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Development of Crop Information System using Satellite Images

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Abstract

A computer system for crop information was developed using Visual Basic and ArcGIS VBA. The system is operated on ArcGIS 8.3 with Microsoft Access MDB. Landsat +ETM, KOMPSAT-1 EOC, ASTER VNIR and IKONOS panchromatic (Pan) and multi-spectral (M/S) images were included in the system to extract agricultural land use items identifiable at various spatial resolutions of images. Agriculture related data inventories using crop cover information such as texture and average pixel value of each band based on crop cultivation calendar were designed and implemented. Three IKONOS images were loaded in the system to show crop cover characteristics such as rice, pear, grape, red pepper, garlic, and surface water cover of reservoir with field surveys. GIS layers such as DEM (Digital Elevation Model), stream, road, soil, land use and administration boundary were prepared to understand the related characteristics and identify the location easily.

Keywords : Crop information, System development, IKONOS, ArcGIS, VBA

I. Introduction

A crop is a plant domesticated for use in agriculture. The practice of agriculture is known as farming, while scientists, inventors and others devoted to improve farming methods and implements are also said to be engaged in agriculture. The development of digital information technologies has had a significant impact on both agriculture and crop management. Many information system applications have been used to facilitate the process of agriculture and crop management. As a consequence, precision farming or precision agriculture, which is an agricultural concept relying on the existence of in-field variability, was introduced. It requires the use of new technologies, such as Global Positioning System (GPS), sensors, satellites or aerial images, and information management tools such as Geographic Information System (GIS) to assess and understand variations.

The very high spatial resolution imagery such

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as IKONOS and KOMPSAT-II (The 2nd generation of KOMPSAT series, which has a high performance MSC (Multi-Spectral Camera) with 1m resolution as a main payload) has a potential use for farm and crop management. Analysis of multi-temporal imageries in the phenological cycle can provide information on how the specific crop variables are changing through time. To provide crop information at a regional scale, regular acquisition of images for the same area is critical. 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 (Kim et al., 2005).

Recently, computer systems have been dramatically developed for visualization and information representation to provide information, particularly through GIS technology with software packages such as ArcView and GeoMedia. The purpose of this study is to suggest a method of setting up a RS/GIS database prototype and develop a computer system for organizing digital data, to facilitate management, visualization and illustration of crops and their related information.

II. Study Area

The study area is Gosam-myeon of 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″. For area of 27.8 km^2, 52.3 % is forested and 16.9 % of lowland is paddy fields. Dry field farming (6.6 %), rangeland (2.7 %), orchard (0.01 %) scattered between the forest and the paddy.

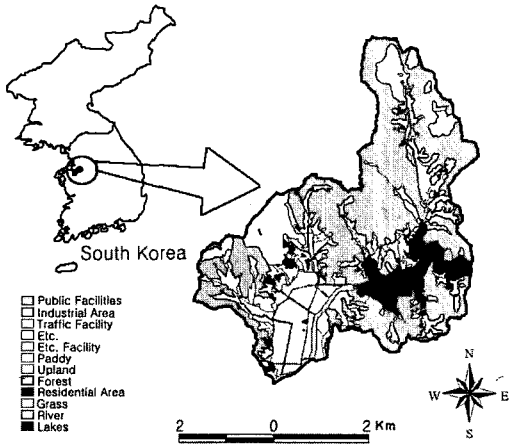

Fig. 1 The study area.

III. Development of Crop Information System

1. System Design and Implementation

Fig. 2 shows the schematic diagram of the developed system. ArcGIS 8.3, VBA (Visual Basic Application) and Visual Basic 6.0 for system development, and Microsoft Office Access 2000 (MDB) for database management were selected. As shown in Fig. 2, the system is operated on ArcGIS 8.3 with the file execution of CIS.exe. Fig. 3 shows the system interface which was designed with four parts which are menu bar, tool bar, layer controller using check boxes and view window. The contents of Agricultural DB in Fig. 2 were designed with 5 items and programmed using Visual Basic including query of MDB contents. Each item is linked with ArcGIS 8.3 using Visual Basic Application.

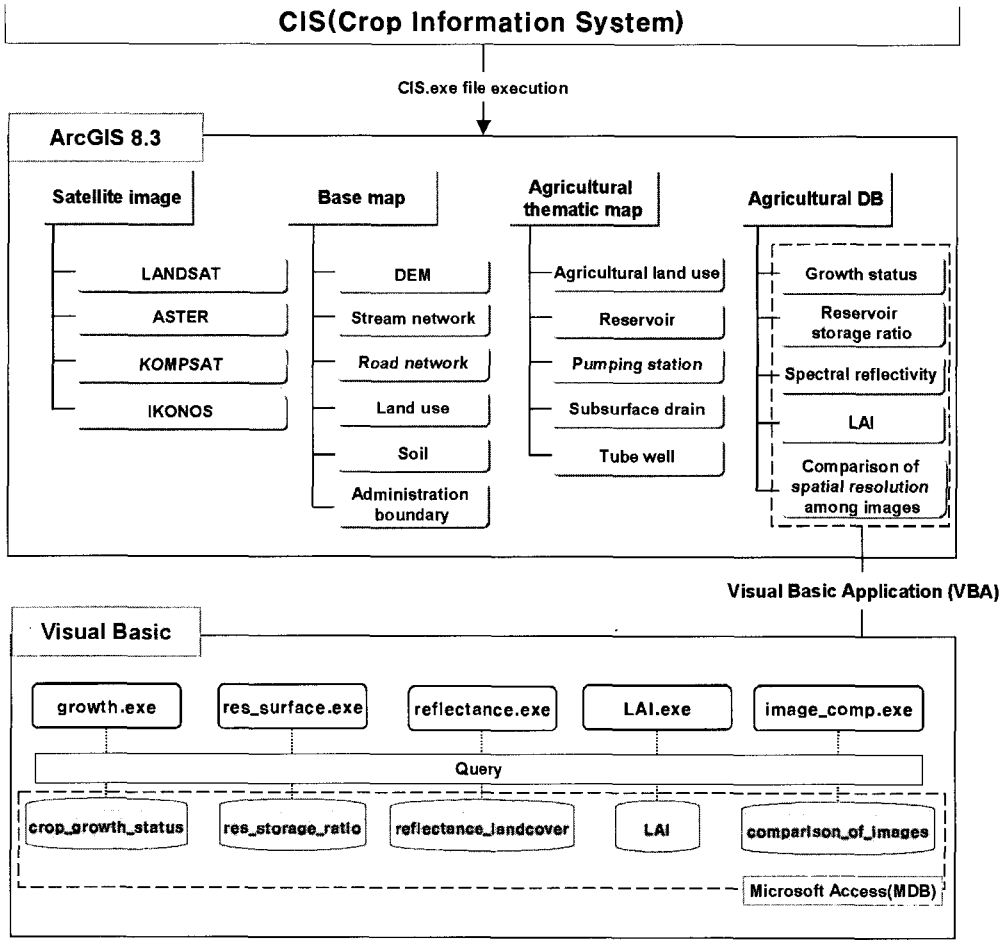

Fig. 2 The schematic diagram of the crop information system

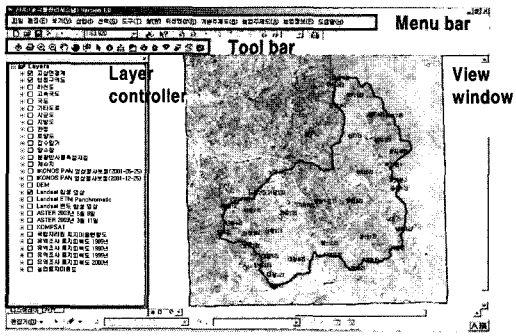

Fig. 3 The system interface

2. Database

Fig. 4 shows the input data used in the system. The data was grouped into four parts (satellite images, GIS base maps, GIS agricultural thematic maps, and crop related information maps) and each of them was formed as main menus in the menu bar. As shown in Fig. 4, nine image layers (LANDSATs, ASTERs, KOMPSATs, IKONOSs), ten base layers (DEM, stream & road network, the past and present land uses, soil, administration boundary) and five thematic layers

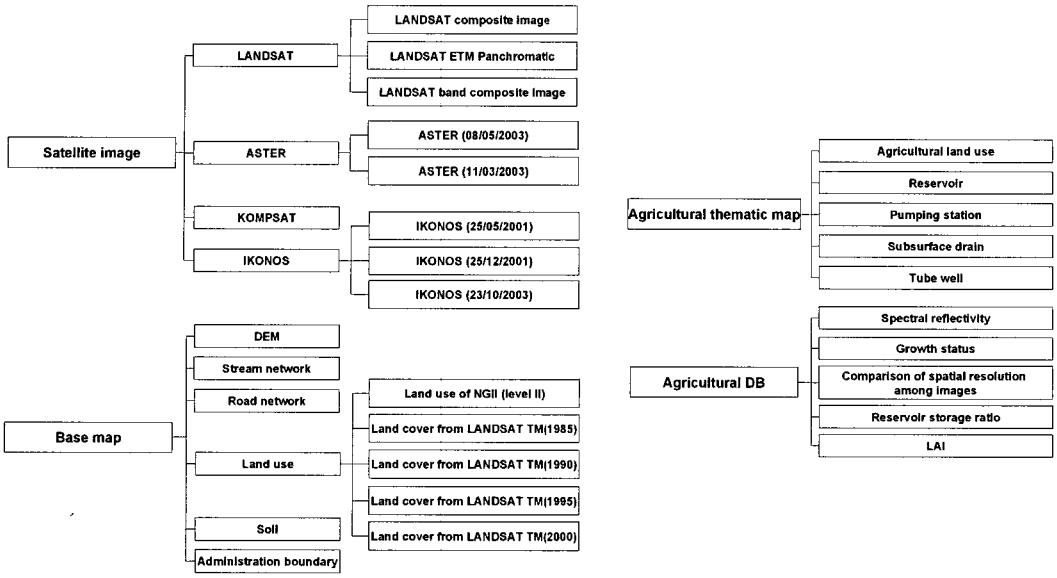

Fig. 4 The input data used in the system.

(agricultural land use, reservoirs, pumping stations, subsurface drain, tube wells) were prepared. Table 1 shows the image layers included in the system. IKONOS Standard Geo Level images were ortho-rectified by using 1:5,000 NGIS digital map and GPS data acquired by Trimble GeoExplorer III. Generic Pushbroom Model of ERDAS IMAGINE OrthoBASE 8.5 was used. Other images were corrected by method of image to image based on ortho-rectified IKONOS image.

As crop related information (Agricultural DB in Fig. 2), five tables (spectral reflectivity of land cover properties, growth status of selected

Table 1 The image layers in the system

Images	Resolution (m)	Date of Acquisition	Number of GCPs	RMSE (m)	Remarks
IKONOS-2 Pan	1×1	20010525	513	(x)3.40(y)3.38(z)1.07	ortho
IKONOS-2 M/S	4×4		499	(x)1.54(y)1.69(z)0.25	〃
IKONOS-2 Pan	1×1	20011225	509	(x)3.12(y)3.10(z)0.75	〃
IKONOS-2 Pan	4×4		497	(x)0.73(y)1.05(z)0.12	〃
IKONOS-2 Pan	1×1	20031023	RPC* (5)	(x)2.01(y)3.18(z)1.05	〃
IKONOS-2 Pan	4×4		RPC (5)	(x)0.06(y)1.43(z)0.23	〃
KOMPSAT EOC	6.6×6.6	20020626	32	(x)2.50(y)2.73(z)1.05	〃
ASTER VNIR	15×15	20020311	22	(x)5.47(y)1.35(z)1.49	〃
Landsat 7 ETM+Pan	15×15	20010603	18	(x)3.29(y)4.01	generic
Landsat 7 ETM+MS	30×30	20010603	18	(x)3.23(y)4.01	〃

* RPC(Rational Polynomial Coefficients)

Table 2 Table list

No.	Table name	Description	Link program
1	reflectance_landcover	- graph of reflectance of selected land cover (October 10, 2003 and December 25, 2004) using spectroradiometer (LI-1800)	reflectance.exe
2	crop_growth_status	- image and photo of crop texture by field survey for May 25 of 2001 and October 23 of 2003 - graph of average pixel value of each band for May 25 of 2001 and October 23 of 2003 - figure of cultivation calendar of rice, pear, grape, red pepper and garlic	growth.exe
3	comparison_of_images	- table of detection ability of agriculture-related items at various spatial resolution (1 m - 30 m) of satellite images	image_comp.exe
4	res_storage_ratio	- image of extracted water surface of Gosam reservoir for three images - table of calculating reservoir storage and its water surface area	res_surface.exe
5	LAI	- Leaf Area Index (LI-3100 AREA METER)	LAI.exe

Table 3 Table schema of spectral reflectivity of land cover properties

Table name		Spectral reflectivity	Creation date	2005. 05	
ID	Field name	Data type	Size	Important	Remarks
1	Wavel length (nm)	DOUBLE		PK	
2	Paddy (after removal of rice straw)	DOUBLE			
3	Paddy (before removal of rice straw)	DOUBLE			
4	Bare soil	DOUBLE			
5	Paddy (normal)	DOUBLE			
6	Paddy (lodged)	DOUBLE			
7	Paddy (rice, head blight)	DOUBLE			
8	Paddy (rice, cnaphalocrocis medinalis disease)	DOUBLE			
9	Weedy grass	DOUBLE			
Description			Comment		
value of spectral reflectivity of each land use properties according to wave length			Image route: C:\CMS\source\IMAGE\spectral reflectivity\picture		

crops, comparison of spatial resolution among images, reservoir storage ratio, LAI (Leaf Area Index)) were included in the database and linked to the relevant feature classes (Table 2). Details of each table contents are found in Hong et al. (2004) and Kim et al. (2005). Table 3 and Table 4 show the table schema of spectral reflectivity and comparison of spatial resolution among images, respectively. Fig. 5 shows the implemented screen of spectral reflectivity of land cover properties, growth status of rice, comparison of spatial resolution among images, reservoir storage ratio, LAI, respectively.

Table 4 Table schema of comparison of spatial resolution among images

Table name		Comparison of spatial resolution among images	Creation date	2005. 05	
ID	Field name	Data type	Size	Important	Remarks
1	ID	Serial number	50	PK	
2	Class	Test	255		
3	Items	Test	255		
4	Images	Test	255		
5	Identifiable	Test	255		
6	Identifiable, but need field investigation to determine the type	Test	255		
7	Presumble	Test	255		
8	Not presumable	Test	255		
9					
Description			Comment		
Possibility of eye identification of land use for each spatial resolution of images			Image route: C:\CMS\source\IMAGE\comparison of spatial resolution among images		

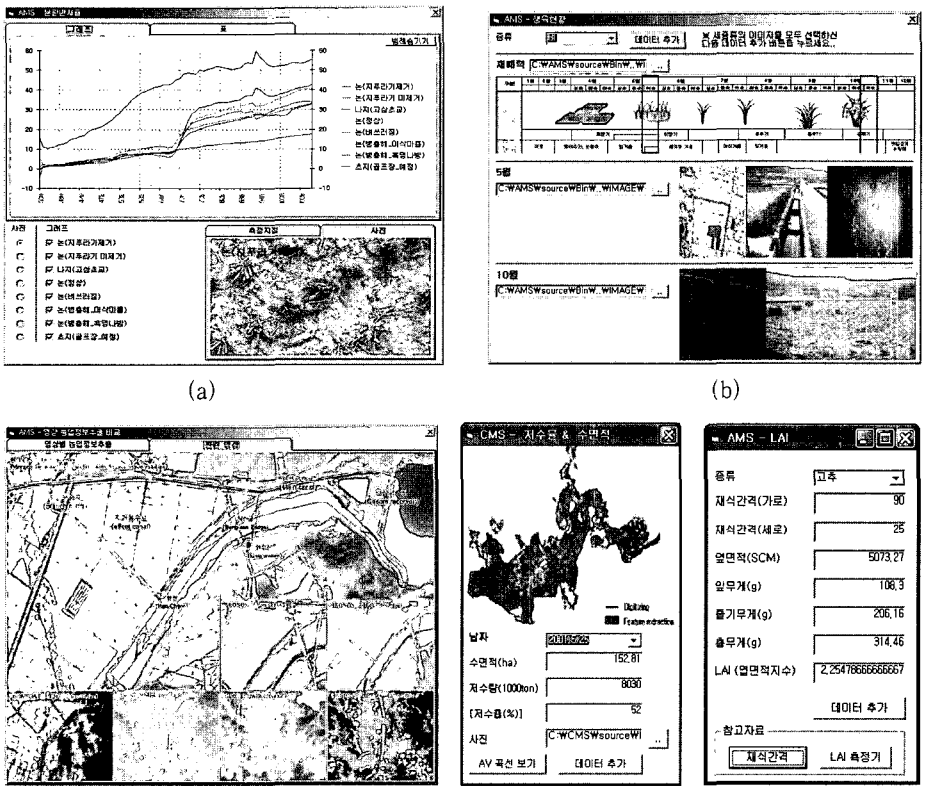

Fig. 5 The implemented screen of (a) spectral reflectivity of land cover properties, (b) growth status of rice, (c) comparison of spatial resolution among images, (d) reservoir storage ratio, and (e) LAI (Leaf Area Index).

Ⅳ. Conclusion

A crop information system was designed and implemented using ArcGIS, VBA and Visual Basic. The system is operated on ArcGIS 8.3 with Microsoft Access MDB. Especially, three IKONOS images (May 25, 2001, December 25, 2001, October 23, 2003) were loaded with GIS layers.

The system gives information for selection criteria of proper image for agricultural information required, data inventory of crop texture derived from high resolution images, and extraction and analysis method for agricultural related information.

This RS/GIS database will benefit all the users in the process of crop management, including administrative authorities, professionals, and the public. However, this study is on the beginning of the RS/GIS database design. It is necessary to add database items and find more contents with further researches.

Acknowledgements

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