Consideration on Configuring Digital Earth Basis Framework

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ABSTRACT This paper focuses on configuring Digital Earth basis framework. The main contents on building the framework is presented, then what we have done is briefly reviewed, and what we should do is discussed in detail.
KEY WORDS Digital Earth, Real 3-D GIS, basis framework, data standard

1. Purpose of Configuring Digital Earth Basis Framework

Maps are applied to various fields extensively those days. Maps are served as education courses of geography in middle and preliminary schools, as positioning tool in traffic, tourism and post, as basis of planning and layout for land administra-tion,resource exploitation and city development, as decision-making information for flood control, disas-ter reduction and community management. The increasing trend in the quantity and quality of maps demonstrates that how the development of our soc-iety and economy rely on the precise spatial position. Furthermore, if we digitize all the current maps and merge them with satellite remote sensing data to build up a multiresolution and 3-D database covering all world, at least all China, then these maps will be utilized at a higher level and in much more fields because of the following:

a. digitized image and graphics can be spread more wider and faster by means of Internet and other communication tool, so the number of users will increase explosively, moreover, intel-ligent map information can provide intelligent service such as automatic path inquiry , spatial analysis etc.
b. A great deal of thematic information can be merged together with maps and satellite images, especially some pure statistical forms can be converted into spatial graphics and images, thus we can deal with the complicated problems concerned with nature, society, and economy etc on the basis of “Digital Earth”.
c. We can build up real 3-D GIS by integrating all the data about atmosphere, land, ocean surface, ocean bottom, underground, which will provide stronger information support for the research on global climate, ecosystem, environment, seism-ology, oil and gas resource, ocean biomass.
d. Geographic information can be updated fast through remote sensing images, thus some departments which have strict requirement for the real time data such as land administration, environmental protection, agriculture planning, public safety, transportation and traffic, disaster control etc, will work more effectively.

All the prospective described above depend on the configuration of Digital Earth basis framework, which includes:

a. To set up the projection relationship between 2-dimension and 3-dimension, which is the skeleton of Digital Earth.
b. To build datum base of Digital Earth on the existed topographic maps at various scale.
c. To explore the method of construct real 3-D GIS so as to accommodate and manipulate megadata.
d. To constitute data standard so that data can be shared and transmitted in various department.

2. What We Have Done

What we have done on building multi-resolution, 3-D geographic information database covering all china is as follows:

a. We have built up GPS A level network and B level network, with the differential GPS precision to centimeters, moreover, we have realized the free transformation between any photogram-metry coordinates and geocenter coordinates.
b. The 1:1,000,000 and 1:250,000 geographic information database covering whole China has been constructed.
c. The GIS served for central government and province government has been set up.
d. The digital photogrammetry workstation, which can automatically generate DEM from remote sensing stereo images, has been developed successively and sold in international market.
e. The production flow of “4D” (DEM, DOM, DRG, DLG) products has been formed. The “4D” products have been successively applied to landuse change detection , flood control and disaster reduction. The “4D” database in the Dongting Lake area covering 13000 Km^2 has

been established, and applied to the flood disaster forecast and control in 1998. Landuse dynamic database in Pearl river delta in Guangdong province covering 67000 Km^2 has been accomplished .1:10000 DEM database in seven main rivers and 1:10000 Digital Orthophoto Model in Changjiang river and Songhuajiang river arebeing constructed.

f. The global sea level datum for surveying and mapping is being researched, which will be applied to topography mapping of ocean floor, oil and gas exploration in ocean and ocean rights and benefits protection.

3. What We Should Do

1.) New theory about geometric reference frame-work and spatial projection of Digital Earth

a. Global consistent 3-D coordinates and sea level datum

In 1950s, China formed the Beijing 54 geodetic coordinates system and Tsingdao height datum with the Krasovsky reference ellipsoid, and formed Xian 80 geodetic coordinates system in 1980, now ,for the Digital Earth, the global consistent coordinates system is necessary, for example ITRF, so we should do works on free transformation from one existed geodetic coordinates to the global identical coordinates; at the same time, the global consistent sea level datum is also necessary, so as to convert the global ocean floor topography data and geolo-gical data into the global consistent coordinates system.

b. Theory and algorithm of projection from 3-D coordinates to 2-D coordinates

The research on theory and algorithm of projection from 3-D ellipsoid coordinates to 2-D planimetric coordinates has a more than one hundred years history, but the conventional algorithm does not meet the needs of current technology. For example, if we zoom out the Asia viewer up to beijing Tiananmen Square viewer using “Eight-step zooming” technique, then the parameters of projection from 3-D ellipsoid to 2-D plane in every “zoom-out” is different. This example demonstrates that the present projection theory and algorithm does not satisfy the needs of browsing and utilizing the Digital Earth data from macroscopy to microscropy, so we should do the following:

 To research the projection mathematical model with little linear deformation and alterable parameters.

 To explore the mathematical model which transforms the 3-D coordinates of spaceborne sensor to 2-D coordinates.

 To explore the mathematical model which converts one type of projection to another.

 To select the proper projection type intelligently according to various eyesight

2).The natural and social information basis framework of digital Earth

a. To set up the data datum of Digital Earth through digitizing the series scale topographic maps. The key technological points are:

 Automatic digitization of topographic maps with high precision

 Hierarchical coding method of scanned raster data

 Automatically systhesizing large scale data to small scale data

 Updating GIS data through high resolution satellite data

We can construct the image database containing muit-resolution, multi-temporal, multi-sensor data under the condition of lacking 1 meter resolution images covering all China or all world, so some advanced image processing technologies are indispensable, for example image geometric rectification without GCPs, image mosaic from various sensor etc.

Now State Bureau of Surveying and mapping (SBSM) has the aerophotographs of most area of china which can be used to construct 1 meter resolution image database , combined with the 1 meter resolution satellite images in the future, we can build up multi-resolution image database refreshed frequently.

The key technologic points of updating GIS data by means of 1 meter resolution satellite images includes automatic classfication of grey scale images, intelligent image interpretation, large image and graphics overlaying analysis.

b. To convert statistical data to space-distributed data

Taking advantage of images and graphics, a lot of statistical data about nature, society, economy information etc can be related with geographic information and perform spatial analysis on them.

3).Real 3-D GIS

All current GIS software only can manipulate data in 2-D or 2.5-D (the surface of 3-D objective) space, but many fields need real 3-D GIS including macroanalysis in gemechanics, ocean ecology, environment, global climate and microanalysis in underground pipeline etc.

The key technologic points includes:

 Data structure of real 3-D GIS

 Spatial inquiry and analysis of real 3-D GIS

 Computer Tomograph (CT) analysis of real 3-D GIS

4). Data standard of Digital Earth

The data standard of Digital Earth is very important because it has to accommodate megadata which is from government, academia and industry etc. The research contents of data standard include:

- Data format standard
- Geometric precision standard
- Data attribute uncertainty standard
- Coding consistency standard
- Data transmission, error check and secrecy

4. Expected Resiluts and Benefits

- Through building up the theoretic framework of Digital Earth and forming the projection relationship between reference ellipsoid and 2-D remote sensing images , the megadata in the future will be built upon a robust mathematical basis
- To build up basic data datum of Digital Earth which will be a pubic basis of subsequent geographic information and thematic information
- Real GIS will provide new technological support for land resource investigation, ocean exploitation, environment protection and disaster prevention
- To support technological standard for construc-tion of Digital Earth
- To develop various information products and technological services and form knowledge econo-my enterprise through fusing information, intellige-nce and ideal.