Using Machine Learning and Internet of Things Framework to Analyze Eggs Hatching

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Abstract. High-efficiency artificial incubation technology is the basis of the development of the poultry industry, and good chicks can be obtained through excellent egg breeding and good incubation technology. In Taiwan, the control of important parameters for waterfowl hatchery is still based on the inheritance of experience. The manual intervention of the cold egg operation during the hatching process will also affect the stability of the hatching environment and the risk of poultry biological safety infection.

Therefore, in addition to discussing the current factors affecting waterfowl hatching, this study will also establish a set of IoT sensing systems suitable for waterfowl hatching. We use thermal imaging cameras and air quality sensors to collect the key factors that affect the hatching of waterfowl during the hatching process, and use the machine learning analysis framework to analyze the collected big data of waterfowl hatching. Although the application of thermal imaging technology has limitations, due to the non-invasive characteristics and the cost of technology, the application of poultry science has gradually received attention.

Combining poultry science and information science, we have reintegrated a complete set of intelligent detection and application improvement solutions, which can enhance the digitalization and intelligence of the hardware and software of the waterfowl industry chain.

Keywords: Waterfowl · Thermal imager · Artificial intelligence · IoT · Sensor

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1 Introduction

High-efficiency artificial incubation technology is the basis of the development of the poultry industry, and good chicks can be obtained through excellent egg breeding and good incubation technology. The manual intervention of the cold egg operation during the hatching process will also affect the stability of the hatching environment and the risk of poultry biological safety infection. In Taiwan, the control of important parameters for waterfowl hatchery is still based on the inheritance of experience. Because of the shortage of young employees in Taiwan's waterfowl breeding industry, the breeding methods have gradually moved from large-scale production to refined agriculture. The scale of operations and the age of employees are no longer comparable to the past, but the demand for waterfowl in the consumer market is increasing year by year.

We can get the number of ducks slaughtered from the annual report of agricultural statistics of the Agricultural Committee of the Executive Yuan of the Republic of China [1]. From 2010 to 2019, the number of meat ducks being raised was 28,546,000, 28,808,000, 27,253,000, 32,460,000, 36,786,000, 33,519,000, 34,748,000, 36,339,000, 35,596,000 and 37,002,000, indicating that the consumption market for meat ducks is increasing year by year. In 2014, the number of farms was 36,786,000. The reason for the decrease in the next year was the occurrence of highly pathogenic poultry influenza (avian influenza) that year. Meat ducks and breeding ducks that tested positive had to be culled, resulting in a decline in the number of farms. From 2016 to 2019, the number of breeding has gradually increased (Fig. 1).

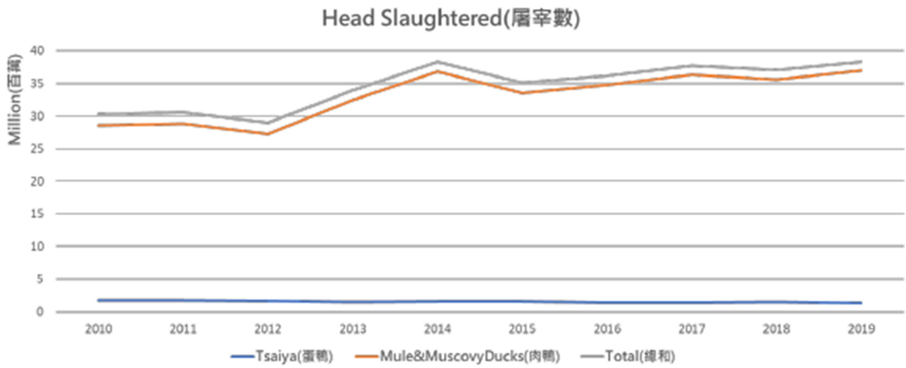

Fig. 1. The number of laying ducks (Tsaiya) and meat ducks (MuscovyDucks) slaughtered in the Republic of China.

This shows that the demand for waterfowl in the consumer market is increasing year by year. Therefore, how to increase the hatching rate in order to increase the production of waterfowl and to achieve a balance between supply and demand is what the market needs. In previous studies, many research results show that the two parameters of temperature and humidity have a decisive influence on the hatchability of breeding eggs [2–6]. However, the current domestic industry's control of temperature and humidity parameters is still mainly based on experience inheritance, and a scientific incubation model has not been established.

2 Literature Review

As far as the poultry industry is concerned, artificial incubation is the basic means to promote good poultry. Because of excellent breeding eggs and good hatching, good young birds can be obtained. The planned elimination of poorly produced poultry species and avoiding the mixing of poultry species will benefit the planned production and supply of young poultry. The operation management during the incubation process has a huge impact on the incubation performance. The eggs enter the incubator, and then move to the generator stage. There are many factors that affect hatching, as described in Table 1:

Table 1. Factors affecting hatching.

Factors of breeding poultry	Factors of breeding eggs
Genetic structure Age Egg production Nutrition management	Egg quality Storage time Storage temperature Disinfect Transport Altitude Temperature Operation management during the incubation period

The application of thermal imaging cameras in poultry science has gradually attracted attention. Although this technology has its limitations and limitations, based on the non-invasive characteristics and the reduction of technical costs, there have been corresponding agreements in various application fields to deal with it. Such as the monitoring of the physiological state of birds, behavioral research and field surveys, etc.

McCafferty [7] compiled the application of thermal imaging in poultry science and provided guidelines for evaluating the investment in thermal imaging technology. Lin et al. [8] used thermal imaging technology to identify and filter broken fertilized chicken eggs, using machine vision to replace manual identification, and the identification rate could reach 96%. Sunardi et al. [9] proposed the use of thermal imaging cameras on the eggs, the study of the data that can be obtained, focusing on the format conversion of image processing.

We use thermal imaging cameras and air quality sensors to build an IoT sensing environment for waterfowl hatching machines, and implement a waterfowl hatching intelligence collection system to collect data on influencing factors in the waterfowl hatching process.

3 Methodology

We installed thermal imaging cameras, gas detectors, temperature and humidity detectors in the incubation environment, and put 30 breeding eggs for system testing. The data during the incubation process will continue to be collected into the database until the

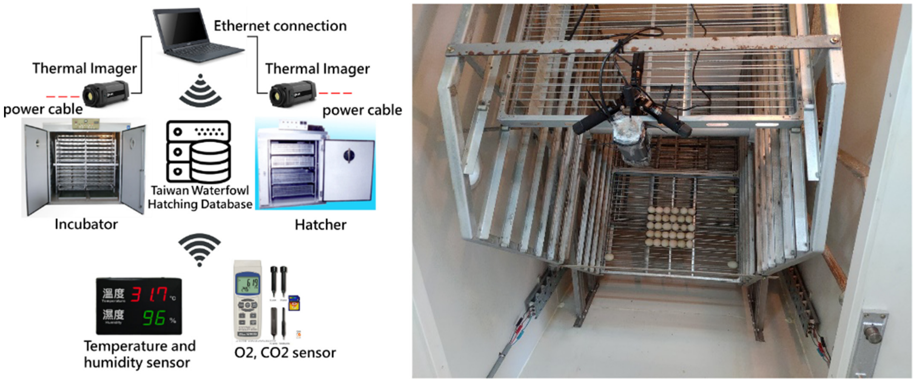

Fig. 2. IOT system architecture diagram and experimental scene.

incubation is completed. We will mark the hatching results of the hatching data and use machine learning for classification training (Fig. 2).

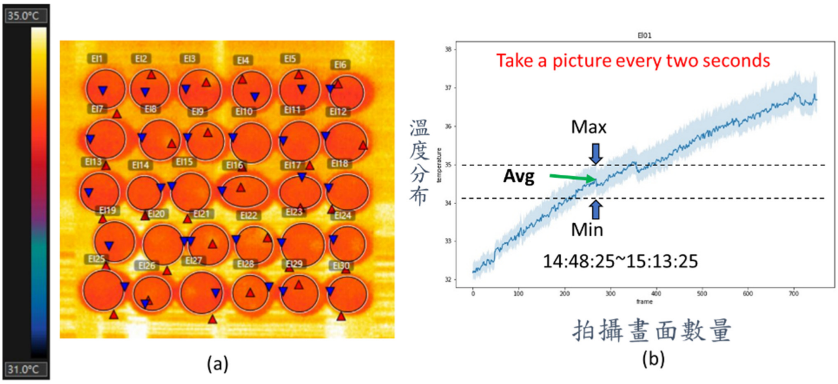

Fig. 3. (a) Thermal imaging of the breeding eggs taken by the thermal imaging camera. (b) The temperature record distribution of the hatching egg number EL1.

Figure 3(a) shows the 6*5 grid thermal image of the egg tray during shooting. We can get the highest temperature, lowest temperature and average temperature of the egg surface temperature through the temperature change of the egg surface taken by the thermal imager. Figure 3(b) is the information about the heating of the breeding egg numbered EL1 in the incubator. We recorded the temperature change in detail within 25 min. The maximum temperature difference of each breeding egg is different. When the hatching egg is completed, we will mark the hatching result of each breeding egg. After the temperature information is recorded in detail, machine learning can be used to build an incubation prediction model. After the model is calibrated and optimized, these temperature parameters can be used as a reference for the improvement of the incubator.

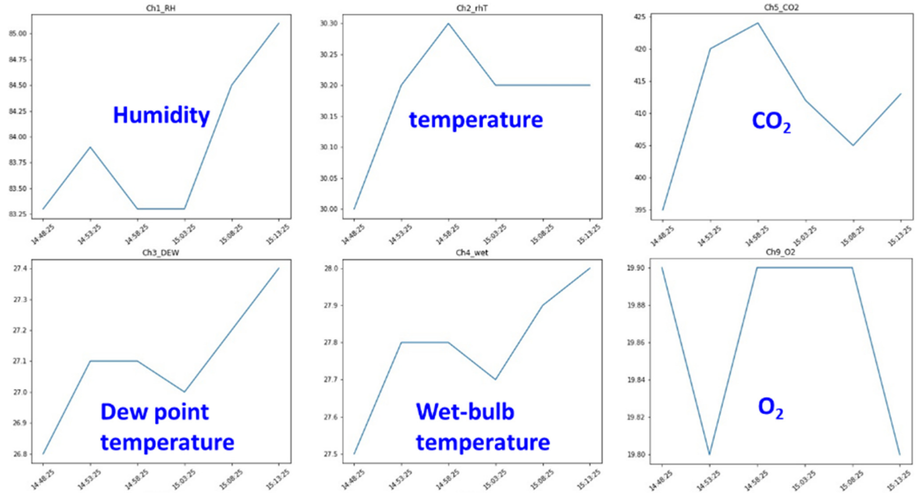

Fig. 4. Six additional recorded air values

Figure 4 is our additional recorded air information inside the incubator, hoping to find out the key parameters that affect the hatching results with diversified characteristics. We recorded the values of temperature, humidity, dew point temperature, wet bulb temperature, oxygen and carbon dioxide.

4 Conclusion

The experiment is still in progress, and the hatching time of the breeding eggs is long. In the process, there have been accidents of power failure, crash, and broken eggs. In order to pursue the integrity of the data, in addition to gradually improving our experimental design and crisis management mechanism, we also plan to incubate four more batches of breeding eggs. We have confidence in the data collected by the thermal imaging camera during the incubation process, which is completely different from the past studies of simply collecting temperature and pursuing a homogenized incubation environment. The experimental results can be used as the basis for setting the parameters of the uniform incubation environment in the past.

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