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Research and development of water quality online monitoring system based on Internet of things technology

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ABSTRACT

With the continuous development of social economy, water environment pollution and water quality are being taken seriously gradually. Water quality monitoring is an important way to prevent water pollution. With the mature application of Internet of things technology, it has more application space in the water quality monitoring than the Internet. The traditional manual water quality monitoring methods will be replaced gradually by wireless real-time water quality monitoring technology. This paper intends to build a water quality online monitoring system. It uses the Internet of things to combine with sensors to monitor the water quality status in real time and transmit various data in real time. It can provide safe and reliable water quality monitoring and water quality data analysis services for environmental protection agencies, aquaculture, and household water use.

Keywords: Water quality monitoring; Internet of things; Online monitoring

1. Introduction

The vast majority of surface water on the earth is neither potable nor toxic. This remains true when seawater in the oceans (which is too salty to drink) is not counted. Another general perception of water quality is that of a simple property that tells whether water is polluted or not [1]. In fact, water quality is a complex subject, in part, because water is a complex medium intrinsically tied to the ecology of the earth [2]. Industrial and commercial activities (e.g., manufacturing, mining, construction, and transport) are a major cause of water pollution as are runoff from agricultural areas [3], urban runoff, and discharge of treated and untreated sewage [4]. Water quality refers to the chemical, physical, biological, and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed [5]. The most common standards used to assess water quality related to health of ecosystems, safety of human contact, and drinking water.

The Internet of things (IoT) is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity which enable these objects to connect and exchange data [6]. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. The IoT architecture is shown in Fig. 1.

The IoT allows objects to be sensed or controlled remotely across existing network infrastructure [7], creating opportunities for more direct integration of the physical world into computer-based systems and resulting in improved efficiency, accuracy, and economic benefit in addition to reduced human intervention [8]. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, virtual power plants, smart homes, intelligent transportation, and smart cities [9].

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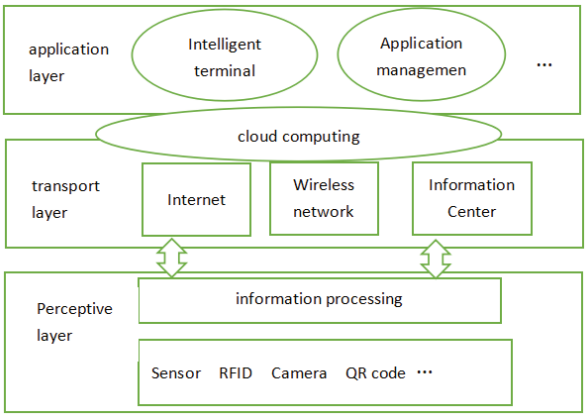

Fig. 1. Internet of things architecture.

Through the reference of IoT technology, our water quality monitoring means a better expansion, using IoT technology to realize an online real-time automatic control water quality monitoring system. The whole system can take advantage of the integrated use of the Internet technology, and Internet technology [10], through effective and reasonable hardware design and the choice and then combined with the software part of effective control and human intervention, can realize real-time online monitoring of water quality [11], to aquaculture or reservoir environmental monitoring provides effective and reliable data.

2. IoT technology

In the setting of standards, agencies make political and technical/scientific decisions about how the water will be used. In the case of natural water bodies, they also make some reasonable estimate of pristine conditions. Natural water bodies will vary in response to environmental conditions. Environmental scientists work to understand how these systems function, which in turn helps to identify the sources and fates of contaminants. Environmental lawyers and policymakers work to define legislation with the intention that water is maintained at an appropriate quality for its identified use [12].

The vast majority of surface water on the earth is neither potable nor toxic. This remains true when seawater in the oceans (which is too salty to drink) is not counted. Another general perception of water quality is that of a simple property that tells whether water is polluted or not. In fact, water quality is a complex subject, in part, because water is a complex medium intrinsically tied to the ecology of the earth. Industrial and commercial activities (e.g., manufacturing, mining, construction, and transport) are a major cause of water pollution as are runoff from agricultural areas, urban runoff, and discharge of treated and untreated sewage.

The use of the IoT technology, basic work is also dependent on the Internet technology, can provide the link, which is the traditional simple exchange of information between computers, into the actual items, and items can be a kind of communication between the technologies [13], the communication between them can make content and content to provide more convenience for our life. Equally IoT technology will be identified by identifying the equipment, or the use of induction equipment for induction, and then by processing and transmission equipment for data transmission of information, realize the communication between different devices together to complete a complex work [14], so that it can realize a starting device of automatic identification, the device of automatic tracking, then to monitoring in the whole process of the equipment, realize the regulation of the whole information compound technology the IoT, such as the Internet technology has now been considered as the "Internet of things technology" [15].

To through the establishment of a system of IoT, for the water quality automatic monitoring in the whole process of the needs in surface waters of the monitored node layout of the whole system, completes the collection part of the whole system, the processing of the whole water node arrangement and the need to use equipment node is as follows: the first is the sensor part of the core (water quality monitoring of water quality and water quality parameters adjusting parameter sensor node), and then was part of the information collection (including video surveillance equipment, the formation of a video monitoring system), then transmission equipment (including wireless gateway, using GPRS gateway communication [16]. Also, video signal transmission USES 3G signal transmission. And cable transmission link) in the server, the last is the central parts of the processing (server, a processor and a logic unit, and manual control part, and artificial monitoring section).

The function of these parts is through the sensor to collect the situation of the water quality directly, including the water quality of acid and alkali, the oxygen content in the water, the water temperature, environmental temperature, water level, water is an important part of the acquisition; then video monitor, monitor the operation of regional water quality monitoring system, can see the situation of the area, real time of abnormal condition can be found in a timely manner, and for processing; then the GPRS and 3G signal of the sensor information and video monitor information transmission to the server at the same time. Finally is through the server for the processing of signal, can the realization of the automatic monitoring of water quality, the system can automatically call the water pump, or some aerobic filter device, the realization of the start of water quality monitoring and adjustment, for there is no way to deal with the monitoring system, start the alarm inform artificial processing, combination of remote video equipment and operation, can realize the process of artificial control, base to manual by mobile phone, tablet and computer real-time receiving and processing information.

3. Design of the hardware in the system

3.1. Overall system design

The water quality detection system of the IoT can be used to detect the water quality in the culture area or the reservoir area. The selected sensors should have the following functions. At the same time, the sensor should be able to realize the transmission function of the information and realize the automatic processing function of the signal acceptance. Water quality test is mainly to test the acidity of water, oxygen content of water, water temperature, turbidity of water, and other indicators [10]. Five basic parameters were measured in detail, as shown in Table 1, in reference to the

national standards and the performance of the sensor and the requirements of the actual water environment detection. The measured physical quantities in this design are designed according to Table 1.

The water quality monitoring system based on IoT is composed of client terminals, servers, wireless gateways, controllers, and water quality sensors. The overall structural design block diagram of the system is shown in Fig. 2.

The water quality sensor detects the water quality information and sends it to the controller. The controller accesses the wireless gateway through communication, then uploads the water quality information to the server, and stores it in the database. The client terminal accesses the server through the Internet, then obtains information on the water quality and water quantity parameters in the database, and then makes a judgment on whether the measured water quality conforms to the standard according to the urban sewage regeneration and utilization standards. Finally, the specific parameter information and judgment results are displayed on the client terminal, so as to achieve remote monitoring of water quality.

The hardware part of the system is constructed from the three levels of perception, control, and execution. The overall block diagram of its hardware is shown in Fig. 3.

3.2. Design of interface circuit

Node design should consider to have the effect of signal amplification can be stable transmission over a long distance so it is best to choose a wireless signal gain profit zoom function of signal transmission node interface, the design of the circuit to be able to and transmission equipment to connect the general electric road. Often interface voltage and circuit voltage sensing equipment requirements. So you need to modify the interface signal equipment circuit and make it match the sensing devices and signal transmission devices are to be able to run smoothly.

Table 1
The parameters being measured indicators

Parameter	Range	Resolution	Deviation
pH	2–12	2–12	2–12
Water temperature (°C)	0–100	0–100	1%
Conductivity (mS/m)	0–500	0.1	1%
Dissolved oxygen (mg/L)	0–20	0.01	0.1
Turbidity (NTU)	0–100	0.01	2%

3.3. Design of control circuit

Mainly is to the equipment that adds oxygen, water pump equipment to add a braking controller, this controller can automatically and signal transmission equipment connected through the received signal, automatically adjust control, make the equipment that add oxygen, water pump equipment can realize automatic switch, achieve the function of water quality automatic adjustment.

Need to design the transmission signal of the whole system at the same time, and the communication module, and to design a good reception transmission part of the CPU part, to join the storage unit to be able to connected with the Internet, and achieve energy-saving automatic control.

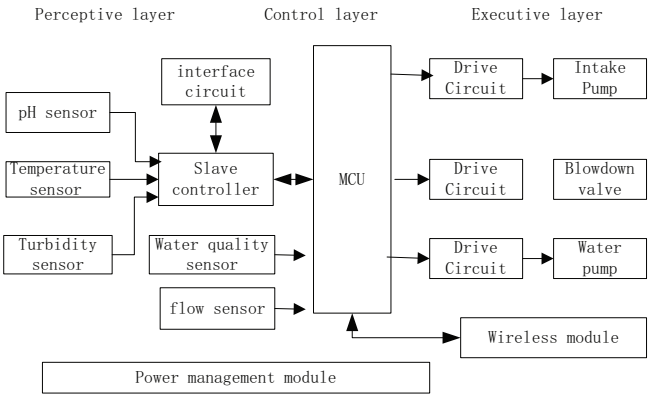

Fig. 3. Overall hardware block diagram.

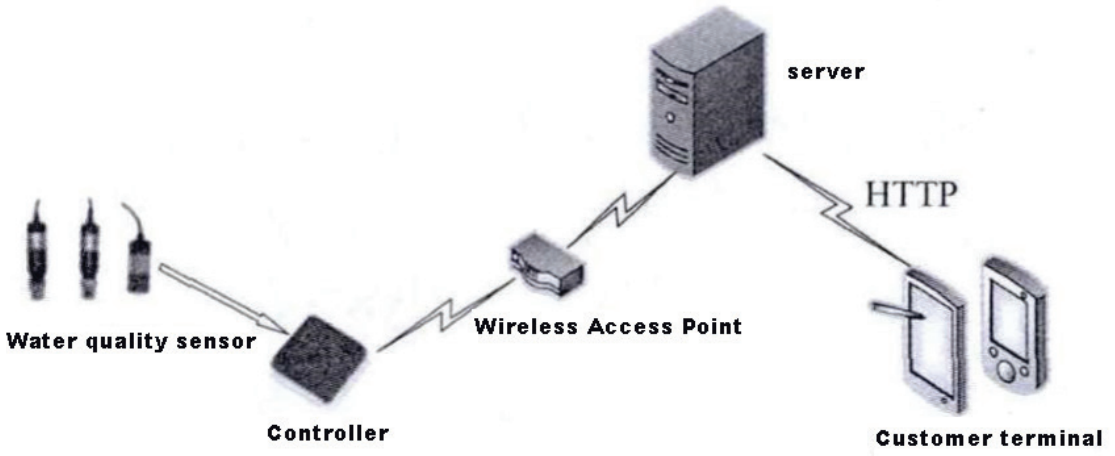

Fig. 2. The diagram of the overall structure.

4. Testing system software design

4.1. Perceptual layer wireless sensor network (WSN) software subsystem design

ZigBee-based star network with self-networking function. The frame type mainly includes node access network, acquisition of network parameters, obtaining sensor parameters, adjusting water quality parameters, etc. As long as the instruction of the specified format is issued in the descending link, the data can be obtained from the uplink link to obtain the parameters of the requirement.

4.2. Transmission layer ZigBee/GPRS wireless gateway software subsystem design

ZigBee/GPRS wireless gateway is used to complete management control, protocol transformation, and data forwarding function, which can support WSN network data coordination and aggregation, and support GPRS access to realize Internet connection.

4.3. Application layer water quality monitoring information management system design

The application layer water quality monitoring information management system adopts the browser/server architecture design to provide ZigBee/GPRS gateway and user service through Web service. The main subsystems include water quality environmental monitoring subsystem, expert decision-making and knowledge query subsystem, system configuration subsystem, and online technical support subsystem.

5. Experimental result

The test results show that the water quality parameters can be uploaded to the server in real time. In order to carry out the sensor accuracy test, the system was simulated in the laboratory. The system collects water quality information every 10 s, and the terminal can get water quality parameters in real time. Take the pH sensor test as an example, use the PH standard buffer solution to test, and record and compare the pH value displayed by the terminal, and the test data are shown in Table 2. From the standard PH of the buffer solution in Table 2 and the comparison of the measured PH from the sensor, it can be seen that the system control PH detection precision is within 0.2, the effect is good, and the monitoring needs can be met. Therefore, the system has good quantitative detection performance.

Table 2
The test data

Time	Standard pH	Measured value pH
9:38:00	5.0	5.1
9:38:10	5.0	4.9
9:38:20	5.0	4.8
9:38:30	5.0	5.2
9:38:40	7.0	7.1
9:38:50	7.0	6.9
9:39:00	7.0	7.0
9:39:10	9.0	9.1
9:39:20	9.0	9.2
9:39:30	9.0	8.9

6. Conclusion

It is found that the water quality monitoring system based on the IoT has realized the functions of reducing human consumption, improving the accuracy of water quality monitoring, real-time transmission of detection information, and on-line display of mobile terminal. The test results show that the whole system runs stably, and the above functions can be realized. The water quality monitoring system based on the IoT can be applied to the intelligent family, monitoring the treated domestic sewage water, ensuring the treated water quality to meet the standard of urban sewage regeneration and utilization, and improve the effect of energy saving and emission reduction. At the same time, the system can also be applied to water environment monitoring in aquaculture plants and swimming pools, and has strong practicability and wide application prospects.

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