EXPLORING IOT BASED BROILER CHICKEN MANAGEMENT TECHNOLOGY

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Abstract
The article reports on the development of labor-saving chicken production management techniques with IoT (Internet of Things)) technology. Ip based video cameras, a variety of sensors (atmospheric pressure, illumination, body temperature (4x4 segments)), and RFID (radio frequency identifier, this is for short-range wireless communication based on the electromagnetic fields, radio waves) technology were utilized. RFID was used for getting the chicken's unique embedded ID (identification) which was recorded from RFID tag. As 1st step, we focused on analyzing the individual chicken's weight which is linked with the RFID tag and conducted a trial of video-based chicken weight inference system by Artificial Intelligence (Deep Learning). The study demonstrates the potential of video-based chicken production monitoring system.

Key words: *Broiler; Chicken's behaviours; RFID; Artificial Intelligence; Deep Learning; IoT.*

INTRODUCTION

As wealth increases, consumers become more particular about what they consume. They are more concerned about food safety and about how their food was produced. This denmand has created a new category of food referred to as premium foods. Research was done on improving the traceability of beef using RFID in China with the aim of meeting consumers rising food safety demands *(*1Feng, J., Fu et al., 2013, *2Wanjie Liang et al., 2015)*. In broiler chicken production, there is a lack of labour and cost-efficient method/technology to manage individual birds. Domestic consumption of chicken meat in Japan was 2,298 thousand tons in 2015, and 2,369 thousand tons in 2016, an increase of 3.1% over the previous year. Similarly, the domestic production volume is expanding in conjunction with the consumption volume, with 1,517 thousand tons in 2015 and 1,545 thousand tons in 2016. The number of domestic broiler chicken farms (brooders) is on the decline with 2,590 units in 2006 and 2,360 units in 2016, mainly for small-scale feeder groups while the number of shipments have increased from 103,687 thousand in 2006 to 138,776 thousand in 2018, where large-scale chicken farmers had more than 500,000 shipments accounting for 11.3% of the whole 2016. This is mainly due to consolidation of the smaller farms, resulting in more large-scale brooders *(*3Livestock Statistics, MAFF Japan, 2018)*. However, at production sites, 5 to 6% of chickens are expected to die during feeding, and even after post-shipment inspection, they are destroyed due to disease. In addition, in recent years the brooding system has been focused on creating comfortable environments for the reduction of diseases. Regarding the individual recognition, in recent years, with the evolution of IoT technology, increase in storage capacity and the technology of artificial intelligence have been established, as such, all growth records can now be stored as electronic data. In addition, food safety requirements are increasing worldwide, and IoT technology can be incorporated into production process management, to establish a high-quality and safe meat production system with minimum human intervention.

In this research, we manage the broiler chicken growth with IoT technology, and improve the brooding environment of chickens in brooding space from the viewpoint of Welfare (animal welfare) and produce safe and high-quality chicken. The purpose is to develop a system for high quality and safe meat production with minimum human intervention. In this study, we used RFID as a method of individual management of chicken and verified a method of chicken's behaviour detection by Deep Learning based on chicken brooding video.

MATERIALS AND METHODS

(1) Individual management technology of chicken

1) Feeding facility

An experiment on the management of individual chickens was conducted at the experimental feeding facility at the Faculty of Agriculture, Yamagata University in Tsuruoka City, Yamagata Prefecture in Japan. The feeding facility was assembled using a total of four panels for two types of general-purpose gardening panels (890 cm x 1800 cm, 900 cm x 900 cm), and the experimental feeding facility as shown in Fig. 1. It was divided into two in the vertical direction by a partition plate (mesh type) (arrangement of feeding unit) and a section (arrangement of water supply). We installed an RFID Tag receiver built-in weight scale which was located in the single passage of the sections as IoT device (Fig.2). The chicken's video was taken with a wide-angle camera recorded directly from above the weight scale. At the same time, 7 segment LED values which are showed the chicken's ID and each weight were recorded as text data. There was a single passage between area of eating area and drinking, in order for the chickens to pass (Fig.3). For this experiment, we selected a common "*Chunky*" young bird, which were fed four times. Table 1 shows the feeding schedule and number of chickens.

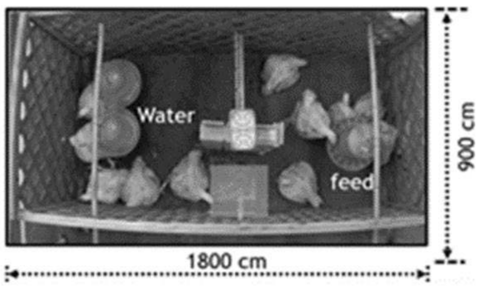

Fig. 1 the experimental feeding facility

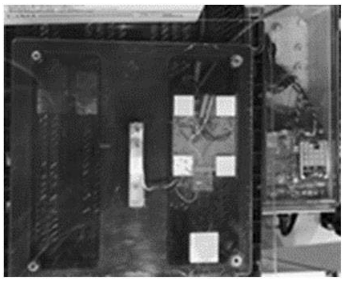

Fig. 2 RFID Tag receiver built-in weight scale as IoT device

Table 1. The Experimental Feedings

Number of experiment Feedings	Feeding Schedule		Feeding Dates	Number of chickens
1st	Oct.11th - Dec. 5th	2017	56	10
2nd	Jun 23rd - Aug. 14th	2018	53	14
3rd	Oct.26th - Nov. 10th		14	11
4th	Nov. 27th - Dec. 19th		23	10

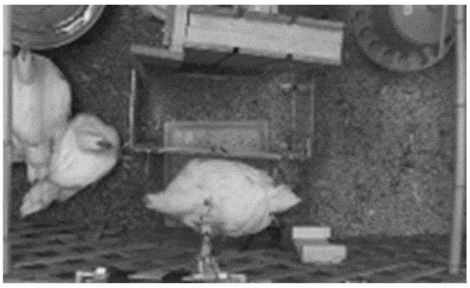

Fig.3 The single passage between area of eating and drinking

(2) System configuration of experimental feedings.

1) Chicken weight scale

Since it is difficult to identify chickens by visual inspection, we developed RFID Tag receiver built-in weight scale using a commercially available RFID. The weight scale used the load cell (SC133-5kg by Sensor and Control), A/D converter, microcomputer, micro SDXC card and WiFi module. The scale sends the data to storage (Micro SDXC) and into cloud server via WiFi. The obtained data was recorded every 0.5 second, and was saved as text data in csv format which showed Chicken's ID and weight as real-time with 7 segments LEDs. The block diagram of RFID Tag receiver built-in weight scale is shown in Fig. 4 and the working status is shown in Fig. 5.

For RFID tag selection, we used the Low-frequency 125 KHz band. Low-frequency transponder has

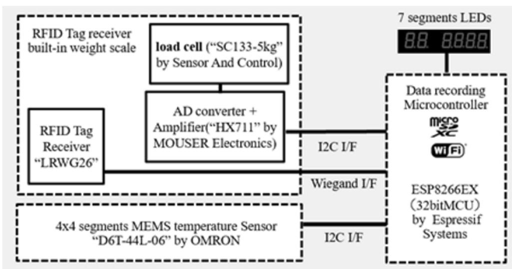

Fig. 4 The block diagram of RFID Tag receiver

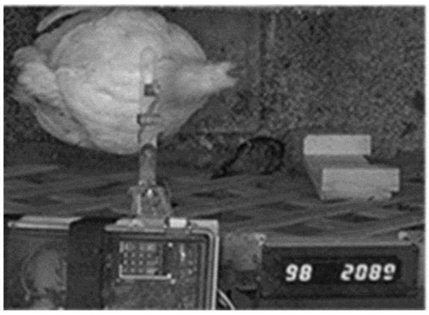

Fig. 5 The RFID Tag receiver built-in weight scale with 7 segments of LED (Chicken's ID and weight (g))

two different reading protocols and 2 frequencies (125KHz and 134.2KHz) and there are others (High-Frequency and Ultra-HIGH Frequency types) (*4T.M. Brown-Brandl et al.,2017). These types are different characteristic, Low-frequency and 125KHz has a wide radio directivity and is less susceptible to metal and water. The RFID is a passive ultra-compact Tag (FAREAD Technology, FRD-LF-GT3: φ2.12x12 mm) that does not have a built-in power supply as a coil antenna wound around a core rod shape using an electromagnetic induction system. RFID was used by Feng et. al, (2013) in a traceability system for cattle in China who found that it could greatly improve automation, efficiency and convenience in cattle/beef enterprises management as a controlling tool for product quality and safety. The RFID mounting on a chicken was attached to a commercial chicken leg ring with a hot melt adhesive (ethylene vinyl acetate) as shown in Fig.6.

Fig 6. The RFID tag mounting for chicken leg ring with a hot melt adhesive (ethylene vinyl acetate)

2) Chicken behavior recording system
Video camera and video server system is shown in Fig.7.
Three IP cameras were set to record the behavior of chickens. Video was shot as sequential JEPG photos than captured the chicken's behavior, ID and weight on 7 segments LED. The video was stored into network attached storage (NAS: Buffalo, Terastation 5400 DN (RAID 4 Drive 8TB)) as JEPG format (Table 2, Fig.8). NAS had enough capacity to record during the experimental feedings.

Table 2. The equipment list of chicken behavior recording system

Items	Vendor	Product Name and Specification	Number of Items
IP camera	Mobitix	M25(horizontal 60 °, vertical 45 °, aperture F1.8)	1
		M25(horizontal 90 °, vertical 67 °, aperture F1.8)	2
NAS(Network attached storage)	Buffalo	Terastation 5400DN (RAID 4 Drive 8TB)	1
PoE(Power over ethernet) ethernet switch	Allied Telesis	AT-SH230-10GP	1
Potable Notebook PC	NEC	Windows10 + Motix Control Center	1
Broadband Router	Corega	CG-WLR300N	1
Dust-proof Cabinet	Nitto Kogyo		1

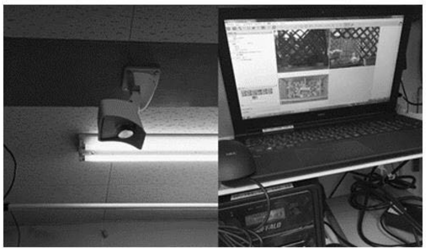

Fig.7 Video camera and video server system

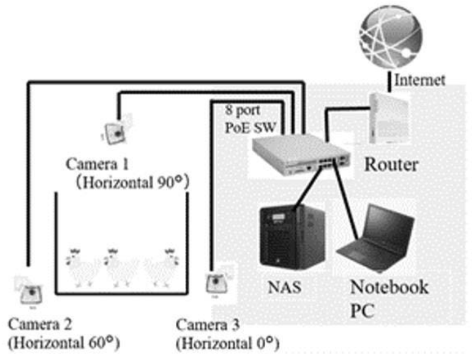

Fig.8 Chicken behavior recording system

3) Weight inference system
The recorded weight data and the recorded Chicken's shape video were utilized for training data of the weight inference system by AI. In this case, Deep Learning was used.
The chicken shape labeled with displayed weight value. The displayed value was dynamically changed every 0.5 second, we considered the actual weight value of each chicken in order to avoid miss labeling. For training the AI chicken images were selected from the 3rd experimental feedings. We set the 4 weight ranks as 1,700 g, 1,800 g, 1,900 g, 2,000 g. 500 pieces of each rank was labeled for training data for Deep Learning analysis.
We selected the Deep Learning frame work "Darknet (Open Source Neural Networks in C language)" and "Yolo V3" (*5Designed by Joseph Redmon et al., 2018) for the inference algorithm. This framework was strong to make the inference as real-time for detecting the chicken weight based on image shape. This was acceptable inference performance for chicken's rapid actions. We executed

10,000 times, 20,000 times and 30,000 times traning with 500 images which were classified into a verification image and a learning image at 8:2. The total number of training data learned was 1,596, and learning accuracy was evaluated with 100 verification images (total: 400 images for 4 ranks) using the trained weight data.

(3) Survey items

The survey was conducted to verify the performance of Chicken weight scale method with regards to ; 1- whether the leg ring attached the RFID tag can keep during the feeding or not. 2-whether it can be measured each chicken's weight data with RFID tag stably or not. 3- whether the measured weight data was accurate or not. 4- whether the weight inference system can be used for getting the progress of growth for chicken's weight, generated by AI(Deep Learning) based on Chicken's photos with Chicken weight scale.

RESULTS AND DISCUSSION

(1) Attachability of RFID Tag to leg ring

The attached RFID tag was dropped twice during the 4 feeding experiments, also there was a problem of the bonded part in the durability. It resulted from a lot of friction between the leg ring and the leg generated from the growth of chicken's activities and deterioration of the adhesion of glue by the manure and high environment temperature (around over 25 ℃). As a countermeasure, we devised a method of fixing RFID to a leg ring with a heat-shrinkable tube. This method was inexpensive and easy to install. In the 4th feeding experiment, the dropout of RFID did not occur. A picture of solution is shown in Fig.9. However, in future, we hope to make available suitable size leg ring with integrated RFID in the market.

Fig 9. Mounted the RFID tag with a heat-shrinkable tube for leg ring

(2) Chicken weight scale

In 4th feeding experiment, Chicken weight scale could record the weight data. We could show the weight gain transition of 10 chickens in Fig 10. Each data was generated based on the histogram of the chicken weight by day. There were some fluctuations of data. The following factors can be considered potential design issues. The representative weight data of each chicken might not be maximum frequency weight value. We observed the scene which the chicken stayed one leg with RFID put on the scale, the other leg put on the ground for long time, in this case, the scale generated lower weight value , (since chicken weight was lower than actual weight) was recorded every second. In other case, if one chicken remains on the scale, other chicken pass over, the scale could not capture the pass though chicken's ID. Also in some cases, when the chicken passed through the scale quickly, the weight value was on transition to target value, but the weight could not reach the target number due to slow response of load

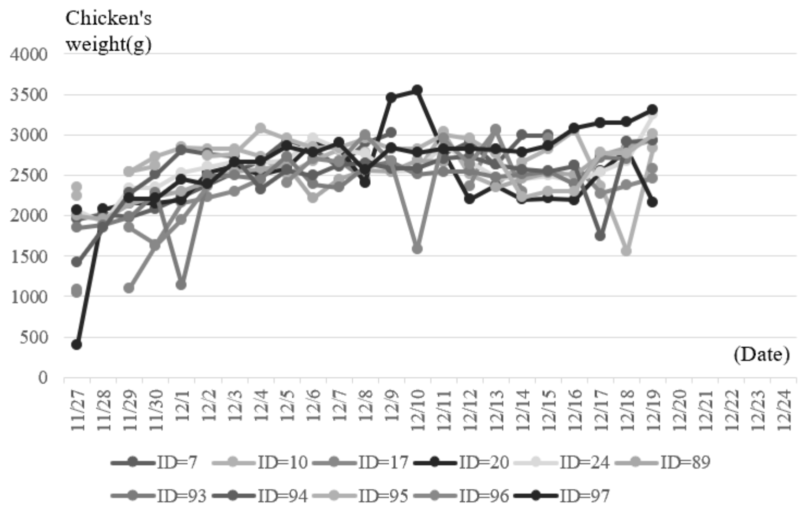

Fig. 10 The weight gaming of 10 chickens on 4th feeding experiments captured with Chicken weight scale

cell. It could not record over 2,500g weight, there were gaps between the actual weight value which are shown in Fig.11 and weight scale value which showed in Fig. 12 as one chart. The solution should be set multiple load cell to make the quick response and capture the more accurate weight.

There is absence of weight data for some birds, this can be attributed to the chicken's quick passing through over the scale. Or it might be the health problem, where the chicken was not active. This is one of key indicator to check the chicken's health, behavior.

From the feeding experiments, it was possible to obtain the behavior and weight transition of the chicken in day by day, and it will help to estimate the target date when they will achieve the target weight based on the feeding curve. It will help for preparation of shipping beforehand.

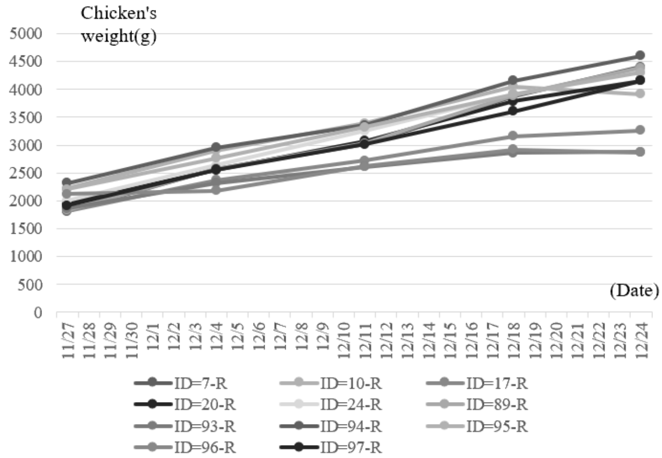

Fig. 11 The weight gaming of 10 chickens on 4th feeding experiments Actual measured weight

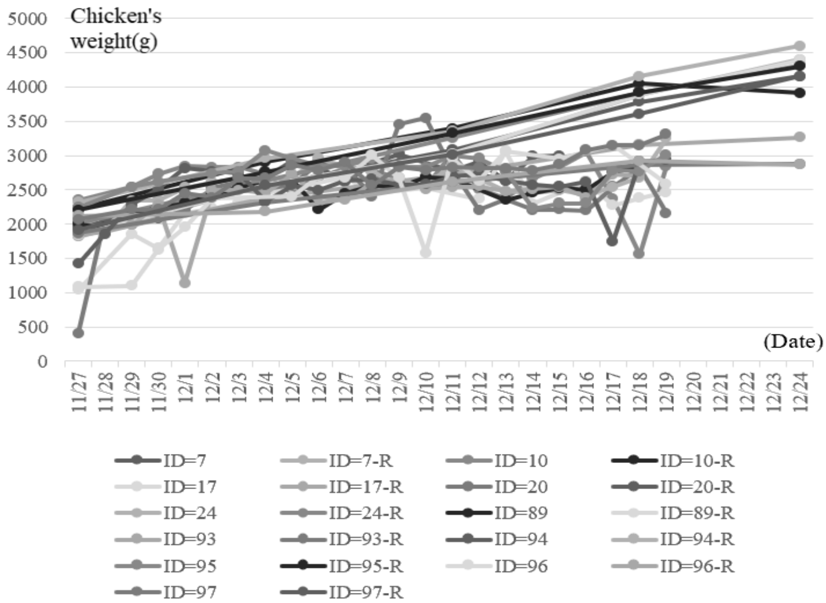

Fig. 12 The weight gaming of 10 chickens on 4th feeding experiments captured with Chicken weight scale and Actual measured weight (-R)

(3) Chicken weight inference by Deep Learning

The weight inference performance result by Deep Learning (AI) is shown in Table 3. and weight inference by AI picture is shown in Fig.13 (Example, ID=97, 2,000g) . We tested 10 pcs of test images for each class (1,700g, 1,800g, 1,900g, 2,000g) and 5 times testing to make sure the AI performance. As a result, the recognition rates of the 2,000g class was 100%, which was acceptable performance, however for the 1,700g, 1,800 g and 1,900 g classes the recognition rate were under 30%, these need to

ght classification by AI

	Chicken's weight range(g)	1st test(%)	2nd test(%)	3rd test(%)	4th test(%)	5th test(%)	Average(%)
10,000 times tranined weight file	1,700	10	10	40	50	10	24
	1,800	10	10	0	10	30	12
	1,900	20	20	40	0	10	18
	2,000	100	100	100	100	100	100
	Average	35	35	45	40	37.5	**38.5**
20,000 times tranined weight file	1,700	10	10	40	50	10	24
	1,800	10	10	0	10	30	12
	1,900	30	20	40	0	10	20
	2,000	100	100	100	100	100	100
	Average	37.5	35	45	40	37.5	**39**
30,000 times trained weight file	1,700	10	10	40	50	10	24
	1,800	10	10	0	10	30	12
	1,900	30	20	40	0	10	20
	2,000	100	100	100	100	100	100
	Average	37.5	35	45	40	37.5	**39**

improve. This resulted from insufficient training images and missing labelled images which should be include varieties of scenes of chicken's behaviour. Usually automating and tracking behavorial measurement of animals is challenging especially when there is more than one animal in close proximity as they often cross touch resulting in partial occlusion (*6Hong et al., 2015). The chicken's captured shape should be considered as against the stable shape, example is the closing of the wings almost the same as captured position. Training with a variety of chicken shapes/pose should be explored. In addition, the classified weight ranks range should be considered and expanded, the classified ranks of example are 1,000 g, 1, 500g, 2,000g, 2,500g.

Fig.13 ID=97, 2,000g weight inference by AI

CONCLUSIONS

In this study, we used RFID as a method for individual management of chicken and verified a method of chicken's behaviour detection by Deep Learning based on chicken brooding video. From the experiments:

1) A robust method of attaching the RFID tag on leg ring during the experimental feedings was determined.
2) We discovered a mechanical architecture issue in chicken weight scale it should prevent other chickens from passing over when a chicken is staying on scale, the aisle will have to be re-designed.
3) We found the accuracy issue of weight data when it is close to 2,000g, multiple load cells should be used to get quick response to measure the weight.
4) The possibility of utilizing video-based chicken growth management system by AI was demonstrated. The future progress, this system could be useful for the management of the growth situation based on the change of chicken weight and the shipping forecast without human resource.

ACKNOWLEDGMENT

This study was supported by the Ito Foundation research grant in FY2018.
"Development of different IoT-type meat production technology by individual management in poultry farming and introduction of cleaning robots"

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