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Development of Agriculture-related Data Inventories Using IKONOS Images

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Abstract : This paper describes the method of using IKONOS imagery in the development of agriculture-related data inventories. Temporally different three images of panchromatic (1m resolution) and multi-spectral bands (4m resolution) were used to obtain the distribution and characteristics of rice, pear, grape, red pepper, garlic, and reservoir surface area with the field surveys. The result of this study suggests the utility of KOMPSAT-II, which increases the use of the crop and water resources data in rural areas by accumulating temporal data inventories.

Key Words : IKONOS, KOMPSAT-II, agriculture, data inventory, texture, pixel value.

1. Introduction

In South Korea, even though satellite images are recognized to have a potential use in the field of agriculture, there have been some constraints in applying images because of high prices, few temporal series of images, and low spatial resolution. KARI (Korea Aerospace Research Institute) is now developing KOMPSAT (Korea Multi-Purpose Satellite)-II, the 2nd generation of KOMPSAT series, which has a high performance MSC (Multi-Spectral Camera) with 1m resolution as a main payload. Thus, it is expected that a lot of agriculture-related information can be obtained from the images of KOMPSAT-II, and furthermore the images will play a role to update rural GIS data and activate data use for agriculture.

The very high satellite resolution imagery such as IKONOS and KOMPSAT-II has a potential use for farm and crop management. To provide crop information at a regional scale, regular acquisition of images for the same area is critical. Analysis of multitemporal imagery in the phenological cycle provides information on how the specific crop variables are changing through time. Thus, the key point for testing the applicability to crop management is that KOMPSAT-II has to establish a special operational policy to acquire imageries off-nadir and oblique viewing at critical dates for agricultural areas.

However, we can expect that there may be some operational and observational difficulties to obtain a series of good quality of images for a target area. So, an

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up to date agriculture related data inventory development using information obtained from data analysis and building databases for crop and rural water resources can be an alternative. This approach can help an identification of agricultural species, cultivation area, and crop condition during the growth stage. If the crop information from both images and field investigations are accumulated, reasonable crop mapping, crop condition and crop yield estimation would be possible. This paper presents a methodology for development of an agriculture related data inventories especially for crop mapping and crop condition using IKONOS multitemporal images and with field surveys.

2. The Study Area, Data Acquisition and Preprocessing

The study area is Gosam-myeon (27.8 km^2) in Anseong-si that has a diverse agricultural environment (Fig. 1). It lies between the coordinates of latitude N 37° 03′ 31″ to N 37° 07′ 53″ and longitude E 127° 13′ 56″ to E 127° 18′ 16″. More than 52.0 % is forested and 16.8 % of lowland is paddy fields. The remaining area is dry field farming (6.6 %) and rangeland (2.7 %) scattered between the forest and the paddy.

Table 1 shows three obtained IKONOS images for this study. IKONOS Standard Geo Level images were ortho-rectified by using GCPs and 5 m DEM from 1:5,000 NGIS digital map and in-situ GPS data acquired from Trimble GeoExplorer III. Generic Pushbroom Model of ERDAS (1999) IMAGINE OrthoBASE 8.5 was used for orthorectification. Fig. 2 shows the IKONOS image before and after orthorectification.

3. Result and Discussion

1) Reservoir Water Surface Area

Fig. 3 and Table 2 show the comparison result of

Table 1. The IKONOS images and their results of orthorectification.

Images	Type	GCPs	RMSE (m) X/Y/Z
May 25, 2001	Pan. 1NIR	513	3.40/3.38/1.07
	M/S 4RGB	499	1.54/1.69/0.25
Dec. 25, 2001	Pan. 1NIR	509	3.12/3.10/0.75
	M/S 4RGB	497	2.01/3.18/1.50
Oct. 23, 2003	Pan. 1NIR_RPC	5	2.01/3.18/1.50
	M/S 4RGB_RPC	5	0.60/1.43/0.23

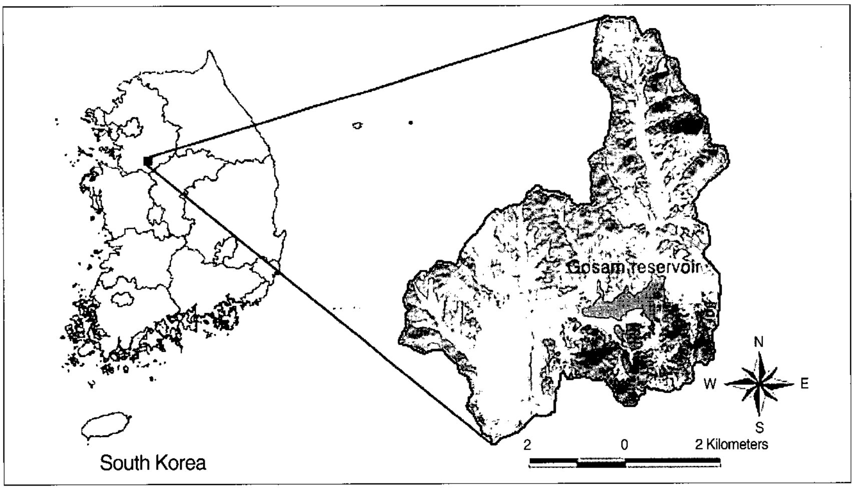
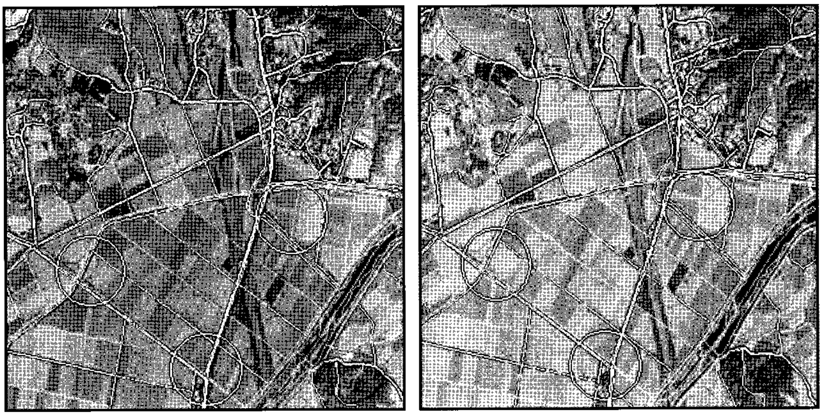
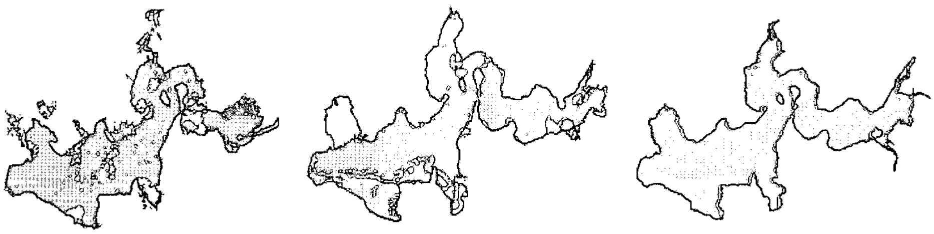


Fig. 1. The study area.



(a) before ortho-rectification (b) after ortho-rectification

Fig. 2. Ortho-rectification using RPC information.



May 25, 2001 Dec. 25, 2001 Oct. 23, 2003

Fig. 3. Comparison of extracted reservoir water surface by feature extraction and digitizing method.

Table 2. Comparison of surface area extracted from digitizing and feature extraction method.

Obs. date		May 25, 2001	Dec. 25, 2001	Oct. 23, 2003
Surface area extracted (km^2)	Digitizing	1.528	2.058	2.161
	Feature extraction	1.564	1.763	2.118
Relative error (%)		2.36	-14.35	-1.96

extracted water surface of Gosam reservoir for three images. Gosam reservoir has the 2.310 km^2 area of full water and total 16.09 million ton storage capacity. The Sobel edge detector filter was adopted to enhance each image and the reservoir water surface was extracted using both feature extraction (filled) and digitizing method (polygon). December 25 image could not fix a certain boundary between land and water because of the ice/snow cover along the waterside. May 25 image showed a 1.528 km^2 water surface area because of the reservoir release for irrigation of downstream paddy fields compared to October 23 image (2.161 km^2).

Based on the digitizing result, the ratios of water surface to full water for May 25, December 25, October 23 images are 66.1 % (1.528 km^2), 89.1 % (2.058 km^2) and 91.7 % (2.161 km^2), respectively. From the reservoir capacity curve (the relationship between water surface and storage) by KARICO (Korea Agricultural and Rural Infrastructure Corporation), the storage ratios could be estimated as 25.0 % (8.03 $\times$ 10^6 ton), 74.6 % (11.77 $\times$ 10^6 ton) and 77.9 % (12.53 × 10^6 ton), respectively.

2) Crop Cover Information in the Phenological Cycle of Selected Crops

Crop texture and average pixel value of each band were chosen as data inventory of crop information. Texture from image and photo by field survey for May 25 and October 23 were made out to cultivation calendar of rice, pear, grape, red pepper and garlic. Fig. 4 - Fig. 6 show an example of pear, grape and

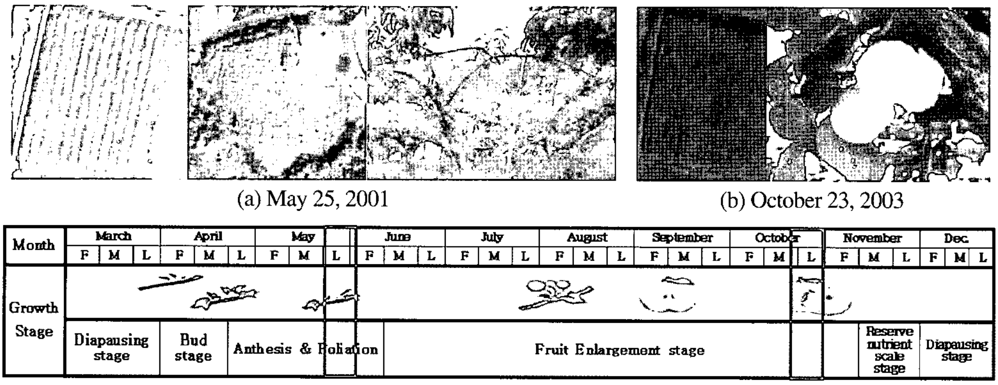


Fig. 4. Texture from image and photo by field survey with cultivation calendar of pear.

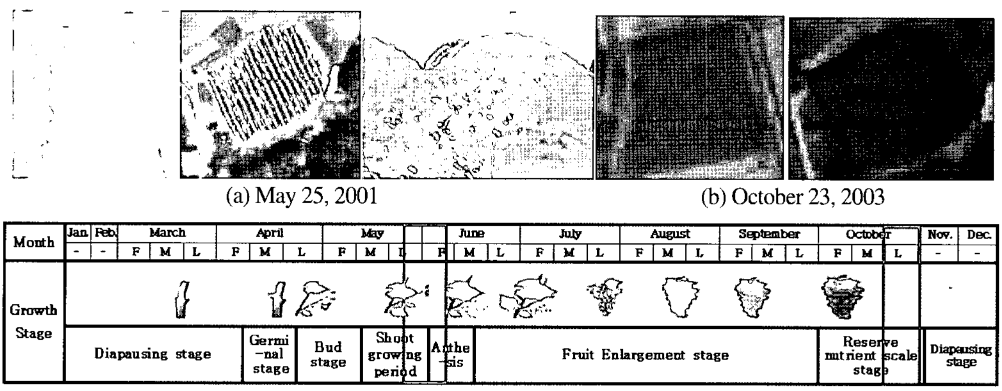


Fig. 5. Texture from image and photo by field survey with cultivation calendar of grape.

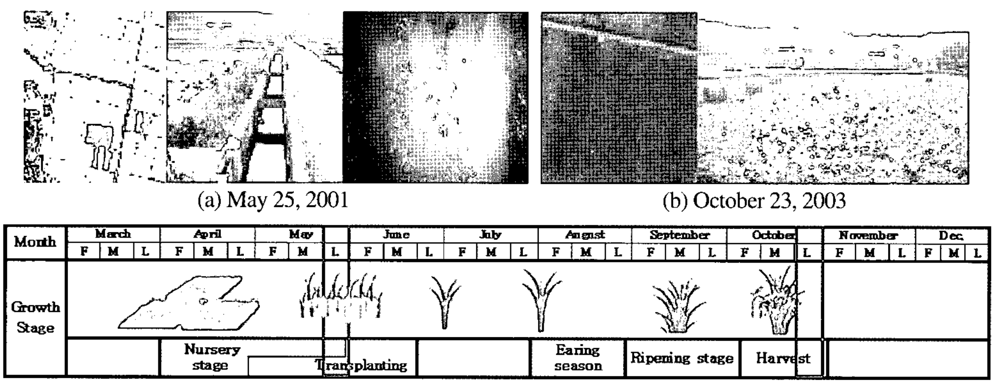


Fig. 6. Texture from image and photo by field survey with cultivation calendar of paddy.

paddy rice, respectively.

Fig. 7 shows the average pixel values of each band for the selected crops of May 25 and October 24. The values of May 25 ranged widely compared to the values of October 24. The spring (May 25) image was better to discriminate crops than the fall (October 24) image. For all bands, ponding paddy showed the highest pixel value among the selected crops. The second was grape field far away from other upland crops. For band 2, 3 and 4, the pixel values for dry paddy and pear on paddy were similar. Thus, band 1 was suitable to discriminate pear field within the paddy areas. Red pepper and garlic showed similar pixel values, but there is some possibility to

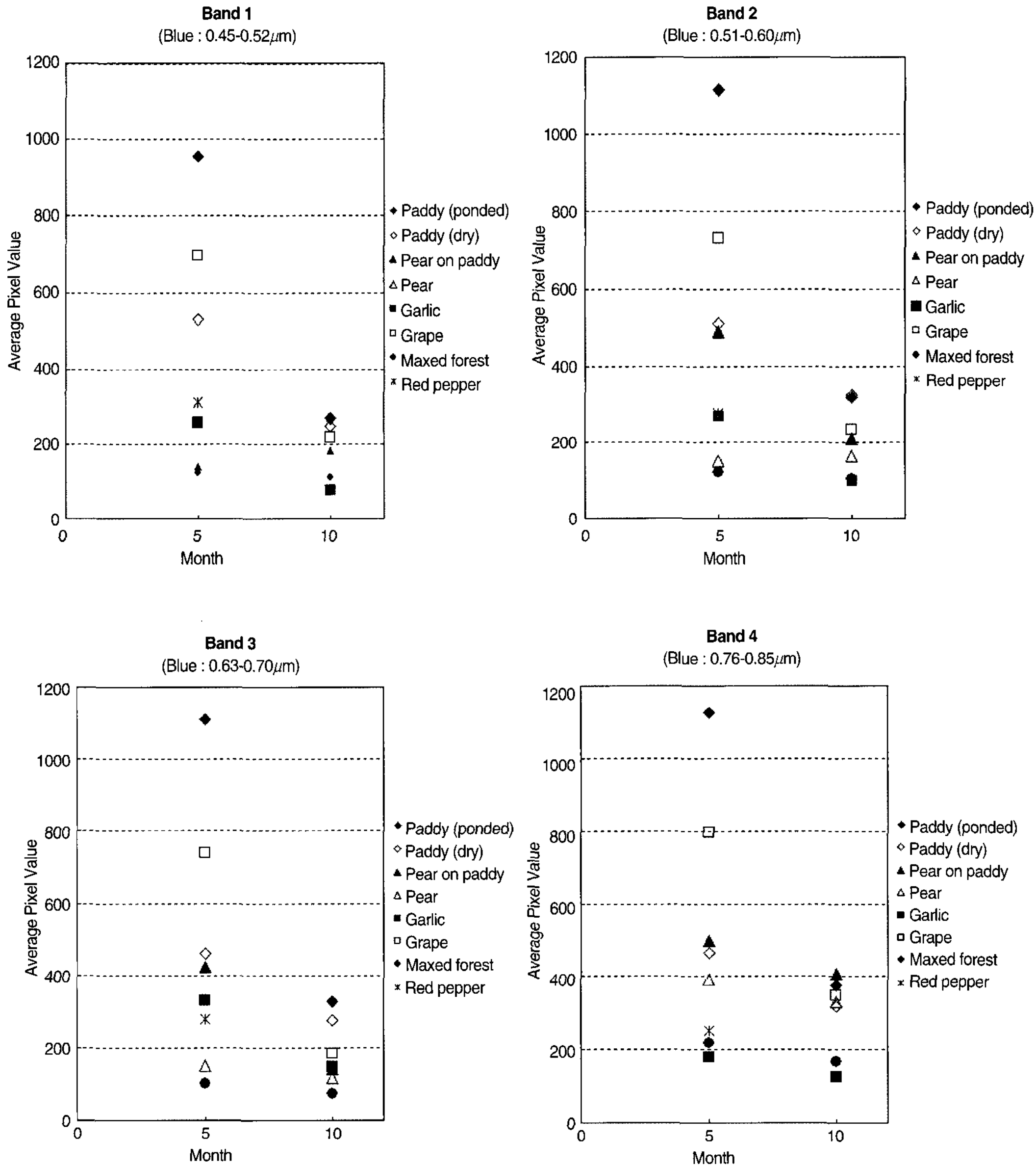


Fig. 7. The average pixel values of selected crops for each band of May 25, 2001 and October 24, 2003 images.

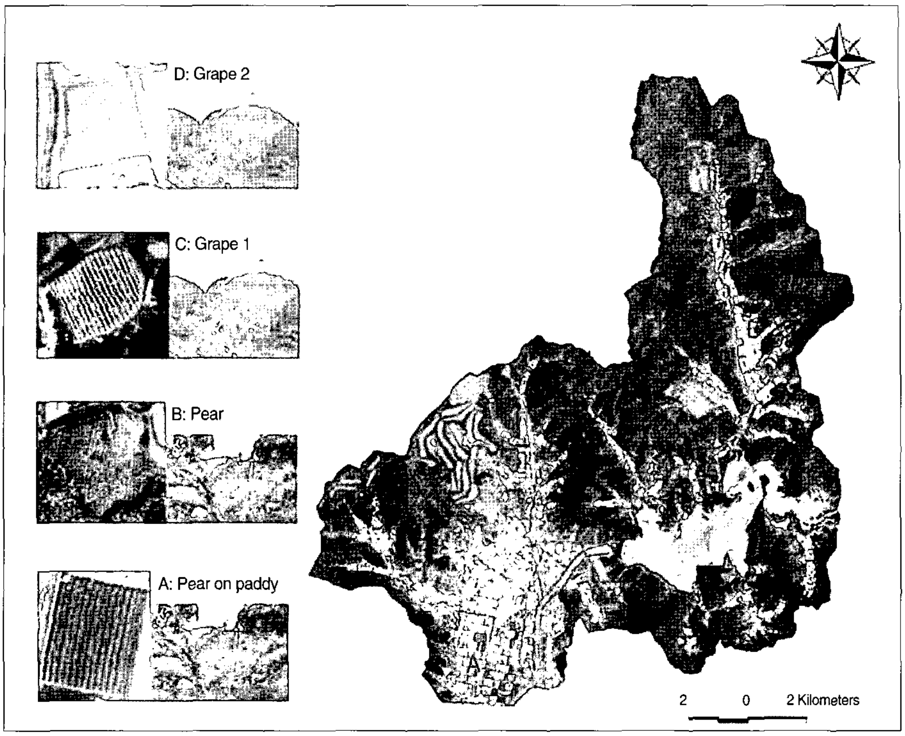


Fig. 8. The pear and grape fields found in May 25, 2001 image.

Table 3. Comparison of extracted vs. statistical data for pear and grape fields in Gosam-myeon.

Area (km^2)	Pear on paddy (A)	Pear (B)	Grape 1 (C)	Grape 2 (D)
Extracted	7,841	14,475	5,534	6,366
Statistical data	7,839	15,076	5,721	6,600
Relative error (%)	-0.03	3.99	3.27	3.55

discriminate each other in band 1, 2 and 4 with careful attention.

Within Gosam-myeon, the pear and grape fields were found from the May 25 image and each area was compared with the statistical data provided by Anseong-si (2004). Fig 8 shows the locations and Table 3 summarizes the comparison results for the statistical data and extracted area from the image. The relative error ranged from 0.03 % to 3.99 %. The main error may be caused by the boundary difference along the field within 1 m spatial resolution of image.

4. Summary and Conclusions

A method of agriculture related data inventory development using crop cover information such as texture and average pixel value of the crop based on cultivation calendar was suggested. Three IKONOS images (May 25, 2001, December 25, 2001, October 23, 2003) were used to obtain crop cover characteristics such as rice, pear, grape, red pepper, garlic, and surface water area of reservoir with field surveys.

It was found that the May 25 image was better to discriminate crops than the October 23 image. Ponding paddy and grape field have the pixel value to be discriminated well among the crops. The extracted area of pear and grape fields within Gosam-myeon matched well with the statistical data. The ratio of water surface to full water and the storage ratio which are useful informations for hydrological application and agricultural reservoir operation were successfully obtained for each image.

Especially during the early period of KOMPSAT-II, this approach would be a practical application for crop management to identify crop species, cultivation area, and crop condition. If the crop information from both images and field surveys are accumulated for several years, reasonable crop mapping, crop condition and crop yield estimation would be possible.

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