Prototype for Monitoring Environmental Conditions in Silkworm Incubators Using STM32

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Publication Date: 2025/05/29

Abstract: Silk, often referred to as the "queen of textiles," is renowned for its softness, durability, and lustrous appearance. The production of high-quality silk is highly dependent on the growth and development of silkworms, which is significantly influenced by environmental factors such as temperature, humidity, and light. Traditional methods of maintaining optimal conditions in silkworm incubators are often labor-intensive and prone to errors, leading to inconsistencies in silk quality. This project proposes a cost-effective, automated prototype for silkworm incubators that monitors and controls environmental conditions using an stm32-based system. The prototype is designed to monitor temperature, humidity, and luminosity within the incubator and automatically adjust these parameters using a heater, humidifier, and light control system. This automation ensures optimal growth conditions for silkworms, leading to the production of high-quality silk.

Keywords: *STM32, Silkworm Incubator, Environmental Monitoring, Temperature Control, Humidity Sensing, Light Intensity, DHT22, IoT, Sericulture, Embedded Systems, Real-Time Monitoring.*

How to Cite: Guruprasad A M; Divya K; Jeevitha G M; Akshaykumar N; Pramoda C Y (2025). Prototype for Monitoring Environmental Conditions in Silkworm Incubators Using STM32. *International Journal of Innovative Science and Research Technology*, 10(5), 2301-2305. https://doi.org/10.38124/ijisrt/25may1580

I. INTRODUCTION

Sericulture, the practice of rearing silkworms for the production of silk, is a highly sensitive process that requires precise environmental control to ensure the healthy growth of silkworm larvae and the quality of silk fibres. Parameters such as temperature, humidity, and light intensity play a crucial role in the various stages of silkworm development, from egg incubation to cocoon formation. Any deviation from the optimal conditions can lead to reduced silk quality, poor larval health, and economic losses.

Traditional methods of monitoring environmental conditions in silkworm incubators are often manual, labor-intensive, and prone to human error. This creates a need for an automated, reliable, and efficient system capable of continuously tracking critical parameters and maintaining them within the desired range.

This project proposes a prototype for monitoring environmental conditions in silkworm incubators using the STM32 microcontroller, a powerful, low-power, and cost-effective solution for embedded systems. The prototype integrates essential sensors, including a DHT22 sensor for temperature and humidity measurement, and an LDR (Light Dependent Resistor) for monitoring light intensity. Sensor data is processed by the STM32 and displayed in real-time on an LCD module. The system also features threshold-based alerts and potential control mechanisms to automatically adjust environmental conditions, ensuring optimal incubator operation.

The design is scalable, with provisions for future integration of Internet of Things (IoT) capabilities, enabling remote monitoring and control via wireless communication modules. This intelligent monitoring system aims to improve the efficiency and productivity of sericulture operations by providing a modern, automated solution for environmental management in silkworm incubators.

II. METHODOLOGY

The proposed prototype for monitoring environmental conditions in silkworm incubators is developed using the STM32 microcontroller, which acts as the central processing unit of the system. The methodology involves the integration of various sensors to continuously monitor temperature, humidity, and light intensity within the incubator. A DHT22 sensor is employed to measure both temperature and humidity levels, while a Light Dependent Resistor (LDR) is used to detect the intensity of light. These sensors are interfaced with the STM32 microcontroller, which reads the sensor data in real-time and processes it accordingly. The collected environmental data is then displayed on a 16x2 LCD display for user reference. In addition, the system is programmed to compare the measured values against predefined threshold levels. If any

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may1580

parameter exceeds or falls below the acceptable range, the STM32 triggers control actions such as switching on a fan, heater, or light source to maintain optimal conditions. The firmware for the microcontroller is developed using STM32CubeIDE.

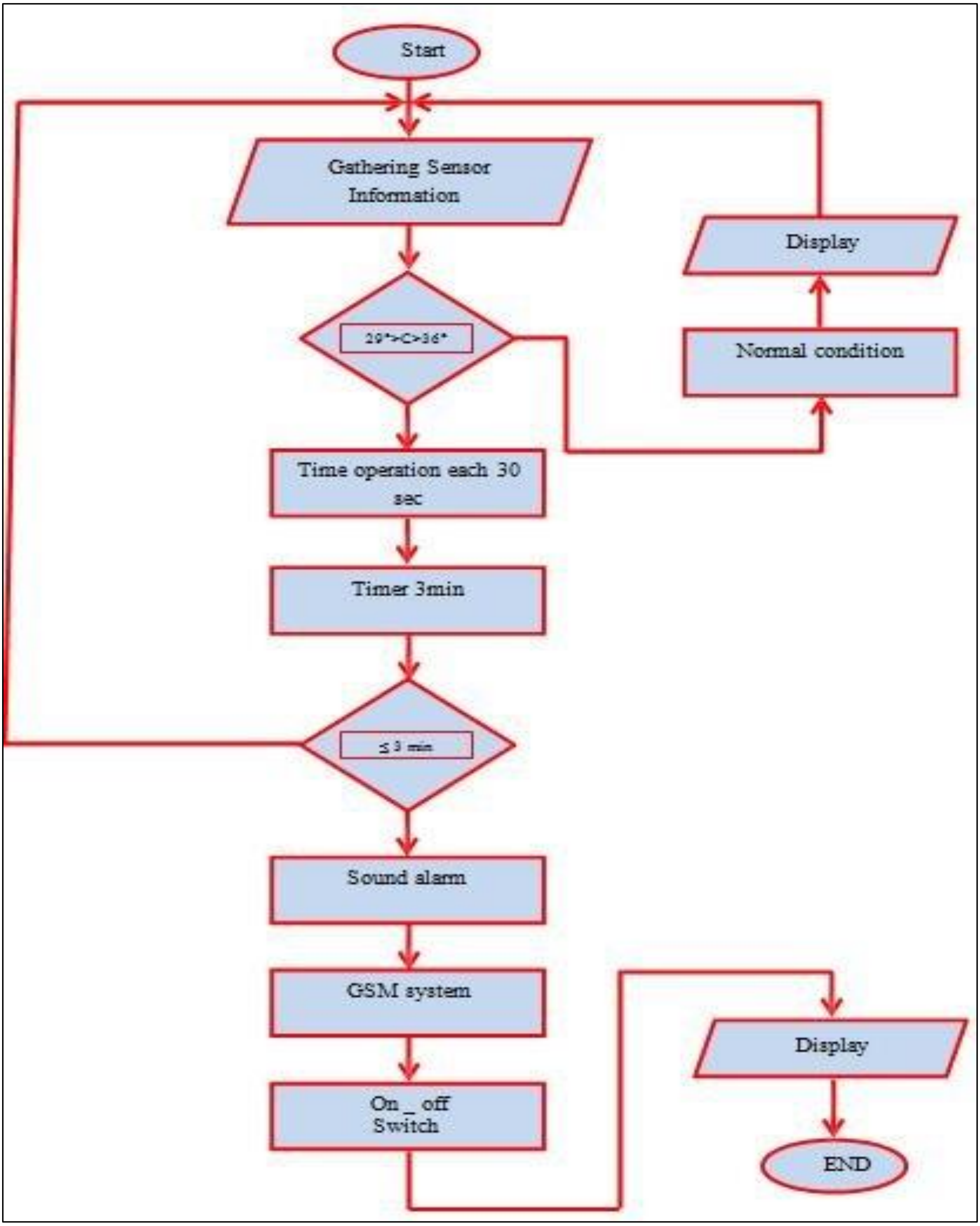

Fig 1 Flowchart

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may1580

III. MODULES AND ITS IMPLEMENTATION

A. System Operations:

➢ *Sensor Module*

This module is responsible for sensing the environmental parameters inside the silkworm incubator. It includes:

- **DHT22 Sensor**: Measures both temperature and humidity. It communicates with the STM32 microcontroller via a single-wire digital interface.
- **LDR (Light Dependent Resistor)**: Detects the intensity of light within the incubator. The LDR is connected to an ADC (Analog-to-Digital Converter) pin on the STM32 to convert the analog voltage to a digital value.
- **Implementation**: Sensors are interfaced with the STM32 using GPIO and ADC pins. The DHT22 provides digital values, while the LDR's resistance change is converted to voltage and then to a digital value using the internal ADC of the STM32.

➢ *Processing Module*

This module processes the sensor data and makes decisions based on predefined threshold values for each parameter.

- **Implementation**: The **STM32 microcontroller** reads real-time data from the sensors, processes the information, and compares it against preset limits. If any value is outside the desired range, appropriate actions are triggered through the output control module.

➢ *Display Module*

This module displays the real-time environmental data for easy monitoring by the operator.

- **Implementation**: A **16x2 LCD display** is interfaced with the STM32 using GPIO pins in 4-bit mode to show temperature, humidity, and light intensity values. The display is updated periodically based on new sensor readings.

➢ *Control and Actuation Module*

This module ensures corrective actions when environmental parameters deviate from acceptable ranges.

- *Implementation:*

  Based on processed sensor data:

✓ A fan is activated if the temperature exceeds the threshold.

✓ A heater is switched on if the temperature falls below the lower limit.

✓ An LED light is controlled based on the light intensity value.

✓ The STM32 controls these devices through GPIO pins configured as digital outputs.

➢ *Power Supply Module*

This module provides a stable DC supply to all system components.

- **Implementation**: A regulated **5V power supply** is used to power the STM32 microcontroller, sensors, LCD, and actuators. A backup battery may be added for uninterrupted operation during power failure.

➢ *Optional IoT Module (Future Scope)*

This module is planned for future implementation to enable wireless monitoring and data logging.

- **Implementation**: An **ESP8266 Wi-Fi module** can be interfaced with the STM32 via UART communication to transmit environmental data to a cloud server or mobile application for remote access.

IV. MODELING AND ANALYSIS

➢ *System Modeling*:

The proposed prototype system is modeled as an embedded real-time monitoring and control setup, comprising several interconnected components to ensure optimal environmental conditions within a silkworm incubator. At the core of the system is the STM32 microcontroller, which functions as the central processing unit, responsible for acquiring data from various sensors, processing it, and initiating appropriate control actions. The sensor module includes a DHT22 sensor, which measures temperature and humidity digitally, and an LDR (Light Dependent Resistor), which monitors light intensity through an analog input. Based on the data received from these sensors, the STM32 compares the values against predefined thresholds. If the temperature exceeds a certain limit, a fan is activated to cool the incubator, while a heater is switched on if the temperature falls below the lower threshold.

Similarly, an LED light is controlled depending on the detected light intensity. A 16x2 LCD display is interfaced with the system to provide real-time updates of temperature, humidity, and light levels to the operator. All components are powered by a regulated power supply unit ensuring reliable operation. The overall system is modeled on a closed-loop control mechanism, where environmental parameters are continuously monitored and corrective actions are automatically triggered whenever deviations from ideal conditions are detected, thereby maintaining a stable and controlled incubator environment for healthy silkworm rearing.

➢ *Operational Flow Analysis:*

The system begins by collecting real-time environmental data using the DHT22 sensor for temperature and humidity, and the LDR sensor for light intensity. This data is sent to the STM32 microcontroller, which processes the readings and compares them to preset threshold values. Based on this comparison, the system makes decisions: if the temperature goes above the limit, the fan is turned on; if it falls below the limit, the heater is activated; and if the light intensity is low, the LED light is switched on. The current temperature, humidity, and light levels are continuously displayed on an LCD screen

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may1580

for easy monitoring. Finally, the STM32 controls the fan, heater, and LED through its GPIO pins, executing the necessary actions to maintain the desired environment inside the incubator.

➢ *Performance Analysis:*

The prototype was tested in different simulated conditions to check its performance. It responded quickly to changes in temperature and light, usually within seconds. The sensor readings were accurate and consistent, staying within acceptable error limits. The system was stable, keeping the environment steady after each adjustment. Additionally, the design is flexible and can be expanded by adding more sensors or IoT features in the future. Overall, the tests showed that the system works well to maintain the desired conditions in the silkworm incubator and reliably controls the environment.

V. RESULTS AND DISCUSSION

The developed prototype successfully monitored and controlled the environmental conditions inside the silkworm incubator using the STM32 microcontroller. During testing, the system accurately measured temperature, humidity, and light intensity, displaying real-time values on the LCD screen. The automatic control actions—such as activating the fan, heater, or LED light—were triggered appropriately whenever environmental parameters crossed the set thresholds.

The response time of the system was found to be satisfactory, with the microcontroller promptly adjusting conditions to maintain a stable environment. Sensor data showed reliable accuracy, which is critical for sensitive sericulture applications. The system's stability was confirmed through continuous operation tests, where the incubator environment was consistently maintained within optimal ranges for silkworm growth.

Furthermore, the modular design allows for future enhancements, including IoT integration for remote monitoring and data logging. However, some limitations were observed, such as slight delays in sensor response under rapidly changing conditions, which can be improved with higher precision sensors or optimized code.

Overall, the prototype demonstrates an effective, low-cost, and automated solution for environmental monitoring and control in silkworm incubators, which can potentially increase productivity and reduce manual intervention in sericulture practices

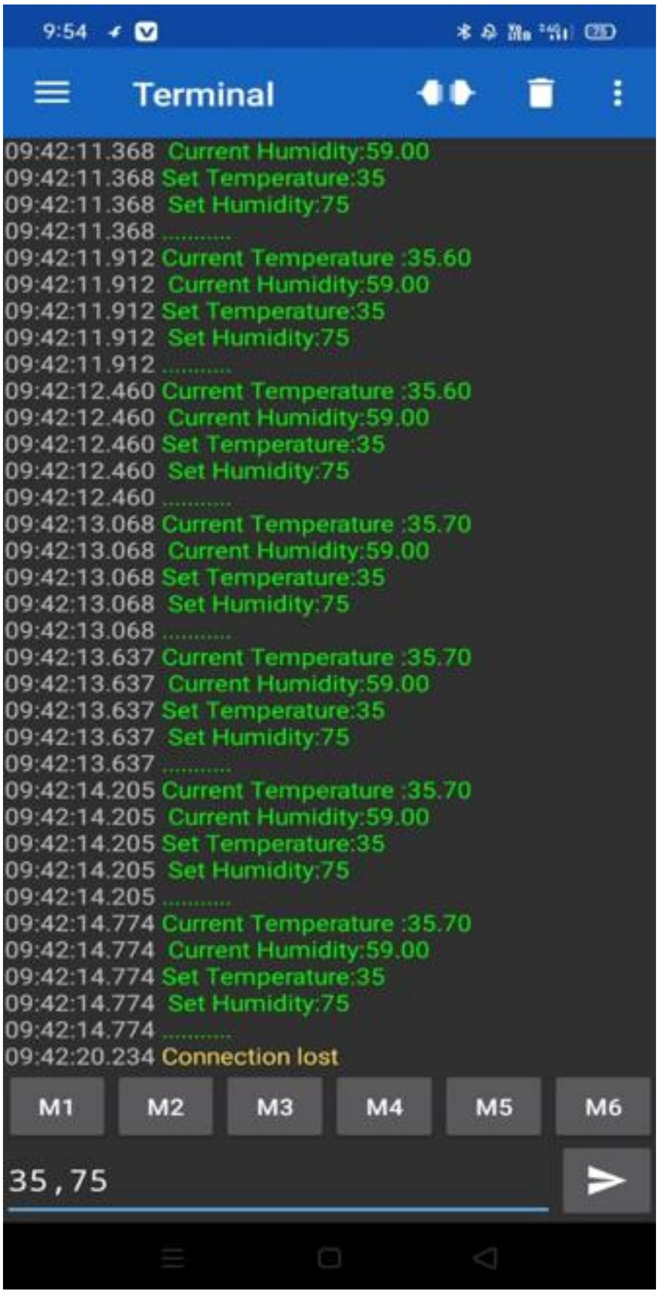

Fig 2 Serial Terminal Output Displaying Real-Time Temperature and Humidity Readings

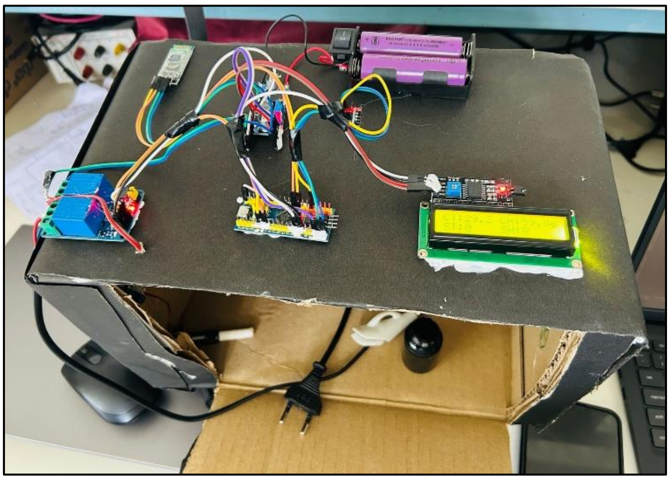
Fig 3 Hardware Architecture

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This figure shows the real-time temperature and humidity values captured by the DHT22 sensor and processed by the STM32 microcontroller. The data is displayed via a serial terminal, indicating the current temperature, current humidity, and the predefined set values for temperature and humidity. The system continuously monitors these parameters and updates the display at regular intervals.

VI. CONCLUSION

In this project, a prototype system was successfully designed and implemented to monitor and control environmental conditions within a silkworm incubator using an STM32 microcontroller. The system efficiently measured temperature, humidity, and light intensity through sensors and automatically controlled a fan, heater, and LED light to maintain the ideal environment for silkworm growth. Real-time data display on the LCD made monitoring simple and effective for operators.

The performance tests confirmed that the system responded quickly and accurately to environmental changes, maintaining stable conditions inside the incubator. The control actions were reliable, and the modular design makes it easy to upgrade the system with additional sensors or IoT modules for remote access and advanced data management in the future.

Overall, this prototype provides a practical, low-cost, and automated solution to support healthy silkworm rearing conditions, helping improve productivity and reduce manual effort in sericulture processes.

REFERENCES

- [1]. STM32 Microcontroller Datasheet, STMicroelectronics. Available at: https://www.st.com
- [2]. DHT22 Temperature and Humidity Sensor Datasheet. Available at: https://www.adafruit.com
- [3]. Light Dependent Resistor (LDR) Basics and Applications, Electronics Tutorials. Available at: https://www.electronics-tutorials.ws
- [4]. Dogan Ibrahim, *Designing Embedded Systems with STM32 Microcontrollers*, Elsevier, 2015.
- [5]. Mahaboob Basha Shaik, “Automated Silkworm Rearing System using Embedded Technology,” *International Journal of Engineering Research & Technology (IJERT)*, Vol. 9, Issue 7, July 2020.
- [6]. STM32CubeIDE User Guide, STMicroelectronics. Available at: https://www.st.com/en/development-tools/stm32cubeide.html
- [7]. Saeed V. Vaseghi, *Advanced Digital Signal Processing and Noise Reduction*, Wiley, 2013.