TẠP CHÍ KHOA HỌC
TRƯỜNG ĐẠI HỌC QUY NHƠN

Nghiên cứu ứng dụng hệ thống giám sát môi trường nuôi tôm theo thời gian thực dựa trên công nghệ IoT

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TÓM TẮT

Việc ứng dụng công nghệ IoT vào cuộc sống đã được triển khai trong những năm qua mang lại nhiều kết quả khả quan trong các lĩnh vực nông nghiệp, công nghiệp, thương mại. Lĩnh vực nông nghiệp được ứng dụng công nghệ IoT trong việc giám sát, chăm sóc, thu hoạch… đã mang lại nhiều lợi ích to lớn. Tuy nhiên việc giám sát các tham số cần kịp thời và chính xác trong một số lĩnh vực quan trọng như nuôi tôm là rất cần thiết, bên cạnh đó nền tảng IoT vẫn còn một số hạn chế như thiếu khả năng quan sát, cơ chế sửa lỗi không đầy đủ. Nhóm tác giả đã nghiên cứu ứng dụng công nghệ IoT vào giám sát môi trường nuôi tôm theo thời gian thực nhằm phát hiện xử lý kịp thời những biến đổi bất lợi đối với tôm, giảm thiểu thiệt hại cho hộ nuôi tôm. Kết quả thực nghiệm cho thấy tính hiệu quả của hệ thống này trong việc giám sát theo thời gian thực, mang lại lợi ích to lớn cho các hộ nuôi tôm ở địa phương.

Từ khóa: *Công nghệ IoT, giám sát môi trường, nuôi tôm, thời gian thực, đo lường xa.*

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Research and application of Real-time monitoring system for shrimp farming environment based on IoT technology

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ABSTRACT

The application of IoT technology to life has been implemented over the years, it has brought many positive results to the fields of agriculture, industry and commerce. The agricultural field is applying IoT in the use of technology to observe, surveillance, and harvest, etc. that has brought many great benefits. However, the monitoring of parameters needs to be timely and accurate in some important areas such as shrimp farming. Besides, the IoT system still has several limitations such as lack of observability and inappropriate debugging mechanisms. The authors have researched and applied real-time monitoring system for shrimp farming environment based on IoT technology to detect and promptly handle adverse changes for shrimp, minimizing great damage to shrimp farmers. Experimental results show the effectiveness of this system in real-time monitoring, thereby bringing great benefits to local shrimp farmers.

Keywords: *IoT technology, environmental monitoring, shrimp farming, real-time, distance measurement.*

1. INTRODUCTION

The damage that occurs to shrimp farmers will negatively affect their economic life. In addition, dead shrimp in the ponds will lead to water pollution and ecological imbalance.[1]

In recent years, many shrimp farming households on Thi Nai lagoon have lost hundreds of millions of dong per crop which leads to their difficult economic life.[2] Besides, there are also some cases where shrimp farming households earn billions of dong per crop.

Currently, shrimp diseases occur frequently in many shrimp farming areas in the country, causing great economic losses to shrimp farming households. The main reasons are that environmental quality monitoring in shrimp ponds (shrimp) is not done regularly and there is a lack of control technologies to be able to react promptly to water quality problems.[3]

There are many studies on the application of IoT (Internet of Things) technology to shrimp farming,[4] but it has not been able to be implemented commercially. This is because the research cannot be done in a real environment and the commercial potential of the devices is not available yet (just for testing or teaching materials).[5,6] The general monitoring system for the whole area[7] cannot meet the specific needs of each specific shrimp farm.

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Figure 1. Manual parameter monitoring.

When actually deployed, IoT research for shrimp farming has some disadvantages such as unstability,[5] communication inadequacies,[4] and disatisfation with real-time calculation (accuracy, low latency) for customers.[7] Therefore, IoT commercial products cannot bring great benefits to aquaculture in general and shrimp farming in particular.

Therefore, the authors study the application of a real-time monitoring system for shrimp farming environment parameters based on IoT technology to monitor these parameters accurately, with low latency, and can overcome limitations in communication. Furthermore, this system can work in harsh environments and has a high commercial orientation.

2. IMPLEMENTATION

2.1. Technological solutions in measuring shrimp farming environmental parameters

To successfully raise shrimp, it is necessary to ensure a series of water quality parameters such as dissolved oxygen concentration (DO), pH, salinity, temperature, ammonium nitrogen, NH_3, nitrite, H_2S, alkalinity, mineral concentration, nitrate concentration, phosphorus concentration, bacteria density, algae density[4] and so on. These parameters must be within the allowable range. As long as one of the above criteria exceeds the threshold, the growth of shrimp will be affected such as growth retardation, reduced resistance, infection or death. Therefore, it is very important to control water quality indicators for timely treatment to ensure that they are within the allowable threshold. The national technical regulation stipulates the threshold of parameters in shrimp ponds in Table 1.

Table 1. Appropriate water quality parameters in vannamei ponds.

No.	Parameter	Unit	Permissible limit
1	Dissolved Oxygen (DO)	mg/l	≥ 3.5
2	pH		7 ÷ 9 (±0.5)
3	Salinity	‰	5 ÷ 35
4	Alkalinity	mg/l	60 ÷ 180
5	Water clarity	cm	20 ÷ 50
6	NH_3	mg/l	< 0,3
7	H_2S	mg/l	< 0.05
8	Temperature	^oC	20 ÷ 25

Many solutions that apply IoT technology to replace manual measurements have been deployed to monitor and control some parameters in the pond environment applying IoT technology to replace manual measurements[3,4,7] and so on. This system can help monitor the temperature and water level in the pond, control the heating device according to the actual temperature in the pond, send a warning signal to the manager and so on.

Figure 2. Manual measurement of environmental parameters.

To measure parameters at measurement points (called nodes) on shrimp ponds, the above parameters are sent to the control center thanks to technologies such as Bluetooth, ZigBee, Wifi, LoRa. Each solution has its own advantages and disadvantages.

LoRa is a form of wireless technology with low energy consumption. It provides long range low power wireless connectivity for devices used in smart meter.[8] This solution is well suited for applications where direct mains power supply poses a hazard for ponds. It allows long distance communication and connection with intermediate nodes to increase the distance to collect measurement parameters.[7] Due to the low power consumption, RoLa technology is selected for application in monitoring the measurement nodes using Battery without power supply.[9]

2.2. Researching and proposing system solutions

Based on the advantages of LoRa such as long transmission distance and low energy consumption as shown in the research results in documents.[8,10,11] and based on the above literature analysis, the authors will use the sensor nodes including an Arduino UNO R3 to collect parameters, and water quality indicators and send these data to the data control station by LoRa wireless network at 433 MHz through the module LoRa Ra-02 SX1278.

Table 2. Communication protocol of the nodes in the measurement and data acquisition system.

LoRa SX1278 Module	Arduino UNO Board
Gnd	Gnd
3.3 V	3.3 V
En/Nss	D10
G0/DIO0	D2
SCK	D13
MISO	D12
MOSI	D11
RST	D9

Figure 3. Proposed measuring node model in shrimp ponds (experimental result).

Gateway (Control Station) is responsible for collecting data at all measuring nodes, then it analyzes, processes data, displays and communicates data accurately to ensure real-time to the user. Because of the important role of the center, the authors propose the Node-Red technology solution for the central control station to replace the previous basic programming methods[9,12,13] for real-time response in processing and displaying the results to the user.[14] The Node-Red technology has been covered in several references.[15-17]

There are four main components in the Node-Red editor namely:

1. The title is at the top, containing the Deploy button and the Main Menu.

2. The palette on the left-hand side contains the node libraries available to use.

3. The main workspace Workspace in the middle, where the Flows are created.

4. Right Sidebar

When accessing the Node-Red editor, the interface is described as displayed in Figure 4.

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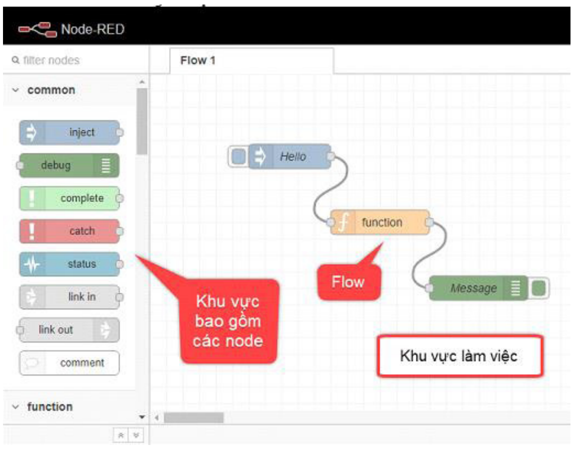

Figure 4. The interface of the tool Node-Red.[18]

After completing the design and running the Node-Red command, an IP address as shown below appears. We copy and paste the path http://127.0.0.1:1880/ into the web browser to access them. Node-Red with new features helps to overcome the disadvantages of previous IoT systems. Program development and debugging tasks help users easily understand the graphical programming structure, ensuring data processing bandwidth speed.

2.3. Designing the monitoring interface

The advantage of LoRa technology when transmitting data to the gateway is that it does not consume too much power. It allows data transmission over long distances. At the same time, the cost of sending will also be much lower than when sending using a regular mobile network.

The authors design a user interface on the Android platform (Figure 7) to access Server data through a central station that provides an IP address. In addition, to make it more convenient to monitor shrimp ponds anytime, anywhere, the system is also designed with a user interface on the Website platform. In this article, the JavaScript programming language is used to take advantage of the available open-source codes to build alarm systems, and control behavior when there is an abnormal change of parameters in the pond environment. In addition to the website, a data storage support tool called Firebase is used. In addition to supporting data storage, Google Firebase can also host and have a free name available so that we can minimize the cost of a system (Figure 6).

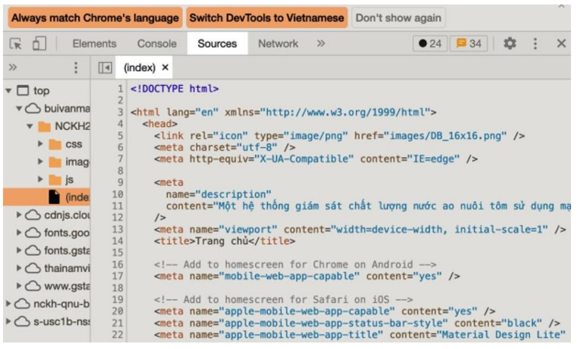

Figure 5. Programming user interface on Website platform using Javascript.

Data storage in the cloud is an important part of IoT projects in general and in wireless sensor networks (WSN) in particular. In this article, the authors use Google Firebase to store real-time data (Realtime Database) and help communication between hardware (sensor nodes and data collection nodes) and software (user interface).

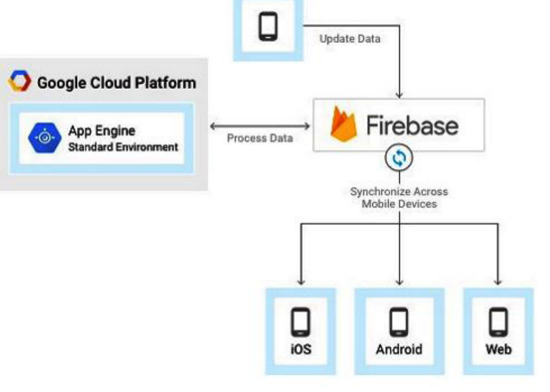

Figure 6. Diagram of data storage model through Firebase and signaling to iOS, Android and Web platforms.

Firebase is a backend system service provided by Google for mobile applications and websites. With Firebase, we can shorten the development, deployment, and scaling times of the mobile app or website we're developing. It supports both Android and IOS mobile platforms and website platforms. Firebase is a powerful, versatile, secure, and useful service for building apps. Google Firebase has a lot of tools to assist users in building mobile or web-based applications.

Figure 7 shows sensor node data placed directly at the shrimp pond (unlimited number of nodes). The sensor nodes will measure the water quality parameters of the lake such as temperature, pH, oxygen concentration, salinity, etc. Then, the sensor node will send data to the gateway to help shrimp farmers monitor the parameters of water in the lagoon continuously and in real time.

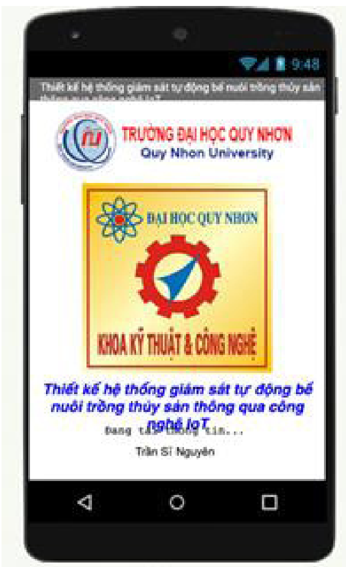

Figure 7. Programming the user interface through the integrated web application development environment (MIT App Inventor).

2.4. Communication solutions for the system

The system monitors the environmental parameters of shrimp ponds using LoRa technology. In a WSN system, there must always be a gateway to collect data from sensor nodes and bring these data to a data processing center for different purposes or to be sent to the cloud via the internet.

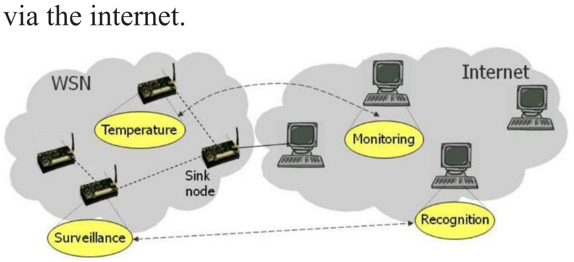

Figure 8. Communication and data acquisition solution of Central Control Station.[16]

The central system is designed by the authors using Node-RED technology. It allows users to combine web services and hardware by replacing common low-level encryption tasks (like a simple service that communicates with a serial port). This can be done with an intuitive drag-and-drop interface.[14] The different com-ponents in Node-RED are linked together to create a flow. Most of the necessary code is automatically generated to avoid data flow congestion, thereby providing a real-time response for systems.[14,18]

From the proposed model above, we can see that the sensor nodes are located at the water surface in the ponds. When receiving data from the sensor nodes, the data collection center will process and bring the data directly to the screen (temperature, pH, oxygen concentration, salinity,...) to give shrimp farmers observation directly at the center. At the same time, the data is updated on the website and App on the phone. At this time, it is easier for shrimp farmers to capture water parameters to manage their ponds when they are not present in the lagoon. This helps shrimp farmers manage the quality of the pond anytime, anywhere, which is convenient for capture and timely handling.

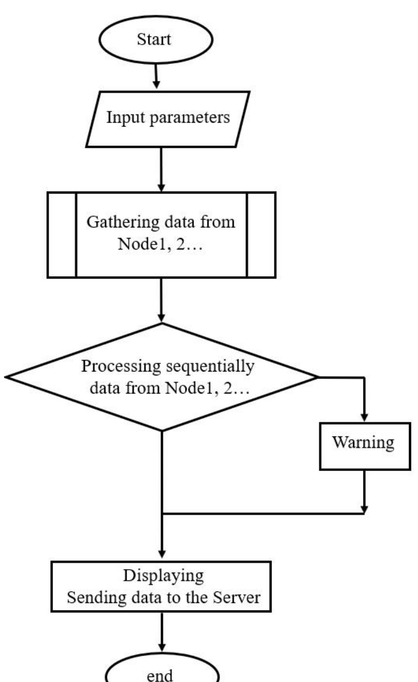

Figure 9. Algorithm flowchart built for Control Center.

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For the central controller, a stable internet connection (LAN, Wifi, 4G, GPRS) Node-Red is required. This allows real-time Modbus data exchange, which previous IoT systems could not do.[14,17]

2.5. Experimental results

Figure 10 shows that the authors have also designed a central controller using Raspberry (can be replaced by a PLC with communication module) and using Node-Red technology to build data exchange solutions with the nodes and send to the Server ensuring real-time requests.

Experimental results at shrimp ponds in Lac Dien village, Tuy Phuoc district, Binh Dinh province show that the control system has successfully sent remote data to Firebase via the link: https://nckh-qnu-bc114-default-rtdb.firebaseio.com.

Figure 10. Experimental model of control center.

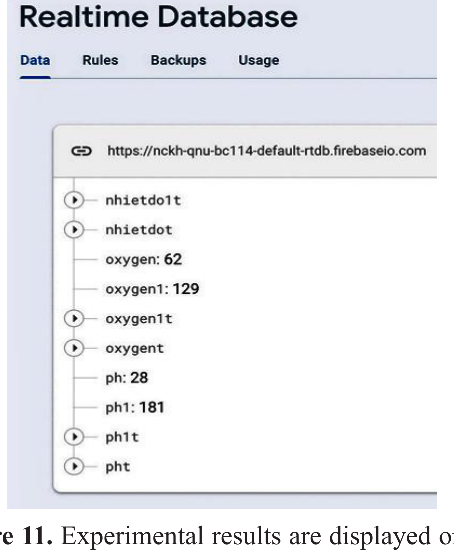

Figure 11. Experimental results are displayed on the calculator.

Parameters are within allowable limits and are updated continuously every 1s, ensuring real-time calculation for shrimp pond monitoring systems. In addition, the above system can provide a common database for scientists, shrimp hatcheries, fishery extension centers and so on.

In addition, the above data is also daily, monthly and yearly graphed to store historical parameters Figure 12.

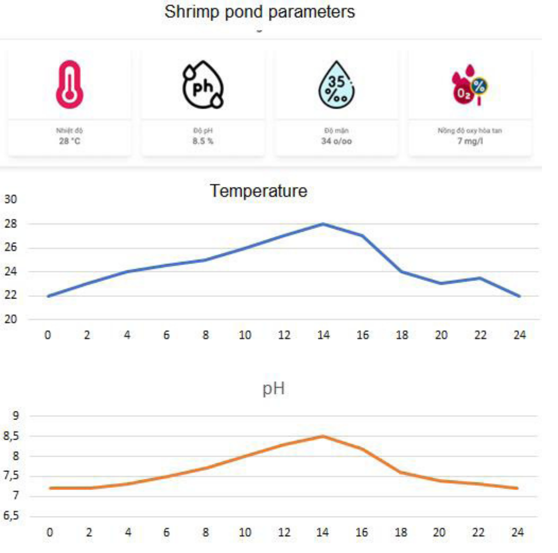

Figure 12. Experimental results are displayed on the computer.

In addition, the author has also designed the user interface to monitor the parameters of the second node with similar functions as the first node and evaluate the ability to communicate between nodes. Similarly, if people raise many shrimp ponds, the group can also develop Web interfaces to monitor water parameters of each pond, meeting the practical needs of the people.

In order for shrimp farmers to monitor environmental changes anytime and anywhere, the author has built a monitoring interface on iOS and Android platforms. The data is always updated on the manager's mobile device (Figure 13). In addition to the measured values displayed, the reference parameters are also given to the shrimp farmer. Because some sensors on the market are quite expensive, the authors only made experimental measurements for 4 main parameters: pH, salinity, temperature, and dissolved oxygen. Figure 13 is the normal operating state of the first measuring node with pH = 8.1, salinity = 17.0‰, water temperature = 27.1 ^oC, and dissolved oxygen = 7.2 mg/l. Thus, the values are within the allowed range and are updated every 1 s (the Arduino board allows updates every 0.1 ms). Data is sent simultaneously to the common database and the user's mobile devices.

Figure 14 shows the same content as Figure 13, but the measured parameters are now assumed to have large fluctuations and exceed the allowable values set by the user. Specifically, the pH index is equal to 9.9, the temperature is equal to 34.0 ^oC. These two parameters will significantly affect the growth of shrimp and can cause shrimp to die in mass. In addition to the monitoring function, the system also has a warning function and an automatic message sending function to the user's device for timely handling.

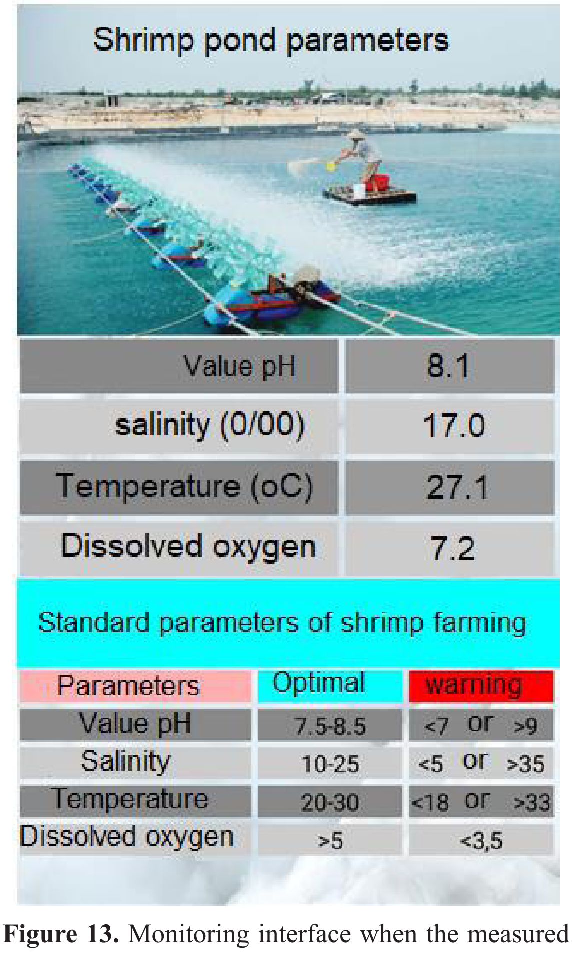

Figure 13. Monitoring interface when the measured parameters are at the allowable level.

Signal transmission by LoRa technology helps to increase the number of measured parameters at a node and the number of nodes in a farm thanks to low installation costs, relatively wide bandwidth, and easy communication between nodes. The authors have also developed nodes with an open structure, allowing users to connect more sensors, or replace sensors from measuring water environments to measuring other environments such as soil and air in plant care, smart greenhouses, etc.

The above research results have won consolation prizes in the contest of Student Scientific Research Prize – Euréka in Ho Chi Minh City 2022. (Proceeding of the Euréka Scientific Research Student Award 2022, http://eureka.khoahoctre.com.vn/)

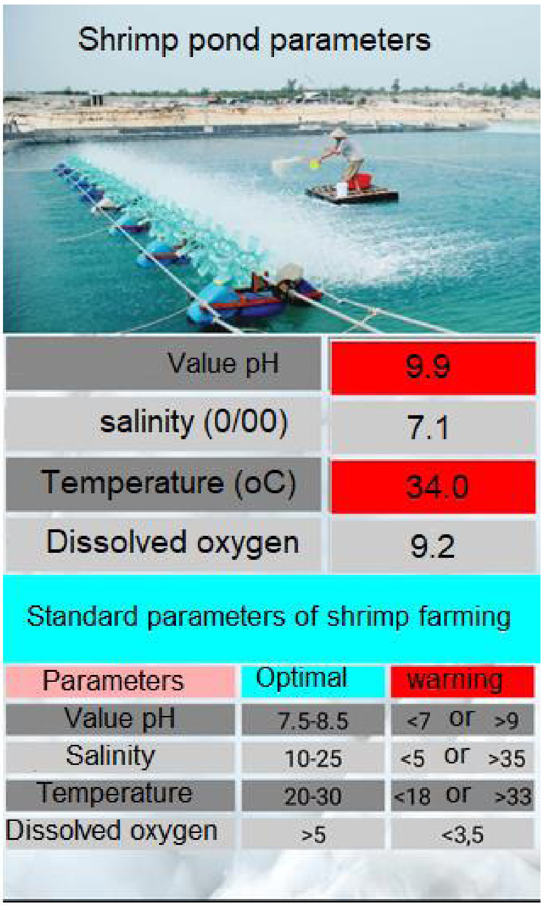

Figure 14. The warning interface in case the parameters exceed the allowable threshold.

3. CONCLUSION

The authors have successfully built a shrimp pond monitoring system using wireless sensor

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network (WSN) with 4 main monitoring parameters of water quality namely temperature, pH, dissolved oxygen concentration and salinity. Successfully configured communication to connect measuring point with control center by LoRa technology, data retrieval and data display on user's mobile device and on web based on platform of "Realtime Database" with Node-Red technology.

The system uses Node-Red technology to ensure real-time communication, increase reliability in measurement, allowing connection of LAN, Wifi, 4G, GPRS, etc.

The experimental results show that the designed system can monitor and display measured parameters continuously, ensuring real-time on users' mobile devices. The system can give warning signals to users when there are environmental parameters out of the set range and can output digital signals to control actuators such as: pump, beating fan, aeration and so on.

Measurement parameters are sent to a common database for various purposes and stored on the system in a time series.

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