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AUTOMATED SELECTION OF TAIWAN NATIVE BREEDING CHICKENS USING MACHINE VISION AND DEEP LEARNING

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Abstract

Chicken is a primary global source of protein. In Taiwan, the poultry sector is a cornerstone of the domestic food supply. A significant part of this sector is the Taiwan Native Chicken (TNC), a collection of indigenous breeds prized for their unique flavor and cultural value, generating over 26 billion New Taiwan Dollars in 2023. Maintaining the quality of TNC relies on the effective selection of superior breeders. Conventionally, this selection is performed through manual inspection of phenotypic traits, a method that is labor-intensive, time-consuming, and subject to inconsistency. A faster and objective method for identifying desirable traits is needed to enhance breeding programs. This study developed an automated breeding chicken selection system that integrates PLC-controlled hardware for image acquisition with a two-stage deep learning approach for phenotypic analysis. First, an object detector, YOLOv11, was trained to locate two key phenotypic traits: the cockscomb and the shank. The trained YOLOv11 achieved an Average Precision (AP) of 97.6% for cockscomb detection and 96.4% for shank detection on a custom image dataset collected by a PLC-controlled acquisition system. Subsequently, Segment Anything Model (SAM), was utilized to segment and generate precise masks of these located traits, demonstrating robust performance in accurately isolating the features. The results highlight the effectiveness of this system; while the object detector provides rapid and accurate localization, the segmentation model delivers the detailed morphological data essential for a comprehensive selection system. This study indicates that a cascaded deep learning pipeline is a highly effective approach for automating the complex task of breeder selection, offering significant potential for improving efficiency and objectivity in chicken farming.

Keywords: Precision Livestock Farming, Deep Learning, Object Detection, Image Segmentation, Breeder Chicken Selection.

INTRODUCTION

Taiwan Native Chicken (TNC) is a cornerstone of Taiwan's poultry industry, prized for its unique flavor and cultural significance. Unlike broiler chickens, which mature in 5 weeks, TNCs require a 12-week growth period, making an efficient and accurate breeder selection program essential for maintaining flock quality and economic viability. Currently, breeder selection depends on manual inspection, where desirable traits such as a large, bright red comb and a thick shank are visually assessed by experts. This traditional method is fundamentally limited;

it is subjective, labor-intensive, time-consuming, and leads to inconsistent outcomes, which complicates the standardization of breeding experience.
To overcome these challenges, this study aims to automate the breeder selection process. We developed a system that utilizes machine vision and a two-stage deep learning pipeline to provide a fast, objective, and scalable alternative to manual inspection. By automatically analyzing key phenotypic traits, our approach addresses the core problems of subjectivity and inconsistency, paving the way for enhanced efficiency and precision in TNC breeding programs.

MATERIALS AND METHODS

Our proposed system automates breeder selection through a multi-stage pipeline that begins with image processing and concludes with a final grading score. This study focuses on the foundational stages: image acquisition, object detection, and segmentation.
Image acquisition was performed using a custom PLC-controlled system to ensure consistent image quality. The core of our analysis is a two-stage deep learning approach. First, a YOLOv11 object detection model, trained on our custom dataset, localizes two key phenotypic traits: the cockscomb and the shank. Following this, the Segment Anything Model (SAM) is utilized to generate precise segmentation masks of these traits from the detected regions. This automated process effectively extracts the detailed morphological data necessary for subsequent quantitative evaluation.

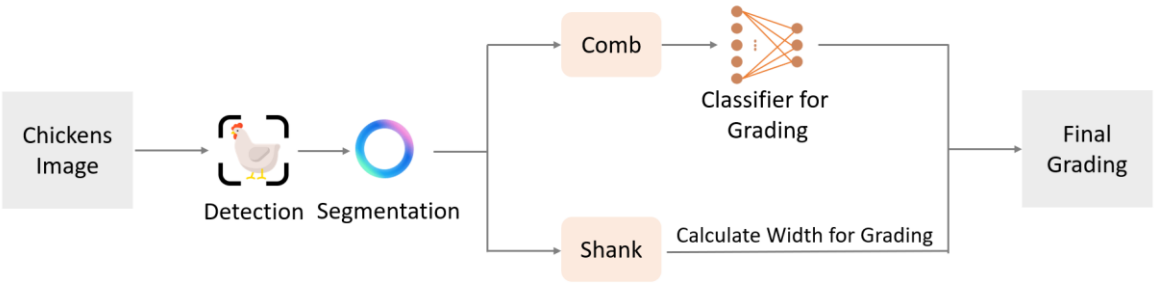

Figure 1. The proposed system pipeline for automated breeder chicken selection.

RESULTS & DISCUSSION

The foundational stages of our automated selection system were successfully implemented. Our PLC-controlled image acquisition system consistently provided high-quality images for analysis. The trained YOLOv11 object detector demonstrated excellent performance, achieving an Average Precision (AP) of 97.6% for cockscomb and 96.4% for shank detection. Following this, the Segment Anything Model (SAM) showed robust performance in generating precise segmentation masks for both traits. These highly accurate detection and segmentation results validate our two-stage deep learning approach, confirming its capability to provide the reliable, detailed data essential for developing a fully automated breeder grading system.

CONCLUSIONS

This study validates a deep learning pipeline that effectively automates the detection and segmentation of key breeder chicken traits, offering a robust and objective alternative to manual inspection. This work provides the critical foundation for a fully automated system, with future efforts directed at developing the final grading modules.