Design of expert system for fault diagnosis of water quality monitoring devices

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Abstract. A new system for automatic detect fault of water quality monitoring devices used in aquaculture is proposed in this paper. The proposed system can detect the whole system which includes platform、gateway、WSN、sensor、actuator. China is the world's largest freshwater culture nation which provides 80% of the freshwater culture fish. The water quality is essential to freshwater culture, and the environment is controllable. In this paper, water quality sensors are used to detect the water quality of culture ponds. By the use of wireless sensor networks, the data can be sent to remote server. So farmers can check the state of the culture ponds where the internet is available. This paper is proposed to detect the state of the monitoring system, if the monitoring system falls, the system will alarm to the user.

Keywords: Automatic, On-line, Fault diagnosis, Aquaculture, Water quality monitoring

1 Introduction

China is the world's largest freshwater culture nation which provides 80% of the freshwater culture fish. The water quality is essential to freshwater culture, and the environment is controllable. In this paper, water quality sensors are used to detect the water quality of culture ponds. By the use of wireless sensor networks, the data can be sent to remote server. So farmers can check the state of the culture ponds where internet is available. Water quality is very important in aquaculture. We use WSN technology to monitoring the water quality to ensure the circumstance is suitable for the fish to grow. In this way, human has been released from hard working. The water quality monitoring system is essential for the aquaculture. If the monitoring system fails, and the water quality become bad, a lot of fish will die, farmer will lost a lot. So a new system for automatic detect fault of water quality monitoring devices used in aquaculture is proposed in this paper [1].

2 Water quality monitoring model

The water quality monitoring system proposed in this paper is used in outdoor aquaculture. The most important attributes of the water quality are dissolved oxygen and water temperature. If the dissolved oxygen is lower than 3mg/l, the growing of fish will be constrained. If the dissolved oxygen is lower than 1mg/l, the fish will die. Both the water temperature is too high or too low will constrain the growing of fish. The water quality monitoring model is illustrated by Figure 1. The first part is sensor which can detect both dissolved oxygen and water temperature. The second part is a transformer which is powered by solar battery and sends out the data collected by sensors wirelessly according to H 15.4 communication protocol. The third part is gateway which receives the data send from transformer and sends them out to the remote server.

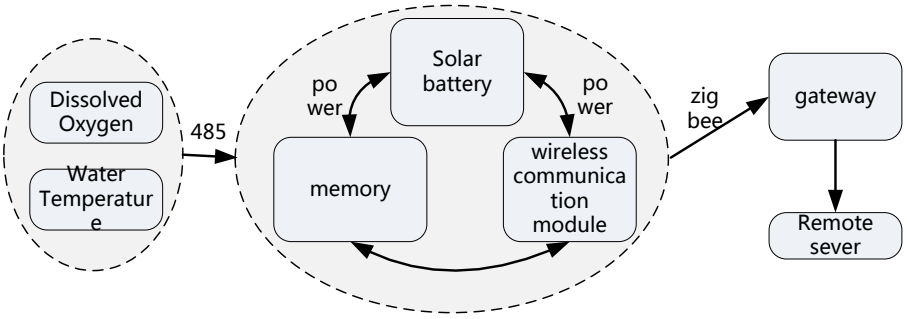

Fig. 1. Water quality monitoring model

In this system, the sensor has three channels, includes dissolved oxygen, water temperature, and dissolved oxygen engineering value. The transformer has three channels, include device information, device voltage, and signal strength[2]. The gateway has seven channels, includes city power supply, current one, current two, switch signal, analog signal one, analog signal two, and device voltage. That information is the source of the fault diagnosis system [3].

3 Design of fault information database table

After three months observation of the current water quality monitoring system, fault object can be divided into five categories: software platform, gateway, transformer, sensor, and actuator. Fault grade can be divided into three categories: mild, moderate, serious[4]. Mild means that operation and maintenance staffs should know that. Moderate means that if operation and maintenance staffs have time, they should deal with the problem. Serious means that the fault is fatal, operation and maintenance staffs should deal with the problem as soon as possible. The fault information database table is illustrated by Figure 2. The fault diagnosis system stores the fault occurring time, and records fault reason and deal method which is added by operation

and maintenance staffs. In this way, if the same kind of fault occurs again, we can check the database to check the previous records [5].

Field meaning	Field name	Data type
ID	def_id	varchar
Smart device ID	dev_id	varchar
Fault type	def_type	int
Fault grade	def_grade	int
Fault occur reason	def_occurReason	Varchar
Fault occur time	def_occurTime	Datetime
Fault solved time	def_dealTime	Datetime
Deal method	def_dealMethod	Varchar
Channel ID	ch_id	Varchar
Fault description	def_desc	Varchar

Fig. 2. Fault information table(smart device)

4 Design of fault diagnosis rule database

The fault diagnosis rule database is illustrated by Figure 3.Rules is made on the base of careful observation of the water quality monitoring system. Each fault object has the expert to give the suggestion of the rule-making. Each fault object has four attributes, communication state, device state, data continuation state, data rationality[6]. Fault level has been divided into three levels. Serious means that the fault is fatal to the operation of the water quality system. Moderate means that the fault is not fatal to the operation of the water quality monitoring system, but the fault will be fatal to the operation of the water quality monitoring system. Mild means that the fault is not fatal to the operation of the water quality monitoring system, but the fault has the possibility to be fatal to the operation of the water quality monitoring system[7].

Fault object	Fault level	Rule
Software platform	serious	Receive no data in 10 minutes;
Software platform	serious	Illegal register;
Software platform	serious	The number of channels is not in compare with the platform;
Software platform	mild	Software platform time and reporting time asynchronous;
Gateway	mild	The reporting time subtract acquisition time is larger than 30 minutes;
Gateway	mild	The interval between two heart beats is larger than 2 times of cycle
Gateway	serious	The acquisition time is the same with the last data
Gateway	mild	The gateway voltage is lower than 4.4 volt
Gateway	mild	The reset number of gateway increased
Transformer	serious	The transformer voltage is the same with the last data
Transformer	mild	The transformer voltage is lower than 3.6 volt
Transformer	mild	The reset number of transformer increased
Sensor	serious	The sensor data is the same with the last data
Sensor	serious	The value is out of the upper limit and lower limit
Sensor	serious	The change rate is larger than 0.1
Actuator	mild	Illegal operation

Fig. 3. Fault diagnosis rule database

5 Design of fault diagnosis flow chart

I The water quality monitoring system is level clearly demarcated. If the gateway fails, the platform can't get the information below the gateway [8]. In the same way, if the transformer fails, the platform can't get the information below the transformer. The fault diagnosis flow chart is illustrated by Figure 4. The expert system of fault diagnosis for water quality monitoring system follows the flow chart illustrated by Figure 4.

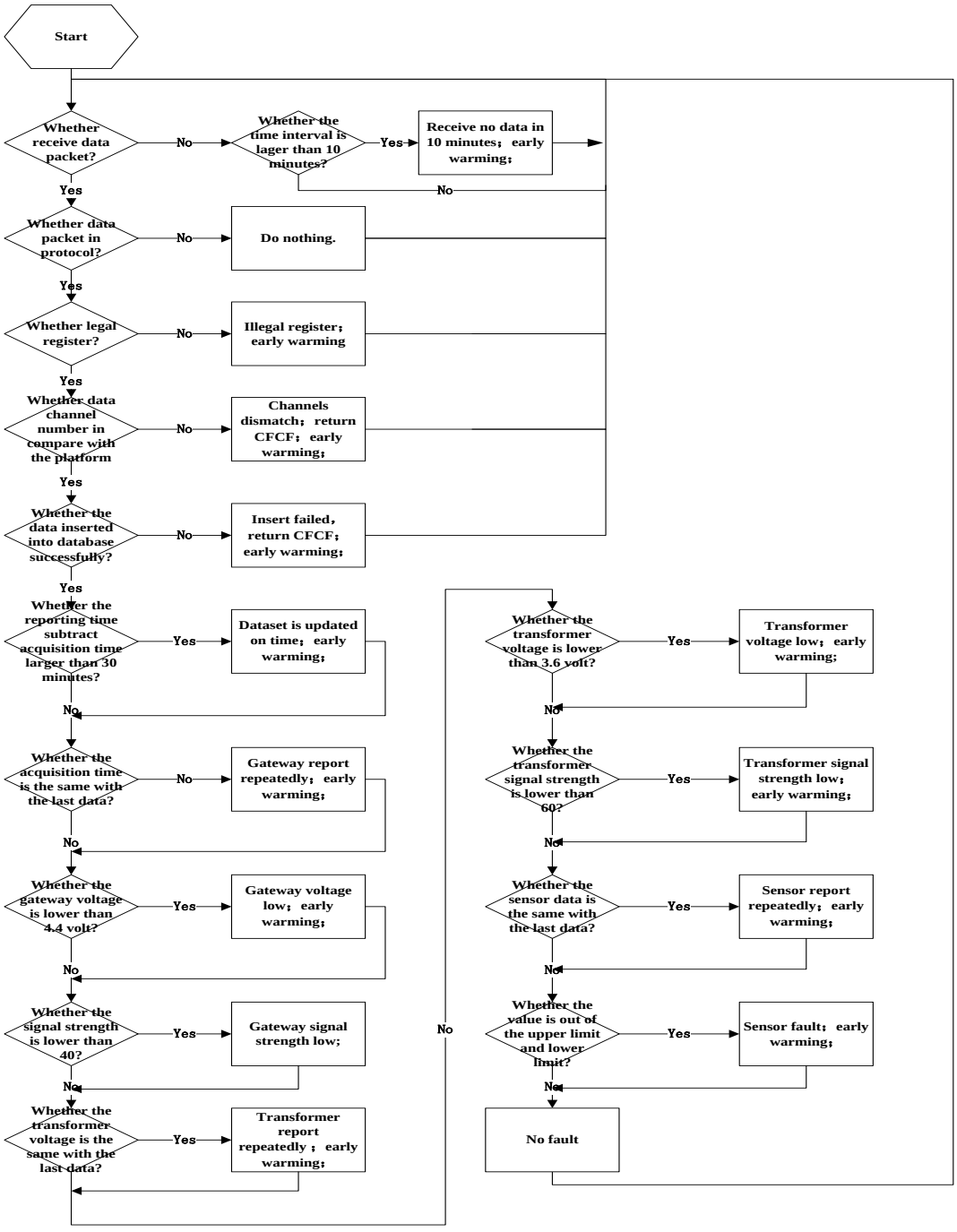

Fig. 4. Flowchart for the identification of deficiency symptoms

6 System interface

Fault information management is illustrated by Figure 5. The result of fault diagnosis is stored in the database. For the purpose of being friendly to the users, a web-based system interface has been developed. Users can search the device Id, fault level, fault type, fault state, fault occurring time[9].

首页 》 故障信息管理

根据 设备编号： 故障等级： 请选择…… 故障类型： 请选择…… 故障状态： 请选择……

故障发生时间： 2011-09-10 00:00:00 至 2011-09-10 23:59:59 查询

设备编号	故障等级	故障类型	发生故障的时间	解决故障的时间	编辑
40076	严重	传感器	2011-09-10 11:04:08.0		编辑/详情
40002	严重	控制设备	2011-09-10 11:02:45.0		编辑/详情
40002	严重	控制设备	2011-09-10 11:02:43.0		编辑/详情
40074	严重	传感器	2011-09-10 11:02:22.0		编辑/详情
40076	严重	传感器	2011-09-10 10:52:16.0		编辑/详情
40074	严重	传感器	2011-09-10 10:51:35.0		编辑/详情
40076	严重	传感器	2011-09-10 10:41:09.0		编辑/详情
40074	严重	传感器	2011-09-10 10:40:49.0		编辑/详情
40002	严重	控制设备	2011-09-10 10:37:54.0		编辑/详情
40002	严重	控制设备	2011-09-10 10:37:52.0		编辑/详情

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Fig. 5. Fault information management

Fault report is illustrated by Figure 6.The report can statistic the fault information. From this report, we can see the amount of each kind of fault happened in a specified period.

故障发生时间： 2011-09-10 00:00:00 至 2011-09-10 23:59:59 查询

场景名称	设备地址	平台故障	网关故障	小无线故障	传感器故障	控制设备故障	合计
史建强-01号池	40008	0	0	0	0	10	10
史建强-02号池	40073	0	15	0	0	0	15
周宝银-01号池	40002	0	0	0	0	44	44
周宝银-02号池	40071	0	5	0	0	0	5
周宝银-03号池	40074	0	5	0	67	0	72
水产模型-01号池	40004	0	5	0	0	0	5
合计		0	30	0	67	54	151

Fig. 6. Fault report

7 Conclusion

In this paper, we presented an expert system for fault diagnosis of water quality monitoring devices based on rule database. The system allows a user to track the detailed information of the whole monitoring system. The architecture of the system has been described from several points of view and it has shown to have the ability to meet the requirements imposed on early warming of the water quality and monitoring devices and fault diagnosis of the monitoring system

In the architecture described above, each fault of the water quality monitoring system can be tracked for detailed information. Therefore, the system's stability can be enhanced. The profit of the aquaculture farmers can be ensured. For this reason, our future work will cover the study of artificial intelligence to make the system smarter[10].

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