

DESIGN OF THE WATER QUALITY MONITORING SYSTEM FOR INLAND LAKES BASED ON REMOTE SENSING DATA

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Abstract

At present, the problem of water resources and environment especially on inland lakes has attracted increasingly attention of researchers. The traditional monitoring methods have many shortcomings, such as long cycle, discontinuities in time and space, higher cost and so on. Remote Sensing technology have been widely used to monitor the water resources and environment with high-frequency, large-scale, multi-spectral characteristics. This paper will present a vision of the Water Quality Monitoring System for Inland Lakes (WQMSIL). The WQMSIL aims to reflect the trend of inland lakes environment quality by making full use of advantages of remote sensing data, combined with ground-based observation data. The WQMSIL will provide a variety of information to reflect the problems of water quality of inland lakes and to make it convenient for the experts to make a further decision-making and the public to participation. In the paper, the design of the WQMSIL is presented including system requirements, system framework, system structure and system features. The WQMSIL will be tested contains three significant components. The improvement of the system in the future is also presented in the paper.

Key words: WQMSIL; water quality; inland lakes; remote sensing; system

1. INTRODUCTION

Inland lakes exhibit a special prominence among our global freshwater resources. Containing more than 90% of all the liquid freshwater on the surface of our planet, they support a range of human activities, including agriculture, commerce,

transportation, recreation, tourism, and food and energy production. They also provide important habitat for a diverse array of organisms. It is because of their fundamental importance that we must enhance control of lake pollution and rehabilitate lakes overloaded with pollutants, so as to restore their ecosystem services as soon as possible and make contributions to the development of ecological civilization. In order to realize the goal, development and implementation of multi-disciplinary technologies must be encouraged. Among these technologies, Remote Sensing has attracted increasingly attention in the field of water quality monitoring.

The traditional monitoring methods have many shortcomings, such as long cycle, discontinuities in time and space, higher cost and so on. Remote Sensing technology have been widely used to monitor the water quality with high-frequency, large-scale, multi-spectral characteristics. This paper will present a design of the Water Quality Monitoring System for Inland Lakes (WQMSIL). The WQMSIL aims to reflect the trend of inland lakes water quality by making full use of advantages of remote sensing, combined with ground-based observation data. The WQMSIL will provide a variety of information to improve the problems of water quality of inland lakes.

2. SYSTEM DESIGN

2.1 System Requirements

2.1.1 Data Requirements

The WQMSIL requires three types of data as system data source, including remote sensing data, ground-based observation data and environmental background data.

Considering the scope of inland lake and monitoring period, the HJ-1A/1B CCD data serve as the main source of remote sensing data in the system and its technical specification of payloads is shown in table 2-1. Other satellite data would also serve as data sources into the system as supplementary including Landsat/TM, SPOT, CBERS-02 and so on.

Table 2-1 Technical Specification of Payloads of HJ-1A/1B

Satellite	Payload	Band no.	Spectral range (μm)	Spatial resolution (m)	Swath width (km)	Repetition cycle (days)	Data transmission rate (Mbps)
HJ-1A	CCD Camera	1	0.43~0.52	30	700	4	120
		2	0.52~0.60	30			
		3	0.63~0.69	30			
		4	0.76~0.9	30			
HJ-1B	CCD Camera	1	0.43-0.52	30	700	4	60
		2	0.52-0.60	30			
		3	0.63-0.69	30			
		4	0.76-0.9	30			

The ground-based observation data include a variety of the water quality monitoring indicators on the point provided by environmental protection departments. These ground-based observation data is used to establish the model of water quality indicator monitoring based on remote sensing data on the one hand and to the routine monitoring of water quality indicator on the point.

The environmental background data is a data set that contains environmental statistical data, land use and cover change data, vegetation data, hydrology data and fundamental geographic information data in the system.

2.1.2 Functional Requirements

The WQMSIL aims to large-scale, continuous, dynamic monitor the water quality of inland lake through the full use of advantages of remote sensing technology and to provide an operational application system, so the WQMSIL should achieve the following functional requirements: 1) The remote sensing data and the ground-based observation data automatic processing; 2) The water quality indicators monitoring based on remote sensing; 3) The water quality assessment based on combination of remote sensing data and the ground-based observation data; 4) Dynamic changes of the water quality monitoring and analysis; 5) The thematic products mapping and visualization. These functional requirements are essential for the system framework and functions design.

2.2 System Framework

According to the above system requirements, the WQMSIL consists of four subsystems: 1) Data Management Subsystem; 2) Data Preprocess Subsystem; 3) Water Quality Monitoring Subsystem; 4) Mapping and Visualization Subsystem. The overall framework of the WQMSIL is shown in figure 2.1.

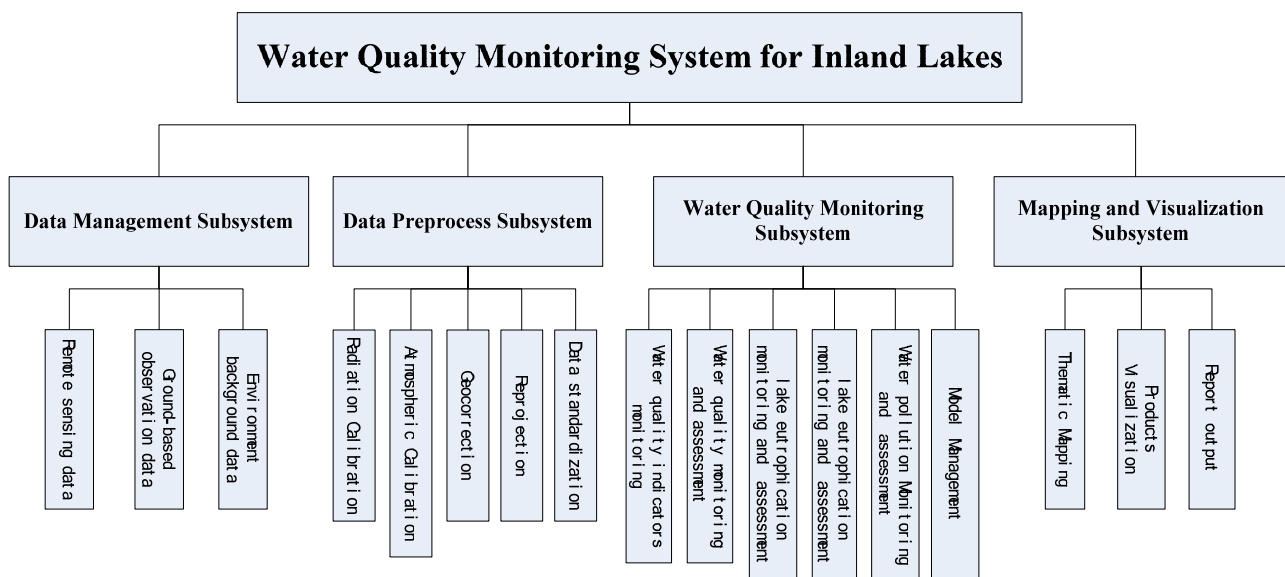


Figure 2.1 System Framework

Data Management Subsystem:

Because of system involving a large number of remote sensing data, the ground-based observation data and environmental background data, the data management subsystem is responsible for data integration to establish a management platform of data resources. It realizes hierarchical storage and unified management of data according to certain data classification and product classification standard. The data management subsystem to provide input/output data interfaces for other subsystems.

Data Preprocess Subsystem:

The data preprocess is an essential section because analysis need to be done at a normalized environment, such as

radiation precision, spatial resolution. With sensor metadata derived during imaging course, there are many mathematic approaches to process original data, to remote sensing data which include radiation calibration, atmospheric calibration, geocorrection and reprojection, while to ground-based observation data there would be data standardization to various ground-based observation data to a specific format, which makes data be easy for analysis The subsystem is mainly formed by above five modules and aims to apply primary product for other subsystems.

Water Quality Monitoring Subsystem:













The water quality monitoring subsystem provides the features and trend products of various water quality indicator parameters through the retrieval and time series analysis models based on remote sensing data. Using these parameters monitoring products, the subsystem can further output a series of advanced data products such as water quality division and classification, lake eutrophication assessment, water pollution assessment. In addition, the subsystem also includes an application model management module in order to support modification, update and customization of models.

Mapping and Visualization Subsystem:

Mapping serves as a products output progress. With caption, legend and other annotations, it gives users, who are unconscious with remote sensing products, more detailed information about monitoring results. The mapping module applies annotations editing and map output function for producers.

In order to meet the needs of water quality monitoring and management, remote sensing products and ground-based observation data must be visualized. In the traditional system, the visualization of water quality information is very single, which mainly display the water environmental data in a static way including document, form, chart and so on. In addition to these common ways of visualization, the visualization subsystem displays the dynamic changes of water environmental data by animation, which can cause the effect of gradient according to visual continuity. At the same time, multimedia data (audio, video) is used for visualization in this subsystem. Moreover, in order to become user-friendly, the subsystem provides two kinds of visualization mode: one is interactive visualization, which selects a visualization method according to the needs of the user; another is automatic visualization. In this mode, a variety of visualization methods are organized and automatically displayed to the user. The subsystem provides many kinds of visualization methods which are shown in table 2-2.

Table 2-2 Visualization Methods

	Point features		Charts
	Polygon features		Line features
	Document		Video
	Image		Animation
	Form		Audio
	Notes		Picture

2.3 System logical structure

The WQMSIL is based on Client/Server architecture to support system has good stability and scalability. The logical structure of the system is divided into three layers as shown in figure 2.2:

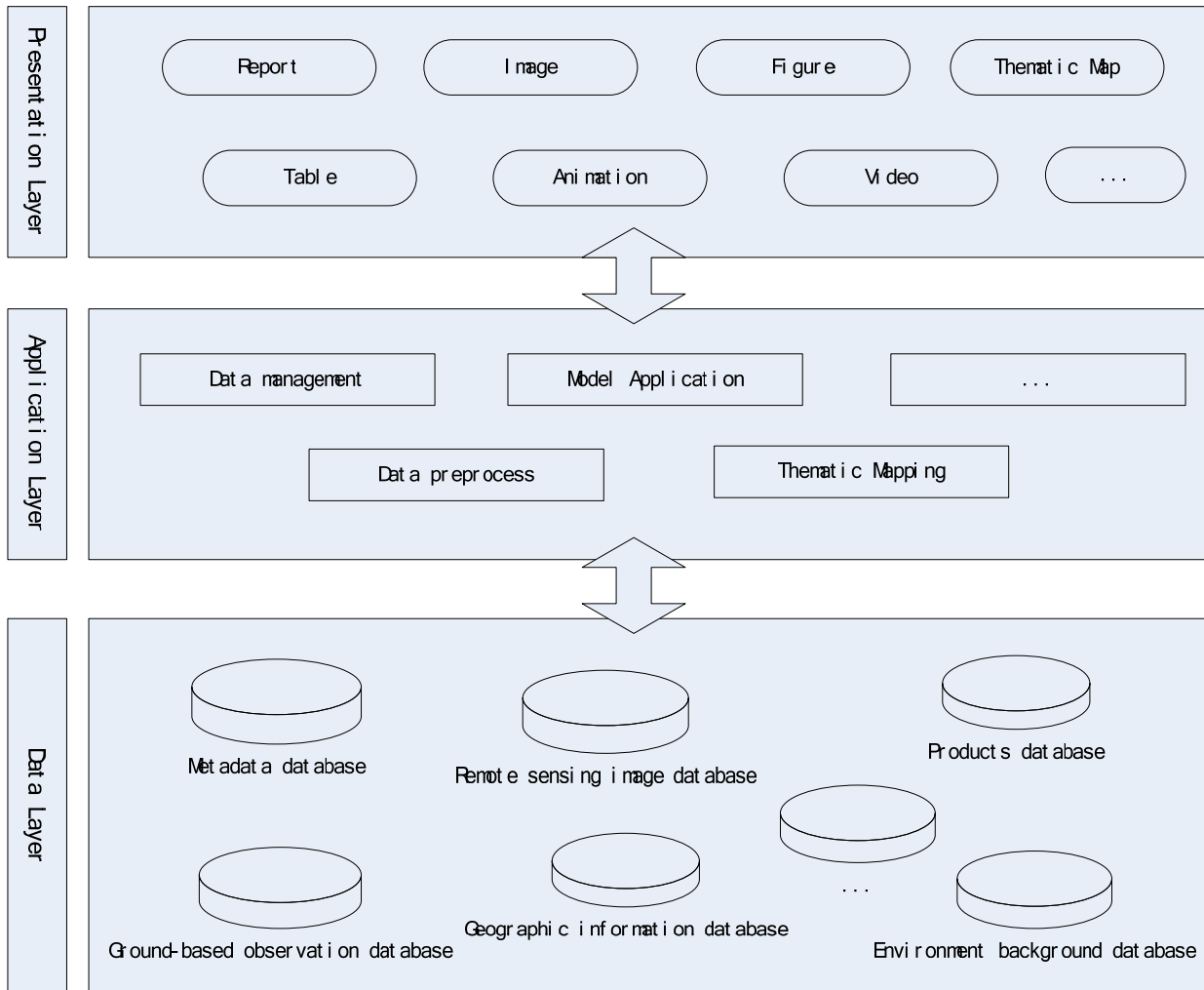


Figure 2.2 System Logic Structure

Data layer manages amounts of spatial data and attribute data to realize integrated management of data in the system. Data layer includes remote sensing image database, ground-based observation database, geographic information database, environment background database and so on.

Application layer provides the operational platform to realize the functions of the system. It receives requirements of users and calls the data of data layer to complete the function and output data products.

Presentation layer is an environment in which data and products of the system are visualized by a variety of forms. It contains images, thematic maps, reports, figures, tables, videos and so on.

2.4 System Features

2.4.1 Time Serials Analysis

More traditional water quality monitoring system for inland lake based on remote sensing data is focus on water quality parameters retrieval depending on single satellite image, which does not reflect the dynamic changes information of water quality of inland lake. In view of this situation, water quality parameters trend model based on time series analysis methods is used in the WQMSIL. Using of sequence of remote sensing images, the system can obtain continuous value of water quality parameters over a period of time, so we could carry out dynamic monitoring on water quality to detect the change information of the lake in time.

2.4.2 Automatic

Because of taking into account the requirements of operational running, the form of configuration file which customize a variety of tasks is used in the WQMSIL. The users only need to fill in the configuration file in accordance with the requirements in the system at the beginning, and then the system will automatically complete the whole process flow and output the related products. It not only improve the efficiency of the system but also save time for users who could concentrate more on analysis on products of system to make the appropriate decisions for the problem of water quality for inland lake.

2.4.3 Integrated of remote sensing data and ground-based observation data

Regular observation on the ground and monitoring based on remote sensing data for water quality of inland lake is fully compatible in the WQMSIL. Because only some water quality indicators could be obtained based on remote sensing data, remote sensing data and ground-based observation data is integrated in the system to output water quality division and classification, lake eutrophication assessment and water pollution assessment which is developed from local into large-scale, from point into surface, from static into dynamic in the system.

3. CONCLUSION

The East Lake which is in Wuhan, Hubei, China will be selected as a demonstration area. Through carrying out water quality monitoring application, we could verify effect of models and methods and test the operational performance of the system in order to provide technical reference for modification and improvement of the system. With the increasing operational requirements of water quality monitoring, need to make improvements to the system in many ways: 1) Adding more new satellite remote sensing data; 2) Warning and forecast of water quality; 3) Data assimilation technology.

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