SMART SYSTEM FOR NON-INVASIVE SILKWORM COCOON GENDER SEGREGATION AND AUTOMATED EGG COUNTING

Project Reference No.: *49S_BE_4098*

College : Siddaganga Institute of Technology, Tumkur
Branch : Department Of Electronics and Communication Engineering
Guide : Dr. Shilpashree P S
Students : Mr. Basavaraj K Banaj
Mr. Kumar M Sunkad
Ms. Pooja U Konnur
Mr. Prajwal M Doddamani

Keywords:
Silkworm Cocoon, Gender Segregation, Load Cell, Automation, Image Processing, Egg Counting.

Introduction:

1. Silk is one of the most valuable natural fibers produced from silkworms and plays a vital role in the sericulture industry. Seed production centers are responsible for maintaining the quality and supply of silkworm breeds. One of the critical processes in these centers is cocoon gender segregation and egg counting. Traditionally, cocoon gender identification is performed by cutting open each cocoon and examining internal markings. This method is invasive and damages the cocoon, making it unusable for silk production. It is also time-consuming, requiring around 40–60 minutes to process one kilogram of cocoons.
2. In addition to this, manual egg counting is a tedious and error-prone process due to the extremely small size and dense arrangement of eggs. This leads to inefficiencies and inaccuracies in production planning. The manual approach also increases labor dependency and operational costs.
3. To overcome these limitations, this project introduces a smart system that performs non-invasive gender segregation using weight-based classification and automates egg counting using image processing techniques. The system integrates hardware and software components to improve accuracy, reduce time, and enhance productivity in sericulture operations.

Objectives:

1. To develop a conveyor-based system for automated segregation of silkworm cocoons.
2. To detect cocoon gender non-invasively using load cell weight measurement.
3. To automate the sorting of cocoons into gender-specific bins based on real-time data.
4. To implement image processing techniques for accurate silkworm egg counting.

Methodology:

1. The system begins with a feeding mechanism where cocoons are placed into a funnel that directs them onto a conveyor belt. The conveyor ensures smooth and continuous movement of cocoons one by one to the weighing platform. A load cell is used to measure the weight of each cocoon accurately. The analog signal from the load cell is amplified and converted into digital form using the HX711 module.
2. An Arduino Uno microcontroller processes the digital data and compares the measured weight with predefined threshold values to determine the gender of the cocoon. If the weight is greater than the threshold, the cocoon is classified as female; otherwise, it is classified as male. Based on this classification, a servo motor is activated to direct the cocoon into the appropriate bin.
3. The system also includes an LCD display to show real-time weight and classification results. For remote monitoring, IoT integration is implemented using a NodeMCU module, which sends data to a Telegram bot.
4. For egg counting, images of silkworm egg sheets are captured using a camera connected to a Raspberry Pi. The images are processed using the YOLOv5 deep learning model, which detects and counts individual eggs. The processed output is displayed and stored for analysis.

Result and Conclusion:

1. The developed system successfully automates cocoon gender segregation and egg counting processes. The load cell-based classification method achieved an accuracy of approximately 60–70% in identifying cocoon gender. The conveyor-based sorting mechanism ensured smooth and continuous operation without damaging the cocoons.
2. The egg counting system using YOLOv5 demonstrated high accuracy and significantly reduced the time required compared to manual counting. The integration of IoT enabled real-time monitoring and improved system transparency.
3. Overall, the system proved to be efficient, reliable, and cost-effective. It reduces manual labor, minimizes errors, and enhances productivity in sericulture operations. The project demonstrates the feasibility of implementing automation and smart technologies in agricultural applications.

Project Outcome & Industry Relevance:

The project provides a practical solution for automating two major processes in sericulture: cocoon gender segregation and egg counting. It reduces labor dependency and operational costs while improving efficiency and accuracy. The non-invasive approach prevents cocoon damage, thereby increasing productivity and economic returns.

The system is highly relevant to sericulture industries, especially seed production centers, where manual processes are still widely used. It benefits small-scale farmers and large-scale industries by providing an affordable and scalable solution. The integration of IoT enables remote monitoring, making the system more adaptable to modern industrial requirements.

Working Model Vs. Simulation/Study:

This project is implemented as a **working hardware model** rather than just a simulation. The system includes real components such as Arduino, load cell, conveyor mechanism, servo motor, and Raspberry Pi. The results are obtained through real-time testing and experimentation, making it suitable for practical applications.

Project Outcomes and Learnings:

Through this project, we gained knowledge in embedded systems, sensor integration, and automation techniques. We learned how to interface load cells, microcontrollers, and IoT modules. The project also enhanced our understanding of image processing and deep learning models like YOLOv5. Additionally, we developed skills in hardware design, programming, and system integration. The project improved our problem-solving abilities and provided hands-on experience in developing real-time applications.

References:

1. [1] A. N. J. Raj, R. Sundaram, V. G. V. Mahesh, Z. Zhuang, and A. Simeone, “A multi-sensor system for silkworm cocoon gender classification via image processing and support vector machine,” *Sensors*, vol. 19, no. 12, p. 2656, Jun. 2019.
2. [2] S. Karthik, K. C. Kiran, M. R. Kishore, B. S. Kumaramanjunath, and M. Madhusudhan, “Gender segregation of silk moths in cocoon stage,” *Int. J. Res. Publication and Reviews*, Dec. 2021.
3. [3] S. T. M. Saleem, M. V. Pramod, B. N. Sneha, V. Vivek, and S. S. Bhagwat, “Design and development of automated system to separate breed and gender of silk moths for better yielding,” Jun. 2022.
4. [4] V. G. V. Mahesh *et al.*, “Silkworm cocoon classification using fusion of Zernike moments and shape features,” *Int. J. Intell. Syst. Appl.*, 2017.
5. [5] H. Shi, “Deep learning-based method for silkworm egg counting,” *Computers and Electronics in Agriculture*, 2025.
6. [6] “YOLO-SEC: YOLO-based silkworm egg counting system,” *KCI Conf.*, 2024.
7. [7] M. A. Xiaolin, “Detecting and counting silkworms using improved YOLOv8n,” *SciOpen*, 2024.
8. [8] “Image processing based silkworm egg counting methods,” *IOSR J. Eng.*, 2019.
9. [9] “Automatic counting and classification of silkworm eggs using deep learning,” Research Preprint, 2021.

Future Scope:

1. The future scope of this project includes improving the accuracy of gender classification using advanced machine learning algorithms. Additional sensors such as image-based detection can be integrated to enhance reliability. The system can be upgraded with higher precision load cells and faster processing units.

2. A mobile application can be developed for better user interaction and real-time monitoring. Cloud integration can be implemented for data storage and analytics. The egg counting system can be further improved using advanced deep learning models for higher accuracy.

The system can also be scaled for large industrial setups with multiple conveyor lines and automated control systems. Future enhancements may include fully autonomous operation with minimal human intervention, making it suitable for smart agriculture and Industry 4.0 applications.

.