Chicken Flock Response Health Evaluation System Based on Laser Stimulation and Deep Learning Technique

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ABSTRACT
The study utilizes laser to stimulate chicken activity changes for evaluating health status by deep learning techniques. System consists of embedded system, galvo scanning, camera monitoring, laser. When low activity, laser apply on test within response. As the results, difference responsiveness (P<0.001) when stimulation healthy chicks with temporary low activity.

1 Introduction
Recently, Agricultural automation technologies, such as auto-feeding supply system, automated environmental control systems, and automated cleaning systems. Can enhance productivity, reduce labor costs, and ensure favorable environment for poultry housing. Typically, chicks health evaluation indicators can reflect on these factors, such as physical appearance, behavioral activities, feces condition, respiratory status, nasal & ocular secretions. When farmers detected low activity level, further stimulus can show well response evaluate on their health status.

When the chicks status are not well, projection will be on their behavior. Leg diseases, can lead to low activity. Research indicates significant correlation between gait scoring and activity [1]. Further studies observed significant correlation between hock burns and deviations in activity [2]. Thus, reduce time lag on activity pattern and health status information can do further help for farmers. Hence, researchers utilized infrared and visible light to monitor poultry’s image, which can provide real-time data analysis. To understand the response patterns and behavioral changes [3]. Continuous monitoring using YOLO v7 object detection and DeepSORT target tracking models to enhance the study [4]. The study also showed that when laser beam stimulates chicken in low behavior, thereby it will increases the mobility and an overall motion in the poultry house [5]. Other research indicates the possibility throughout laser stimulation the approval of activity and walking distance can be done [6].

Though, activity level shows close related to health status, such activity level factors are passive due to health condition levels. Thus, this study established a laser alert system for flocks to enhance their mobility and health status.

By using deep learning and density-based calculations in continuous monitoring for optimal timing laser disturbances, pulsed lasers will be activated when the activity level below the certain threshold. Simultaneously, the recorded data will be uploaded to the cloud. as shown in Fig. 1

Fig 1. Flock evaluation process diagram.

2 Material and methods

2.1 Chicken Flock Response Evaluation System
Developing a flock response health assessment system based on laser stimulation using deep learning technology. This embedded system is control by camera to capture images for YOLO V7 object recognition and activity calculation. And by continuous activity monitoring the calculations allows us to choose the effective timing for laser disturbances. Experiments of testing showed that laser pulsed auto-activate during low activity periods improves rapidly. Equipment such as, an embedded system (Jetson Nano, Nvidia Corporation, USA) as the control board, a visible camera (IM2, Sony Corporation, Japan), lasers, mirror motors, and an integrated power control board. While these components were put into a dust box as shown of Fig. 2(a). as for top view and (b) for Interior view.

Fig 2. Chicken flock response health evaluation system (a) top view (b) Interior view.

2.2 Chicken detection based on Deep learning
By using YOLO as the chicken detection model. The system and an overhead camera collected a large amount of photos of chick flocks aged from week 1 to week 11 in the poultry house. In the experiment, 1,000 labeled images were used for marking the footage and coordinates by open-source software LabelImg. 80% images were used for training and 20% of them for
testing.

After completing, the model will divide the results into four parts of confusion matrix; which is, True Positives (TP) when the predicted result and the actual result are both chicks, False Positives (FP) when the predicted result are chicks but the actual result is not, False Negatives (FN) when the predicted result is not chicks but the actual result is, and True Negatives (TN) when the predicted result and the actual result are both not chicks. Precision and recall are calculated based on the confusion matrix to quantify the model's accuracy.

\[
\text{Precision} = \frac{TP}{TP + FP} \quad (1)
\]

\[
\text{Recall} = \frac{TP}{TP + FN} \quad (2)
\]

2.3 Activity Algorithm

Using the density method based on consecutive images, as Fig. 3, has shown. While the chick mark detection model has been employed, see in Fig.3(a). The marked area is subsequently divided into n unit cell, though the selection of the unit cell size is sensitive that could affect the result. Test shows that, 20x20 pixels per unit is the best result. Thus, resulting a total amount up to 32x32 units for calculation should be more appropriate method see Fig. 3 (b). The density value D for each unit, projecting the distribution of chicks see Fig. 3 (c). Density frames subtraction to determine changes in activity level see Fig. 3 (d).

![Fig 3. Density-based activity algorithm diagram.](image)

In consecutive footage, the density variation for each unit is computed as \( \Delta D(i)=D(i)-D_{i-1}(i) \). Density variations are summarized into \( D_{i}(i)+D_{i-1}(i) \) (total number of chicks in frame) and then divided (see formula 3). This algorithm avoids activity variations caused by differential number in the frame. Computed activity values are then processed through an embedded system and uploaded to the cloud server.

\[
\text{Activity}(t) = \frac{\sum_{t=1}^{n} D_{i}(i) - D_{i-1}(i)}{\sum_{t=1}^{n} D_{i}(i) + D_{i-1}(i)} \cdot 100\%
\]  

(3)

2.4 Activity monitoring and response test

Process of visual light flock responsive laser disturbance system is shown as below. Mainly divided into activity monitoring and responsive testing two parts. Activity monitoring, is a detection model used to label chicks and calculate their activity using consecutive footage. Monitoring the activity and adjusts laser timing, in order to stimulate temporary activity decline that was observed in the flock. The response test was based on activity monitoring results. This testing stimulates to exhibit a clustering response and outputted the responsive data into the cloud see Fig 4. To provide valuable insights into the health status of chicken flocks for operators through assessment by using visible light and laser disturbance.

![Fig 4. Chicken flock response health evaluation system and activity monitoring base on deep learning diagram](image)
2.5 Experimental field
The experimental site was conducted in a commercial poultry house at Lingang Livestock Farm in Changhua County, Taiwan, where the chicks were Red Jungle Fowl in breed. The equipment was posted on column beam which is three meters above the ground. With controlled temperature (water curtains & fans) in the facility.

3 Results and discussion
3.1 Chicken detect result
The chicken detection model in this study consists of a training set of 1000 images and a test set of 200 images, which include red-feathered indigenous chickens ranging from 1 to 11 weeks old. The YOLO v7 model will be trained using these images. Once the training is completed, the model will be implemented in the current system to achieve real-time and accurate chicken recognition results. The model has achieved high precision and recall rates of 95.6% and 96.65% respectively. The loss value is 1.38%, as shown of Fig 7.

3.2 Different unit cell sizes for activity algorithm
In this study, the density-based activity algorithm was used to analyze unit sizes. The analysis was conducted using one record per second during the same time period and using the same equipment. The tracking method was used as a baseline for comparison. The tracking method used in this study is based on YOLO v7 and DeepSORT to calculate the activity of the chickens. This method involves tracking individual chickens across consecutive frames of the video. The shortest distance traveled by each chicken in consecutive frames is considered as the movement of the same chicken, and each chicken is assigned a specific identifier. This allows for the calculation of the distance traveled by each chicken in consecutive frames, which is then converted into activity. However, the tracking method requires significant computational power and cannot be performed in real-time on embedded systems. Therefore, the tracking computations were conducted on a computer (Razer Blade, RTX 2060 Aspire 7 Intel, Acer, Singapore). In this study, the density-based calculations were performed on an embedded system. The density-based method involves utilizing the chicken detection model to label chickens and perform image segmentation. It then calculates the pixel density for each unit and utilizes consecutive frames to calculate the activity. The study compared the results obtained using unit sizes of 80x80 pixels, 40x40 pixels, and 20x20 pixels. Based on the experiments conducted, it has been demonstrated that using a unit size of 20x20 pixels for calculating activity yields results that are closest to those obtained using the YOLO v7 tracking method. Furthermore, it has been observed that the size of the chickens in the image also tends to be close to the 20x20 pixel unit size. This analysis confirms that the closer the unit size is to the size of the chickens in the image, the more accurate the calculation of activity becomes, as shown of Fig 8.
50 and 50-60, as shown in Fig 9. Additionally, there is no significant difference in responsiveness observed, as evidenced by the lack of significant changes in $P<0.1$ and $P<0.5$ responsiveness levels.

![Fig 9. Activity Threshold Selection 40 to 60. (a) The chicken flock response to laser stimulation in activity threshold setting 40–50. (b) The chicken flock response to laser stimulation in activity threshold setting 50–60.](image)

When the activity level of the chicken flock is slightly lower, setting the threshold below 30 and in the range of 30-40, as shown in Fig 10, results in an increase in the activity level of the chickens when subjected to laser disturbances. Additionally, there is a noticeable change in responsiveness. When laser disturbances are applied under the most suitable conditions in terms of activity and threshold, and the chicken flock is in a brief resting state without any significant abnormalities, the activity level of the chickens will significantly increase, and there will be a noticeable change in responsiveness ($P<0.01$).

![Fig 10. Activity Threshold Selection less than 30 and 30 to 40. (a) The chicken flock response to laser stimulation in activity threshold setting less than 30. (b) The chicken flock response to laser stimulation in activity threshold setting 30–40.](image)

However, this effect may not be observed under different circumstances. Therefore, in this study, a threshold of below 30 was determined to be more accurate in detecting abnormalities in chicken flocks with low activity levels. Finally, the study also conducted an analysis using a threshold below 20 and found that the chicken flock’s current health condition was normal, with no occurrence of abnormal health conditions. From this, it can be concluded that setting the activity threshold too low resulted in the system not undergoing laser disturbances even after two days. Through analysis, it was discovered that the optimal threshold is below 30. This threshold allows for a significant increase in activity level and noticeable changes in responsiveness after laser disturbances. It also provides a more meaningful reference for evaluating whether the chickens are abnormal.

4. Conclusion

This study developed a chicken flock laser assessment system for monitoring activity and responsiveness. Data is uploaded to a cloud database for real-time retrieval. The system allows live video streaming and remote control of laser disturbances. Laser disturbances were conducted on chicken flocks in various activity states to determine the optimal threshold. This threshold effectively increases the activity level of healthy chickens and produces noticeable changes in responsiveness. It serves as a valuable reference for assessing abnormal chicken behavior. The research demonstrates that laser stimulation significantly boosts chicken activity, with varied responses based on activity conditions and environments.

References


