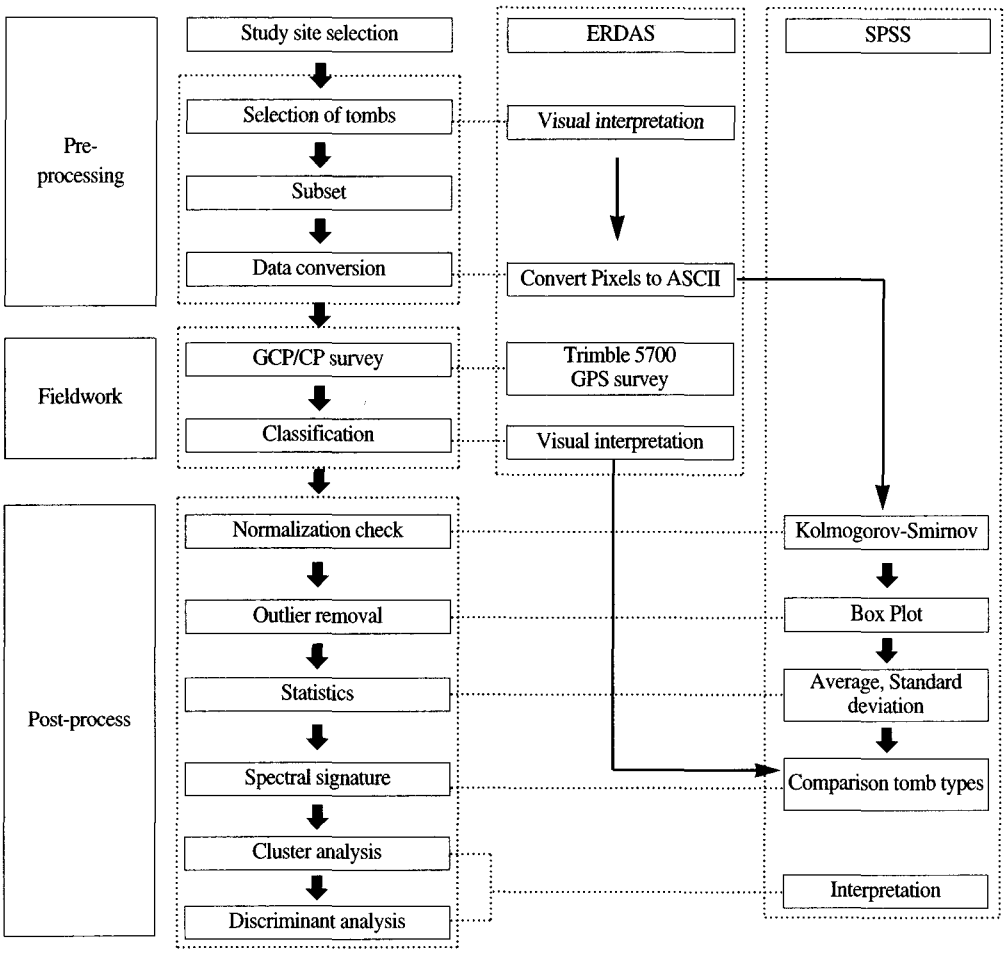

Figure 3. Study Flow

Five cemeteries are located within the study area as shown in Figure 2. Two cemeteries in southern part were extensively surveyed. Some of the cemeteries are older than thirty year, other cemeteries are municipal cemetery and they still have some space for new burial. Numerous private tombs were also observed within the study area.

4) Study Methods

The values of energy were separately recorded as a DN value of pixel. The satellite image data is composed of series of digital numbers with head file of geographic coordinates. Converting digital value to analogue maps on the screen is one of the basic procedures of image processing. We used Erdas Imagine 8.4 (USA, Leica Geosystem) and PCI (Canada, PCI) software for the job. The detailed study flow is as follows.

We chose 24 tombs from the ortho-image. We subset the image with the function of AOI(Area Of Interest) of Erdas Imagine. The shadow area from each tomb is excluded from the subset[8]. The procedure for subset is shown in figure 3.

Left image of figure 4 represents the selected tombs on the IKONOS image. Upper right picture is zoomed-in image and lower right picture is subset image. After subset procedure, the DN values are converted into ASCII format for further analyses.

The average, variance and standard variation of pixel values of twenty four tombs were analyzed with SPSS. Before the procedure, box plotting method was applied to exclude outliers from artificial features such as stone walls and stone table.

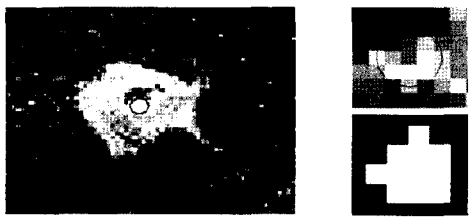

Figure 4. subset of Tomb from the IKONOS image

Cluster analysis was done to classify the tombs based solely on the spectral values. The average, standard deviation, mode, median values were chosen as input variables. Hierarchical classification methods, Ward method as clustering method, and distance measurement based on squared Euclidean distance are performed.

After three clusters were obtained, discriminant analysis was carried out with independent variables of average, standard deviation, median, and dependent variable as number of cluster. As the number of clusters is three, multiple discriminant analysis was carried out to check the relationship between the dependent variables and independent variables.

2. Research Findings

1) Classification of tombs based on the field survey

We selected 24 tombs from the ortho-image which we generated with PCA, and checked the situation of the tombs in the field. We can classify the status of tombs which may affect the radiometric values into four groups

- Type 1
- no tree surrounds the tomb and sunny
- grasses stabilized and managed very well
- little effect from soil
- Type 2
- recently buried tomb
- considerable effect from soil
- Type 3
- trees surround the tomb
- shadow by trees
- Type 4
- similar to surrounding areas, covered with fallen leaves.

Photographs of each type are shown in Figure 5 through Figure 8.

Figure 5. Type 1

Figure 6. Type 2

Figure 7. Type 3

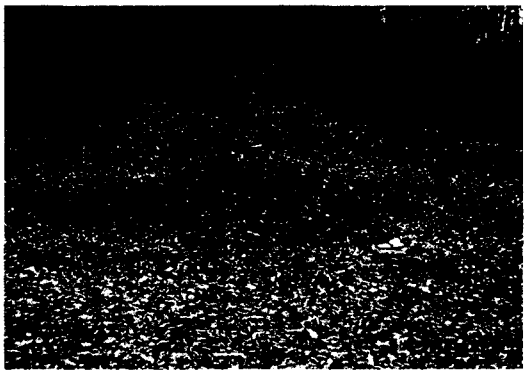

Figure 8. Type 4

2) Results from the image processing

The effects of artificial features located near the tomb are not distinguishable, as the size of stone table is around one meter which is too small to be detected. But it is not safe to say that no effect of the shadow of stone table can excluded. In the field study of public cemetery, the size of tombs ranges from 10 square meters to 65 square meters. On the other hand, some of the private tombs are larger than several hundred square meters.

The averages of pixel values for each band were plotted in the Figure 9 through Figure 12.

All the band values except blue band have maximum average values in number five. On the other hand, all the band values except blue band have minimum average values in number six.

Number five tomb and number nineteen are recently built, therefore bare ground is exposed. Number six and twenty three are surrounded by shrubs and trees and belong to type 4, which results in lower average values. Number seven and twelve are covered with grasses, which belong to type 1. The average values of type 1 showed similar values to the total tombs. Tombs in shadow area also had lower average values, compared to the total average.

3) Result of Cluster Analyses and Discriminant Analyses

Combination of field works and descriptive statistics indicates the importance of vegetation index. NDVI (Normalized Difference Vegetation Index)[9]are shown in the table 4. The higher the values are, the more active the vegetation over the tombs is. Two types of values can be obtained in Table 4, one is negative and the other is positive.

Dendrogram is shown in figure 19.

Table 2. The average values of pixel for each tomb

number	Blue	Green	Red	NIR
1	91.18182	98.95455	108.0682	104.0000
2	75.92308	87.97436	99.05128	97.12821
3	88.3600	91.4000	102.3600	103.3200
4	90.8681	100.3626	113.5934	114.4945
5	94.3478	110.7391	124.6957	127.9130
6	82.4857	79.0571	84.9428	85.7142
7	103.1481	104.0000	109.4815	106.2963
8	101.1020	98.5918	99.4898	95.8571
9	80.8750	93.3250	102.9500	100.5500
10	101.4074	104.4815	113.2963	120.9630
11	108.9286	107.7500	108.8571	103.7500
12	93.2340	100.8936	107.7872	103.6383
13	90.3703	94.2963	109.3704	106.5926
14	92.3750	100.9167	112.3750	123.1667
15	90.0454	108.0909	127.1364	121.1364
16	73.2000	87.8000	95.0666	91.9555
17	94.2683	95.9027	102.3056	100.6806
18	87.2222	94.4222	102.4222	100.5111
19	97.0581	110.3140	126.1279	126.3721
20	96.7586	109.9885	125.7931	126.3721
21	103.5000	99.6551	96.3793	89.9827
22	95.4285	107.5238	115.2857	119.9524
23	100.4211	91.4736	86.0526	87.9473
24	79.6222	93.0666	101.6222	117.0000

Table 3. Standard deviation of pixel values for each tomb

number	Blue	Green	Red	NIR
1	11.9325	11.6679	12.0915	12.5661
2	9.5954	8.6434	7.4124	7.8310
3	12.1136	11.3100	10.5193	10.7188
4	6.1503	5.5186	6.4204	6.2367
5	8.6476	8.3677	8.6362	8.3606
6	7.4493	8.1020	6.8210	6.7934
7	7.4663	8.2322	9.8853	12.5784
8	8.3472	8.9020	8.4853	8.7106
9	10.8632	11.2281	12.5615	14.3811
10	14.7498	16.4652	15.8692	18.5979
11	8.1737	8.1859	9.0419	9.1595
12	6.0080	5.6423	7.1015	6.6901
13	9.8377	10.1102	10.8562	12.4784
14	7.9225	7.3361	7.6431	8.9620
15	11.6393	9.7243	11.2601	9.6179
16	8.0611	8.2230	6.9980	7.0257
17	7.7076	7.9277	8.4680	8.4467
18	10.4661	10.5237	10.0893	11.9727
19	9.0050	8.7195	9.7362	10.5295
20	9.3783	9.1847	10.1707	10.8158
21	7.3251	8.3383	8.8512	9.2233
22	9.7497	8.8691	10.0256	10.0422
23	7.9534	9.1309	8.6118	11.2865
24	11.5528	11.5156	10.7413	11.7202

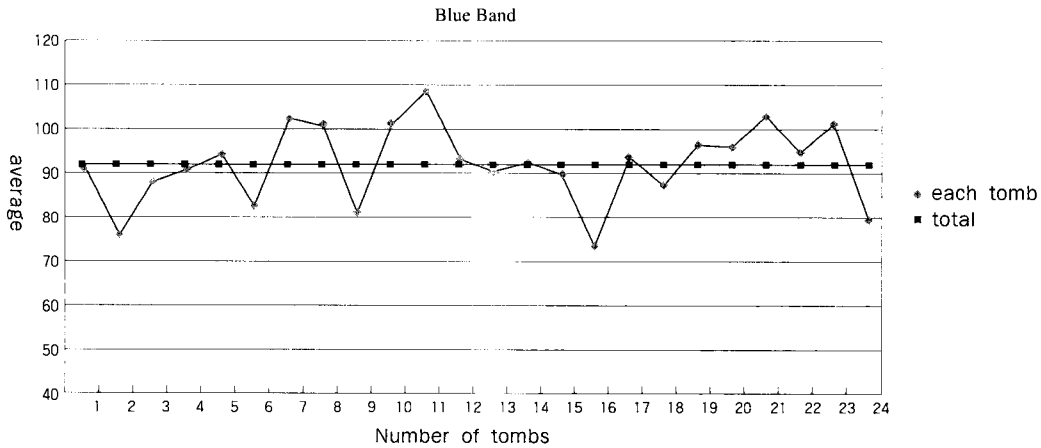

Figure 9. Average values of each pixel for blue band

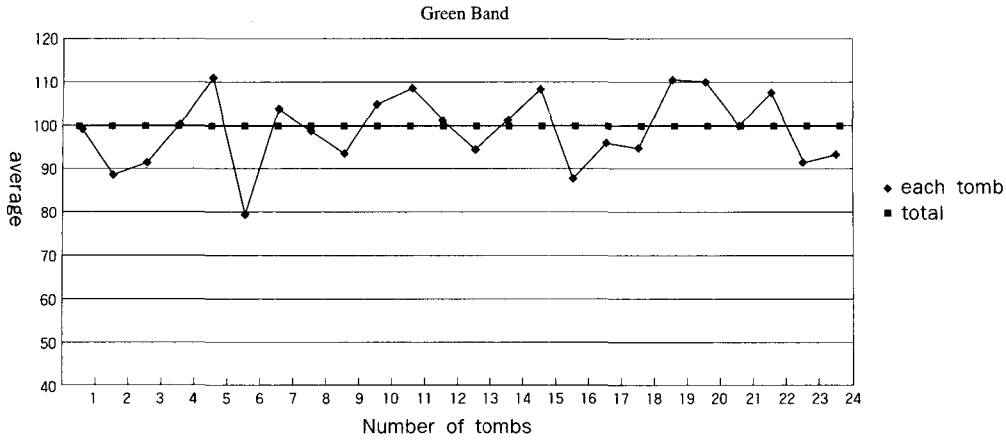

Figure 10. Average values of each pixel for green band

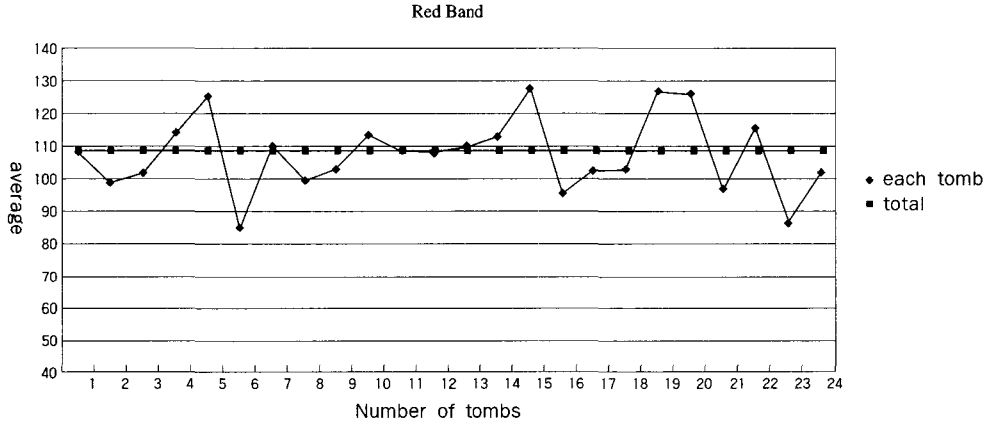

Figure 11. Average values of each pixel for red band

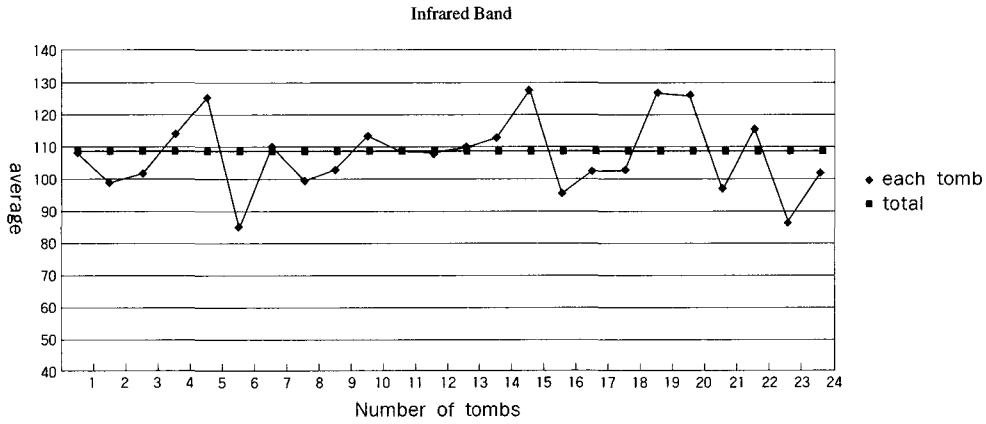

Figure 12. Average values of each pixel for infrared band

Figure 13. # 5 tomb

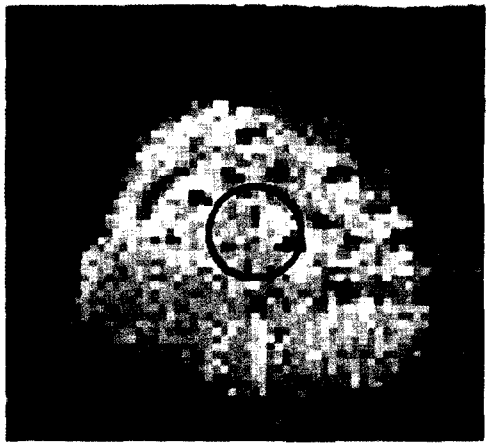

Figure 14. # 19 tomb

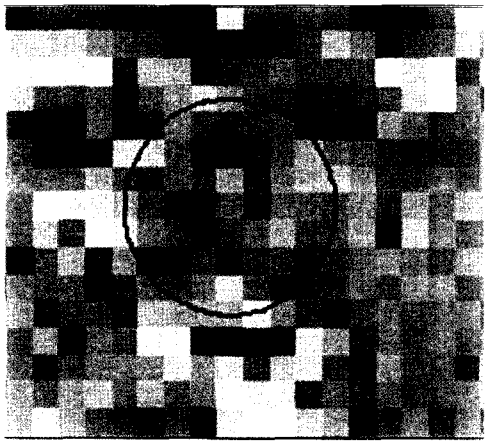

Figure 15. # 7 tomb

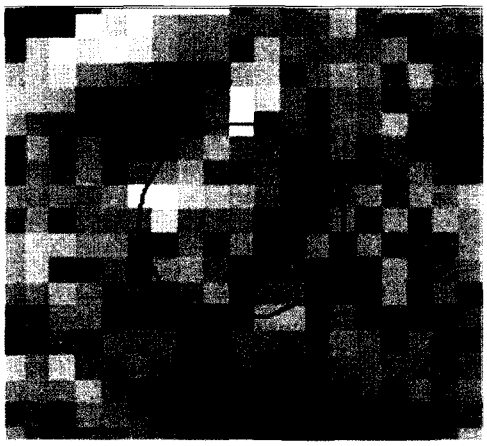

Figure 16. #12 tomb

Figure 17. # 6 tomb

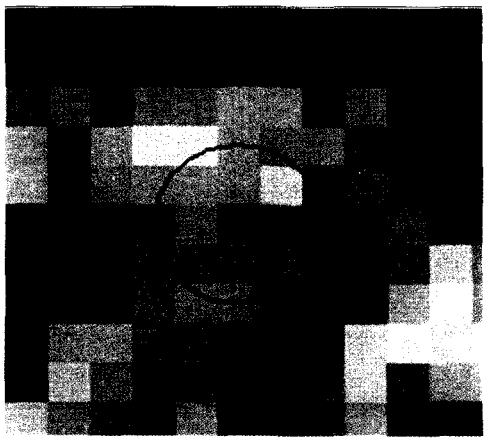

Figure 18. # 19 tomb

Table 4. Normalized Difference Vegetation Index of each tomb

number	NDVI	number	NDVI
1	-0.5167	13	-0.4327
2	-0.3258	**14**	**1.2237**
3	-0.1049	15	-0.6701
4	**0.3033**	16	-0.7382
5	**0.2592**	17	-0.4938
6	**0.7014**	18	-0.4872
7	-0.4723	19	-0.0132
8	-0.8317	**20**	**0.2349**
9	-0.5527	21	-2.1197
10	**0.8535**	**22**	**0.3899**
11	-0.3655	**23**	**0.3195**
12	-0.9204	**24**	**3.4652**

It is interesting to compare the results of cluster analyses with the NDVI. The NDVI of tombs of number 4, 5, 6, 10, 14, 20, 22, 23, 24, are positive, in other words, the near-infrared values are higher than red values. Figure 19 showed that three clusters could be selected, and positive NDVI group and negative NDVI group belong to each cluster. The tombs of number six and fifteen belong to opposite cluster. The tombs of number nineteen and twenty three belong to neither the positive nor the negative cluster. The result shows that both NDVI and Ward cluster analysis can distinguish the groups of tombs affected by grasses from those affected by soil and shadows. Significance of discriminant probability was 0.004 with 2 statistics to Wilks' Lamda, which

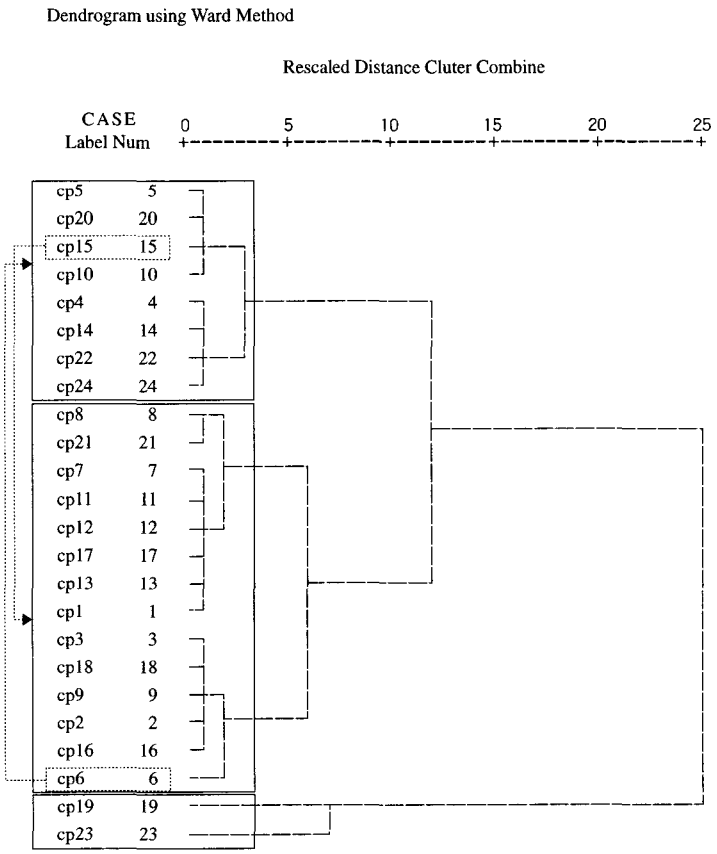

Figure 19. Dendrogram of each tomb

Table 5. The result of classification based on multi discriminant analyses

Ward method			predicted group			total
			1	2	3	
original values	frequency	1	14	0	0	14
		2	0	8	0	8
		3	0	0	2	2
	%	1	100	0	0	100
		2	0	100	0	100
		3	0	0	100	100
reciprocal values	frequency	1	12	2	0	14
		2	1	7	0	8
		3	0	0	2	2
	%	1	85.7	14.3	0	100
		2	12.5	87.5	0	100
		3	0	0	100	100

means the classified clusters have significant differences. The hit ratio was 87.5% as a result of discriminant function. The results are shown Table 5.

4) Effect of Aspect and Slope

The reflection values are affected by both sun angle azimuth and elevation. The feature with similar characteristic may show different DN values, whether it is located in leeward of sun angles or it is located toward the sun. The hypothesis is that the slope and aspect of each tomb may affect the reflectance values or types of tombs. To verify the hypothesis, the contour layers were extracted from 1:5,000 digital topographic maps and DEM data with five meter interval were generated using ArcGIS. The aspect and slope of the study area were built based on the DEM data. The tomb numbers and clusters are plotted on the diagram of slope which is shown in figure 20. Table 6 summarizes the information on the slope and aspect for each tomb.

Table 6. Aspects and Slopes of each tomb, criteria 1 is based on NDVI, criteria 2 is based on cluster analysis

number	aspect	slope	criteria1	criteria2	number	aspect	slope	criteria1	criteria2
1	135	0	1	1	13	135	13	1	1
2	174	15	1	1	14	129	19	2	2
3	236	10	1	1	15	102	24	1	2
4	180	21	2	2	16	63	18	1	1
5	233	14	2	2	17	180	11	1	1
6	83	12	2	1	18	225	8	1	1
7	203	10	1	1	19	189	16	1	3
8	246	10	1	1	20	-1	0	2	2
9	248	15	1	1	21	333	12	1	1
10	135	15	2	2	22	113	10	2	2
11	248	15	1	1	23	286	23	2	3
12	90	11	1	1	24	-1	0	2	2

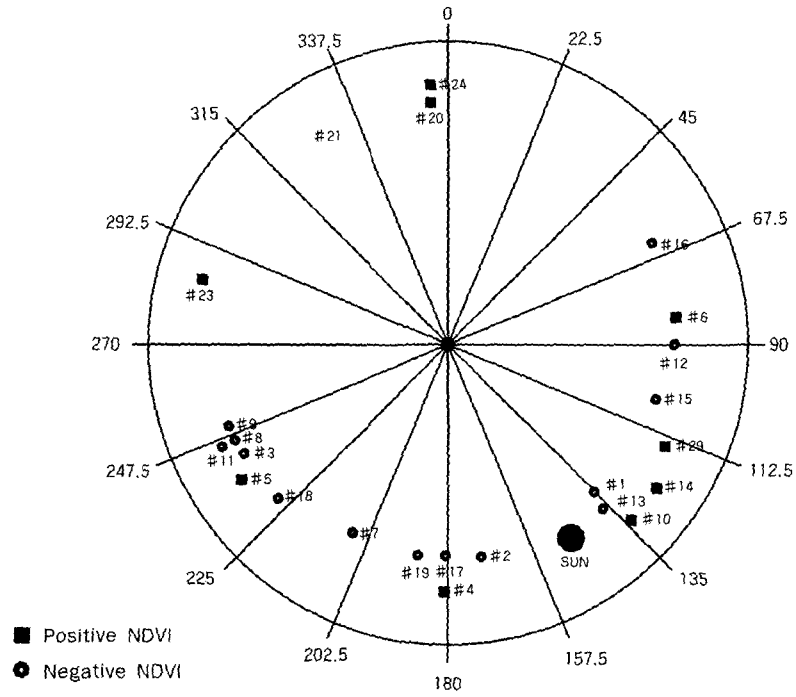

Figure 20. The effects of aspect on the NDVI of each tomb

On the contrary to the expectation, we could not find a strong correlation between the slope and digital values. Figure 20 shows that the most of tombs located toward the sun show lower NDVI values, while the tombs with higher NDVI values are randomly distributed. So the hypothesis could not be verified not to be true, that is to say, the slope and the aspect of each tomb do not affect the classification of spectral signatures significantly.

3. Conclusion

Cemeteries and tombs are space for the dead, which aggravate the degradation of mountainous areas. Cremation rate is increasing, however the rate illegal or unregistered tombs are also rising. For the purpose of proper management of tombs and reenforcement of new laws on the burial, we investigate the feasibility of high-resolution images. The visual interpretation and field works allowed us to classify the tombs and their spectral signatures. The conclusions we reached are as follows.

First, basic statistics on the spectral signatures of tombs show very high variance among the tombs. In a semantic sense, tomb may be categorized as an identical layer; however, the status of management, grasses on the tombs, shadows from the trees resulted in wider range of spectral values, which is totally different symptom from artificial and linear feature extraction.

Second, classification based on NDVI shows similar results to classification based on cluster analysis.

Third, north-facing tombs tend to have higher NDVI values than south-facing tombs. There were no significant effects of slope on the spectral signatures.

In summary, the spectral signatures based on the basic statistics show that semi-automatic feature extraction may not easily be accomplished.

Algorithms for feature extraction should be based on the field study and the ground truth. Therefore, not only descriptive statistics but also pattern recognition method should be applied. Knowledge-based classification may be appropriate; however, it is impossible to overemphasize the importance of field survey for accuracy tests. This kind of application of IKONOS images can be useful to expand the potential use of KOMPSAT-2 images for the local governments' enforcement of burial law and management of mountainous areas. The interview results, and reports on the current status and the prospect for satellite images will be discussed in separate papers. We focused only on the spectral characteristics of tombs and procedures to extract the information. Further studies are necessary to adopt the object-oriented classification and knowledge-based classification, on the basis of the results from this study.

Notes

1) Ministry of health and social welfare, department of social welfare for elder 2000, 2001 burial facility statistics, digital government documents
2) Detailed enforcement regulations on the burial and part 10.
3) It is mandatory for head of local government to keep the record on the tomb and report file in the law on the burial and executive part 9 section.
4) Public cemeteries increased, especially in metropolitan city of Incheon, from 75 in 1996 to 118 in 2001.
5) The cremation rate in Korea is still very low, compared with 97 percent of Japan and with 67% of England.
6) Ministry of health and social welfare, Department of social welfare for elder 2000, 2001 burial facility statistics, digital government documents
7) GLCM is co-occurrence matrix composed of probability of a pair of pixel, which is called as CM(Co-occurrence Matrices), Grey-Tone Spatial -Dependence Matrix. GLCM method showed detailed information for local or limited areas of images (Schowengerdt,1997).
8) It is easy to make a subset for larger tomb, while the some shadow pixels inevitably are included in case of small tombs.
9) NDVI = (NIR - Red) / (NIR + Red)

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