Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2021.26871

219 (2021) 18–23
April

Research on marine pollution detection system based on wireless sensor network

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Received 15 August 2020; Accepted 23 November 2020

ABSTRACT

Based on wireless sensor network, a marine pollution monitoring system is proposed. Based on wireless sensor network technology, data acquisition system is constructed; multi-level and multi-mode data network transmission models are established by using wireless sensor network, wireless microwave communication network, wireless mobile communication network and Internet, and the monitoring system is constructed to realize seamless connection between multiple networks; Combining the traditional fuzzy C-means (FCM) clustering method and genetic algorithm, this paper proposes a method based on spatial vector genetic clustering analysis to process massive monitoring data, and achieve good results.

Keywords: Wireless sensor network; Spatial vector genetic clustering analysis; Marine pollution detection system

1. Introduction

With the acceleration of China's urbanization and the rapid development of coastal economy, China's coastal sea environment is facing more and more pressure, and the pollution area of the sea area continues to expand. In addition to the impact on people's lives in the coastal areas, China's coastal waters are facing more and more pressure, Marine ecological environment is also under great threat. The pollution of marine environment and the destruction of marine ecological structure has become major obstacles to the sustainable development of China's social economy. Protecting the marine ecological environment and realizing sustainable development have become urgent and arduous task in the future [1]. In order to better develop the marine economy and enhance the ability of marine environmental protection, it is necessary to increase the research and development of high-tech marine environmental monitoring. Strengthening the monitoring of marine environmental pollution is the premise of protecting and controlling the marine environment [2]. Marine environmental monitoring technology provides technical support and support for the protection and governance of the marine environment. Nowadays, the purpose of marine environmental protection and monitoring is to obtain accurate and effective marine environmental data in real time. It can provide scientific data and basis for protecting marine environment and improving marine disaster warning.

Among them, the most important technologies are computer technology, sensor network technology and communication technology. It can realize remote real-time detection, perception and collection of the information of various monitoring objects in the network distribution area, analyze and process the information, and provide real-time and detailed information platform for scientific researchers. It is one of the frontier research hotspots and has great scientific significance. Hainet started the actual underwater sensor network experiment as early as 1998. The purpose of developing underwater monitoring system is to support the rapid deployment of underwater distributed monitoring system used by the United States [3]. The system can be deployed by manual or automatic vehicles, with

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network nodes up to several thousand meters, and communication distance up to several thousand meters. These nodes can be deployed in the depth of tens to hundreds of meters; then it forms a real-time monitoring network with wireless buoys, ship nodes and air mobile nodes deployed on the sea to provide real-time ocean state information for naval operations, and realize underwater command and control, communication and navigation. It can also be used to monitor the global ocean temperature in large-scale, such as the ocean temperature monitoring of the United States. In China, the development of marine water quality parameter detection and monitoring technology is in the development stage. In this paper, based on wireless sensor network, a marine pollution monitoring system is proposed in order to judge the marine pollution by monitoring the marine water quality.

1.1. Literature review

Shang et al. [7] proposed a new hybrid intrusion detection model that combines distributed and centralized strategies. A new algorithm to detect Sinkhole attack in base station is proposed, and a new intrusion detection model CUSUM_MV is presented. The hybrid model can detect not only Sinkhole and DoS attacks but also other specific vulnerabilities. Simulation experiments on Castalia simulator show that this method has better performance than the traditional Sinkhole attack detection method [4]. Xian-li et al. [5] designed a real-time urban air quality monitoring system based on wireless sensor network in order to solve the problem that the traditional air quality monitoring method combined with manual sampling and laboratory analysis and cannot carry out real-time on-line monitoring of multiple points at the same time. Because the system does not need cable, base station and other infrastructure, it is more convenient to network, and the real-time monitoring data collected can be transmitted to the remote data management center through the GPRS network, which can realize large-scale air quality monitoring [5]. With the rapid growth of China's aging population and the increasing demand for medical services, it is more necessary to establish a TCM health management system based on wireless sensor network. Xiang et al. [6] combined ZigBee technology, urban grid management and virtual reality technology to establish a real-time, accurate and precise health monitoring system to comprehensively improve the efficiency, quality and level of people's health management [6].

2. System architecture

The data acquisition subsystem of wireless sensor network technology is responsible for the collection of system monitoring data. The monitoring terminal realizes the transfer and transmission of monitoring data through the wireless network communication technology of the Internet of things. The information management subsystem of marine environmental monitoring realizes the storage and analysis of monitoring data, and publishes the results of data analysis through Internet technology. The sensor nodes mainly include sensor unit, processor unit, wireless communication unit and energy supply unit. The monitoring terminal on land mainly includes the transfer device for receiving sensor node data, video acquisition module for video monitoring of monitoring area, and wireless communication module for transmitting monitoring data. The final data are transmitted to the monitoring center. The monitoring center mainly includes wireless communication module for data transmission, industrial computer for receiving data and data preprocessing, server for data storage, calculation and release. The monitoring center publishes the monitoring results of monitoring area in the form of browser through the network. Users can query through personal computer or hand-held mobile devices. By setting up wireless sensor networks and monitoring terminals in different areas, multi-site monitoring can be realized.

3. System design

3.1. Data acquisition subsystem

According to the design of water quality sensor, there are different types of sensors, such as CC30 and water quality sensor. The installation position of the sensor can be adjusted, and the detection mode of combination of water and water is used to meet the requirements of each monitoring point. The data acquisition unit samples the information collected by the sensor through the ADC channel. The microcontroller completes the data processing, storage, sending and receiving [7]. The wireless communication module is responsible for the transmission of data and commands. When the monitoring center sends the command to read the data, the command is transmitted to the sink node through the network, and then the command is sent to the sensor node through the wireless communication module of the sink node. The sensor node completes the data acquisition and transmits the data to the sink node through the wireless communication module [8]. The sink node transmits the monitoring data to the monitoring terminal through serial port connection, and finally uploads the data to the monitoring center through the communication module to complete the whole process of data collection and transmission as shown in Fig. 1.

3.1.1. Hardware design of sensor node

The established sensor network needs to have efficient data transmission efficiency and maximum node power utilization efficiency. Therefore, ZigBee protocol is used to communicate between sensor nodes. ZigBee works in 2.4 GHz frequency band and has the highest data transmission rate of 250 kbps. The transmission distance depends on the transmission power and application. The CC2430 chip produced by Chipcon company (San Francisco Bay Area, Silicon Valley, West Coast) is used as the control core of the sensor node [9]. In order to realize the data acquisition of pH value, temperature value, dissolved oxygen and salinity of seawater, the main parameter sensors used in the sensor node are shown in Table 1.

3.1.2. Sensor network node power supply

When the energy management module of the battery is insufficient, the system uses the battery power management

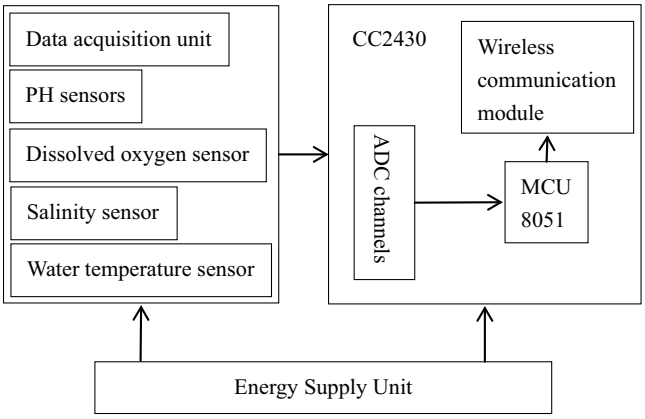

Fig. 1. Sensor node structure.

module to supply power to the battery. The charging management module is to charge the battery effectively and reasonably according to the situation of solar energy resources and the state of battery power. When the solar panel charges the battery, the battery cannot supply power to the system. Therefore, the dual power supply mode is adopted in the system design to maintain the working state of "one charging and one supplying". The dual power switch management module is responsible for the safe and fast switching of dual power supply.

3.1.3. Workflow of sensor network node

The MCU 8051 of sensor node and sink node supports C language programming. Fig. 2 shows the work flow of sensor node. The system chip of sensor node is initialized first, MCU enters sleep state and sets timing time [10]. When the timing time is over, MCU is awakened, sensor node enters data acquisition state and sensor collects data. The sensor node sends the collected data to the sink node.

Fig. 3 shows the work flow of sink node. The system chip of sink node is initialized first, and the node enters the data receiving state. After receiving the data from the acquisition node, the data are stored and the feedback signal is sent to the acquisition node. Finally, the sink node sends the stored data to the monitoring terminal.

3.2. Monitoring terminal

The monitoring terminal of marine pollution detection system mainly realizes the functions of receiving, storing and transmitting monitoring data. In order to realize more direct monitoring and management of monitoring area,

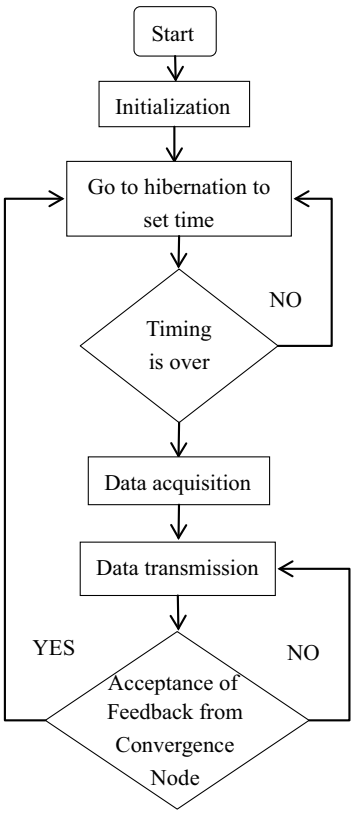

Fig. 2. Work flow of sensor node.

video monitoring measures are adopted. The monitoring terminal takes data collector as the core (Fig. 4). The data of the water quality monitoring system are transmitted to the front-end data acquisition module of the water quality monitoring unit, and the data are transmitted to the water quality monitoring unit through the Bluetooth data acquisition module. CTD (temperature and salinity depth meter), temperature and humidity sensor, wind speed and wind direction sensor are connected with data acquisition device through serial port [11,12].

Among them, the core part of the monitoring terminal is CR1000 of Campbell company (815 W 1800 N Logan, UT 84321-1784 USA), which can be used to collect analog signals and digital signals of various sensors. ZigBee communication module mainly receives data sent by wireless sensor network through ZigBee wireless communication technology. The ZigBee communication module transmits the collected data to the data collector CR1000 through serial port. In order to monitor the monitoring area, due

Table 1
Node sensors

Sensor	Model	Brand	Measurement quantity	Precision and range
pH sensor	SensoLyt 700IQSW	WTW, Germany	pH value	2–12 < 0.02
Dissolved oxygen sensor	FDO 700IQSW	WTW, Germany	Dissolved oxygen (DO)	0–20.00 ± 0.02 mg/L
Salinity sensor	SAL-BTA	VERNIER	Salinity	0–50,000 ppm
Water temperature sensor	WQ101	GWI, USA	Water temperature	–50°C~+50°C ± 0.1°C

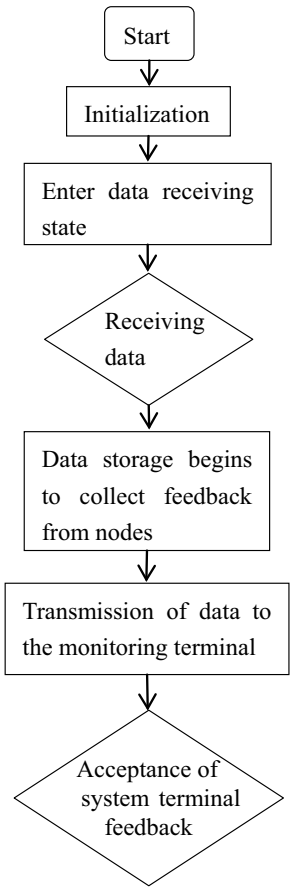

Fig. 3. Sink node workflow.

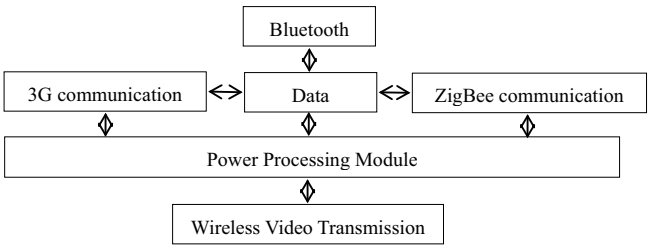

Fig. 4. Monitoring terminal structure.

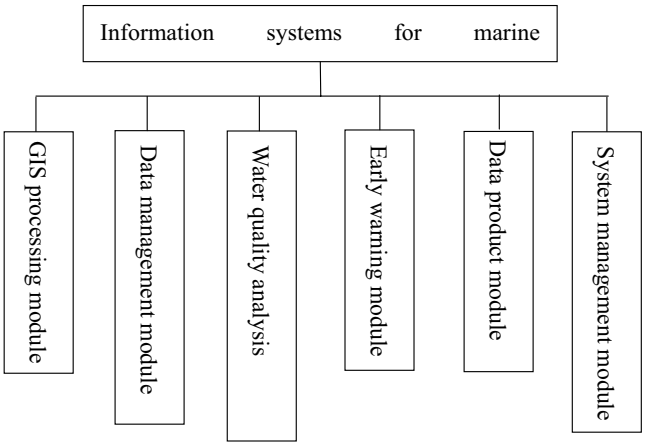

Fig. 5. Function division of management system.

to the implementation of all-weather video shooting, a huge number of data are generated every day. Considering the problems of transmission speed and cost, the point-to-point wireless microwave communication technology is adopted. It has the advantages of small size, light weight, practical function, stable performance and high-cost performance [13]. The longest outdoor transmission distance can reach more than 15 km, and the maximum throughput can reach more than 150 Mbps. Nano station M5 connects with the video camera through the Ethernet port, and transmits the video data captured by the camera to the monitoring center through wireless microwave in real time.

3.3. Software design

The software design of the system is based on the visualization function of geographic information system (GIS). The functional modules include GIS processing module, system management module, data management module, water quality analysis module, early warning processing module and data product module. According to the idea of structured programming, the functional modules of the system are divided as shown in Fig. 5.

Among them, its GIS (geographic information system) processing module mainly performs spatial data analysis and processing and interactive display of data and graphics. GIS can not only realize data storage and management but also perform spatial data analysis and processing and data and interactive display of graphics. GIS has many uses, the most common and best use is to provide data collection, data management and data analysis methods, and generate auxiliary decision-making information based on this. The main functions of GIS are data collection and editing, cartography, spatial database management, spatial analysis, spatial query, etc. The data storage of GIS is mainly realized through geodatabase, which is a data model that uses standard relational database technology to express geographic information. The information management system for marine environment monitoring is realized through GIS, which includes information extraction, thematic map production, statistical analysis, spatial analysis query and other functions.

The system management module mainly uses a hierarchical authorization system and password verification, and the administrator manages and maintains the security, consistency, and integrity of system users and databases. The users of the system are ordinary administrators and system administrators. Ordinary users can enter the system through the assigned account and password to query and export related data. In addition to all the permissions that ordinary users have, the system administrator also has the rights to manage ordinary administrators and system administrators. The system operation log records the user's work process in the system, including login time, logout time, and operated modules. When the user starts the log query module, the system retrieves the log records from the database and presents the results to the user in a list.

The data management module mainly processes the data uploaded from the monitoring, including temperature and humidity data, wind speed and direction data, CTD (temperature and salt depth meter) data, ADCP (water velocity profiler) data, etc., classified and stored in the database in Excel file format in, for other modules to call.

The water quality analysis module is mainly in accordance with the sea water quality standard of the People's Republic of China (gb3097–1997), and uses the space vector genetic cluster analysis method to obtain water quality classification. For the processing of multi-parameter data analysis of sea water quality monitoring, the data received by the monitoring center is all with massive data, the monitoring center takes a long time to implement further data processing and control measures. Therefore, data mining must be carried out before the confirmation and processing of abnormal conditions, from a large number of incomplete, noisy, and from fuzzy, random data, extract hidden, unknown but potentially useful information. Cluster analysis is one of the important methods of data mining, and the changes in marine environmental parameters are gradual, even if there is a national seawater water quality standards, but the analysis of water quality conditions not only requires comprehensive evaluation of multiple indicators but also has the characteristics of fuzzy transition [14]. Therefore, it is more reasonable to introduce the concept of membership degree and use the fuzzy c-mean (fcm) clustering method for analysis, which overcomes the rigidity. The classification is insufficient, but the fcm based on the objective function is a local optimization algorithm, which has the defects of being sensitive to initialization and difficult to obtain the global optimal solution. The number of clusters is also selected based on experience, lacking sufficient scientificity, and the clustering of massive data will waste a lot of time and resources; genetic algorithm (ga) is a random search algorithm with self-adaptability and self-organization developed based on the natural selection and evolution mechanism of the biological world, with global search and parallelism. Computing power is widely used to solve complex optimization problems. Genetic algorithms imitate the principle of "survival of the fittest" in the biological world, without special knowledge in the field of the problem to be solved, without processing all the data one by one, but randomly generating optimization problems A set of possible solutions, after genetic mutation operation, the global approximate optimal solution of the optimization problem can be obtained. Therefore, this paper adopts the space vector genetic clustering analysis method to process massive data, which can greatly reduce the amount of data processing, can obtain scientific reasonable processing results, and can also improve the response speed of the monitoring center to abnormal situations.

The early warning module mainly uses the simulation calculation of the water quality model to realize rapid early warning of marine water quality. According to the set early warning alarm method, the indicators are monitored and alarmed in real time. When the data value of the site reaches or exceeds the preset early warning value, the clock trigger inside the system program will automatically analyze the current monitoring data, a yellow alarm will be issued when abnormal, a red alarm will be issued when the limit is exceeded, and the related alarm information will be reminded on the page and displayed in the list in the form of flashing and text. After an alarm occurs, you can also call the function of viewing real-time monitoring data to understand the water quality of the sea water. Table 2 is the sea water quality alarm information table.

The data product module can store, display, query, and print the analysis results of seawater quality data.

3.4. Experimental test

In the monitoring experiment on the marine pollution situation along the coast of Jiangsu, it was found that the distribution of sampling point data in the multi-parameter feature space can realize the classification, identification and analysis of the sea water quality status, and conduct further monitoring and processing, and find and determine that the water quality is abnormal in sea areas. In addition, the data of monitoring points at different periods can also be analyzed.

4. Summary

Based on the wireless sensor network, this paper researches and proposes a marine pollution detection system. Based on wireless sensor network technology, a data acquisition system is constructed; wireless sensor networks, wireless microwave communication networks, wireless mobile communication networks, and the Internet are used to establish multi-level and multi-mode. The data network transmission model of the company built a monitoring system to realize seamless connection between multiple networks; combined the traditional fuzzy c-mean (fcm) clustering method and genetic algorithm, proposed a space vector genetic clustering analysis based on space vector genetic clustering to process massive monitoring data method and achieved good results.

Table 2
Sea water quality warning information table

Seawater warning indicators	Warning type
A monitoring element exceeds the fourth type water quality standard	Blue alert
Two monitoring elements exceed the fourth category water quality standards	Yellow warning
Three monitoring elements exceed the fourth category water quality standards	Orange warning
More than four monitoring elements exceed the fourth category water quality standards	Red alert

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