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A Monitoring and Control System for Aquaculture via Wireless Network and Android Platform

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Abstract: Web applications, databases and advanced mobile platform can facilitate real-time data acquisition for effective monitoring on intelligent agriculture. To improve facilities for aquaculture production automation and efficient, this paper presents an application for wireless network and Android platform that interacts with an advanced control system based on Apache, SQL Server, Java, to collect and monitor variables applied in aquaculture. The test and application shows that is stable, high price-performance ratio, good mobility and easy to operate, It has a strong practicality and application prospects. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Aquaculture, Remote monitoring, Wireless network, Android.

1. Introduction

One of the most important changes in the southeast of China is the switch from traditional Aquaculture to intensive Aquaculture. For this type of Aquaculture, it is important to use advanced techniques to improve automation and efficiency. Wireless Sensor Networks (WSNs) represent an emerging technology that yields flexibility in sensor installation and network robustness, while reducing both maintenance complexity and the associated costs (Li *et al.*, 2011) [1]. Previous work (Shi *et al.*, 2011) [2] has contributed to industrialized aquaculture through the implementation intelligent monitoring system based on Wireless Sensor Networks. Researchers used computer-controlled technology, web technology, GPRS and GSM technology [3] to develop and design a range of facilities environment, remote monitoring and control systems [4], which have played positive roles in promoting the development of Chinese aquaculture facilities.

However, current trends are converging on mobile technologies. Smartphones are a common and important part of our daily life primarily because they are portable, ubiquitous, small and light. In recent years, the Android operating system and Android Smartphone have developed rapidly, especially since the launch of the Android 3G smartphone fewer than 1000 Yuan (RMB). The Android operating system is open source and free, it not only reduces the system development costs, but also has a better human computer interaction technology because of object-oriented Java language supporting. Therefore, many applications based on Android platform are under development in several science and engineering fields [5-7]. Similarly, Aquaculture is adopting such changes, and several Aquaculture applications have been generated [8] describe real-time mobile phone applications.

The primary objective for this paper is to develop and integrate a multiplatform application for advanced intensive Aquaculture monitoring and

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control. It describes a system that is based on Android technology, Socket technology and Java technology, Wireless Sensors Networks, over Android application terminals to monitor and control water quality of Aquaculture.

This paper is organized as follows: Section 2 describes the materials and methods used, Section 3 shows the results and Section 4 includes the concluding remarks.

2. System Architecture

The article based on Android platform for the real Aquaculture environment monitoring system status, combines Wireless Sensors Networks, and gives the design of system architecture. The figure of system architecture shows as Fig. 1.

As Fig. 1 shows, the system architecture contains perception layer, transport layer and application layer. Application layer is based on the Web applications and Android Smartphone application terminal for sending and checking relevant instruction and information by human-computer interaction. Transfer layer refers to the entire system operation that depends on network environment. The data transmission of the system is by ZigBee and 3G network. Perceptual layer contains water quality parameter collector (Do, pH, temperature, water level, Salinity, Turbidity, nitrite), and water quality parameter regulator, such as, aerator, drainage pump, water pump and other facilities environmental site implementing agencies.

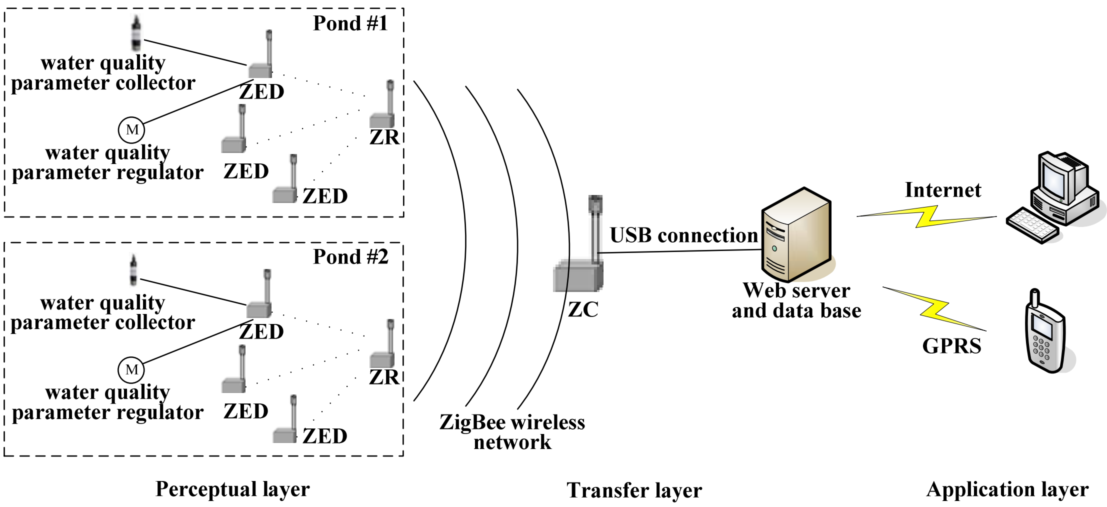

Fig. 1. System architecture.

3. System Hardware

The following points describe the hardware used to implement the system.

Aquaculture devices: It contains water quality parameter collectors and water quality parameter regulators as shown in the left of Fig. 1. Do sensor is Do-952 oxygen electrode. PH sensor is E-201-C type composite electrode developed by Leici Company. In addition, there are water level sensor and temperature sensor and so on. These are water quality parameter collectors, while aerator, drainage pump, water pump are aquaculture regulators.

ZigBee devices: Electronic devices based on the "ZigBee'' platform have been used to deploy the WSNs, which is composed of a ZigBee coordinator (ZC), ZigBee Routers (ZR) and many ZigBee End Devices (ZED). We use System-on-Chip (SoC) CC2430.These devices are responsible for acquiring the data from aquaculture devices and transporting data or commands. The sampling time is 5 min.

4. System Software

The ZigBee network flow chart of main program is shown in Fig. 2.The following points describe the software used to implement the system.

4.1. Lower Computer Application

Implementation in OSAL: The ZigBee modules were programmed with OSAL Operating System. The network nodes make use of Z-Stack protocol stack, which is implemented in OSAL. Communication was supported by links comprising one or more hops across nodes depending on the wireless coverage between the node and the coordinator node.

ZigBee coordinator (ZC): ZC at power-on initialization state, the event of triggering the key determines the device as a coordinator. It starts the network originally, then enters the monitor and waits state of the network. Upon receiving the request from the child node for joining network, assigns a network address, and transmits a confirmation message to the child node, establishes a binding connection. Then, the coordinator waits for the data request, after receiving the data transmitted from sensor nodes, analyzes the data packets, confirms that the information is the data information, data will be communicated with the server and the other interface through the serial link.

ZigBee Routers (ZR): ZR at power-on initialization state, the event of triggering the key determines the device as a router.it triggers the ZDO_StartDevice () function, and sets ZDO_Config_Node_Descriptor.LogicalType as NODETYPE_ROUTER and devStartMode as MODE_JOIN. It can participate in the route discovery, forward information, and extend the network by connecting the nodes etc. In addition, it can gather information as a ZED.

ZigBee End Devices (ZED): ZED at power-on initialization state, the event of triggering the key determines the device as an end device. It scans channel and attempts to join the appropriate network. After successfully entering into the network, a 16 bit network address is sent to the coordinator, if receives data information, the program begins to enter the application layer, calls the mission processing function, triggers the corresponding task event function. Such as MY_REPORT_TEMP_EVT event, MY_REPORT_ PH_EVT event, then starts A/D acquires parameters value. CC2430 has 8 inputs of 8 ~ 14 ADC. It first selects the acquisition input channel, sets related port and configures register. Data stores in the ADCH and ADCL registers, waiting to be sent to the coordinator.

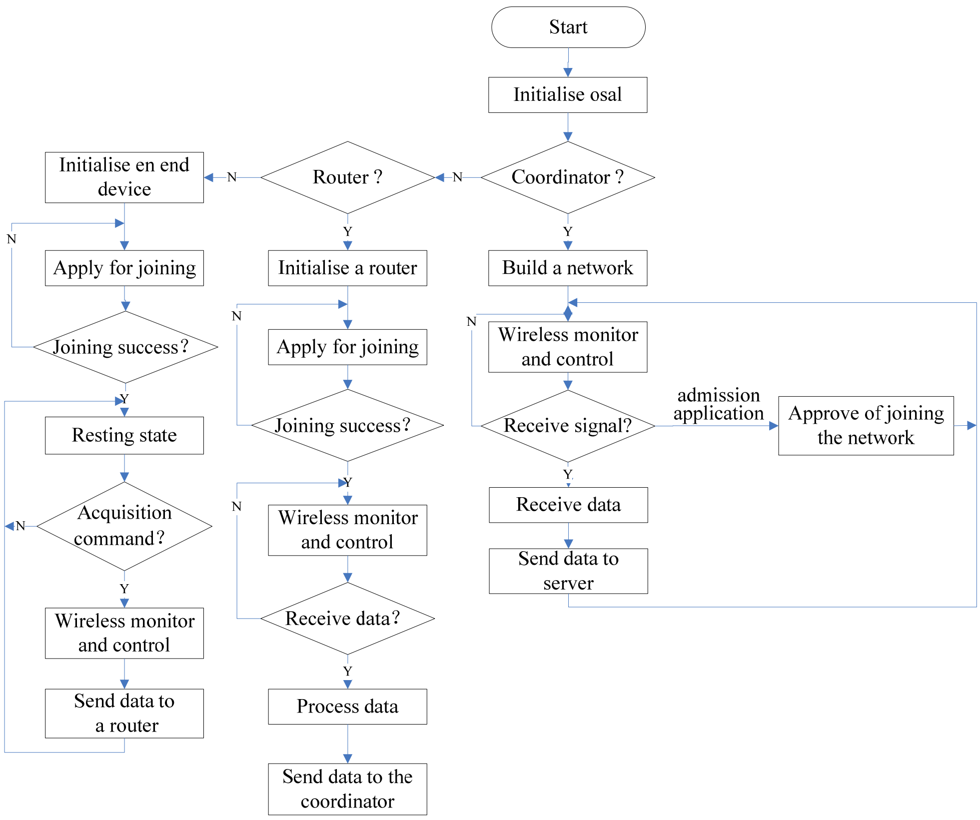

Fig. 2. ZigBee network flow chart of main program.

4.2. Upper Computer and Web Application

The coordinator is connected to upper computer through the RS-232 serial port Microsoft Visual Basic 6.0, as a development tool, it is used in the communication program development of the upper computer and Web application. It provides many methods for serial communication. The system adopts MSComm control provided by Windows system to develop serial communication program, which has the advantages of simple operation, powerful function. Attribute of the control sets serial, event of the control drives serial response, and method of the control makes serial port send and receive data. In addition, the system chooses SQL Server 2000 as the database, to preserve data, which is convenient for the operator to analysis the historical data.

Upper computer can be connected to internet through the wireless network, and now in fact, it is connected to remote PC monitor terminal or Android platform. The web application is very necessary. Our web application is divided in six sections as shown in Fig. 3: Real time monitor, Equipment control, Data query, Curve analysis, Map view and Data back-up. The Real time monitor section mainly supplies environmental parameters (Do, pH, temperature, water level, Salinity, Turbidity, nitrite, work state of the motor), and is also used for server to checks communication state of ZigBee node. Equipment control section is used to control Aquaculture devices, such as aerator, drainage pump, and water pump when the users feel it is need to adjust the water quality. At first it sends commands to the lower computer, and then lower computer interprets the commands to corresponding timing signal and directly controls equipment. Data query section provides a table if given a query. Environment parameters can also be displayed in chart through a given time period in Curve analysis section. The global map of fish ponds are given in Map view section. With developer access to data backup, it is easy for storage, data report print, as a historical record.

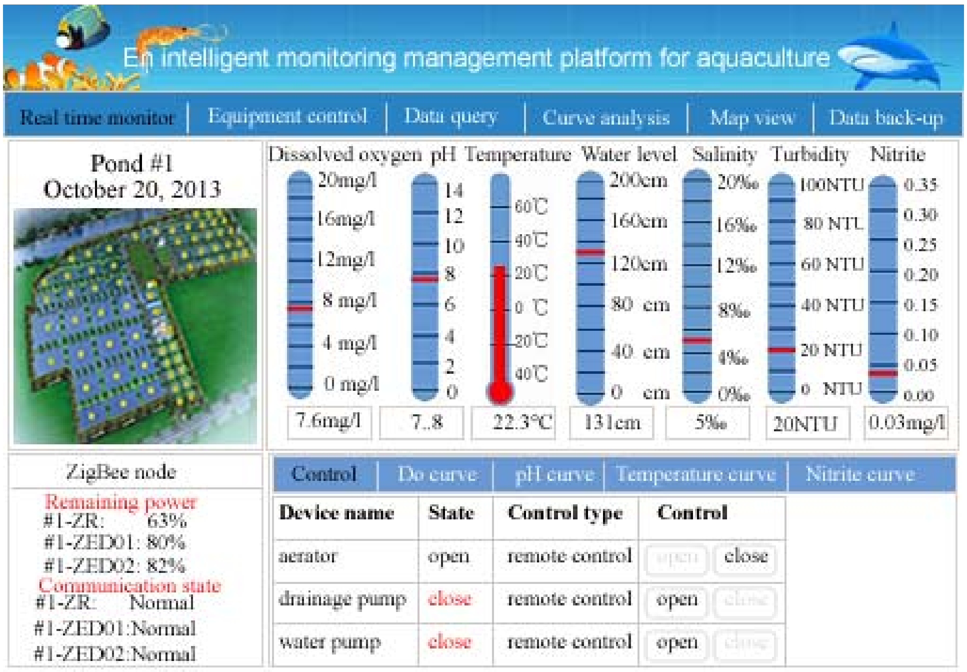

Fig. 3. Main control interface of upper computer and Web application.

4.3. Android application:

The development environment of Android application program is built over JDK6 +Eclipse3.5+Android SDK+ADT. The system adopts the client/server mode. The server adopts VB, SQL and SOCKET programming. The client uses Android JAVA development, whose data storage uses its own database SQLite, SOCKET completing network communication. Finally, it generates APK file after compiling. In Android platform, users can connect the server through IP and port number, and monitor or control the Aquaculture environmental parameters according to the flow chart shown in Fig. 4. Without such monitoring system, they should go to the pond to ensure that everything works properly. Fig. 5 shows three screens of Android application. The farmer can have it launched on the pc, or on the phone. The core technology is as follows.

4.3.1 Design of Communication Module

This system uses SOCKET communication based on TCP/IP protocol. In order to improve the efficiency of communication system, the receiving section of SOCKET communication is executed in a separate thread. Firstly, we use the domain name (IP address) and port of the server to create a new SOCKET connection, send a connection request to the server by the port number. If the connection is not successful, the client throws an exception. If successful, the client starts listening, receives from the environmental parameter information from the specified port of the server. Specific receiving parameter format is as follows: temperature of No. 1 fish ponds, DO of No. 1 fish ponds, pH of No. 1 fish ponds, aerator of No. 1 fish ponds, drainage pump of No. 1 fish ponds, water pump of No. 1 fish ponds and so on. Each data occupies 4 bytes.

Transmission and reception of data is in the data stream. Data needs character code conversion. In the implementation of communication program, in the configuration file manifest.xml, the user should declare permission, otherwise it is impossible to use. The user can manually set the address and port, add them to the database. A set can be preserved permanently, and then in the next communication the system searches the database, get out the communication parameters to communicate with remote servers.

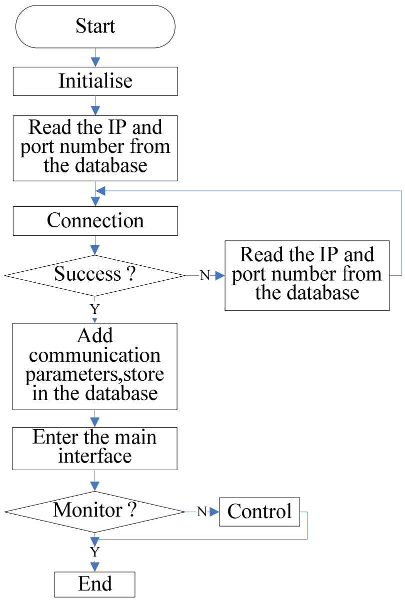

Fig. 4. Main control flow chart of aquaculture monitoring on Android platform.

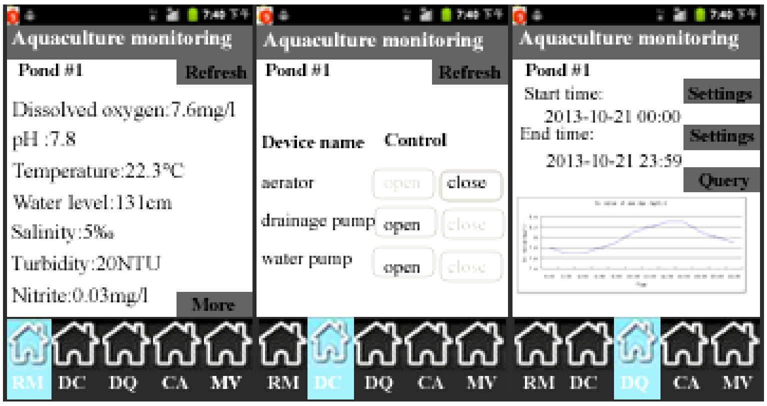

Fig. 5. Main control interface of aquaculture monitoring on Android platform.

4.3.2. Design of Data Access Module

In this module, it could update, real-time query and store the data of environment parameter from the remote server. Taking into account the limited capacity of the SQLite database of the mobile phone, the system could store all the information in a text to user's SD card.

4.3.3. Design of Data Processing Module

Global variables can't directly share between different Android Activity. We use Bundle putString and getString functions to transfer data between Activities, Respectively for transferring data to the source Activity and getting data from target Activity. The specific implementation is as follows:

1) Transferring data to the source Activity

bundle. putString ("DO_1", DO_s1); // transferring DO to the source Activity

bundle. putString ("wl_1", wl_s1); // transferring water level to the source Activity

2) Getting data from target Activity

DO_s1=bundle. getString ("DO_1"); // getting DO from target Activity

wl_s1=bundle. getString ("wl_1"); // getting water level from target Activity

5. Results

The experiment was carried out within intensive fish tanks, aquatic breeding site, located in Liyang city, Jiangsu province, China. Each fish tank is approximately 30 m*30 m*1.5 m. The purpose is to obtain real-time temperature, water level, pH value and Do in water quality parameter information, at the same time, to control water level and the dissolved oxygen. The aerator increases oxygen based on frequency converter, and its motor parameter is 380 V, 2.2 kW, rated speed 1470 r/min. Drainage pump and water pump control water level.

To validate the accuracy of the system, two sets of data sampled though different strategies (manually and automatically) have been compared. Manual measurement means farmers need to go to the pond to measure the water personally. The result in this way is called reference standard, while the result from our system is named actual one. We use 24 h uninterrupted testing on the pond. Table 1 provides comparisons with automatic and manual measurement of water quality parameters.

From Table 1, an excellent result is achieved that the temperature measurement accuracy of the system is within ± 0.6 ºC, pH precision is within ± 0.3. When dissolved oxygen is set to 8 mg/L, under the action of the control devices, its precision is kept within ± 0.3 mg/L, satisfying the requirement of aquaculture. The fluctuation of water level is controlled in ± 1 cm.

It can be seen from Fig. 6, the multi-parameters relative error is very low. The result is not influenced by environmental factors, and data control is stable, reflecting the strong robustness of the control system. The response time of remote control motor is within 100 ms, fully meeting the real-time requirement of the system.

Table 1. Comparisons with automatic and manual measurement of water quality parameters.

Time	Do /mg•L-1		Temperature / ºC		pH		Water level /dm	
	Actual	Standard	Actual	Standard	Actual	Standard	Actual	Standard
0:00	7.8	7.8	20.4	20.0	8.0	8.1	13.0	13.1
2:00	7.8	7.7	21.0	21.1	7.5	7.6	13.0	13.1
4:00	8.2	7.7	20.6	21.2	7.8	7.7	13.1	13.1
6:00	8.3	7.8	22.5	22.1	8.0	8.0	12.9	13.0
8:00	7.7	7.9	23.8	23.6	8.5	8.2	13.1	13.0
10:00	8.1	8.1	24.5	24.0	8.2	8.3	13.0	13.1
12:00	8.1	8.2	25.2	25.8	8.3	8.3	13.2	13.1
14:00	8	8.3	26.1	26.3	8.6	8.5	13.0	13.1
16:00	8.2	8.3	25.4	25.6	8.5	8.5	13.0	13.1
18:00	7.9	8.1	24.5	24.9	8.5	8.4	12.9	13.0
20:00	8.1	8.0	23.3	23.0	8.3	8.4	13.0	13.0
22:00	8.1	7.9	21.2	21.6	8.2	8.1	13.1	13.0

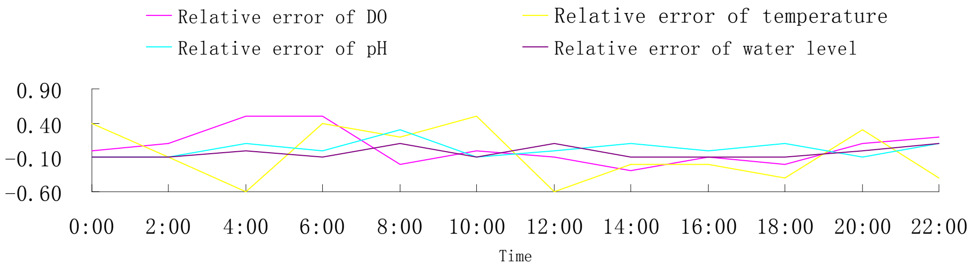

Fig. 6. Relative error of water quality parameters.

6. Conclusions

In this work, we described and tested a Web and Android application for monitoring and control purposes in intensive high-effect ecological aquaculture. It can simultaneously operate with several installations, which allows the manager or farmer to control ponds through a better decision-making process. The use of this system instead of manual systems can cost savings and benefit productivity. At present, this system has been applied successfully in intensive aquaculture research demonstration of Liyang city, Jiangsu province, China. So it has a widely application value and market prospect in factory aquaculture, water environment, and many other fields of intelligent greenhouse.

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References

[1]. Li Z., Wang N., Franzen A., Taher P., Godsey C., Zhang H., Li X., Practical deployment of an in-field soil property wireless sensor network, *Computer Standards & Interfaces*, 2011, http://www.sciencedirect.com/science/article/pii/S0920548911000651

[2]. Shi Bing, Zhao Dean, Liu Xinqiao, *et al*., Intelligent monitoring system for industrialized aquaculture based on wireless sensor network, *Transactions of the Chinese Society of Agricultural Engineering*, 27, 9, 2011, pp. 136-140.

[3]. Du Z. G., Xiao D. Q., *et al*., Design of water quality monitoring wireless sensor network system based Oil wireless sensor, *Computer Engineering and Design*, 17, 2008, pp. 4568-4570.

[4]. Wang Z., Hao X. Q., *et al.*, Remote Water Quality Monitoring System Based on WSN and GPRS, *Instrument Technique and Sensor*, 1, 2010, pp. 48-52.

[5]. Liu Shengqian, Chen Liding, Design and implementation of vehicle's navigation system based on the android, *Automation and Instrumentation*, 4, 2012, pp. 1-4.

[6]. Han Di, Pan Zhihong, Somatic Operation based on sensor of android mobile devices, *Journal of South China University of Technology: Natural Science Edition*, 40, 9, 2012, pp. 75-80.

[7]. Noma M., Saiwaki N., Itakura S., *et al*., Composition and Evaluation of the Humanlike Motions of an Android, in *Proceedings of the 6th IEEE-RAS International Conference on Humanoid Robots*, Genova, 2006, pp. 163-168.

[8]. Yanle Wang, Changsong Qi, Hongjun Pan, Design of Remote Monitoring System for Aquaculture Cages Based on 3G Networks and ARM-Android Embedded System [C], in *Proceedings of the International Workshop on Information and Electronics Engineering (IWIEE' 12), Procedia Engineering*, 29, 2012, pp. 79-83.

[9]. Huang Jianqing, Wang Weixing, Jiang Shen, Development and test of aquaculture water quality monitoring system based on wireless sensor network, *Transactions of the Chinese Society of Agricultural Engineering*, 2013, 29, 4, pp. 183-190.

[10]. Liu Xingguo, Liu Zhaopu, Wang Pengxiang, Aquaculture security guarantee system based on water quality monitoring and its application, *Transactions of the Chinese Society of Agricultural Engineering*, 25, 6, 2009, pp. 186-191.

[11]. Bing Zhigang, Lu Shengli, Liu Jingtai, Research on sensor networks for precision irrigation, *Chinese Journal of Scientific Instrument*, 27, 6, 2006, pp. 294-296.

[12]. A. Ribeiro, G. B. Giannakis, Bandwidth-Constrained Distributed Estimation for Wireless Sensor Networks-Part I: Gaussian case, *IEEE Trans. Signal Processing*, 54, 3, 2006, pp. 1131-1143.
