Automated Smart Sericulture System Based on IOT and Image Processing Technique

Dhruvakumar K[1], Kruthik M V[2], Manoj Gowda A M[3], Madhu Gowda M H[4], Padmavathi C[5]

[1,2,3,4,5]Department of Electronics and Communication Engineering
Sapthagiri College of Engineering Bengaluru-57, KA, India
Affiliated to Visvesvaraya Technological University, Belagavi, KA, India

Abstract
Sericulture, the practice of raising silkworms for silk production, plays a crucial role in India's social, economic, cultural, and political landscape. As the second-largest silk producer globally, India relies on optimal environmental conditions, particularly temperature and humidity, to ensure the healthy growth of silkworms at every stage of their lifecycle. Maintaining these conditions is especially critical during the larval development phase. Additionally, effective disinfection is essential for preventing diseases and ensuring successful silkworm rearing. This paper presents an IoT-based approach for real-time sericulture monitoring and automated disinfection using an Arduino-enabled system. The proposed prototype integrates image processing technology to identify and track different stages of the silkworm lifecycle. The system continuously collects environmental data using sensors connected to an Arduino microcontroller, ensuring precise control over temperature and humidity based on the requirements of each developmental stage. The implemented prototype consists of a Wi-Fi-enabled module operating on a REST API framework, interfaced with temperature and humidity sensors for real-time data acquisition. Additionally, a disinfection actuation mechanism is incorporated to maintain hygienic conditions. A serial camera module captures images of silkworms, which are then analysed using image processing techniques to monitor their growth and lifecycle progression. impact key parameters such as cocoon weight, shell weight, and the cocoon shell ratio. To ensure sustainable cocoon production, maintaining optimal temperature and humidity levels is essential. Additionally, the mulberry plant, the sole food source for silkworms, requires consistent irrigation. However, traditional irrigation methods demand significant time and the physical presence of farmers.

A. Objective of Analysis
In this project aims to automate various aspects of sericulture to reduce manual labor and enhance efficiency. An Arduino-based system is implemented to control the irrigation of mulberry plantations and regulate temperature within the silkworm rearing unit. Additionally, a pesticide spraying mechanism is developed, which activates based on disease detection to maintain a healthy environment for silkworms. A network of sensors is deployed to continuously monitor environmental conditions, and appropriate measures are taken based on the collected data. An IoT platform is integrated to enable real-time monitoring and remote control of the system. Advanced color image processing techniques using adaptive multichannel filters are applied to analyze silkworm images, while deep neural networks are utilized for

classifying silkworm health status. Furthermore, the DHT11 sensor is used to measure temperature and humidity levels in the silkworm rearing unit, ensuring optimal conditions for their growth and silk production.

B. Literature Survey
G. Montenegro et al. [1] present a framework for transmitting IPv6 packets, defining the structure for IPv6 link-local addresses and stateless autoconfigured addresses over IEEE 802.15.4 networks. The document also details a lightweight header compression method using shared context and mechanisms for efficient packet delivery in IEEE 802.15.4 mesh networks. Konstantinos N et al. [2] introduce and evaluate new adaptive filters designed for colour image processing. This study focuses on classifying and recognizing silkworms using Deep Neural Networks, which enhances the seed production process and contributes to increased silk output by developing a highly precise silkworm classification model. Konstantinos N et al. [2]

Keywords: module, DHT11 sensor, Relay, LED, Exhaust Fan.

1. Introduction

Sericulture is the scientific practice of silk production through the rearing of silkworms. Silk, often referred to as the "queen of textiles," is highly valued for its natural sheen, softness, durability, and tensile strength. The process of silk production is intricate and requires careful management at every stage. Silkworms, one of the most significant domesticated insects, spin high-quality silk threads in the form of cocoons while feeding on mulberry leaves during their larval stage. Environmental factors, including temperature and humidity, play a crucial role in determining the yield and quality of silk. Variations in these conditions, both daily and seasonally.
introduce adaptive filters for color image processing, offering a unified approach to multichannel signal processing. This research focuses on classifying silkworms using Deep Neural Networks to enhance seed production, ultimately increasing silk output by developing a high-precision classification model. Additionally, the system identifies healthy and diseased silkworms to improve silk production [6]. It extracts general features, categorizes them based on multiple parameters, and aids in recognizing diseased and healthy silkworms, improving seed cocoon quality and revolving cocoon production. The system also provides financial assistance for constructing cocooning sheds and rearing equipment, benefiting farmers economically. Image classification using DNNs plays a vital role in monitoring silkworm health and detecting diseases, automating the identification of growth stages, health conditions, and infections using real-time image analysis. Deep learning-based processing enhances accuracy significantly over traditional methods. The proposed color image filtering methodology integrates Bayesian techniques and nonparametric approaches to adapt to local image data. The principles of these filters are comprehensively detailed, with simulations demonstrating their computational efficiency and high performance. Ricardo L. de Queiroz [3] discusses image processing in the "JPEG-compressed" domain, optimizing memory usage and speed by eliminating decompression steps. Techniques are provided for operations like scaling, previewing, rotating, mirroring, cropping, recompressing, and segmenting JPEG data, focusing primarily on scanned documents as the primary image source.

Andrea Zanella et al. [4] examine urban IoT systems, which, despite their broad scope, are distinguished by their specific application in smart cities. Urban IoT solutions are developed to enhance the Smart City vision by utilizing advanced communication technologies to deliver value-added services for city administration and residents. This study provides an indepth review of the key technologies, protocols, and architectural frameworks that enable urban IoT systems. These technologies form the foundation of smart city infrastructures, ensuring efficient urban management. Wireless Sensor Networks (WSNs) play a pivotal role in data collection, monitoring environmental and structural conditions. Cloud computing facilitates data storage and real-time analysis, while edge computing reduces latency by processing information near the data source. Mubashar Hussain et al. [5] analyse the impact of temperature and humidity variations on silkworm moth fertility, as demonstrated in Table III. Among the studied silkworm lines, Pak-3 exhibited the highest fertility, followed by Pak-2 and Pak-4, with no statistically significant differences among them. The lowest fertility rate was recorded in PFI-II. The data in Table I further illustrate a steady decline in fertility under fluctuating environmental conditions. This study provides an in-depth review of the key technologies, protocols, and architectural frameworks that enable urban IoT systems. These technologies form the foundation of smart city infrastructures, ensuring efficient urban management. Wireless Sensor Networks (WSNs) play a pivotal role in data collection, monitoring environmental and structural conditions.

Working principle

An intelligent sericulture system utilizing IoT and image processing incorporates modern technology to enhance silk production efficiency. IoT-based sensors continuously track key environmental factors such as temperature, humidity, and light to maintain ideal conditions for silkworm development. Real-time image analysis is employed to evaluate silkworm health, identify potential diseases, and monitor various growth stages. The collected data is transmitted to a cloud-based system, facilitating remote supervision and automated decision-making through machine learning techniques. The system autonomously controls climate settings, feeding schedules, and other critical parameters to optimize the rearing process. By integrating IoT and image analysis, this approach reduces the need for manual labour, cuts operational costs, and enhances both productivity and silk quality. Fig.1 Additionally, advanced imaging methods contribute significantly to disease detection and health assessment. High-resolution cameras capture images of silkworms and their surroundings, which are then analysed using deep learning and computer vision techniques.

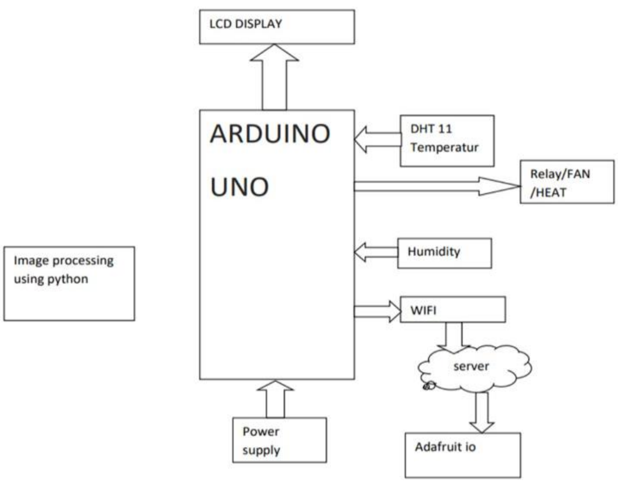


Fig.1 Block Diagram

2. Hardware discription

The NodeMCU is an open-source firmware and development

A. Requirement: board designed for rapid IoT prototyping, enabling users to This system is designed for sericulture identification and create IoT applications with just a few lines of Lua script, as requires specific components, as illustrated in “Fig.2.”. shown in Fig.3.

Features of node MCU:

1. **DHT11 Sensor** – Monitors temperature and humidity levels.
2. **Arduino Uno** – Serves as a data storage and processing unit.
3. **16×2 LCD** – Displays the obtained results.
4. **LED** – Functions as a heat energy source.
5. **Connecting Wires** – Establish necessary circuit connections.
6. **Resistors** – Regulate the flow of electric current.

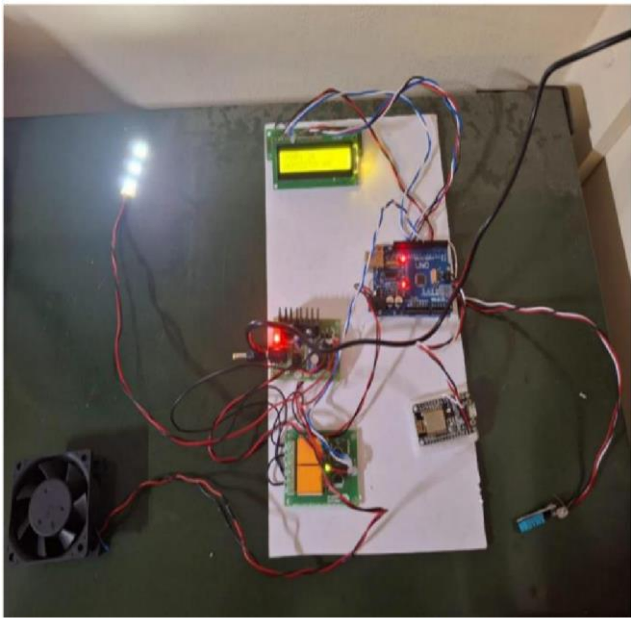


Fig.2 Sericulture Circuit Setup

B. Arduino:

The Arduino Uno is a microcontroller board powered by the ATmega328, as depicted on the board. It includes 14 digital input/output pins, six analog inputs, a 16 MHz ceramic resonator, a USB port, a power jack, an ICSP header, and a reset button. It comes with all necessary components to operate the microcontroller—simply connect it to a computer via USB or power it using an ACto-DC adapter or battery. Unlike earlier models, the Uno does not utilize the FTDI USB-to-serial driver chip. Instead, it is equipped with the Atmega16U2, configured as a USB-to-serial converter. The second revision of the Uno board features a resistor pulling the 8U2 HWB line to ground, simplifying the process of entering DFU mode. The term "Uno" means "one" in Italian, symbolizing the transition to Arduino 1.0. Moving forward, the Uno and version 1.0 will serve as reference models for the Arduino platform. As the most recent addition to the USB-based Arduino series, it acts as the standard board.

C. Node MCU v2 WIFI MODULE

1. Open-source
2. Interactive
3. Programmable
4. Low cost
5. Simple
6. Smart

WI-FI enabled

Arduino-style hardware IO with a PCB antenna features an advanced API for hardware interaction, significantly minimizing redundant tasks related to configuration and control. It operates like Arduino but allows interactive coding using Lua script.

Fig.3 Node MCU v2 WIFI MODULE

TABLE 1: LCD DISPLAY TO ARDUINO INTERFACE

LCD DISPLAY	**ARDUINO BOARD**
VSS	GND
VDD	5V PIN
RS PIN	GPIO PIN 13
ENABLE PIN	GPIO PIN 12
D4	GPIO PIN 11
D5	GPIO PIN 10
D6	GPIO PIN 09
D7	GPIO PIN 08
ANODE TERMINAL	5V PIN
CATHODE TERMINAL	GROUND TERMINAL

In "Table 1," the connections between the LCD display and the Arduino board are illustrated. The VSS and Cathode pins of the LCD are linked to the GND pin of the Arduino, while the VDD and Anode pins are connected to the 5V pin to power the LCD for illumination. The Enable pin of the LCD display is assigned to the GPIO pin of the Arduino.

TABLE2. FINGERPRINT MODULE TO ARDUINO INTERFACE

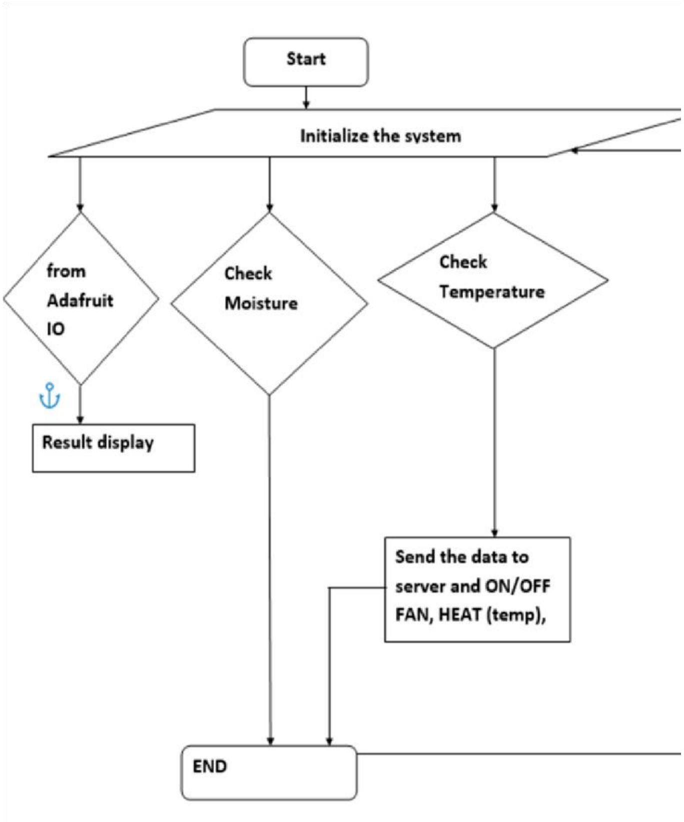
NODEMCU V2 MODULE	**ARDUINO CONTROLLER BOARD**
POWER SUPPLY (VCC)	5V POWER PIN
GROUND TERMINAL (GND)	GROUND TERMINAL (GND)
TRANSMITTER (TX)	RECEIVE DATA (RXD)
RECEIVER PIN (RX)	TRANSMIT DATA (TXD)

In "Table 2," the connections between the NodeMCU V2 module and the Arduino board are illustrated. For data transmission, the TX pin of the NodeMCU V2 module is linked to the RXD pin of the Arduino board, while the RX pin of the NodeMCU V2 module is connected to the TXD pin of the Arduino board.

D. Algorithm:
As Depicted in Fig.4 working flow chart sericulture system.
Start: The system turns on and gets ready.
Initialize the system: The system prepares the sensors and connections.
Check Moisture: The system measures the moisture level.
Check Temperature: The system measures the temperature.
Show Results: The system displays the moisture and temperature readings.
Send Data & Control: The system sends the readings to a server and turns the fan and heater on or off based on the readings.
End: The system finishes this cycle and likely starts over again.

E. Flowchart
Step 1: Begin start.
Step 2: Initialize IoT sensors and camera module.
Step 3: Capture environmental parameters.
Step 4: Capture and analyze.
Step 5: Process and display data.
Step 6: Trigger actuators.

Step 7: Repeat monitoring.
Step 8: success.
Step 9: Stop.



3. Advantages and disadvantages

Advantages:

1. Early Disease Detection
2. Improved Silk Production Efficiency
3. Automated and Accurate Classification
4. Confidence Score for Better Decision-Making

Disadvantage:

1.Equipment costs
2.Technical expertise

paper	Methodology	Proposed System
IPv6 Packet Transfer Over IEEE 802.15.4 Networks [1]	Used compression header and fragmentation techniques.	We rectify and improve High overhead for low-power devices affect scalability.
Adaptive Multichannel Filtering for Color Image Processing [2]	Utilizing Adaptive Multichannel Filtering for Noise Reduction in Color Image Processing.	We rectify and improve the Increased computational complexity for and color accuracy. high-resolution images.
Processing JPEG Compressed Images and Documents [3]	Proposed processing techniques for JPEG images without full decompression.	We rectify and Improved processing efficiency JPEG.
Internet of Things for Smart Cities [4]	Developed IoT transport, environment, and energy.	We rectify and improve Security and data privacy concerns.

4. Result comparison

Silkworm image classification system developed in this project utilizes a Flask web application integrated with the VGG16 deep learning model for real-time image analysis. The primary objective of this system is to classify silkworm images as either diseased or un diseased with high accuracy. The results are based on testing multiple sample images, and the system provides the classification result along with a probability score, indicating the confidence level of the prediction. During the testing phase, various silkworm images were processed through the model. The sample outputs demonstrate the system's effectiveness in accurately Identifying Healthy and Infected worms. For NonDiseased Silkworms, the classification result was displayed with high probability scores (e.g., 95.86%), indicating a high level of confidence in the prediction. Similarly, for diseased silkworms, the system successfully detected abnormalities and classified the images with a comparable confidence level. This ensures that the model can reliably identify diseased silkworms, providing essential support for monitoring and managing silkworm health in sericulture. The integration of the VGG16 model with the Flask web interface allows for real-time detection and makes the system user-friendly. Users can upload images easily and receive instant results, making this tool practical for researchers and sericulture farmers. The high classification accuracy can help prevent the spread of diseases by enabling early detection and timely intervention. The system's capability to assign probability scores enhances transparency and reliability in classifying silkworm health status. This innovative approach offers a practical solution for early disease detection in sericulture, potentially reducing economic losses by enabling timely interventions. The successful implementation of deep learning techniques demonstrates the potential for applying AI-based solutions in agriculture and sericulture, contributing to improved productivity and disease management. Future enhancements could involve expanding the dataset to include more disease types and optimizing the model for even higher accuracy and faster.

5. Conclusion

The model will work continuously to monitor the framework and effectively send the messages by screening the parameters. Image processing is done in order to identify the continuous condition in total sericulture process.

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