A laying hen breeding environment monitoring system based on internet of things

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Abstract. The breeding environment of laying hens has an important influence on the growth of laying hens, the prevention and control of diseases, and the yield and quality of eggs. Therefore, the real-time collection and utilization of the environment information of laying hens is the key point of breeding laying hens. In this study, the environmental information monitoring and control equipment and systems for egg-breeding laying hens were integrated and developed. The real-time monitoring of the environment information of the laying hens and the information query function on the webpage and mobile devices was realized. The stability and versatility testing of equipment and systems were completed through the pilot deployment of equipment and systems in a laying hen farm in Beijing. The design and development of the equipment and system can provide technical support for the modernization, mechanization and information management of laying hens.

1. Introduction
With the improvement of people's living standards, people began to pay more attention to the quality and nutritional value of agricultural products[1]. In order to meet the demand for agricultural products in the new era, it is necessary to improve the quality of eggs while ensuring the production as the primary goal[2].

The advantages and disadvantages of the growing environment will play an important role in the laying of laying hens[3]. The extraction and analysis of the environmental parameters of laying hens mainly include the harmful gases generated during the breeding process of the laying hens[4]. When the CO2 concentration is too high, the chicken will suffocate and die. The H2S concentration of the central nervous system may cause paralysis of the central nervous system and even suffocation. At low concentrations, it is easy to adsorb in the mucous membrane of chickens, and the upper respiratory tract mucosa is congested and edema. At higher NH3 concentrations, the egg production rate will decrease.

Temperature and humidity are important monitoring parameters in the environment around the laying hens[5]. In the high temperature and high humidity environment, it will cause laying hens' appetite loss, increased disease and growth rate of laying hens. When low temperature and high humidity, chicken weight loss will slow down, consumption will increase, susceptible to cold and digestive tract diseases. In a low-humidity environment, dust in the chicken house increases, chicken
feathers are unkempt, respiratory diseases increase, and weight gain is also affected. As for the light intensity, when it is low, it will affect the feeding and drinking of laying hens. It will not stimulate and affect the egg production. When it is too high, the chicken will show neuroticism and it will be easy to fight. Atmospheric pressure is a physical quantity that is simultaneously affected by temperature and humidity in the environment. Observations of it help to study the effects of temperature and humidity on the growth of laying hens.

In general, the concentration of harmful gases is too high, and the unsuitability of environmental parameters will cause various stress responses in laying hens[6]. The above conditions will affect the health of laying hens, which in turn leads to reduced egg quality or reduced yield.

The automated process of laying hen farms in China has just started. Some large and medium-sized laying hen farms have realized automatic water supply and feeding[7]. However, real-time monitoring and feedback on the environment of laying hens is relatively lacking[8]. The development and innovation of Internet of Things technology in the agricultural field provides the possibility of intelligent automatic control of the growth environment of laying hens[9, 10]. The development of China's agricultural Internet of Things is combined with the future and directions of multimedia data, cloud computing and 5G transmission[11]. We also refer to the existing types of agricultural Internet of Things monitoring systems at home and abroad, such as: Intelligent agriculture greenhouse environment monitoring system, Environmental Monitoring System for Smart City, Ecological Farming Control System, Botanical Internet of Things[12-14]. And we also summarize the functional advantages and existing problems of existing systems to improve the selection and deployment of sensors in the system.

The system designed in this paper uploads the information collected by illumination, temperature, humidity, and gas sensors to the server through the wireless transmission technology. Then, the integrated management system realizes the real-time monitoring of the environmental information of the laying hens and the query, analysis and remote control on the webpage and the mobile side, providing a good growth environment for the laying hens and promoting the increase of egg yield and quality.

2. Overall design of monitoring system

The equipment and system pilot farm have 80,000 laying hens and 6 chicken houses, with an annual output of 150,000 kg. According to the field situation of the laying hen farm, the internal schematic of the chicken house is shown in figure 1a.

The design plan for the IoT Farm is as follows: Sensor equipment is arranged in the chick breeding area, the middle chicken breeding area and the big chicken breeding area, connect the power interface and device with data cables, the equipment control unit is installed at the door. Real-time transmission and device control of sensor monitoring data using GPRS wireless transmission mode. Figure 1b is the
layout plan of the laying hen farm.

3. Integrated IoT Farm Equipment and System

3.1. Screen out sensor devices suitable for poultry farms
Environmental monitoring sensors used in 8 poultry farms including temperature, humidity, illumination intensity, atmospheric pressure, CO₂, CH₄, H₂S and NH₃.

3.2. Integrated poultry environmental information monitoring equipment
It integrates the poultry environment and the in-house information monitoring equipment for real-time collection of the culture environment information, and uploads the collected sensor data to the server through the wireless data transmission module. In order to meet the power supply requirements of the field work of the monitoring station, the monitoring station is equipped with a solar power supply system. At present, the monitored culture environment information mainly includes eight indicators such as temperature, humidity, illumination intensity, atmospheric pressure, CO₂, CH₄, H₂S and NH₃. Figure 2 shows the flow chart of the operation of the poultry environmental information monitoring equipment.

3.3. Integrated poultry environmental information control equipment
The poultry environmental information control equipment is shown in the figure 3a. The equipment can be connected to farm control unit such as fans, heaters, illuminations, motors, pumps and solenoid valves. The equipment is easy to move and is suitable for poultry control. The operation interface of the poultry information control unit control system is shown in figure 3b.

Integrated poultry environmental information control equipment enables farmers to remotely control the start and stop of unit such as fans, illuminations, pumps, heaters, motors and solenoid valves through mobile APP.
4. Equipment installation and system deployment

In November 2018, the equipment and system installation and commissioning of the IOT Farm were carried out in the laying hen farm in Beijing. Eight sensors, such as temperature, humidity, light intensity, atmospheric pressure, CO₂, CH₄, H₂S and NH₃, were installed and deployed. The function of collecting environmental information in the house is realized. At the same time, the relay of the remote control system is connected to the 5 fans and lights in the house. Field manual control and remote control of the lighting and fan opening and closing in the house are achieved.

![Figure 4](image1.png)

**Figure 4.** Chicken house environment collection and remote control mobile APP.

Through the mobile APP, you can view the environmental information, video information and remote control in the house in real time. Real-time viewing of environmental information in the house and remote control of the control units such as 5 fans and lights in the house can be done on the phone. The main interface of the mobile phone software, the monitoring information interface and the switch control interface are as shown in figure 4a, 4b and 4c.

After opening the website through the browser and logging in to the property information management system, you can view the environment information and remote control in the house in real time. As shown in figure 5a, the environmental information in the house is viewed in real time. The control unit in the house can be remotely controlled, as shown in Figure 5b.

![Figure 5](image2.png)

**Figure 5.** Chicken house environment collection and remote control system.

Through the IOT Farm Information Management System, the collected chicken house environmental information data can be downloaded after selecting the time period. The downloaded data curve shows that the environmental information in the chicken house can be remotely controlled through the IoT Farm Information Management System.

Figure 6a shows the temperature change in the house from May 2 to May 31, 2019. It can be seen from the figure that the temperature in the house is always in the range of 20 °C to 35 °C, and the temperature is generated in the interval. The reasons for the change are factors such as temperature difference between day and night, heater temperature control and fan wind speed control.

Figure 6b shows the humidity change curve in the house from May 2 to May 30, 2019. It can be seen from the figure that the humidity in the house is generally in the range of 20% RH to 35% RH. Humidity changes are mainly related to outside air humidity and water curtain control.
Figure 6c shows the change in CO$_2$ concentration in the house from May 2 to May 30, 2019. It can be seen from the figure that the CO$_2$ concentration in the house is in the range of 0.02% VOL to 0.1% VOL. The diurnal breathing intensity of the laying hens, the wind power of the wind turbines, and the construction of the farm operators will result in changes in CO$_2$ concentration.

Figure 6d shows the NH$_3$ concentration change in the house from May 2 to May 30, 2019. It can be seen from the figure that the NH$_3$ concentration in the house is in the range of 0 PPM to 2 PPM. While NH3 is mainly derived from chicken manure, the cleanup of chicken manure and the speed of the fan wind will cause fluctuations in NH$_3$ concentration.

The influence of the above-mentioned chicken house environment, the control of the wind speed of the fan, the control of the heater, and the control of the water curtain can all be realized by the Internet of Things technology, replacing the original manual control. Through the Internet of Things technology, the variation of the environmental parameters of the house can be controlled more accurately, so that the environmental parameters of the house are always within the comfort range of the laying hen.

5. Conclusion
The factual measurement of the environmental information of the laying hens is realized through the implementation of this project, and the environmental control management in the production of laying hens is optimized. Armed egg production technology through agricultural Internet of Things technology and agricultural information technology will effectively improve egg production and quality of laying hens, and further reduce manual labor to save production costs. This project will provide new ideas and establish a typical model for the upgrading of large-scale laying hens in the region, and form a basic application model that can be applied, replicated and promoted. With the application of 5G communication technologies, Internet of Things technology and artificial intelligence technology will play a greater role in the management of laying hens, and promote the automation, informatization and intelligence of laying hens.

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