The Establishment of a High Resolution Digital National Park

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Abstract

Located in the north of Taiwan, the volcanic area of Yangmingshan National Park has recently been confirmed as showing live volcanic activity. Applications of Geographic Information System (GIS) on environmental monitoring and natural hazard management have been carried out around the national park and the surrounding area and have proved very successful in providing protection to rare animals and plants. Yangmingshan is also a very important place for studying environmental conservation, hazard prevention and sustainable development of natural resources.
High resolution digital aerial images and Lidar images are available in Taiwan, and Taiwan's remote sensing satellite Formosat-2 also efficiently provides new two- meter high-resolution imagery for everyone. Therefore, there are more needs and applications in using such new material.
In order to implement the idea of Digital Earth and to reach the goal of substantial development of natural resources, the aim of this study is to establish a high resolution geo-database for Yangmingshan National Park by using all the available Geo-information. Using such massive high resolution images to merge into a Geo-database creates all kinds of problems, such as mass data storage, large image server, and the need for more efficient computer operation functions. In order to handle such mass information and expand future new applications, we have introduced a high performance computing system and used it to establish a high resolution digital national park database. With this new computer system we expect the new applications with high resolution images will fulfill the future application needs.

Keywords: WebGIS, Digital National Park, High Performance Computing System.

1. Introduction

Since US former Vice President Al Gore brought up the concept of Digital Earth during his 1998 speech at California Science Center, a lot of studies around the world have focused on the issues of digitizing national geographical and environmental information. This year studies relating to environmental protection issues are drawing the attention of more people, due to the Oscar winning film *An Inconvenient Truth*. The major components of Digital Earth are: collecting all kinds of information from different resources, especial from satellites, to build a mass geodatabase; sharing and communicating this information via the global internet infrastructure; and presenting data with 3D virtual reality simulation for scientific study and application in order to reach the sustainable management and development of the earth's natural resources. The implementation of Digital Earth has become more realistic due to recent technical developments such as high resolution satellites, the availability of Google Earth, and high performance computing systems.

In Taiwan, many projects (for example Taiwan National Land Information System, WebGIS platforms from city and county governments, and all the departments of the Taiwan government) have become enthusiastically involved in the developing of spatial information technology for both government and civilian use in recent years. There are seven national parks on this small island, all of which have different characteristics. Yangmingshan National Park, located in the Tatun volcanic area of north Taiwan, has much volcanic activity and abundant biological diversity, and is also an important environmental conservation area. The Chinese Culture University (CCU), located right on the border of Yangmingshan National Park, has many related study projects. In order to implement the idea of Digital Earth and to reach the goal of sustainable development of natural resources, the aim of this study is to establish a high resolution geodatabase for Yangmingshan National Park by using all the available Geo-information.

2. Methodology

Located on the edge of Yangmingshan National Park, we have for years collected various different kinds of maps and digital images of the national park from satellite and aerial photo images. However, there is no data-sharing function or information communication platform between different departments. The information is in different formats or scales, and there is no efficient way to share information. Therefore, we collected and preprocessed all the information relating to the national park using 3S spatial technique to establish a geodatabase for the convenient use of all Remote

Sensing and GIS users. Figure 1 shows the high performance computing system and EVA storage system of CCU. Figure 2 shows the steps of establishing geodatabase and WebGIS.

Figure 1 CCU high performance computing system and EVA storage system

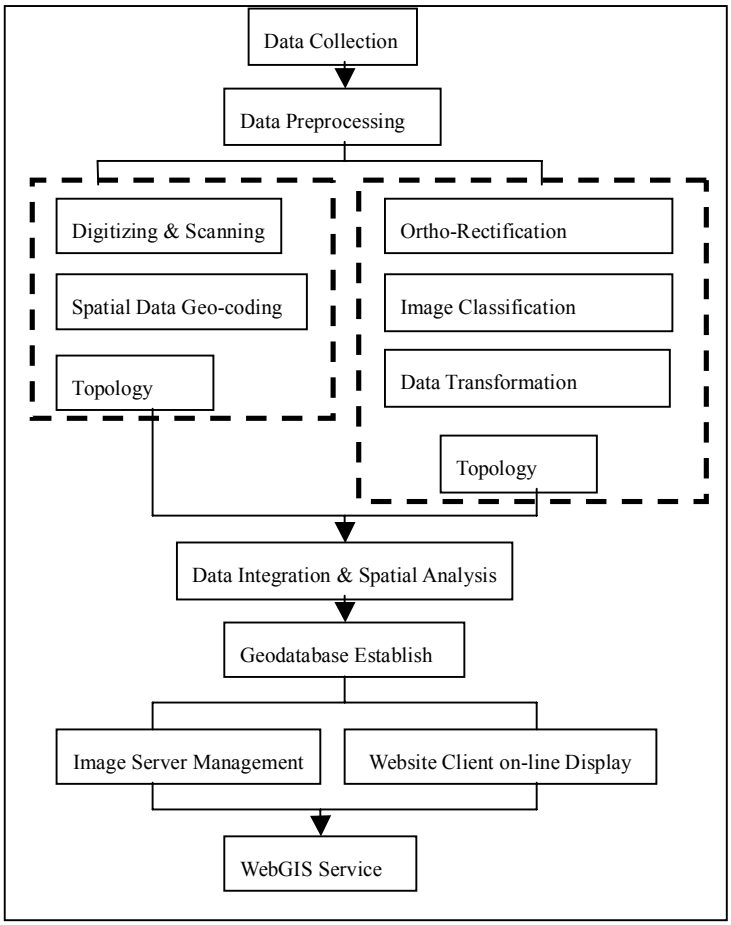


Figure 2 The flow chart of establishing geodatabase and WebGIS

2.1 Data Collection

The data from many published maps, results from research, and academic articles from government and civilian sources are collected from Yangmingshan National Park and adjacent areas, and are catalogued into four categories: natural resources; land use; ecology conservation; and hazard prevention, in GIS vector and raster format for the following data preprocessing. The collected data from different resolutions, type sensors and spectrums for the establishment of the geodatabase includes digital aerial photos; conventional scanned photos; satellite images of Landsat; SPOT; topographic maps; digital maps; and thematic vector maps etc. We are especially interested in high resolution satellite images, such as IKONOS, QuickBird and Formosat-2 satellite images (the latter launched on May 2004 from Taiwan, See Figure 3) and Lidar images which provide high resolution DEM and DSM, generated by using digital Photogrammetric techniques (See Figure 4; the orange color represents the points on the ground). The thematic maps are based on object-oriented classification from both high resolution satellite and aerial images.

Figure 3 Two meter-resolution Formosat-2 satellite image of Yangmingshan area

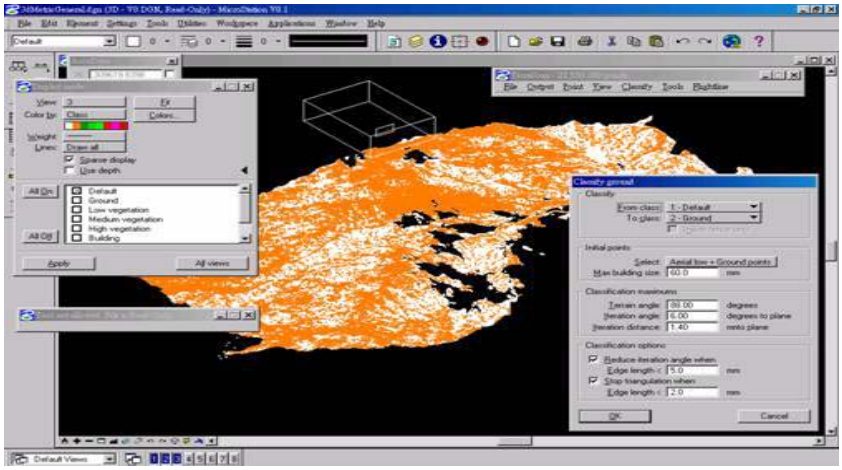


Figure 4 Filtered Lidar cloud points images of Yangmingshan National Park

2.2 Data Preprocessing

Before storing in the geodatabase, all the collected map data is geo-coded into geo-coordinate systems with high accuracy, in order to be more efficient in GIS overlapping operations and to match the requirement of high resolution images. Since higher resolution images provide more detailed information from image pixels (in other words, one object can be composed of several image pixels) the unit for using classification changes from pixel size to object unit. The image classification method for using high resolution satellite or digital images therefore uses image object classification to retrieve image features and create high resolution thematic maps, consequently providing more accurate and detailed classification features for interpretation of information.

Other than performing image rectification to create orthophoto images for GIS data acquisition, we also use digital stereo pair digital images and the Digital Photogrammetry method to create high resolution DEM which can create one- to five-meter grid intervals for 3D GIS or 3D virtual reality fly through simulation. Other work involves using Lidar images to create DSM and DTM for the national park. There is a lot of work involved other than preparing orthophotomaps and DEM. The statistic and attribute information must be rearranged into the geodatabase files. The attribute data transformation from different files into a unique organized geodatabase format is especially labor-intensive as well. For the implementation of the Digital Earth concept of data sharing, we need to modify the GIS geodatabase in order to make it suitable for WebGIS use.

3. Implementation

3.1 Establish Geodatabase

The data created for the geodatabase should consider the accuracy of geo-coding coordinates, fulfill the requirements of topology and be stored in layers for GIS in order for use in spatial analysis. For the convenient management of the database and integration of different types of information, the items of Yangmingshan National Park geodatabase category are listed in Table 1.

Table 1 The Items of Yangmingshan Geodatabase

Class	Layer	Content	Data Form	Format
Base Map of Land Use	Administration Boundary	City Boundary, County Boundary, National Park Boundary, etc.	Lines, Polygons	Vector
	Traffic	Road, Highway, Trail, Sidewalk, etc.	Lines, Polygons	Vector
	Cadastre	Buildings, Land Use, Zoning, etc.	Lines, Polygons	Vector

	Landmark	Station, Bus Stop, Police Station, School, Gas Station, Hospital, Visitor Center, etc.	Points, Lines, Polygons	Vector
Natural Resources	Topology	Geology Map, Soil Map, DTM, Slope, etc.	Polygons	Vector / Raster
	Hydrology	River Name, River Grading, Watershed, Precipitation Station, Hydrometric Station, Qater Quality Monitoring Station, etc.	Points, Lines, Polygons	Vector
Ecologic Conservation	Land Cover	Forest, Orchard, Farm.	Polygons	Vector
	Rare Plants	Taiwan Isoetes, Silver Grass, Arrow Bamboo.	Polygons	Vector
	Rare Animals	Formosan Macaque, Parantica Sica Butterfly.	Points, Polygons	Vector
Hazard Prevention	Environmentally Sensitive Areas	Geologically Sensitive Areas, Natural Landscape Sensitive Areas, Ecologically Sensitive Areas.	Polygons	Vector / Raster
	Landslide hazard	Landslides, Debris flow.	Polygons	Vector / Raster

3.2 Establish Metadata

Aside from establishing the attribute data of the geodatabase, the establishment of metadata is also labor-intensive work. This metadata information is also a very important reference for users. In order to reach the goal of data sharing, the input of metadata information will follow the specifications announced by the Information Center of Taiwan's Department of Interior which include: information identity name; data quality; spatial information structure; spatial reference information; entity and attribute information; data offered resource; quoted information; data time; contact information; and others. Furthermore, a function is required for updating the standard specifications, contents and format in order to meet the data-sharing aims of the National Land Information System project in Taiwan.

3.3 3D Fly-through Simulation

One of the key elements to implementing the Digital Earth concept is to use the virtual reality technique to present the spatial information results in a dynamic and 3D stereo view. A 3D volcano fly-through simulation scenario of Yangmingshan National Park is available for public viewing on the website of Digital Yangmingshan National Park. This 'scientific reality' 3D fly-through scenario model provides a better understanding

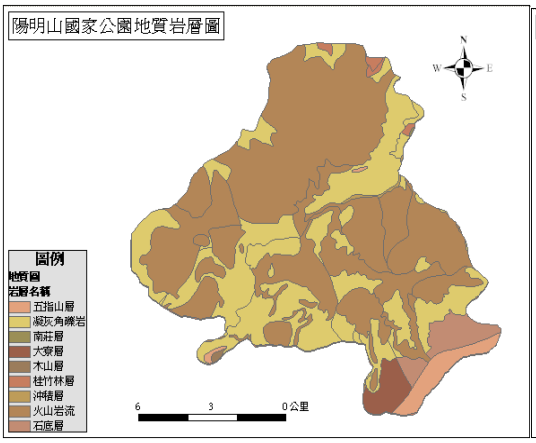
scenario for public presentation and education.
Another challenge is to establish the high resolution digital national park geodatabase in the high performance computing system at the Chinese Culture University by using high resolution digital images and DEMs.

3.4 WebGIS Query System

The primary work in this project is to build up a geodatabase for the national park. The major parts of the project focus on the design of the website and on converting all the data for the WebGIS applications. One of the goals of this project is also to provide all the available GIS information for scientific study needs: for instance, the study of landslide sensitive areas in the national park, the correlation between geology data and geographic data, and the application of land use/land cover. All the information from different times and dates is provided by the national park geodatabase and can also be operated by WebGIS.
The convenience and accuracy of data for users is a major concern. The time frequency of image data provided should also be considered in order to reach the goal of providing near real-time data and increase the automation process of the spatial data analysis operation. The design of WebGIS for the national park geodatabase provides an interactive platform for the different spatial information users.
The digital image data updating of the national park geodatabase is arranged in sequence by date and time during the data acquisition. Multi-layers, multi-resolution, multi-spectrum, multi-elevation, and multi-scale concepts are involved in the design of the geodatabase for studies such as the change detections of the image object correspond to the fast changing reality of Mother Nature.

4. Application Scenarios

Some application scenarios for the Digital High Resolution Yangmingshan National Park are as follows: The geology layers and the soil thickness layers of natural resource samples in the raster format for Yangmingshan National Park geodatabase are shown as Figures 5 and 6.



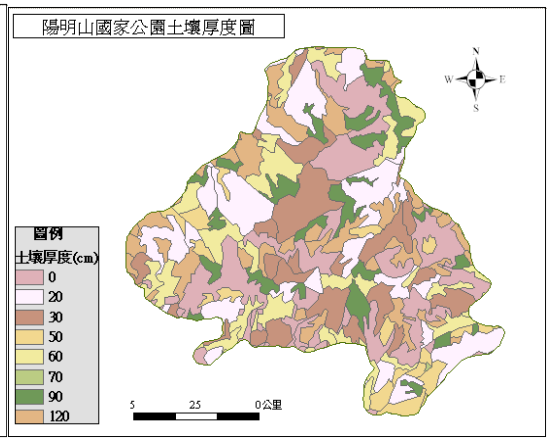


Figure 5 YMS Geology Layers **Figure 6 YMS Soil Thickness Layers**

Some project final output layer maps are obtained by the GIS spatial analysis operation process from overlapping geology, soil, and slope layers and are very useful for future research usage. The landslide sensitive area layers of hazard prevention samples in the raster format for Yangmingshan National Park geodatabase are shown as Figure 7.

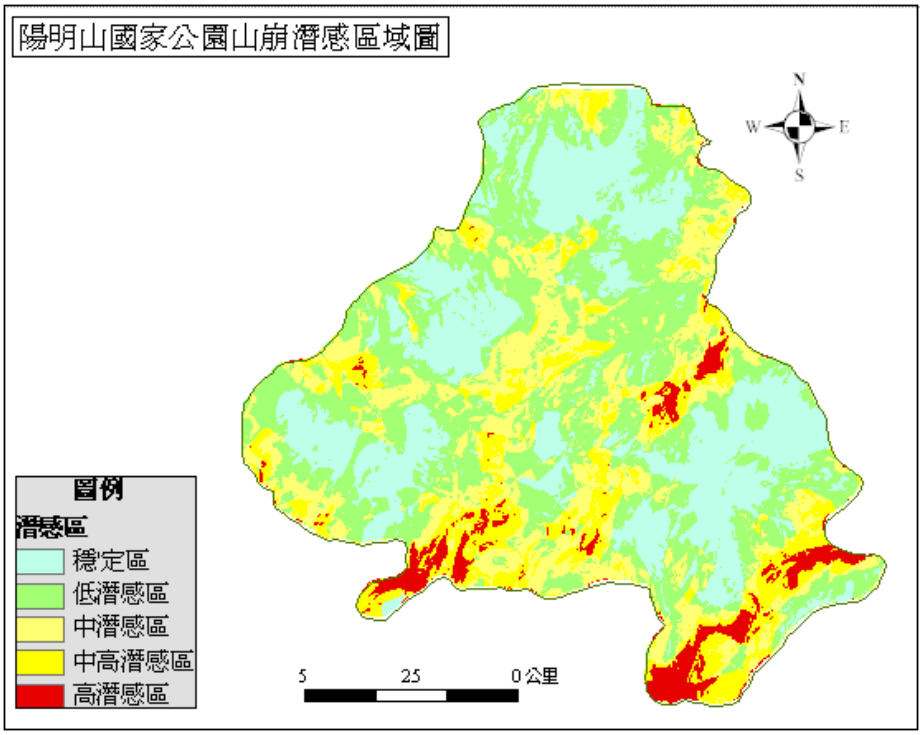
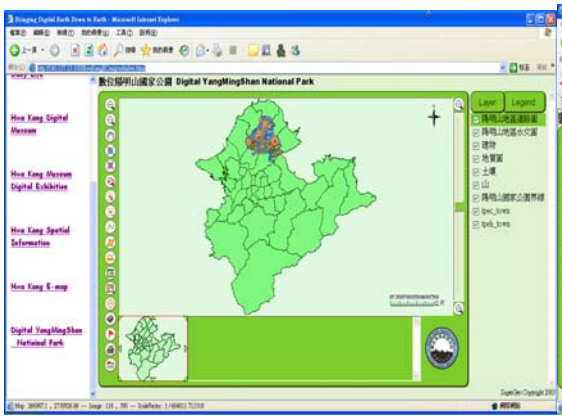


Figure 7 Yangmingshan National Park GIS Landslide Sensitive Area Layer

The website of Digital Yangmingshan National Park geodatabase includes all the related research information and descriptions and online WebGIS operation procedure. The website of Digital Yangmingshan National Park geodatabase is shown as Figure 8. An example of a geological data query taken from the WebGIS Query System webpage

for Digital Yangmingshan National Park geodatabase is shown as Figure 9.



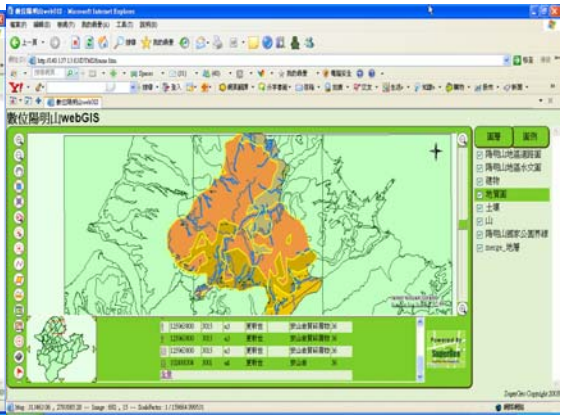


Figure 8 YMS Geodatabase Website **Figure 9 WebGIS Geological Query**

The 3D Fly simulation for Yangmingshan National Park is shown as Figure 10.

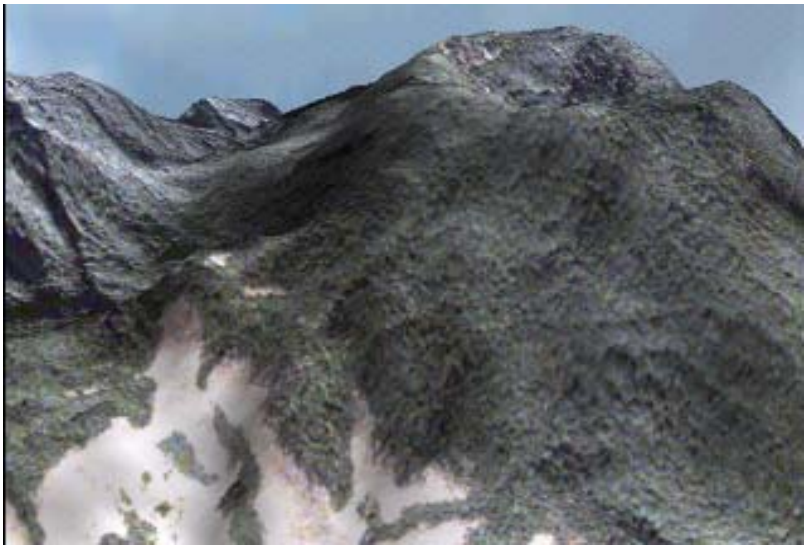


Figure10 Yangmingshan National Park 3D Fly Simulation

5. Summery

As high resolution digital aerial images and Lidar images are available in Taiwan, Taiwan's remote sensing satellite Formosat-2 also efficiently provides new two-meter high-resolution imagery. There are more needs and applications in using new material. Therefore, in this study we explore the possibility of establishing a high resolution geodatabase for Yangmingshan National Park by using all the available Geo-information.

In order to implement the idea of Digital Earth and to reach the goal of substantial development of natural resources, this project merges massive high resolution images into a geodatabase, creating problems in mass data storage, large image server, and the

need for more efficient computer operation functions. In order to handle such mass information and expand new applications, the established digital high resolution geodatabase has been introduced into CCU's high performance computing system. With the new computer system we face the fresh challenge of new applications.
The high resolution geodatabase with interactive WebGIS operations should lead to an increase in new demands for near real-time images from users. The geodatabase preprocessing and attribute information updating work will have to be more intensive in the future. We will continue maintaining the established digital geodatabase and try to provide new updated information for the studies of environmental conservation, hazard prevention and sustainable development of natural resources.

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