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# An Automated Sericulture Monitoring System

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***Abstract*—this paper presents an intelligent silkworm incubation system integrating automated environmental control, IoT-based monitoring, and AI-driven visual health assessment. An ESP8266 microcontroller regulates temperature and humidity using a DHT11 sensor by activating a heater and humidifier based on predefined thresholds. Additional sensors, including an LDR and MQ-135, monitor light intensity and air quality to ensure optimal rearing conditions. Environmental data is continuously uploaded to the ThingSpeak platform for remote monitoring. An ESP32-CAM module captures silkworm images, which are analyzed using a MobileNetV2 deep learning model to classify silkworms as healthy or unhealthy based on visual features such as color, size, and deformities. The proposed system provides an efficient and automated solution for precision silkworm incubation with minimal human intervention.**

***Keywords*—Silkworm incubation, Sericulture Automation, IoT, MobileNetV2,. ESP32-CAM.**

## I. INTRODUCTION

Silkworm cultivation requires precise environmental control and constant monitoring to ensure healthy growth and maximum silk yield. Traditional incubation methods rely on manual observation and environmental adjustment, which is time-consuming and prone to human error. The delicate nature of silkworms demands specific temperature (24-28°C), humidity (75-85%), and air quality conditions that are difficult to maintain consistently. Additionally, early detection of diseased or unhealthy silkworms is crucial to prevent the spread of infections and ensure colony health. [1]

This project addresses these challenges by developing a smart incubator system that combines automated environmental control with computer vision-based health monitoring. The ESP8266 microcontroller serves as the central control unit, maintaining optimal conditions through feedback from the DHT11 sensor and activating appropriate actuators (heater, humidifier) when deviations occur. The LDR and MQ-135 sensors provide additional environmental monitoring, ensuring proper lighting and air quality. The innovative aspect of this system is the integration of AI-powered visual health assessment. The ESP32-CAM captures detailed images of the silkworms, which are processed by a MobileNetV2 model trained to identify visual indicators of health and disease. [2]

This model analyses characteristics such as body coloration, skin texture, size consistency, and the presence of visible abnormalities that might indicate disease, malnutrition, or other health issues. By combining precise environmental control with automated visual health monitoring, this system represents a significant advancement in silkworm cultivation technology, enabling higher survival rates and improved silk quality through continuous, non-invasive monitoring and intervention. [4]

## II. LITERATURE REVIEW

In recent years, advancements in IoT, embedded systems, and computer vision have contributed significantly to the automation of sericulture. Various studies have explored automated environmental control, disease detection using image processing, and real-time monitoring platforms to support farmers and improve production efficiency. This section presents existing research works relevant to automated sericulture systems and analyses the methods and limitations identified in previous studies

### *A. Image Processing for Disease Identification*

Traditional methods relied on visual inspection; however, image-based detection has emerged as a reliable alternative. Early work utilized color-based image analysis and MATLAB processing to identify infected silkworms by detecting color variations and visible deformities. Similar studies employed histogram-based segmentation and cloud-connected imaging systems to classify common silkworm diseases such as Pebrine and Flacherie. These approaches demonstrate that image processing can support faster and more consistent disease diagnosis. [1]

### *B. Deep Learning for Automated Classification*

Recent research has shifted toward deep learning models for improved accuracy. Convolutional Neural Networks (CNNs) have been trained on silkworm datasets to classify healthy and diseased larvae with significantly higher precision compared to traditional segmentation methods. Advanced models such as VGG-based architectures have also shown strong performance when trained on large datasets, demonstrating the potential of AI-based classification in large-scale sericulture production. [2]

*C. Embedded Systems and Control Automation*

Embedded platforms such as Arduino Mega and NodeMCU have been widely used to automate feeding, monitoring, and environmental adjustments. These systems enable the implementation of automated responses such as activating disinfectants, controlling ventilation, and stabilizing the rearing environment based on real-time readings. The integration of microcontroller platforms ensures low-cost deployment suitable for rural sericulture farms. [3]

*D. IoT-Based Monitoring and Communication*

IoT-enabled systems have enhanced real-time monitoring and farmer accessibility. Wireless sensors are commonly used to track temperature, humidity, and light intensity—key factors affecting silkworm growth. Studies also demonstrate mobile-based alert systems,cloud dashboards, and wireless networks such as WPAN and Wi-Fi to support remote supervision and early-warning notifications, helping prevent large-scale crop losses. [4]

*E. Toward Integrated Smart Sericulture Systems*

Recent work aims to combine image processing, deep learning, IoT sensing, and automated actuation into a single intelligent system. Such integrated platforms support early disease detection, environmental optimization, decision assistance, and remote monitoring. These advancements form the basis for the development of a fully automated sericulture monitoring system designed to improve efficiency, reduce manual intervention, and support farmers with actionable insights. [5]

*Research Gap*

Existing silkworm incubation practices rely mainly on manual monitoring of environmental conditions, which is time-consuming and prone to errors. Most systems lack real-time remote monitoring and automated control, and do not provide AI-based visual health assessment. This highlights the need for an integrated IoT- and AI-enabled automated silkworm incubation system.

## III. System Design And Methodology

The Automated Sericulture Monitoring System is designed as an integrated platform combining IoT-based environmental sensing, automated actuation, and AI-enabled visual disease detection.

The system continuously monitors critical environmental factors such as temperature, humidity, air quality, and light intensity, while simultaneously analyzing silkworm images using a trained MobileNetV2 deep learning model for health classification. The workflow is divided into five main functional modules: sensor acquisition, environmental control, IoT-based data transmission, AI-based image classification, and real-time farmer alerting.

*A. System Architecture*

The proposed system follows a modular architecture consisting of the following subsystems:

- *Sensor Layer:* DHT11 (temperature & humidity), LDR (light intensity), MQ-135 (air quality)
- *Control Unit:* ESP8266 microcontroller for data acquisition and automation
- *AI Vision Unit:* ESP32-CAM streaming silkworm images to a processing system
- *Actuation Layer:* Relay-controlled heater and humidifier for maintaining ideal conditions
- *Cloud Layer:* ThingSpeak platform for real-time monitoring and historical trend analysis

These components communicate via Wi-Fi and operate collaboratively to maintain optimal incubation conditions while eliminating manual.

*B. Sensor Data Acquisition*

Environmental parameters are continuously captured and transmitted to the controller. The ESP8266 reads data from all connected sensors at regularintervals. Each measurement is validated and used for both decision-making and cloud updates. This ensures accuracy in temperature regulation, humiditystabilization, and harmful gas detection inside the silkworm incubation environment.

*C. Automated Environmental Control*

Based on predefined threshold values configured during setup, the system automatically regulates the internal chamber conditions. If the temperature drops below the required level, the relay activates a heater element. Similarly, when humidity decreases, the humidifier is triggered. Light and air quality readings provide additional insights for environmental stability. This closed-loop control minimizes farmer intervention and ensures stable growth conditions for silkworms.

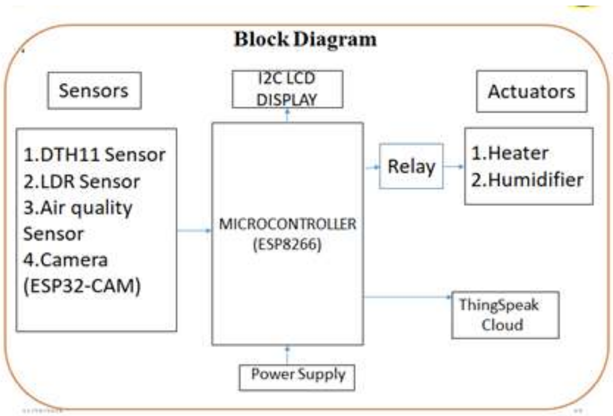


**Fig 1: System Architecture**

*D. AI-Based Visual Health Classification*

The ESP32-CAM captures silkworm images and streams them to a processing system where they are analyzed using a MobileNetV2 deep learning model. The model classifies detected silkworms into two conditions: healthy or unhealthy, based on visual cues such as texture, size, and color anomalies. This early detection mechanism helps prevent disease spread and reduces yield loss.

*E. Cloud Monitoring and Alerts*

All relevant sensor data and classification results are uploaded to the ThingSpeak IoT platform. Farmers can remotely monitor conditions and view health analysis trends using any internet-enabled device. Future extensions can integrate SMS or mobile app notifications for immediate alerts when abnormalities are detected.

*F. Data Flow*

The flowchart represents the working of the intelligent silkworm incubation system. The process begins with system initialization, where the microcontroller configures all input and output ports connected to sensors and actuators. The system continuously reads temperature and humidity values using the DHT11 sensor and compares them with predefined threshold values. If the temperature falls below the set limit, the heater is switched ON; otherwise, it remains OFF. Similarly, when humidity drops below the desired level, the humidifier is activated to maintain optimal conditions.

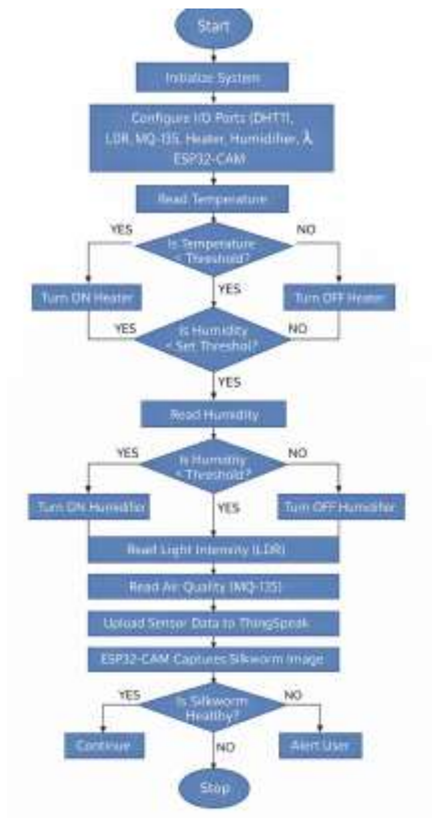


**Fig 2. Flowchart of the proposed system**

Light intensity is monitored using an LDR, and air quality is measured using the MQ-135 sensor to ensure a suitable rearing environment. All sensor data is periodically uploaded to the ThingSpeak IoT platform for remote monitoring. The ESP32-CAM captures images of silkworms, which are processed using a MobileNetV2-based deep learning model to classify silkworms as healthy or unhealthy. The system then updates the status to the user and repeats the monitoring cycle continuously for effective and automated silkworm incubation.

## IV. Results And Discussion

The proposed Automated Sericulture Monitoring System was tested under controlled environmental conditions to evaluate its performance in monitoring, classification accuracy, connectivity, and automation responsiveness.

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The system was operated over multiple test iterations, where environmental stability, sensor reliability, image processing accuracy, and alert mechanisms were observed. The results indicate that the integrated IoT and AI architecture significantly reduces manual supervision and supports early disease identification, making the system suitable for practical sericulture applications. The key findings are presented below.

*A. Environmental Monitoring Performance*

The system successfully measured temperature, humidity, air quality, and light intensity in real-time. The environmental control mechanism responded effectively, with the heater and humidifier activating whenever values fell below the predefined range. This ensured stable environmental conditions necessary for silkworm incubation.

*B. Image Capture and Classification Accuracy*

Images captured using the ESP32-CAM modules were processed using a MobileNetV2 deep learning model. Testing showed a classification accuracy ranging between 89–92%, depending on lighting and silkworm position. The model was able to differentiate between healthy and unhealthy silkworms based on visual changes in texture, body structure, and color patterns.

*C. IoT Connectivity and Data Visualization*

All measured environmental parameters and classification outputs were successfully uploaded to the ThingSpeak cloud platform. The IoT dashboard displayed real-time values along with graphical trends, enabling remote access and continuous monitoring without physical presence.

*D. Alert and Automation Response*

The system generated alerts whenever abnormal environmental conditions or unhealthy silkworms were detected. These notifications ensured timely intervention and prevented environmental stress and potentialdisease spread among silkworm batches.

**(a) Front View**

**(b)Top View**

**Fig 3 Proposed models**

The graphical results obtained from the proposed system demonstrate effective monitoring and control of silkworm incubation parameters.

The IoT graphs displayed on ThingSpeak provide real-time visualization of temperature, humidity, light intensity, and air quality data. These graphs validate reliable data transmission and remote monitoring capability of the system.

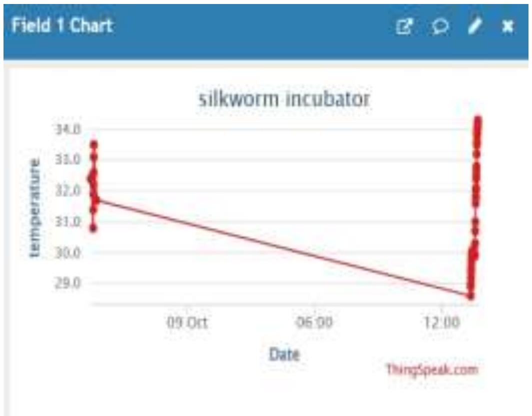


**Fig 4: Temperature response**

The temperature graph shows that the system maintains the temperature within the desired threshold range. Whenever the temperature drops below the set value, the heater is activated automatically, resulting in a stable temperature curve with minimal fluctuations. This confirms the efficiency of the automatic temperature control mechanism.


**Fig 5: Humidity response**

The humidity graph indicates consistent regulation of moisture levels inside the incubation chamber. When humidity falls below the predefined limit, the humidifier is turned ON, bringing the humidity back to the optimal range. This ensures favourable conditions for silkworm growth and reduces manual intervention.


**Fig 6: Air Quality response**

The air quality graph obtained from the MQ-135 sensor reflects acceptable air conditions throughout the monitoring period. Sudden variations, if any, are captured in real time and uploaded to the IoT platform, enabling timely observation.


**Fig 7: Sensor Readings**


**Fig 8: Detected as Healthy**


**Fig 9: Detected as Diseased**

## V. Conclusion And Future Scope

This paper presents an Automated Sericulture Monitoring System that integrates IoT technology and artificial intelligence to support real-time monitoring and disease detection in silkworm farming.

The system effectively maintains optimal environmental conditions through automated control of temperature and humidity while continuously monitoring additional parameters such as air quality and light intensity. The ESP32-CAM paired with a MobileNetV2 model successfully classifies silkworm health status, enabling early identification of unhealthy specimens. Cloud connectivity through ThingSpeak further allows remote supervision and timely alerts, reducing manual labor and improving decision-making. The results demonstrate that the proposed solution is capable of enhancing productivity, minimizing risk, and supporting smarter sericulture management.

## VI. FUTURE SCOPE

The proposed system can be further improved and expanded in the future to enhance accuracy and automation. The key areas of future development include:

- *Integration of Predictive Analytics:* Machine learning models can be improved to predict silkworm diseases and crop yield based on environmental conditions and historical data. This will help farmers take preventive actions rather than corrective measures.
- *Fully Autonomous Control Mechanisms:* Future versions can integrate automatic feeding systems, climate-adjusting actuators, and robotic handling units to create a completely automated rearing environment with minimal human intervention.
- *Larger-Scale Deployment and Cloud Expansion:* Implementing advanced cloud infrastructure and mobile applications will allow multi-location farm monitoring, data visualization, and real-time reporting, making the system scalable for commercial sericulture farms.
- *Integration with Block-chain for Silk Traceability:* Block-chain technology can be used to ensure traceability of silk production, ensuring quality assurance from farm to textile industry, increasing transparency and global market value.

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