Design and Implementation of Environment Monitoring and Alarm System for Broiler Breeding Based on Internet of Things

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Abstract Environment plays a vital role in the breeding process of broilers. In order to effectively monitor and control the breeding environment of broilers, a broiler breeding environment monitoring and alarm system based on internet of things is studied and established. The system adopts the narrow band internet of things communication technology, and can transmit the temperature, humidity, illumination and ammonia and other environmental data in the chicken house remotely through terminal collection unified interface device. Meantime, it realizes the control of fans, wet curtains, small windows and illumination in the chicken house by threshold method. The system software is designed and implemented by C#, SQL Server, WeX5 and other development tools, including platform terminal and enterprise terminal. Since its operation, the system is featured by stable state, reliable data and timely alarm, which solves the problem of unified control of different sensors and realizes the effective control of house environment.

Keywords Internet of things; Broiler; Breeding environment; Monitoring; Alarm

With the development of China's economy and the continuous improvement of people's living standards, the whole society's demand for livestock and poultry meat products is also increasing year by year. Chicken has become the second most consumed meat product in China[1]. Although China's broiler production is increasing every year, it still can not meet the market demand. Therefore, it is an inevitable trend for broiler breeding to develop towards industrialization. The industrialization of broiler breeding is the high density and intensive breeding mode, which is bound to raise higher requirements on the breeding environment. Related studies show that environmental factors account for 25% of the healthy growth of broilers. Therefore, a monitoring and control system for the healthy breeding environment of broilers can be established to adjust the breeding environment of broilers dynamically and timely and to forewarn abnormal environment that may affect broiler growth, which not only reduces the morbidity and epidemic spread of broilers, but also improves the production capacity and economic benefits of broiler breeding enterprises[2].

In recent years, some domestic experts and scholars continue to conduct research on the informatization of broiler breeding. For example, Zheng *et al.*[3] designed and realized an environmental monitoring system for broiler healthy breeding by taking the environmental quality of broiler breeding as the monitoring object. The system consists of terminal collector, controller and remote server. Liu *et al.*[4] designed and realized an intelligent breeding management and monitoring platform, which can collect, manage and monitor the whole process of breeding objects from birth to slaughter, with detailed, reliable data and traceability of products. Zhang *et al.*[5] developed the production environment monitoring and management system for broiler house by using the internet of things, cloud computing and other technologies, and significantly improved the economic benefit of broiler breeding. Liu *et al.*[6] developed a monitoring platform with fuzzy PID control algorithm, which realized the optimization of livestock and poultry breeding environment and improved the accuracy and efficiency of environmental control.

Although domestic research on breeding environment monitoring technology has made some progress, there are still problems such as artificial readings of sensor data, relatively simple environmental control strategy and slightly complex deployment mode in practical application[7]. Aiming at local microenvironment in broiler breeding house, the system uses temperature, humidity, illumination, ammonia and other sensor devices to upload environmental data to the cloud through wireless network, and the data are read from the cloud and displayed in real time based on the application program of handheld terminal and desktop terminal. The data are analyzed and controlled by big data model, so as to ensure that the environment of broiler breeding house is suitable for the

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healthy growth of broilers[8–9].

1 Architecture Design

The system adopts ARM architecture to collect real –time environmental data such as temperature, humidity, illumination and ammonia, and transmits them to the cloud server through 4G network. The cloud calculates the threshold value to manually or automatically control the fan, wet curtain, illumination and heating switch of the breeding house. When the monitoring data exceed a certain threshold, a pop-up window on the page or SMS alarm will be provided[10]. The overall architecture is composed of three layers: perception layer, transmission layer and application layer[11], as shown in Fig.1.

1.1 System hardware design The whole system hardware consists of terminal sensor, terminal collection unified interface device, terminal controller and video monitoring device[12].

1.1.1 Terminal sensor. At present, the production process and performance indexes of terminal sensors for environmental collection in broiler breeding houses meet the environmental collection standards. Therefore, temperature, humidity, illumination, ammonia and other terminal sensors are purchased from the market.

1.1.2 Terminal collection unified interface device. The terminal collection unified interface device integrates terminal sensors and uploads collected environment data to the cloud platform. The interface device adopts NB-IoT communication, which is featured by wide coverage, multiple connections, low speed, low cost, low power consumption and excellent architecture. Meantime, the device supports data collection of four environmental indicators including temperature, humidity, illumination and ammonia concentration. A single device can support up to 8 sensors, while the number of sensors supported by multiple devices at the same time can theoretically reach an unlimited number, and the system has strong scalability. The device saves the collected environment information locally. Once the network is interrupted, the temporarily stored data can be sent again after the network is recovered, ensuring the security of data (Fig.2).

1.1.3 Control device. The control device is used to send the start or stop command to the fan and wet curtain in the broiler breeding house. The device uses 32-bit Cortex-M4 kernel processor, including signal acquisition, signal conditioning, data processing, network communication, power management, a variety of sensors and other modules, and simultaneously connects with ventilation, illumination, temperature regulation devices in the chicken breeding house, realizing the dynamic regulation of breeding environment in the chicken breeding house (Fig.3).

1.1.4 Video monitoring device. The device is used for video viewing of broiler breeding house. The device selected is TC-C52EN all-in-one machine manufactured by Tiandy Technologies Co., Ltd. The machine, with a resolution of 1 920 × 1 080, supports a variety of video compression standards, which can transmit data through RJ45 network cable, and also has an audio interface. The device also has infrared function, and the situation of chicken house can still be viewed through this video device when the lights are turned off at night.

1.2 Software design

1.2.1 Function design. The whole system is consisted of platform terminal and enterprise terminal. The platform terminal mainly completes the registration and review of enterprises. The functional structure diagram of the platform terminal sys-

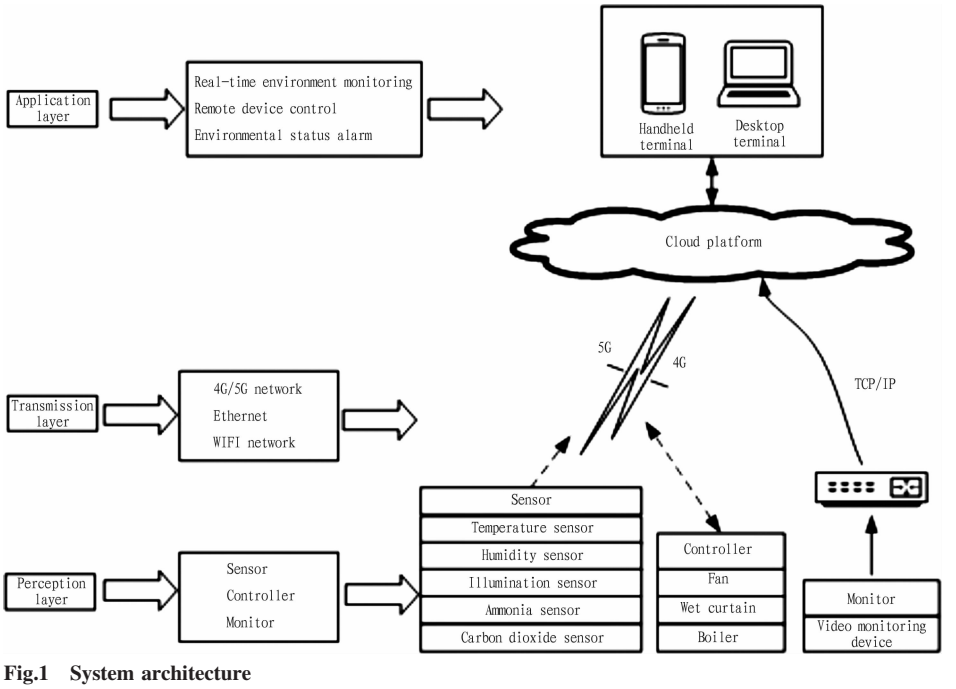

Fig.1 System architecture

Fig.2 Terminal collection unified interface device

Fig.3 Controller

tem is shown in Fig.4.

(1) Role management: The function implements personnel rights management, and different access rights can be set for different users.

(2) User management: The function achieves the management of accounts, password resets and roles of users who access the system.

(3) Enterprise management: The function can be used to review the enterprises applying for joining, and database and management account can be generated automatically after successful review.

(4) Category management: The function realizes the definition of menu item name of "technical services" on the front page.

(5) News management: The function achieves the edit of the contents of each option in the "technical services" menu, including adding, deleting and modifying.

(6) Video management: The function can add, edit and delete videos.

(7) Menu management: The function can dynamically realize the backstage menu.

(8) System management: The function includes the management of logs and databases.

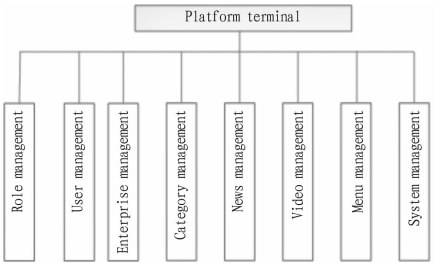

Fig.4 Function of platform terminal

The enterprise terminal of the system is used for enterprise users to manage the system, including checking the environmental information of breeding houses and manually controlling the environment. It mainly consists of basic data management, real-time monitoring management and control panel management. The functional modules are shown in Fig.5.

(1) Department management: The function realizes the management of departments under the jurisdiction of the enterprise.

(2) Post management: The function realizes the management of subordinate posts in a department.

(3) House management: The function realizes the management of breeding houses in a breeding farm.

(4) Coop management: The function realizes the management of broiler coops in the breeding house.

(5) Device installation point management: The function realizes the management of location information of environmental acquisition devices.

(6) Environmental parameter management: The function can add, delete and modify environmental information such as temperature and humidity in the breeding house.

(7) Device type management: The function realizes the management of facilities in the breeding house, such as water curtain, heating and other device types.

(8) Environmental monitoring device management: The function realizes the management of monitoring devices in the breeding house.

(9) Remote control device management: The function realizes the management of master control device in the breeding house.

(10) Environmental control device management: The function realizes the management of control devices in the breeding house.

(11) Video device management: The function realizes the management of video monitoring devices installed in the breeding house.

(12) Control and monitoring relationship management: The function realizes the associated management of control device and monitoring device in the breeding house.

(13) Broiler breed management: The function realizes the management of broiler breeds in the breeding house.

(14) Day-age threshold management: The function realizes the management of an extreme value for the day-age of broilers in the breeding house.

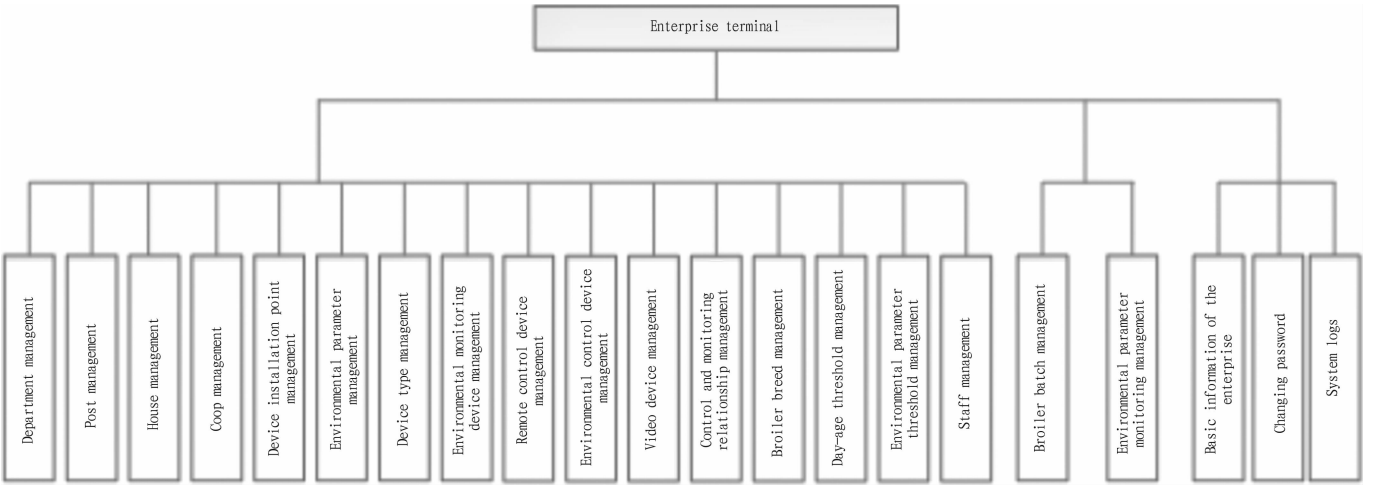

Fig.5 Function of enterprise terminal

(15) Environmental parameter threshold management: The function realizes the management of environment parameter setting and management extreme values in the breeding house.

(16) Staff management: The function realizes the management of the staff of broiler breeding enterprises.

(17) Broiler batch management: The function realizes the management of broiler batches in the breeding house.

(18) Environmental parameter monitoring and management: The function can view and browse the environmental data of a monitoring point and edit the data.

(19) Basic information of the enterprise: The function realizes the management of relevant information of the enterprise.

(20) Changing password: The function can reset the password of the user who logs in to the system.

(21) System logs: The function can browse and delete user logins and manage various operations.

The application system of enterprise terminal also supports handheld applications in addition to the desktop application developed above[13]. The handheld system is developed using WeX5 open source technology and mainly includes the following functions.

(1) Environment monitoring: The module can view the environmental data collected by the terminal sensor, including temperature, humidity, illumination, ammonia, *etc*.

(2) Device control: The module can start and stop control the device in the breeding house, such as fans and wet curtains.

(3) Historical data: The module can view the environmental data information of the breeding house within 24 h, 3 d or 7 d and display it in a graphical manner.

(4) Alarm information: The module can view the alarm information of environmental data. When the environmental data exceeds or is lower than a certain value, a alarm record will be generated.

Fig.6 Enterprise registration page

Fig.7 Data collection display of desktop terminal

1.2.2 Interface design. The system is designed by C# language, ASP.NET technology and SQL Server database. User operations are minimized as far as possible in the development, and the internal logic calculation is completed through a large number of stored procedures. Fig.6 shows the enterprise application page on the platform, in which enterprise users are required to input relevant enterprise name, person in charge, business license number, enterprise email address and other information. After a user submits an application, the admin reviews and then creates an independent account and management system for the enterprise (Fig.6).

Fig.7 is the data collection situation of a certain point displayed on the desktop terminal of the enterprise sub-platform. The monitoring data in Fig.7 are displayed in a numerical way or a graphical way. The data are collected every 10 min.

Fig.8 shows a screenshot of the handheld terminal page, which shows the main menu displayed after entering the handheld terminal system. When clicking one of these items, more detailed data of the items can be displayed.

2 Discussion

The existing broiler breeding environment monitoring and alarm systems in the market are compared and analyzed, and the monitoring and alarm of the breeding environment in the breeding house is realized through NB-IoT technology[14-15]. The system has the following characteristics.

(1) The NB-IoT technology adopted

Fig.8 Home page of handheld terminal

in this system has strong advantages in network deployment and application.

(2) The terminal sensors are integrated together through a unified interface device to facilitate data uploading to the cloud through 4G network.

(3) The system effectively stores and displays the structured and unstructured data collected in real time, gives a timely alarm to abnormal data, and automatically adjusts the running status of control facilities.

In short, the system has achieved the expected goal, but there are still areas for improvement. For example, the system currently still controls the environment by threshold value, and the research and application of PID control and fuzzy control theory should be strengthened in the late stage[16–17].

3 Conclusions

Aiming at monitoring and regulating the healthy breeding environment of broilers, the system establishes a monitoring and alarm system of broiler breeding environment by using the internet of things. Broiler breeders can view the changes of environmental data and video images of the breeding house at any time through the desktop or handheld terminal without the limitation of time and space. The threshold-based control strategy is developed, which realizes remote automatic control and manual control. The application of the system completes the closed-loop precise control of the microclimate in the broiler breeding house, and reduces the occurrence of broiler diseases, which has good application and promotion value.

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