Research on networking scheme of Internet of things based on marine environment monitoring

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ABSTRACT

In order to realize the technology of Internet of things (IOT), realize the intelligent monitoring of marine environment and protect the marine environment, this paper uses sensor network technology, 3G wireless communication technology, ZigBee communication protocol, and GIS spatial information processing technology to realize the automation of marine environment monitoring. A dynamic monitoring system of IOT based on marine environmental data is proposed. The results show that the sampling points of class I data sources are located in the area with the best water quality, followed by class II data sources, and the water quality of the sampling points of class III and IV data sources is poor. Conclusion: through the distribution of the data of sampling points in multi-parameter feature space, the classification, identification, and analysis of seawater quality can be realized. Further monitoring and processing were carried out finally, real-time data processing is realized.

Keywords: Internet of things; Marine environment; Sensor; Detection data

1. Introduction

With the rapid development of society and economy, the marine environment has been damaged more and more seriously by human activities [1]. Marine environmental monitoring is a crucial issue and has attracted extensive attention. In the past decade, various marine environmental monitoring systems have been developed and applied in practice, The Internet of things (IOT) is considered as a potential and promising alternative for monitoring the marine environment because of its advantages, such as unmanned operation, easy deployment, real-time monitoring, and relatively low cost. At present, there is no widely recognized architecture for the IOT. Each object in the IOT system has a unique identification or address and the ability to transmit data through the network to achieve identification, monitoring, and positioning tracking [2].

2. Literature review

IOT is a comprehensive application of sensor network and Internet. Through sensor network, the Internet can obtain real-time data of any object in the system, and intelligently process the data. The IOT can facilitate people to obtain information of things, improve work efficiency, save operating costs, and embody the essence of "technology is the first productivity". The IOT technology has been applied in some real-time monitoring fields [3]. Liang et al. [4] proposed a three-layer network transmission monitoring system based on the IOT for water ecological monitoring. The medium range wireless sensor network technology of the system was improved by dynamic TDMA sensor network protocol. Wang [3] used radio-frequency identification (RFID) tag technology and sensor technology to meet the needs of forest resources monitoring.

A monitoring system of forest environmental factors based on the IOT is designed. The system uses ZigBee technology to collect data, and RFID technology is used for inventory to realize the monitoring of forest environmental information [5]. Harmful algal blooms observing system (Habsos), the system is mainly composed of satellite, coastal automatic observation station, buoy, and other on-site monitoring systems. The system is a highly integrated and integrated information and communication system aimed at managing harmful algal bloom data, events, analysis, and prediction of their impacts. The system was initially used in the Gulf of Mexico and has been gradually applied to the coastal areas of the United States [6]. The research on marine monitoring in China started relatively late, China's marine monitoring technology lags behind the advanced marine countries. At present, some marine monitoring stations in China are mainly manual monitoring, which is still a long way from intelligent monitoring of marine environment. There are few advanced monitoring equipment independently developed in China, and foreign products occupy the majority of domestic high-grade marine instrument market, relying on the National 863 program and other key scientific and technological projects, a three-dimensional marine environment monitoring network has been gradually established based on monitoring stations, survey vessels, marine buoys, satellite remote sensing and aerial remote sensing, China's marine environment monitoring and evaluation work has made rapid development [7–10]. In the monitoring system, the wireless sensor network technology and Internet technology of the IOT have been used. The above research shows the feasibility of the IOT in marine environment monitoring. Therefore, this paper designs a dynamic monitoring system of the IOT based on the marine environmental data and realizes the dynamic monitoring by combining the sensor network and Internet.

The innovation of this paper is through the use of the IOT wireless sensor network technology to achieve the monitoring area of environmental elements (air temperature and humidity, water flow direction, water temperature, and salt depth, etc.), using 3G communication technology to transmit monitoring data to the management platform of the monitoring center, using wireless microwave communication technology to send video monitoring data to the monitoring center. Finally, intelligent, systematic, and visual marine environment monitoring can be realized.

3. Research methods

3.1. Communication technology of marine environment monitoring system

3.1.1. 3G communication technology

3G is the abbreviation of 3rd generation in English, which refers to the third generation mobile communication technology. The third generation mobile communication system adopts code-division multiple access (CDMA) modulation. CDMA system has the advantages of good communication quality, large system capacity, strong resistance to multipath, high frequency reuse coefficient, soft capacity, and soft handover [11].

3.1.2. ZigBee technology

ZigBee is a group of networking, security, and application software technologies developed based on IEEE802.15.4 wireless standard. It uses the global free frequency band for communication. It can communicate in three different frequency bands, namely, the global universal frequency band of 2.400~2.484 GHz, the frequency band of 868.00~868.66 MHz adopted in Europe, and the frequency band of 902~928 MHz used in the United States, ed with Bluetooth, and other wireless communication technologies, ZigBee has the characteristics of low complexity (Table 1), low cost, low power consumption, and low rate [12].

3.2. Overall architecture of IOT dynamic monitoring system

The dynamic monitoring system of IOT is mainly composed of wireless sensor network, data transmission system, and monitoring center. The wireless sensor of the whole system consists of sensor node, sink node, base station, server, and client. The sensor node can collect and monitor the ocean environment parameters, such as water temperature, salinity, turbidity, pH, oxygen content, etc. The sink node collects data from a group of sensor nodes and sends the collected data to the base station via 3G network. The server stores and processes the data received from the base station. The client reads the parameter information through the Internet connection server, check, and query [13–15].

3.3. Hardware design of IOT dynamic monitoring system

3.3.1. Sensor hardware node design

The sensor nodes of marine environmental monitoring system usually include buoy devices to protect the electronic devices from water. Marine sensor monitoring nodes are usually composed of four main modules: sensing module, central processing module, wireless transceiver module, and power module. In this paper, CC2430 chip is used as the control core. The chip includes ZigBee RF front end, memory, and microcontroller. It has 128 KB RAM, analog-to-digital converter (ADC), timer, and AES_128 coprocessor, power on reset circuit, watchdog timer, power down detection circuit, 32 kHz crystal oscillator sleep mode timer, and 21 programmable IIO pins. The system can fully meet the needs of the system. The energy supply module uses lead-acid batteries and solar panels. Solar cells are used to effectively charge according to the energy status of the battery to ensure that the system can run effectively for a long time.

3.3.2. Wireless communication mode based on ZigBee and 3G

The wireless communication of the dynamic monitoring system of the IOT is mainly divided into two parts, one is the data transmission of a single node, the other is the data transmission of the sink node, ZigBee is a low transmission rate and low power local area network (LAN) protocol based on IEEE802.15.4 standard. It can extend the battery life by low rate secure communication. ZigBee is a multi-hop communication protocol. If two nodes exceed the transmission range, they only need to add nodes between

them, and then the two nodes can communicate, 3G is a cellular mobile communication technology supporting high-speed data transmission, which has the advantages of fast transmission speed and high transmission quality. In addition, 3G technology can be used to connect the wireless communication system with the Internet to provide relevant data to mobile terminal users.

3.4. Microprocessing software design of 2.4 node

The MCU 8051 of the node supports C language programming and is compatible with standard C language, which improves the development efficiency and reliability of software design.

Because the main control center should have the functions of data storage and processing, IOT management, and network wake-up, the whole system combines Client/Server (CS) and Browser/Server (BS) architectures, based on ArcGIS development, Visual C ∞ as the front-end development tool, oracle110g server database as the background development tool. CS mainly realizes the marine environment monitoring data input, query and retrieval, data trend analysis, and environmental assessment. BS is mainly used for online query and release of data and products. Ordinary users can query and visualize data on the Internet. Fig. 1 shows the system architecture.

4. Research results

In order to ensure the continuity and normal operation of each part of the marine environment monitoring system, the relevant basic experimental tests of the system were carried out, including debugging the relevant sensors of the system in order to achieve the normal collection of marine environmental data, testing of 3G communication module to ensure the normal receiving and sending of data, and the realization of visual management of monitoring area. The wireless microwave video monitoring module is debugged; through the water quality evaluation model established by the system, the test data is simulated, and the data processing results are displayed visually, so as to complete the experimental test of the whole system.

4.1. Experimental analysis of system monitoring data

Through the simulation test, taking the coastal water quality monitoring in Shanghai as an example, one sampling point is set every 5 km away from the coast, and 30

monitoring sampling points are marked as sampling points 1–30 from the north to the south. Combined with the measured data, four parameters of temperature, salinity, pH, and do are extracted for analysis, among which do value is oxygen content in water.

4.2. Cluster analysis of a certain period of time

300 groups of data from 30 monitoring points in a certain period were analyzed. The initial conditions of clustering were as follows: population size $n = 100$, maximum evolution algebra $g = 50$, crossover probability PC = 0.9, and mutation probability PM = 0.01. The clustering results show that the sampling point data can be divided into four categories, as shown in Fig. 2 and Table 2.

The results of cluster analysis are shown in the environmental monitoring map 2.

Among them, type I, as shown in Figs. 2a and b, pH is between 7 and 9, most of them are around 8. Do values are between 4 and 8, most of them are between 6 and 8. Salinity is between 25 and 35, most of them are between 30 and 35, and temperature is basically between 21.5 and 22.5. The water quality is lower than the basic value of do (2.5–5) and do (2.5–5) of the river water, which is similar to the basic value of do (2.2–5) and do (2.5), which is similar to the basic value of do (2.2–5) of the river water. The temperature is basically between 22–23, and the temperature of a few monitoring points is higher than 23. But the pH value is low, between 6 and 7. The salinity is between 5 and 20, which is also lower than that of class II. There is a land-based sewage outlet near such points, and the water quality is poor, which needs further monitoring or treatment. For class IV, according to Figs. 3a and c, the do value of such monitoring points is the lowest, basically between 1 and 3. The pH range is large, between 8.5 and 12, and the salinity value is the lowest. The temperature is between 0–15 and 23.5–25. The water quality of these monitoring points is poor, and there is a land-based sewage outlet nearby. The highest temperature is mainly caused by the discharged sewage, and the sewage treatment is very poor, which needs further monitoring or treatment. The results show that the water quality of class I and class II is the best, and the location of water quality is the second.

4.3. Analysis of monitoring point data in different periods

The 300 groups of multi-parameter data monitored in another period after 2 d of 30 monitoring points were analyzed. According to the classification of clustering results
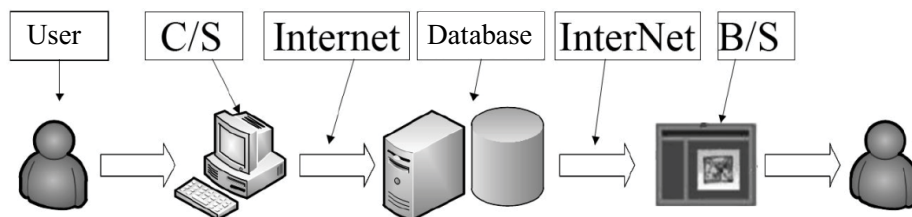

Fig. 1. Software architecture of main control center.

Table 1
Performance parameters comparison between ZigBee and other wireless communication technologies

Name	ZigBee	Wi-Fi	GPRS–GSM	Bluetooth
System resources	4–32 KB	1 MB+	16 MB+	250 KB+
Broadband	20–250	11,000+	64–128+	720
Transmission distance	1–100+	1–100	1,000+	1–10+
Battery life	100–1,000+	0.5–5	1–7	1–7

Table 2
Types of sampling points

	Sampling point
Class I	21, 22, 23, 24, 25, 26, 27, 28, 29
Class II	12, 13, 14, 15, 16, 17, 30
Class III	9, 10, 11, 18, 19, 20
Class IV	1, 2, 3, 4, 5, 6, 7, 8

given above, 300 groups of data were projected in the feature space of environmental monitoring parameters, as shown in Fig. 3.

Comparing Figs. 2 with 3, it can be seen that part of the data in the sampling points of type I data source moves to the direction of class II data, indicating that the water quality situation at some sampling points in this class is getting worse, and some data in the sampling points of class II data source is moving toward the direction of class III data, indicating that the water quality situation at some sampling points in this class is getting worse, and the data location of class III data source has no significant change. The results show that the water quality of these sampling points has no obvious change, the sampling points of class IV data source move to the direction of class II data with low pH value, and do value also increases, indicating that the water quality of some sampling points in this category is getting better, but the water quality situation of such sampling points is still not optimistic. If it cannot be distinguished, it can be clustered again according to the above method.
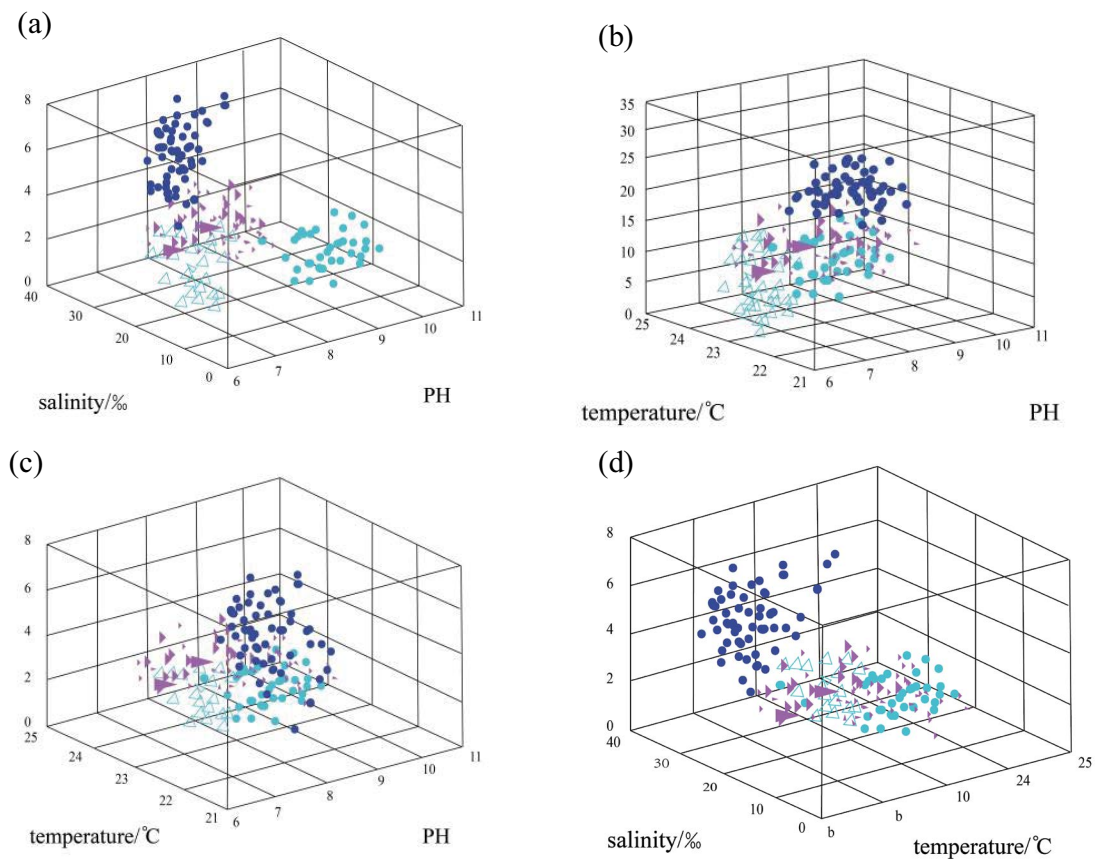

Fig. 3. (a–d) Projection of clustering results in feature space of environmental monitoring parameters in another period after 2 d.
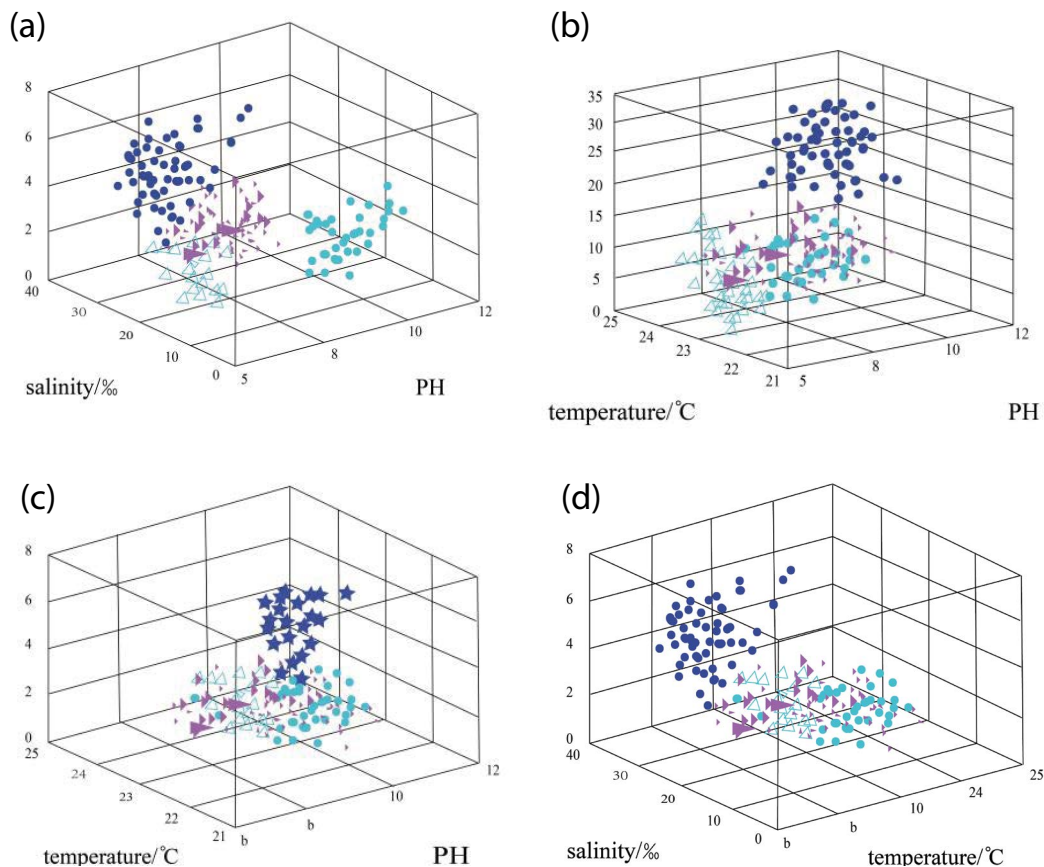
Fig. 3. (a–d) Projection of clustering results in feature space of environmental monitoring parameters in another period after 2 d.

5. Conclusions

In the past decade, the monitoring of marine environment has attracted a lot of research and development. IOT is a promising technology that can be used to monitor the marine environment, because it has the advantages of easy deployment, real-time monitoring, automatic operation, and low cost. In this paper, a dynamic monitoring system of the IOT based on marine environmental data is designed. In view of the wide area of marine environmental monitoring but the small amount of data transmission, the communication mode of combination of ZigBee, and 3G is adopted. Based on the analysis of the research results and development trend in the field of marine environmental monitoring at home and abroad, aiming at the problems existing in the field of marine environmental monitoring, the application of IOT technology to marine environmental monitoring is proposed. The system is designed based on the ocean environment monitoring system with high reliability and low energy consumption.

Acknowledgments

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