Study on Digital Water Conservancy Based on 3S Technology

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Key words: Digital Earth; Digital Water Conservancy; 3S Technology; Spatial Analysis; Database; Model

SUMMARY

Water conservancy is one of the basic infrastructures of national economy, but now traditional water conservancy is faced with many issues such as slow acquisition, transmission and refresh of data, invisibility of data, weak power to make spatial analysis, lack of share of the information and so on. Digital Water Conservancy is one solution to above problems. Definition of 'Digital Water Conservancy' is proposed on basis of Digital Earth in this paper, and necessity, feasibility, construction principles of 'Digital Water Conservancy' are analyzed, and the framework of it is presented that is composed of fundamental technology, basic infrastructure, and specific applications. Fundamental technologies consist of 3S (GIS, GPS, RS) technology, database technology, communication and computer network technology, and interactive operation technology and so on. Basic infrastructures consist of national information infrastructure, national spatial information infrastructure, special data of water conservancy, and security measures. Specific applications are made up of management information systems, decision-making systems and expert systems and so on. The above three levels provide hardware and software to water conservancy around data acquisition and refresh, process and access, information extraction and analysis, transmission of information, construction and refresh of databases, web and information share, decision-making support and so on. And spatial information infrastructure, special data of water conservancy, decision-making models are the cores of digital water conservancy, but the construction of spatial information infrastructure depends on 3S technology. GIS can manage the geographical information data and attributes data and make spatial analysis, RS can be used to extract the water surface, water depth, direction of water' movement, soil and sand quantity contained in the water and so on from remote sensed images and data, GPS can be used to fast acquire the coordinates of features and monitor landslip, deformation of dams and so on. 'Digital Water Conservancy' is large and complex systematic engineering, but it can be regarded as be composed of points (reservoir), lines (watershed), and areas (popularization of points and lines). Digital reservoir is carried out in Xue Ye Reservoir, Shandong Province, China, which will provide experience for informatization of water conservancy.

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1. INTRODUCTION

Digital Earth'[(11)] is firstly proposed and used by AL Gore, former vice president of U.S.A, to describe a multi-resolutions, three dimensional representation of the planet and huge amount of geo-referenced information collected from different sources in California Science Center on January 31st, 1998. And 'Digital Earth' is regarded as the third breakthrough of cognition of the earth, the first being the earth is proved to be a globe while the second being heliocentric theory is proposed instead of geocenter theory. 'Digital Earth' is aimed to promote the progress of informatization and to solve real world problems and decision-making activities by spatial information, so it is paid much attention by the international society, which leads the proposition of 'Digital Agriculture', 'Digital City', and 'Digital Home' and so on.

Digital Water Conservancy' is also proposed at this background and it is very important for us to manage the water conservancy due to the following reasons. First of all, most of the data needed by water conservancy is geo-referenced and new development in satellite imagery allows us to collect spatial information over the entire planet with high spatial and temporal resolutions. Secondary, current water conservancy is oriented to sustainability, which requires us not only understand individual phenomena but also the interactions among different phenomena. 'Digital Water Conservancy' represents spatial, temporal and textual information over the entire planet, so is naturally a perfect tool for monitoring and analyzing the spatial and temporal interactions among spatial processes in the global complex system. Lastly, current technologies in geographical information systems (GIS) allow us to integrate spatial information from different sources. This is an excellent foundation to develop 'Digital Water Conservancy'. It is defined as a description of large amount of water conservancy information in multi-resolution, multi-scale, multi-temporal, multi-spatial by RS, GPS, GIS, RC, RM,VR with wideband as linkage and with computer, multimedia, and large-scale access technology as basis.

But there is no report on the framework of 'Digital Water Conservancy' and on the constitution of it, so those are given in this paper.

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2. FEASIBILITY AND NECESSITY OF 'DIGITAL WATER CONSERVANCY'

Water conservancy is playing a more and more important role with the fast development of the economy due to increasing dependence and demand. Therefore, advanced management of water conservancy is greatly needed to meet the demand of development of economy.

Advanced access means are needed to store and retrieve the large amount of data and maps. Traditionally, the documents such as relief maps, the hydrological data and plans of facilities are printed or written on papers, but they can't be long-tem stored due to the loss, destroying of the papers or deterioration of the ink with time. But in 'Digital Water Conservancy', those documents, texts or maps, can be stored in hard or compact discs to realize the long-term storage and fast and real-time query.

'Digital Water Conservancy' is needed to support flood control and regulation. Flood forecast and regulation system can extract real-time rainfall from the automatic remote measurement system for situation of rain, inquire rainfall of each station belonging to the watersheds, calculate the amount of contained water of soil, predict the flood by the rain reaching to the ground or by the rainfall reported by the weather forecast, generate the interactive schemes for flood regulation, evaluate the schemes, and simulate and regulate the historical flood and the designed flood and so on. And the schemes for flood control and regulation are built based on comprehensive analysis of large amount of rain conditions, water conditions and drought conditions and so on, thus the real-time information of them are demandingly needed, but the traditional means of information propagation is so relatively slow that it can't meet the real-time demand. But the development of 'Digital Water Conservancy' can do this.

'Digital Water Conservancy' is needed to support fast query, process, statistic and analysis. The accumulated document of water conservancy can be used to make data mining and knowledge discovery thanks to the fast query, process, statistic and analysis of 'Digital Water Conservancy'.

'Digital Water Conservancy' is needed to make model analysis for decision making. Large amount of complex design, calculation, mapping are needed in water conservancy. That work is done by hand in traditional way while they are done by computer due to GIS' strong ability in combination of spatial data and attributes data and in spatial analysis.

Water quality is paid much more attention in addition to water quantity with the fast improvement of people' livings, while the water resources have obvious spatial-temporal characters. 'Digital Water Conservancy' can help the manager of water conservancy to learn the spatial distribution of water resources to make more scientific and efficient scheme.

Thanks to the great development in 3S technology computer science and and Internet technology 'Digital Water Conservancy' is feasible.

3. CONSTRUCTION PRINCIPLES OF ‘DIGITAL WATER CONSERVANCY’

Construction principles of ‘Digital Water Conservancy’ are as follows: *Serve the development of national economy and society*. ‘Digital Water Conservancy’ is one part of ‘Digital Earth’, and it will not only store and retrieve the data of past, current and real-time, but also it will supply accurate information and decision making support of flood control and regulation, water supply, and environment conservation of water and so on those have close relationship to economy and society.

Share the resources. The water conservancy resources and the relevant resources of the same region such as a county, a city or a province should be shared and interlinked.

Uniqueness of the code, university of the algorithm, and extensibility. The code, the algorithm and the database of the system should be unique and universal, and the system should be extensible.

Practicability. Practicability is also one of the fundamental principles that is to meet the demand of users.

Advancement. The current most advanced hardware, software and the technology of the system should be adopt, and open component structure is adopt in the design of the system, standard interfaces are adopt in the design method. The above means is aimed to extend the system and maintain it. And this system will have good university.

Normative. Normative is basis of system construction. So the normative criterion and construction way should be firstly be made to assure the complement of the system on time and to extend it and manage it.

Dependency. Dependency is the basic guarantee to run the system which requires that it can functions well under bad situations and supply dependable data.

Security. Security can prevent the loss of the data.

4. CONSTRUCTION FRAMEWORK OF ‘DIGITAL WATER CONSERVANCY’

‘Digital Water Conservancy’ is a very large systematic engineering, and it is integrated by much disciplines, technology and engineering such as water conservancy, geomatics, information science, management science, and engineering construction and so on, and it is oriented to the construction and management of modernization of water conservancy, and it is aimed to promote the informatization and sustainable development of water conservancy. The above determines that ‘Digital Water conservancy’ is a scientific framework (5, 6) that is composed of key technology, basic infrastructure, and comprehensive applications. Key technology is composed of spatial information technology, management information technology, and comprehensive information technology; basic infrastructure consists of NDI, NSDI, special data of water conservancy and security measures; comprehensive applications are made up of management system, decision-making models, application systems. The above three levels supply hardware and software[8-14] to water conservancy around data (such as rainfall situation, engineering situation, weather, drought situations, disaster condition, water environment, water and soil conservancy, underground water, monitoring of spatial movement) acquisition and refresh, process and access, information extraction and analysis, propagation of information, building and refresh of databases, web and transmission, model pool, knowledge pool, graphic pool, and decision-making support and so on. The framework of it refers to Table 1. And spatial information infrastructure, special data of water conservancy, decision-making models are the core and are detailed discussed.

Table 1: The framework of 'Digital Water conservancy'

Key technology level	Spatial Management Comprehensive	RS, GPS, GIS, VR, Web GIS, RC, RM ERP, CRM, SCM, LBS(Web MIS) Web(G1S+MIS)
Basic infrastructure level	NII	Wideband wire net: internet, www,grid, WDM Wideband wire net: mobile internet, WAP, Blue Tooth, mobile grid Wideband integrated net□Mob, Web, GGG
	SNII	Basic data: DLG, DOQ, DEM, DRG, Geographic Name
	Specialty data of water conservancy	Specialty data□metrological data, water resources, water environment, water and soil conservancy Human data□population, resources, economy, culture, education, science and technology and so on
	security	Criterion and normative, safety and secrecy, monitoring and assessment, policy and law and rule, talent cultivation and education
Comprehensive application level	Management system	Management of water facility, hydrological document management, files management, finance management, personal management, management of license for permit ion of water utility
	Decision making model system	Flood control and drought prevention system, e-governance for water system, expert system of statistic and analysis for rainfall, regulation and decision-making system for water resources, calculation models system of underground water, assessment system of water resources
	Service system	Query of amount of water extraction, query of price of water, explore and query of famous scenery relevant to water

4.1 Content of Spatial Basic Data

The framework data of NSDI (National spatial data infrastructure), 4D (DLG, DOQ, DEM, DRG,) products and Geographic Name, is one of the basic data of 'Digital Water Conservancy'.

DLG(Digital Line Graphs) can display and determine the shape, size and position of the boundary of a region, streams, first-order watercourse, second-order watercourse, pool, lakes, reservoir, road, railway, residential, lock, dam, culvert, bridge, rainfall station, stream measurement station and water level measuring post and so on. GLG data can be used to make proximity analysis, network analysis, length measurement, and area measurement and so on. Moreover, the plan of a project can be storage in the format of DLG. DRG (Digital Raster Graphs) can be converted from DLG by rasterizing.

DEM (Digital Elevation Model) is the bases of spatial analysis, especially the slope analysis, fill sinks, water flow direction analysis, stream network analysis, contributing area determination, submergence analysis, and conversion between water level and water volume, linear distance and area measurement and so on.

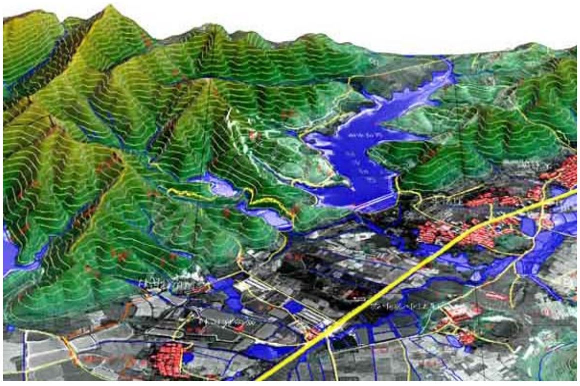

Fig. 1 DEM+DLG+DOM

DOQ (Digital Orthophoto Quadrangles) is playing an increasing role in 'Digital Water Conservancy' due to its fast acquisition, and periods and it can also be used to refresh other spatial data products. DOQ can be used to determine the water level, water area, assessment of disaster, detection of the contained water of the soil, check of the engineering for flood control, and clearance of flood channel obstruction and so on. They are can also be used to be the skin and texture of the 3d terrain models.

4.2 Contents of Specialty Database and Other Database

Specialty database consist of the parts as follows: metrological database, water resources database (including industrial water, agricultural water, water for life, rainfall, groundwater, underground water, management of permission of water catchments and so on), water environment database (including monitoring stations, water quality monitoring, water ecology, water pollution, pollution sources and so on, note that the water includes ground and underground water and rainfall), water and soil conservancy database (including land use, rock and soil, rainfall, sediment load, vegetation cover, soil erosion and so on), engineering database(including dam, watercourse, culvert, irrigated area, wells, pump stations and so on), disaster prevention database(including flood, drought, materials for flood prevention, organizations and so on), construction database (including plan of a project, prepared work,

examine and approve of the project, plan authorization, invitation of public biding and biding, quality monitoring, check and accept of the completion of the project, investment of the project and its completion), economic database (including basic finance information, state-owned assets, management and charge of running of the engineering, multi industry and so on), science and technology database (including scientific and technological project, scientific and technological achievement, achievement population, expert, and dynamics of science and technology), documents database(including files and their list, borrow and return and so on), administrative management database(including laws and regulations, and headship information), personal database(including organization, personal, policy and law and so on), comprehensive information database(economic and social data including population, GDP, total product of industry and agriculture, area and so on).
Other database includes code database, metadata database, multimedia database and statistical data of economy and society.

4.3 Contents of Decision Making Models

Models are the core of decision making system, and the models employed in 'Digital Water Conservancy' can be cataloged into the classes as follows.(1) mathematical class used to make mathematical analysis such as inversion of a matrix, correlation coefficient calculation. (2)graphics class used to display or processing of graphics such as contour mapping, process line mapping, and correlation line mapping.(3)hydrological and hydraulic method and algorithm such as storm analysis model, rainfall water flow model, infiltration fitting, calculation of volume of water, calculation of area of profile.(4)metrological method and algorithm used to make analysis such as metrological simulation prediction model, physical calculation, and objective analysis and so on.(5)flood control and regulation methods such as flood evolution model, reservoir flooding routing, flood discharge simulation model, bank failure simulation model and so on.(6)disaster assessment methods such economy and population forecast model.(7) drought fight class used to make drought situation analysis, drought forecast such as water lack analysis, crop production prediction.(8)comprehensive class such as conversion between time, file, reports generation, encryption algorithm, sorting and so on.

5. CONCLUSION AND DISCUSSION

'Digital Water Conservancy' is a very large systematic engineering and it can be divided into point, line and face in its practice. A point is a reservoir while a line is a drainage area and sum of point s and lines is face. And the research on a digital reservoir is undertaking in Xue Ye Reservoir, Shandong Province revolving the acquisition, refresh, management and application service of spatial data. And the key technology, software development and integration have made some achievement[11-14]. The construction of digital reservoir will supply experience to informationization of water conservancy.

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