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Water Environment Monitoring System Based on Wireless Sensor Network

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Abstract: The working environment of water environment monitoring is relatively harsh, and it is not suitable for human beings to station for a long time. Wireless sensor network provides a new concept for this field, which not only has lower cost and power consumption, but also is more convenient for monitoring data access management in this network era, real-time monitoring. This is a revolutionary innovation for water environment monitoring in terms of actual function and equipment cost. The purpose of this paper is to study the construction of water environment monitoring system based on wireless sensor network. The data-related control flow of the microprocessor when the system is working is introduced in detail. Then the flow of the main program of the monitoring system is proposed, and four functional modules are designed: the data acquisition program of the nodes, the wireless communication program between the nodes and the GPRS sending short message program, and the performance of the system is tested by experiments. The results show that the application effect of the monitoring system meets the requirements.

1. Introduction

With the increasing emphasis on water resources, how to protect water bodies from pollution has also attracted much attention, and at the same time, higher requirements have been placed on the monitoring of water quality parameters. Water quality parameter monitoring plays an important role in water pollution defense and water body protection, but the methods used in actual water environment monitoring in my country can no longer cover the growing social needs and environmental protection [1-2]. At present, the water environment monitoring equipment on the market is relatively expensive, and the scalability of household equipment is low. Combined with the water environment monitoring methods currently used in my country, they cannot meet the

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needs of accurate analysis, and are not suitable for large-scale applications to process water quality parameters. The collected data information Generally, it is transmitted to the upper layer by wire, the distance is limited, and it is inconvenient to use. Unable to achieve random distribution of monitoring nodes, unable to obtain and manage accurate information in a timely and dynamic manner, unable to predict and prevent natural disasters and major pollution events in a timely manner, these drawbacks greatly limit the development of water environment monitoring. Therefore, the use of modern technology for water environment monitoring planning is extremely important and prudent, and it is also the most urgent task at present [3].

In recent years, the application of wireless sensor network in water environment monitoring system has become a research topic at home and abroad. Morozs N studies the application of underwater acoustic sensor network (UASN) in large-scale marine environment monitoring. The low propagation speed of acoustic waves presents a fundamental challenge to medium access control (MAC) that coordinates access of multiple nodes to a shared acoustic communication medium. A method to incorporate routing redundancy into the SDH-TDA-MAC protocol is also proposed, which achieves a good trade-off between network throughput and reliability [4]. Other scholars reviewed the operational framework and methods of remote sensing big data for water environment monitoring, focusing on water extraction and quantitative estimation of water quality. Researched state-of-the-art water extraction methods, including threshold-based methods, water indices, and machine learning-based methods; state-of-the-art models for quantitative estimation of water quality, including empirical, semi-empirical/semi-analytical, and machine learning-based models; remote sensing There are some deficiencies and three major challenges in big data water environment monitoring, namely, new data gaps caused by massive heterogeneous data, low water environment monitoring efficiency caused by "low spatial and temporal resolution", and low water quality accuracy [5]. Therefore, long-term monitoring of the water environment is an important basis for discovering water pollution sources and testing the effectiveness of measures.

This paper proposes the design process of the water environment monitoring system, using the wireless sensor network to select the high-performance, low-power microprocessor C8051F310 and wireless CC2420 radio frequency chips. Taking the hardware node as the core, a wireless wireless network hardware node that can collect the temperature, salinity and pH value of the water environment is designed, and the software and hardware of each functional module of the sensor node is designed.

2. Research on the Construction of Water Environment Monitoring System Based on Wireless Sensor Network

2.1. Wireless Sensor Networks

Wireless sensor nodes are miniature embedded devices, generally including some low-power sensors, embedded backplanes, communication chips and energy modules. These devices are mainly used to collect and process the signals obtained by the sensors, and different sensors basically determine the main role of the entire wireless sensor network [6-7]. Wireless communication provides a communication channel between sensor nodes and the outside world to exchange information, so that a single node can transmit the collected data to other nodes or upload it to a computer network through a sink node. Each part works in coordination with each other to ensure the normal work of the node [8-9].

2.2. ZigBee Network Topology

The two network topologies of ZigBee wireless sensor network are as follows:

In the star network topology, by selecting a PAN authentication number that is not used by other nearby networks and configuring it, then searching for the terminal device that sends the request to join and confirming it, so as to complete the startup and normal work of the entire network [10] .

Tree-type network topology can be said to be a special form of mesh topology. In tree-type networks, information transmission between nodes can often be relayed by routers to achieve the purpose of increasing network coverage. When there are geographical barriers such as obstacles in the working environment, the multi-hop transmission of information can be completed by increasing the number of nodes. At the same time, due to the complexity of the tree network, its robustness is also the best among the three types of networks [11-12].

2.3. System Design Goals

According to the characteristics of water environment monitoring, the following design goals are proposed for the water environment monitoring system:

(1) In the monitored water environment area, it is necessary to select the wireless sensor network technology with low cost, low power consumption and strong self-organizing network capability, and combine with the relevant routing algorithm suitable for the application of water environment monitoring [13].

(2) The network base station is responsible for the collection and remote transmission of the entire network information, and is also the hub connecting the wireless sensor network and the data processing center of the upper computer, and should have strong data processing capabilities [14].

(3) With the advancement of science and technology, there are more and more acquisition parameters for water environment monitoring. In recent years, requirements for image and video information of the monitoring environment have also been put forward. In the selection of mobile communication technology, high-speed and high-bandwidth data should be selected. related technology [15].

3. Design of Water Environment Monitoring System Based on Wireless Sensor Network

3.1. The Data Control Flow of the Microprocessor

The communication between the wireless communication module CC2420 and MSP430F1611 is mainly completed by means of SPI bus and interrupt. The interrupt mainly uses the P1 interrupt, and the SPI uses the P3 port. It is realized by four-wire SPI bus (serial digital input SI, serial digital output SO, serial shift clock SCLK, and read the status information of CC2420 through SPI bus again, check the interface status of FIFO and FIFOP pins, To put the chip in transmit or receive mode, the MCU uses an interrupt to read and write the CC2420 of the first-come-first-register output (FIFO) to receive wireless communications. Idle channel evaluation is performed by reading the CCA pin status information of the CC2420. SFD is used for clock control or Timing information input control, MCU sends timing information to CC2420 by connecting the SFD pin of CC2420, indicating Frame Data Start (especially for beacon network).

3.2. Main Program Design

In the whole monitoring system, the software design adopts the modular idea. The software design mainly includes data collection of nodes, data routing and transmission between nodes, data transmission of aggregation nodes to GPRS module, GPRS networking, GPRS communication, data transmission, etc. The short message is sent in these six parts.

3.3. Node Data Collection Procedure

In this system, through A/D conversion, the collected voltage signal is converted into a 12-bit digital signal, and the water dissolved oxygen and water temperature data are stored in the FLASH chip, so that the monitoring host can query the data in real time. In addition, by controlling the A/D conversion time, the acquisition node can also change the sampling frequency of the data. The performance indicators that ADC need to pay attention to are resolution, quantization error, conversion accuracy, conversion time, etc. MSP430F1611 microcontroller contains ADC12 module. When ADC12 converts, it needs to deal with the following problems: set specific mode; input analog signal; select start signal; pay attention to conversion end signal, etc.

3.4. Wireless Communication Procedures between Nodes

The wireless communication program between nodes consists of two parts: one part is responsible for completing the communication with the CC2420 module, and controlling the CC2420 module to realize the function of sending and receiving wireless signals. The other part is responsible for parsing and processing the received wireless signal command group, executing the relevant commands, and using wireless communication to return the corresponding data information or confirm the frame signal.

3.5. GPRS Communication Programming

First, initialize the single-chip microcomputer; then start the GPRS module, and perform the initial configuration of the GPRS module; Then continue to connect to the network; when the connection is successful, check whether the data is received, if not, continue to wait, if so, send the received data.

4. Accuracy Detection of Water Environment Monitoring System

4.1. System Detection Method

In this work, parameters such as temperature, salinity and pH were tested in the aquatic environment. Since both salinity and pH are affected by water temperature, a current water temperature calibration must be completed to obtain accurate sensing data.

In order to simplify the calculation and improve the performance, this paper performs fitting according to the least squares method.

salinity(%):

$$y = 85x3 - 60x2 + 40x + 0.05 \tag{1}$$

pH value:

$$y = K(x - B) \tag{2}$$

Where x represents the A/D sampling output voltage value, and y represents the actual measured value.

4.2. Test Results and Analysis

The system accuracy test uses a 78HW-1 constant temperature magnetic stirrer at temperatures of 10 ℃, 20 ℃, 30 ℃ and 40 ℃, respectively. The experimental data are shown in Table 1, Table 2, and Table 3, respectively.

Table 1. Temperature measurement experimental data

Temperature ℃	The output voltage
10	0.5
20	0.6
30	0.7
40	0.8

Table 2. Experimental data for salinity measurement

The output voltage (V)		Salinity%	
		10	20
Temperature ℃	10	0.25	0.56
	20	0.28	0.59
	30	0.31	0.61
	40	0.35	0.66

Table 3. pH measurement experimental data

The output voltage (mV)		pH	
		5	10
Temperature ℃	10	510	650
	20	580	669
	30	610	680
	40	620	688

After temperature compensation or correction for these data, users can query the data in two ways: query by node and query by date. When querying data by node, after the user selects (multiple selection) the relevant node number to query, the system will automatically access the background database, perform keyword matching, and automatically filter out the information related to the keyword node number and display it in the table below the middle. When querying data by date, there are 3 ways to choose: before a certain time point, before a certain time period, and a certain time point, the user can only select one way to query, check the small box in front of the text box to select by date Query mode, enter the specific time to realize data query.

The results of the data inquired by the temperature experiment are shown in Figure 1, and the experimental results when the pH value = 10 are shown in Figure 2.

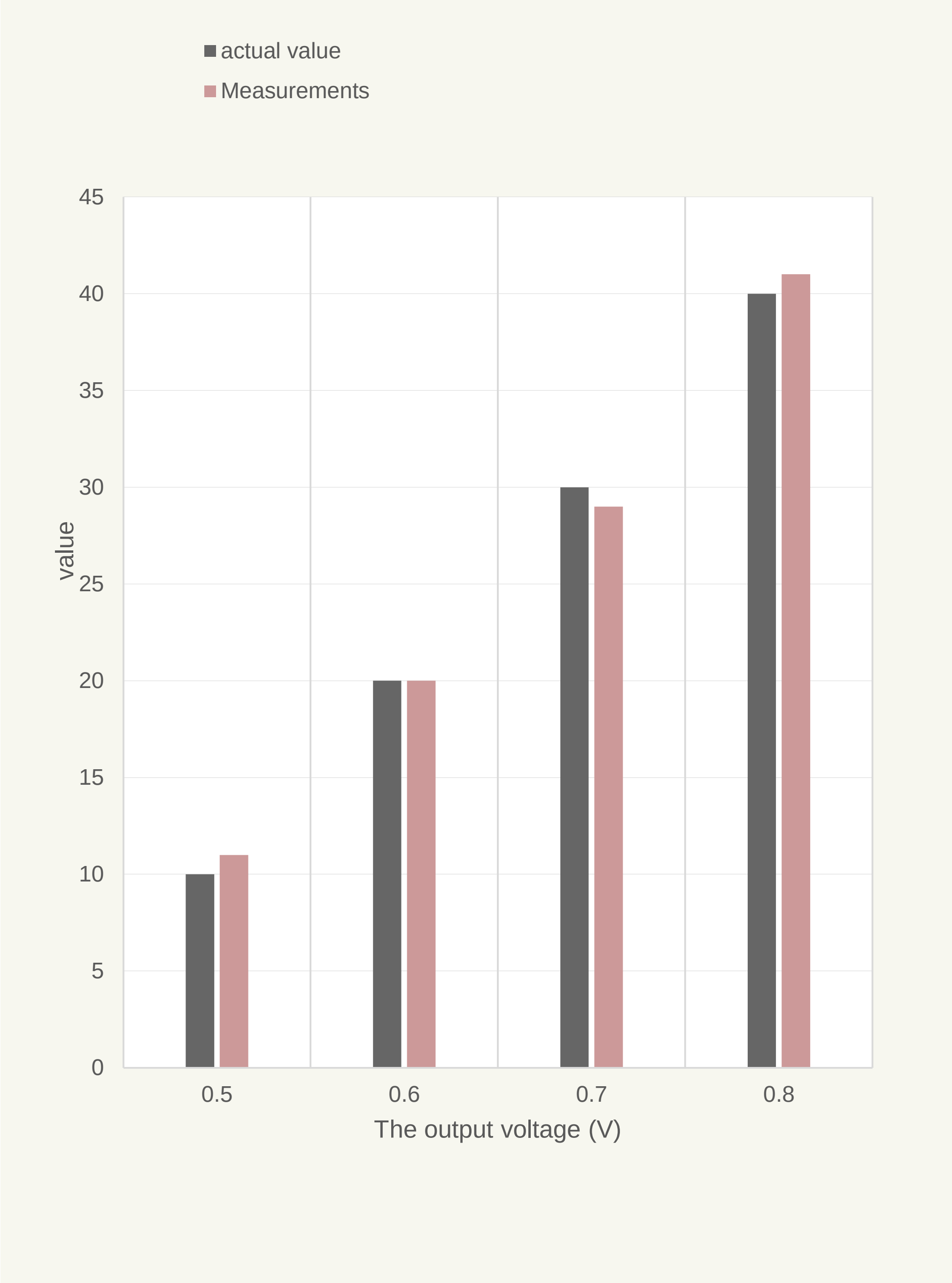

Figure 1. Comparison of measured and actual temperature values

According to the comprehensive data results, it is concluded that the measurement accuracy of the system is: temperature measurement accuracy: <+1℃, salinity measurement accuracy: <+0.3%.

pH measurement accuracy: <+0.1 The experimental results fully meet the system design requirements, and the results are satisfactory.

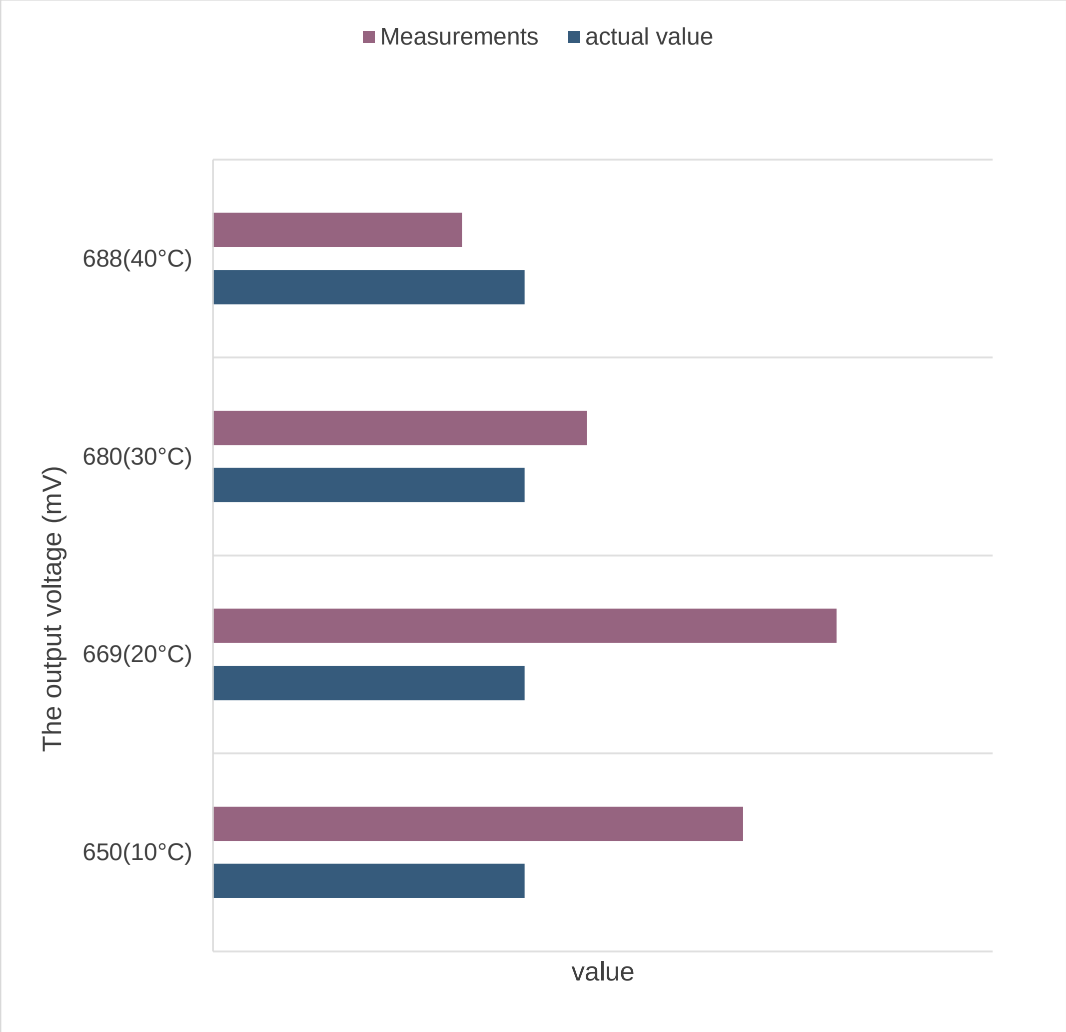

Figure 2. Standard solution at pH=10

5.Conclusion

This paper designs a water environment monitoring system based on wireless sensor network, including software and hardware design, and realizes the functions of collecting data. The advantage of this monitoring system is that it can be easily transplanted to various fields of environmental monitoring, and realize automatic monitoring and intelligent management of environmental information. There are still many areas worth improving in this system. The idea of follow-up work is as follows: adding a design that can intelligently affect the water environment factors in the system; because the wireless sensor network has a wide range of applications, due to the limitations of each hardware node and the difference of each platform Properties, whether building a network or testing a protocol, needs to be assessed objectively. In view of this, it is necessary to use network simulation technology for network planning and design.

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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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