Information Integration and Environmental Monitoring for Cage Pigeons

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Abstract. Environmental changes in the farm can have a significant impact on the healthy growth of cage pigeons, disease prevention and the quality of pigeon meat. The stability and adaptability testing of environmental monitoring equipment and systems was completed through the pilot deployment of IoT Ranch in a pigeon farm in Beijing. An integrated program for real-time monitoring of environmental parameters of cage pigeons is implemented. Moreover, a system for informatizing and researching environmental information and real-time querying information on a webpage or mobile terminal is developed. The information-integrated environmental monitoring equipment and system can provide technical support for the modernization, automation and digital management of cage pigeons.

1. Introduction
With the improvement of people's living standards, pigeons are more and more appearing on the Chinese table. For the breeding of pigeons, China's large cage pigeons are completely in the stage of independent exploration. Because European and American countries have very little demand for pigeons, there is no formed breeding system.

In order to study the effects of various environmental factors on the growth and health of pigeons and provide a suitable environment for cage pigeons, the information on the loft's environment is extracted through information technology: mainly in the breeding process of pigeons. Monitoring of harmful gases such as CO₂, NH₃, H₂S and CH₄[1]. As well as monitoring of temperature, humidity, illumination, PM2.5, PM10 and atmospheric pressure in the environment surrounding the pigeons[2]. At this stage, the breeding experience of other poultry and some pigeons, excessive concentration of harmful gases or drastic changes in environmental parameters will cause various stress responses in poultry[3]. High temperature and high humidity affect the heat regulation of the pigeons and destroy the heat balance. The resistance of the pigeon body is reduced. The parasitic diseases of the pigeons, skin diseases and fungal diseases and poisoning are prone to occur. Pigeons are susceptible to cold diseases and digestive tract diseases in low temperature and high humidity conditions. In cold winters, relative humidity >85% has an adverse effect on the production of the pigeons. If the humidity is too low, such as less than 7%, the feathers of the young pigeons will be badly formed, the feathers of the meat pigeons will be cracked, and the skin will be dry. Harmful gases and respirable particulate matter cause the occurrence of respiratory ectopic lesions. Eventually, it affects the physical health of poultry,
which in turn leads to a decline in the quality of poultry-related agricultural products or a reduction in production[4].

The application of agricultural informatization technology in rural modernized pastures has made important contributions to the development and prosperity of the rural economy[5]. And it also increased the productivity of various agricultural products[6]. The digitization process of pigeon farms in China is still in the exploratory stage[7]. Some large and medium-sized pigeon farms have realized automatic water supply and feeding according to the deployment of other poultry farms and livestock farms[8, 9]. The real-time monitoring and feedback on the environment of pigeon farms is still in the process of learning and imitation[10].

In this paper, the cage pigeon information monitoring management system is integrated[11]. Agricultural information technology and Internet of Things technology are applied to the system[12]. At the same time, the development direction of 5G transmission technology, supply chain, cloud computing technology and artificial intelligence is referenced[13]. The cage pigeon information monitoring management system was designed and installed for the field situation of the loft and the equipment was piloted. The information technology uses the information collected by the illumination, temperature and humidity, and gas sensors to upload to the server through the wireless transmission technology. The integrated management system realizes the real-time monitoring of the environment information of the pigeon farm and the query and analysis on the webpage and the mobile terminal. Provide a suitable environment for the pigeons to grow and promote the yield and quality of the pigeon-related agricultural products.

2. Environmental information monitoring integrated system

2.1. Screen out sensor devices suitable for poultry farms
Environmental monitoring sensors in 10 poultry farms including temperature, humidity, illumination, atmospheric pressure, PM2.5, PM10, CO2, NH3, H2S and CH4.

![Figure 1. System work flow graph.](image)

2.2. 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 10 indicators such as temperature, humidity, illumination, atmospheric pressure, PM2.5, PM10, CO2, NH3, H2S and CH4. The system work flow graph is shown in figure 1.
2.3. Integrated pigeon environment information control device

Integrated pigeon environment information control equipment enables farmers to remotely control the start and stop of devices such as fans, lights, pumps, heaters, motors, and solenoid valves through mobile APP. Figure 2 shows the interface of the mobile phone software. The main interface of the mobile phone software is shown in the figure 2a, the real-time environment parameters are shown in the figure 2b, and the switch control interface is shown in the figure 2c.

Figure 2. Loft breeding environment collection and remote control mobile APP.

Figure 3a shows poultry environmental information control unit. The unit can be connected to farm control devices such as fans, heaters, lights, motors, pumps, and solenoid valves. The unit is easy to move and is suitable for poultry control. The poultry environmental information control device control system operation interface is shown in the figure 3b.

Figure 3. Loft environment information control unit.

3. IoT Ranch Design

Equipment and system pilot pigeon farm has 20 lofts and 1 million pigeons. According to the actual situation of the pigeon farm, the internal diagram of the loft is shown in the figure 4a. Referring to the figure 4b, the equipment control unit is installed at the door. The sensor device is installed in the pigeon breeding area, and the data cable is connected to the unit through the data cable. Real-time transmission of sensor monitoring data is realized by GPRS wireless transmission mode, and wire realizes connection of device control unit and device.
4. Equipment installation and system deployment

In November, 2018, in the pigeon farm in Beijing carried out the installation and commissioning of the equipment and system of the IoT Ranch. 10 sensors including temperature, humidity, illumination, atmospheric pressure, PM2.5, PM10, CO2, NH3, H2S and CH4 are installed to collect environmental information in the loft in real time. At the same time, the remote control system was installed. The relays are connected to the lights in the lofts for manual control and remote control of the opening and closing of the lights in the loft. Some equipment in the loft is shown in figure 5.

After opening the website through the browser and logging in to the property information management system, you can view the environment information, video information and remote control in the loft in real time, real-time view of the environment information in the loft, and remote control of the control unit in the loft. Figure 6a shows the real-time monitoring information page of the loft. Figure 6b shows the remote control page of the loft control unit.

Through the IOT Ranch Information Management System, the collected loft environment information data can be downloaded after selecting the time period. The downloaded data graph shows that the environmental information in the loft can be remotely controlled through the IoT Ranch Information Management System.

The graph shown in figure 7 is part of the environmental monitoring parameters recorded by the
equipment of the equipment farm in Beijing, from May 2nd to May 30th, 2019.

Figure 7a is a graph of CH$_4$ concentration change in the loft. It can be seen from the figure that the CH$_4$ concentration in the loft is always in the range of 1% LEL to 5% LEL. The reason why the CH$_4$ concentration changes within the range is mainly due to feces, so factors such as the cleanup of the manure and the fan wind control cause fluctuations in the data.

Figure 7b is a graph of PM2.5 concentration change in the loft. It can be seen from the figure that the PM2.5 concentration in the loft is generally in the range of 0ug/m$^3$ to 150ug/m$^3$. The change of PM2.5 concentration is mainly related to the external air quality, and fan wind control also has a certain influence on the indoor and outdoor air circulation.

Figure 7c is a graph showing the change in atmospheric pressure in the loft. It can be seen from the figure that the atmospheric pressure in the loft is in the range of 99.5 kPa to 101.5 kPa. Atmospheric pressure is mainly affected by temperature and humidity in the loft, that is, the control of fan wind, the control of the heater, the control of the water curtain, etc., which will change the temperature and humidity in the loft will affect the value of the air pressure in the loft.

Figure 7d is a graph of the change in illuminance in the loft. It can be seen from the figure that the illuminance in the loft is generally in the range of 0kLux to 0.7kLux. The illuminance is mainly from the light and natural light in the loft, so the lighting control of the loft and the changes in the natural environment will cause the illuminance to fluctuate.

Image a) CH$_4$ concentration change
Image b) PM2.5 concentration change
Image c) Atmospheric pressure change
Image d) Illuminance change

Figure 7. Loft environmental information graph.

The influence of the above-mentioned loft environment, the control of the fan wind, the control of the heater, the control of the water curtain and the control of the lighting can all be realized by the combination of agricultural information technology and the Internet of Things technology. This technology can more accurately control the range of changes in the loft's environmental parameters, so that the loft environment is always within the range of suitable pigeon growth.

5. Conclusion
In this study, the three-dimensional structure diagram of the environmental monitoring equipment was designed, and the environmental information monitoring equipment for cage pigeons through system integration was developed. Through the pilot application of the equipment in Beijing, real-time monitoring of temperature, humidity, atmospheric pressure, illumination, CO$_2$, NH$_3$, H$_2$S, CH$_4$, PM2.5 and PM10 in the livestock and poultry breeding environment, effectively solving the problem of
real-time remote monitoring of cage breeding environment. The problem of real-time remote monitoring of pigeon breeding environment provides support for the digitization and information management of cage pigeons. With the application of 5G technology, agricultural information technology will make a major leap, which will accelerate the informatization, digitization and automation of the pasture.

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References

[1] Zhang, S., Chen, J., Jiao, L. (2017) Design and development of online system for monitoring harmful gas in animal house. IEEE: 406-410.
[2] Wang, Z., Wang, G., Wang, D., et al. (2017) An Integrated Purifier for Livestock and Poultry Based on Safe Air and Drinking Water.
[3] David, B., Mejdell, C., Michel, V., et al. (2015) Air Quality in Alternative Housing Systems may have an Impact on Laying Hen Welfare. Part II-Ammonia. Animals (Basel), 5: 886-96.
[4] Brouček, J., Čermák, B. (2015) Emission of Harmful Gases from Poultry Farms and Possibilities of Their Reduction. Ekologia, 34.
[5] Zhang, X. (2017) Research on the Role of Agricultural Informatization in Rural Economic Development. Atlantis Press.
[6] Deng, R., Ran, G., Zheng, Q., et al. (2018) The nonlinear effect of agricultural informatization on agricultural total factor productivity in China: A threshold test approach. Cust. Agronegocio, 14: 213-236.
[7] LIANG, Z., LU, C. (2018) The Impacts of Agricultural Informatization on Rural Economic Growth in Henan Province. Journal of Henan Agricultural Sciences: 26.
[8] Tang, J., Dong, T., Li, L., et al. (2018) Intelligent Monitoring System Based on Internet of Things. Wireless Personal Communications, 102: 1521-1537.
[9] Zhang, J., Kong, F., Zhai, Z., et al. (2016) Design and development of IoT monitoring equipment for open livestock environment. Int. J. Simul. Syst. Sci. Technol, 17: 2-7.
[10] ZHANG, J., Fantao, K., Zhifen, Z., et al. (2017) Development of Wireless Remote Control Electric Devices for Livestock Farming Environment. Atlantis Press.
[11] Lacerda, F., Lima-Maques, M., Resmini, A. (2018) An Information Architecture Framework for the Internet of Things. Philosophy & Technology.
[12] Vuran, M. C., Salam, A., Wong, R., et al. (2018) Internet of underground things in precision agriculture: Architecture and technology aspects. Ad Hoc Networks, 81: 160-173.
[13] Koshy, S. S., Sunnam, V. S., Rajgarhia, P., et al. (2018) Application of the internet of things (IoT) for smart farming: a case study on groundnut and castor pest and disease forewarning. CSI Transactions on ICT, 6: 311-318.