Scholar Publishing Group
Frontiers in Ocean Engineering
https://doi.org/10.38007/FOE.2020.010103
ISSN 2790-2706 Vol. 1, Issue 1: 19-26

Integration and Application of Marine Engineering Environmental Monitoring Data Based on Big Data

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Keywords: Big Data, Ocean Engineering, Environmental Monitoring, Data Integration Application

Abstract: Marine resources are abundant and diverse in China. With the deepening of the strategy of Marine power, the research on Marine environment observation becomes more and more important. However, the currently used offshore data observation systems have only one observation element, limited data transmission distance, and the observation platform can not observe continuously for a long time. In this paper, the hardware design of Marine engineering environmental monitoring is firstly carried out, and then the development framework is built. The framework of environmental monitoring data integration and application is built by MVC mode. The function and performance of the environmental monitoring system are tested. The test results show that the system can accurately and effectively collect and publish Marine environmental elements.

1. Introduction

The ocean occupies 71 percent of the earth's area and is rich in natural resources, providing abundant resources for human production and life. The Marine ecosystem is the system with the richest diversity of species on the earth, which provides valuable wealth for the sustainable development of human beings in the next hundred years. The development and utilization of Marine resources play a crucial role in the development of the world economy in the future [1-2]. First of all, as far as the society is concerned, science and technology continue to develop, and the social economy is stable and improving. However, with the continuous increase of the population base, the shortage of resources is becoming more and more serious. The rapid economic development needs to consume a lot of resources. At the present stage, the land resource is increasingly scarce in China. People gradually turn their vision from land to sea. There are many indicators in the integrated observation data of Marine environment, such as real-time monitoring of air temperature, air pressure, wind speed and wind direction at the air-sea interface, seawater temperature, salinity, underwater pressure, wave height, wave direction, oxygen content in seawater, PH value, seawater velocity and flow direction [3-4]. By monitoring these parameters and using satellite communication technology and mobile Internet technology, it is of great practical significance to transmit Marine environmental observation data to shore-based monitoring system in real time, accurately and reliably. Traditionally, buoys, ocean survey ships, satellite remote sensing and shoreline monitoring stations are used for Marine environment observation [5]. The Marine environment is rich and diverse, and the requirements of Marine environment observation are strict, and the traditional observation scheme can not meet the needs of measurement.

In the 1970s, Europe and the United States and other developed countries have already realized the importance of ocean monitoring technology. After decades of investment and development, these countries are at the top of the world in Marine monitoring technology. HABSOS system in the United States: Red tide Observation system [6]. ROSES System in Europe: ROSES is a comprehensive Marine environmental information resource platform that provides a wealth of data products and services through the on-site monitoring system, which can obtain real-time Marine monitoring data. In the near future, ROSES will expand to all of Europe, but currently ROSES only monitors harmful algal blooms in seven regions, with other parts of Europe under construction [7]. GOOS is the Marine monitoring system with the widest monitoring range, the most measured parameters, and the most abundant data and services proposed by the Oceanographic Commission so far. The idea is in the existing global Marine environmental monitoring system in various countries, the global ocean station integrated monitoring system, such as the ocean monitoring system on the basis of professional through developing satellite technology, a new sensor technology, computer technology and other high and new technology to further improve and enhance monitoring means, to the Marine disaster prediction and research, the protection of the Marine environment, The rational development of Marine resources provides long-term and systematic data [8-9]. China is a big ocean country, but the level of Marine environmental monitoring science and technology is far from the world's Marine power such as the United States, Canada, etc. Before the founding of New China, the state basically did not have the ability to monitor Marine environment and forecast Marine disasters [10]. Since the founding of the People's Republic of China, the ability of Marine meteorological monitoring and forecasting has been strengthened to varying degrees, and the ability of coastal areas to resist disasters has been greatly improved.

The data of systematic observation is of great significance for improving the accuracy of Marine meteorological forecast, protecting the Marine ecological environment, and further studying the global Marine climate change and network observation.

2. Marine Engineering Environmental Monitoring

2.1. Hardware Design of Marine Engineering Environment Monitoring

The acquisition device in the field equipment layer includes seabed environment monitoring sensor group, data acquisition unit, terminal communication unit and so on. In the monitoring layer, the monitoring terminals of each system are responsible for managing the collection devices in the equipment layer, issuing control instructions, and receiving environmental monitoring data information [11]. The main task of the integrated monitoring system is to receive and back up all monitoring data in a unified way and display the seabed environment information in a digital and graphical manner. Therefore, this paper mainly designs the communication network structure between the integrated monitoring system and other monitoring system terminals in the monitoring layer.

The STM32 minimum system constructed in this paper consists of MCU, power supply circuit, crystal oscillator, I/O expansion, reset circuit and download circuit. The sensor part, GPS positioning module and GPRS communication module are all designed and developed on the minimum system. STM32F103ZET6 has 144 pins, including 112 universal IO ports and pins of many peripherals, all of which are introduced in this paper to facilitate the expansion of functions. For the external clock, 8MHz crystal oscillator is connected with 1M feedback resistance and 22PF starting capacitance [12].

The power module is the power source of each node of the monitoring terminal, and is the basis of the normal operation of the system. The monitoring terminal works in the offshore sea area, so the transmission line cannot be used for power supply. This system uses 12V lithium battery to power the whole monitoring terminal.

The battery of this system uses two 12V 300Ah series to form a 24V 300Ah battery pack, and the solar panel uses eight 12V 25W to form a solar battery pack. Combined use constitutes the entire power supply system. According to the conversion efficiency of solar energy, based on the calculation of using solar energy alone, the daily light is about 8 hours, and the production capacity is as follows:

$$Q_{\text{producing}} = 25W \times 8 \times 8h \times 50\% = 800Wh \tag{1}$$

The average power consumption of the monitoring system is about 300W, and it is used for 24h every day. The daily energy consumption is as follows:

$$Q_{\text{Power consumption}} = 300 \times 24h = 7200Wh \tag{2}$$

When the energy supply of the monitoring system is all supplied by batteries, the system can be used for the following time when the battery bank is fully charged:

$$T = \frac{24v \times 300Ah}{300w} = \frac{7200Wh}{300W} = 24h \tag{3}$$

According to the above statistics, under normal operation, the power supply system can ensure that the monitoring system can reach a continuous working time of about 24 hours.

SIM900A module is used in this paper. SIM900A is a dual-frequency GSM/GPRS module, the working frequency band is GSM900/1800mhz, which can realize the functions of telephone voice, SMS(short message, MMS), GPRS data transmission, DTMF decoding and so on.

Component development technology is an important software development method. It follows the characteristics of inheritance and encapsulation in object-oriented, uses certain programming methods to encapsulate the complex operation and design details of a certain function, and forms a reusable component that is independent of programming language, and realizes specific functions by providing external interfaces [13-14]. Componentized development method can improve the portability and development efficiency of software. In order to effectively solve the complex problem of communication function design among multiple systems, avoid the cumbersome TCP/IP network communication connection process, and optimize the communication program code, this paper designs a reusable communication component for different monitoring system terminals [15-16]. According to different monitoring system objects, a unified communication protocol and data transmission interface are designed, and the underlying Socket communication details are encapsulated to realize communication connection and data transmission.

2.2. The Construction of Monitoring Software Development Framework

As shown in Figure 1, the core of MVC is the idea of layering, which is developed from the three-tier architecture. In short, the three-tier architecture adds a "middle layer" between the client and the database to achieve business isolation. The client no longer accesses the database directly, but uses COM/DCOM to exchange data with the "middle layer". The "middle tier" then calls the database. The three layers are divided into data access layer, business logic layer and presentation layer from bottom to top (MODEL layer is usually added when building the architecture, but it still belongs to the category of three layers) [17-18]. Here's what each layer does:

Data Access Layer (DAL): Operations on raw data allow direct access to the database and provide data services for the business logic layer and presentation layer.

Business Logic Layer (BLL): For specific problems, the data access layer is directly invoked, while providing data services to the presentation layer.

Presentation layer (UI): receives and sends user requests and calls the business logic layer to provide users with access to the application. The most intuitive representation is the Web page.

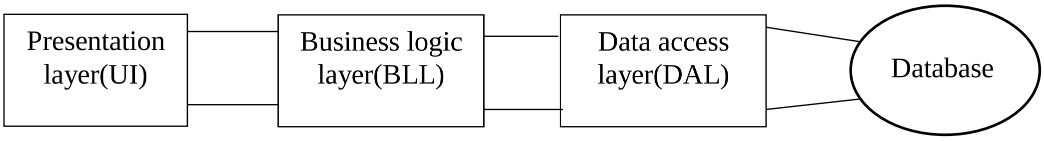

Figure 1. Schematic diagram of three-tier architecture

MVC is more complex than the simple three-tier architecture, and the core idea of the three-tier architecture is "high cohesion, low coupling". ASP.NET MVC is a further separation of the presentation layer, which completes the maximum decoupling between the front page and the background control. M represents the Model, V represents the View. C stands for Controller. The MVC architecture model is shown in Figure 2.

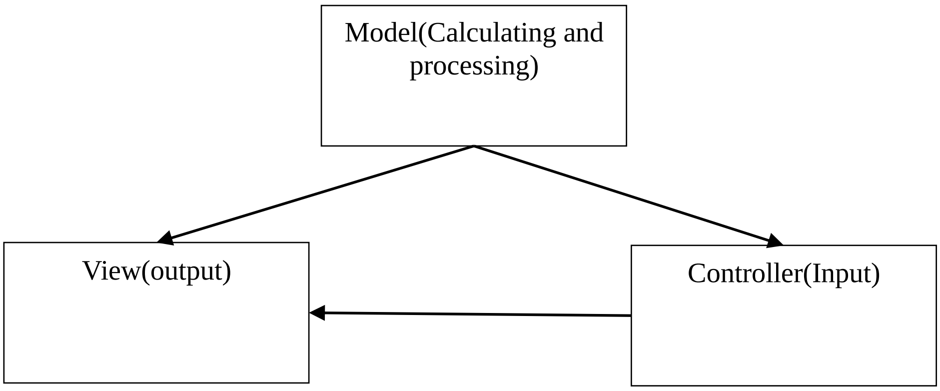

Figure 2. MVC architecture model diagram

Entity Framework (EF) Entity data model is a database access technology based on ADO.NET. It is a set of ORM Framework. Data fields are converted to properties, and relationships are converted to associative properties for easy invocation in various development languages. EF has many advantages over native ADO.NET, such as:

Greatly improve the development efficiency. EF has a high degree of integration with Visual Studio, uses strongly typed programming language, imperative programming, and code efficiency is high.

Powerful model designer. It not only changes the design method of database, but also has the function of automatically generating model code, which greatly improves the efficiency of development and architecture design.

Support across databases. Only need to change the configuration of the XML file to complete the cross-database function, more flexible and convenient.

In view of the powerful characteristics of MVC+EF, the monitoring software architecture of Marine environmental monitoring system adopts MVC+EF framework, which greatly improves the development efficiency and software stability.

In this solution, DAL, BLL and Model libraries are firstly created, which are data access layer, business logic layer and Model layer respectively. Then the class libraries IDAL and IBLL are created to realize the decoupling between different layers. Interfaces are created between the business layer and the data layer, and between the presentation layer and the business layer, so that the business layer can call the Interface of the data layer, and the presentation layer can call the Interface of the business layer. Then add the utility class library Common and abstract factory DALFactory. Finally, for the presentation layer, select the new ASP.NET MVC 4 Web application.

3. System Test and Experiment

3.1. Test Environment Construction

In the laboratory, the simulated underwater multi-monitoring system was used to carry out functional tests such as inter-system communication, data transmission and display. The laboratory test equipment consists of computer, network cable and switch. Among them, four computers simulate different monitoring terminals and are connected to the same LAN through network cables and switches. The system test environment is shown in Table 1.

Table 1. System test environment

Model	Environmental parameters
CPU	Intel Core i5-10400
Memory	16G
Hard disk	1T
Operating system	Windows 10

After the communication is established, the integrated monitoring system, as the central monitoring terminal, receives data from other monitoring terminals. The data reception and display of the observation system.

3.2. System Function Test

The function test of the comprehensive monitoring system is reflected in the overall operation effect of the system in the test process. The whole system receives data in real time after several hours of continuous work, and the system works smoothly. There is no data loss or damage in the test process, and the stored data format is correct without garbled code. The data analysis is correct, the monitoring interface runs smoothly, the image drawing is normal, the main form and other sub-forms switch normally, no interface stagnation phenomenon.

4. Analysis of System Performance Test Results

4.1. Testing the Number of Concurrent Users

Server as shown in figure 3, the hardware of physical memory, CPU efficiency and comprehensive factors such as network environment, when 100 system simulation are communication connection, comprehensive monitoring system CPU utilization of 75%, to allow index of the adjacent values, but for project application, the system of concurrent ability to fully meet the project actual needs.

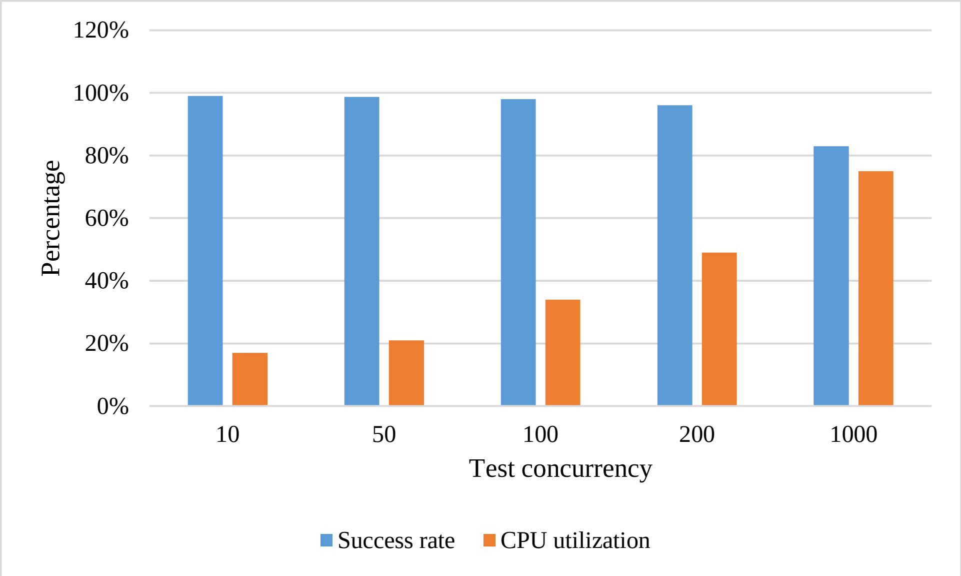

Figure 3. Concurrent connection test

4.2. Testing the Number of Concurrent Users

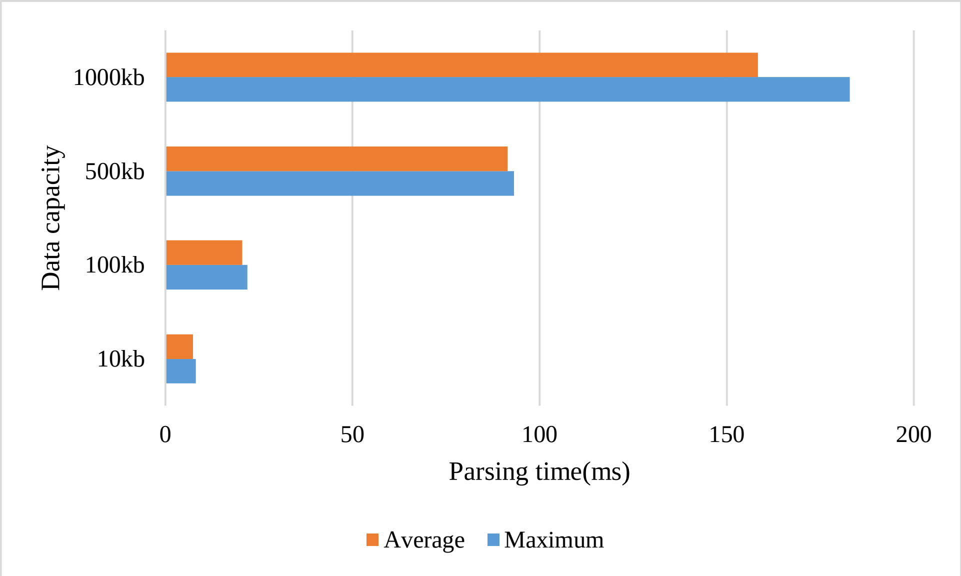

Figure 4. System data efficiency test

As shown in FIG. 4, with the increase of the size of the transmitted files, the storage and parsing time of the comprehensive monitoring system increases gradually. When the maximum data capacity of the system is 1000KB, the average parsing time is only 158.32ms, and the error rate is 0.00%, which meets the requirements of the indicators. The test results show that the capability of data analysis, storage and processing of the monitoring system meets the real-time requirement of seabed environment monitoring.

5. Conclusion

This paper designs the overall design scheme and operation details of the Marine environment monitoring system, completes the hardware design and program design of the monitoring terminal, the monitoring software design of the system, completes the acquisition, transmission, reception, storage and viewing of the environmental elements, and tests each functional module of the system. In the process of system development, whether it is the drawing of the monitoring terminal schematic diagram, or the writing of the program, are meticulous, clear purpose, clear steps, simple and easy to understand. Continuously debug the circuit and program, find the error in the operation and carefully modify, so that the system to achieve the expected goal. In the process of programming, module hierarchy, strive to do each line of code annotation interpretation, to achieve the standard code writing format. In the interface design of monitoring software, we strive to make the layout reasonable and beautiful, simple and standard, convenient for operators to use. Although the system has been debugging and improved for many times, but there are still some shortcomings, in the future work will continue to improve.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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