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Silksage: Empowering Sericulture with Intelligent Environmental Monitoring and Control

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***Abstract*— Our study investigates into the sericulture farming system, intending to improve both silk quality and production efficiency and decrease human intervention with worms. The primary elements influencing silkworms—temperature, humidity, and air quality—are meticulously regulated using an Arduino microcontroller and the Internet of Things (IoT). Data from on- field sensors is easily sent to a cloud platform, enabling farmers to monitor the fields remotely at any time with an internet connection. Our major goal is to attain top-tier silk quality with little human interaction, providing an inexpensive and effective answer to the sericulture sector.**

***Index Terms*— Sericulture, Arduino, IoT, Cloud platform, Remote Monitoring.**

I. INTRODUCTION

Sericulture is the practice of manufacturing silk, dates back thousands of years, and has its roots in ancient China. It entails growing silkworms and producing gorgeous textiles from their silk. This complex procedure may be broken down into multiple phases. The voyage begins with silkworm eggs hatching, which results in the larva stage. During this stage, silkworms are carefully fostered, with particular attention paid to elements such as temperature and humidity, which have an influence on their health and the quality of the silk they produce. They devour mulberry leaves voraciously as they develop to prepare for their next change.

The pupa stage follows, during which silkworms spin their cocoons using silk generated by their silk glands. This is when they undergo a spectacular transformation. After that, during the adult stage, the cocoons are unraveled to harvest the silk strands. This delicate technique, known as reeling, ensures that the continuous silk thread remains unbroken. These extracted silk threads are subsequently turned into a variety of items.

Sericulture is a timeless craft that combines old processes with contemporary ones. While sericulture is a time-honored activity with a rich history and economic value, it is not without its obstacles and faults. Silkworm cultivation and silk fiber extraction are both sophisticated procedures that require careful human intervention. These procedures are critical, but they can be prone to a variety of difficulties that impact both the quality of silk production and the labor involved. Errors can arise at several phases of the sericulture process. Silkworm health might be jeopardized if temperature and humidity are not carefully managed. Such mistakes might result in lower-quality silk and financial losses for sericulturists.

Furthermore, the transition of silkworms from pupa to adult stage, where silk is harvested, is crucial. Errors in

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handling and reeling can cause damage to the silk strands, lowering its quality and worth. Furthermore, the labor-intensive nature of sericulture necessitates professional personnel who are well- versed in the procedures necessary for each stage. Labor mistakes, whether in handling silkworms, reeling cocoons, or managing the production process, can contribute to a decrease in silk quality. These flaws not only have an influence on the finished product but also on the livelihoods of individuals involved in sericulture.

We've used modern technology to address a variety of difficulties over time. We are reinventing sericulture by combining temperature, humidity, and air quality monitoring devices, as well as a handy automatic window opener operated by a mobile app. These advancements maintain exact climatic conditions, which reduces mistakes and improves silk quality. Automation of labor-intensive processes not only enhances efficiency but also allows sericulturists to easily fine-tune their facilities. In today's changing world, our priority is to make sericulture more efficient, economical, and sustainable. We also did an image classification for the detection of any diseased silkworms present. The Convolutional Neural Network (CNN)'s application extends beyond its initial use in recognizing animals entering the farm. This flexible multi- layered deep learning technology, which is well-known for its performance in image processing and recognition applications, has a novel use in sericulture. The CNN model has been retrained to distinguish between ill and healthy silkworms in this setting.

II. Literature Survey

Our literature survey serves as the cornerstone of our research, enabling us to explore the landscape of existing knowledge and set the stage for our study. We focus on Modern Sericulture Techniques and Methods and through this survey, we will examine key research, theories, and insights relevant to our work. This survey not only provides the foundational context but also identifies gaps and trends in the field, shaping the direction of our research.

According to Mubashar Hussain, Shakil Ahmad Khan, Muhammad Naeem, and M. Farooq Nasir's studies, temperature and humidity are critical components in the effective production of silkworms [1]. Silkworms, Bombyx mori, are extremely delicate organisms whose well-being is tightly linked to the environmental circumstances in which they are nurtured. Temperature and humidity fluctuations can have a significant impact on their general growth, health, and reproductive potential. The study looks into this crucial component of sericulture. The study of the link between temperature, humidity, and silkworm growth gives significant information for sericulturists looking to increase silk output. This paper tackles the key issue in sericulture: how to generate perfect rearing circumstances that enable strong silkworm development and, as a result, optimize silk output.

S. Kamili and M.A. Masoodi's "Principles of Temperature Sericulture" is a significant addition to the subject of sericulture [2].Temperature control is critical in sericulture since it directly affects the health, growth, and output of silkworms. A basic technique in sericulture is the rigorous regulation of temperature conditions throughout the silkworm's life cycle. The work of S. Kamili and M.A. Masoodi gives a thorough knowledge of the concepts behind good temperature management. The book dives into the important components of how temperature effects silkworm growth and development, from the larval stage to cocoon creation and adult moth emergence. Based on V.K. Rahmathulla's research, there is a complex link between climatic circumstances, silkworm health, and the resulting silk quality [3]. It explains how temperature, humidity, and other environmental variables may have a substantial influence on silkworm development, cocoon quality, and, eventually, silk output. Rahmathulla's assessment emphasizes not only the theoretical relevance of climate control in sericulture, but also the practical ramifications. Sericulturists understand that the environment in which silkworms are nurtured is critical to their success. The assessment emphasizes the need of precise temperature management and provides practical advice for improving these settings.

" Arduino Based Automated Sericulture System," written by Manjunatha and Mr. Mahesh B. Neelagar [4], The in- corporation of Arduino-based automation in sericulture has several advantages. The capacity of the system to detect and alter environmental factors like temperature and humidity is a significant breakthrough. It ensures the establishment of an ideal silkworm rearing habitat, which has a direct influence on their health and, as a result, the quality and quantity of silk production. The research also looks at how the automated system may be controlled remotely, giving sericulturists more freedom and ease in managing their farms.

The health and well-being of the mulberry silkworm (Bombyx mori) is critical in sericulture [5]. However, silkworms are susceptible to a variety of illnesses and pests that can decimate a silkworm population and, as a result, significantly damage silk output. The importance of controlling diseases and pests in sericulture cannot be emphasized. The industry is not only a source of economic life, but it is also a reservoir of traditional knowledge and cultural history. The publication by the Central Silk Board demonstrates the Central Silk Board's dedication

to conserving and improving the art and science of sericulture. It is a crucial resource for students, researchers, and practitioners, providing practical insights into disease and pest control in mulberry silkworm rearing.
Farmers are always concerned about pest control [6], and quick diagnosis and response are crucial for safeguarding crop harvests. Image processing techniques provide a novel answer to this problem by giving a non-invasive and fast method of recognizing and measuring the presence of insects in field crops.
The invention of adaptive multichannel filters offers a revolutionary method to image processing [7], allowing for the extraction of relevant features while decreasing noise and artifacts. The creation of adaptive multichannel filters brings up new opportunities for image analysis and pattern identification. These filters provide a flexible approach for increasing picture quality, which is critical in a variety of real-world applications. Traditional CNN architectures may not be well-suited to the particular constraints provided by remote sensing data, such as complicated backdrops, size changes, and different land cover classifications [8]. The ability to search for and create customized CNN architectures in an effective manner directly meets the demands of remote sensing practitioners. Researchers and professionals' benefit from personalized CNNs as a helpful tool for effectively identifying complicated remote sensing imagery. Furthermore, the authors' work adds to the progress of image analysis methodologies, which is critical in tackling a variety of real-world geoscience and remote sensing difficulties.
We have navigated the currents of known knowledge with this survey, identifying major results, trends, and research needs in the chosen topic. As we embark on new investigations, it is critical to recognize and build on the contributions of previous researchers, thereby enriching the ever-changing landscape of knowledge. Literature reviews not only determine the direction of future study, but they also serve as a witness to the ongoing expansion of human understanding and the collaborative character of academic effort.

III. PROPOSED DESIGN

Everything is interfaced on an Arduino Uno Board, which makes it financially friendly, and the software used is Arduino IDE for programming of Arduino Board and Thing speak for updating parameters in the cloud for monitoring and Image Classification is done with the help of Convolution Neural Network.

A Hardware

Number The board utilized is an Arduino Uno board, which is a basic microcontroller that serves as the brain of the sericulture system. The sensors we incorporated in the kit (inside the room in real-time) will all feed the signals to the Arduino Board. For the measurement of Temperature and Humidity at the same time as they are major key parameters that affect the silkworm lifecycle and growth, we used DTH11 and for the measurement of air quality we used MQ-135, to measure the light intensity we used a LDR (Light Dependent Resistor). The interfacing which is done is shown in Fig. 1.

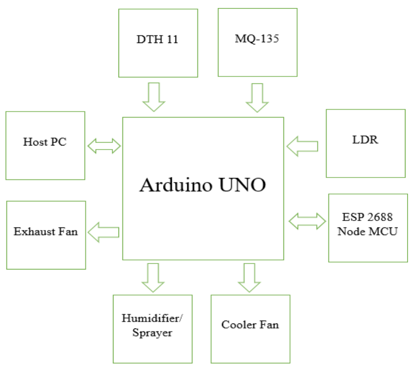

Figure 1. Block Diagram of Interfacing

We need a separate power source for each of the fans and sprinkler motor, out of which one is an exhaust fan that is triggered by the air quality sensor i.e., MQ-135, and the other fan is a replica of a cooler for maintaining temperature We utilized an L298N motor driver IC to power them up by a 12V - 1A power adapter, which allows us to run all of them without any under-voltage. The board should also be powered by uninterrupted power so using a dedicated power source with a UPS (Uninterruptible Power Supply) will be more efficient. We utilized a Node-MCU esp8266 to write data in real- time to a cloud channel made by the user to monitor different parameters remotely from any place he/she wants to. We used Thing Speak for this. Also, we used the same method for our

automatic ventilation system which will open the window- typed structure that will be placed around the walls of the sericulture block which can be operated by mobile application from anywhere.
This ventilation idea is for late winter nights where the temperature and humidity are good enough in the outer environment so controlling is not required at that time. So the farmer can lift the window letting it to the open environment, also while monitoring the parameters from the cloud if he/she wants to lift the closed environment in that case also it will be useful. The setup of the hardware will look as in Fig. 2.

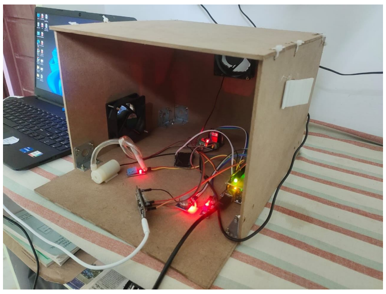

Figure 2. Hardware Setup.

The optimal environmental conditions are given in Table I for the healthy growth of the silkworm.

TABLE I. DESIRED AND OPTIMAL PARAMETER VALUES

S.No	Parameter	Value
1	Temperature	20-28°C (Desired) 23-27°C (Optimal)
2	Humidity	70-85% Relative (Desired) 75-82% Relative (Optimal)
3	Air Quality	<100 (Desired) 70-95(Optimal)

B. Software

Arduino IDE, an open-source resource, is used to program the microcontroller. The Arduino Integrated Development Environment (IDE) is a software tool for programming Arduino microcontrollers. It provides a straightforward and easy-to- use interface for creating, building and uploading code to the Arduino board. The IDE is open-source and free to use, and it supports a variety of programming languages such as C++ and Wiring.
We used Thing Speak to update the parameters in its cloud channel, the write API key of the channel is used in the Arduino code where the Node-MCU will connect to the Wi-Fi through the SSID and Password given in the program and update the values in the channel based on the API key given to it. Thing Speak is a MathWorks Internet of Things (IoT) platform. It is used to gather, analyze, and visualize data for IoT applications. Thing Speak allows users to effortlessly connect sensors, devices, and other data sources, and the plat- form supports real-time data streaming, storage, and analysis. It offers user-customizable dashboards and visuals to assist them in monitoring and interpreting their data. Thing Speak is very popular in environmental monitoring, home automation, and industrial IoT projects. Its user-friendly interface and connection with MATLAB make it a viable option for both enthusiasts and professionals interested in harnessing the potential of IoT for data-driven decision-making. Similar logic is used for the automatic window opening system where the thing speak channel is set to a value which is read by the Read-API of the channel by Arduino, here it is implemented in a way that a button pressed in app made by MIT App Inventor tool will change the channel value which will trigger the servo motors connected to windows resulting in its motion. MIT App Inventor is a user-friendly, visual programming tool that allows anyone to develop mobile applications for Android devices without considerable coding skills. It was created by the Massachusetts Institute of Technology and provides users with a block-based interface, streamlining the app creation process. Users may use App Inventor to design, create, and test their apps in a user-friendly environment. This tool is especially useful for educators, novices, and hobbyists since it gives a simple introduction to app creation and programming fundamentals, allowing a wide spectrum of individuals to bring their creative app ideas to life on the Android platform.
We used Convolutional Neural Networks (CNNs) for categorizing the health condition of silkworms, discriminating between ill and healthy individuals. CNNs, a subset of deep learning models, excel in image

classification tasks, making them an excellent fit for our specific goal. Our CNN was trained to distinguish subtle visual signals and patterns linked with various health issues by utilizing a large collection of silkworm photos. The CNN's capacity to learn and adapt from this data enabled precise, automatic, and speedy classification, drastically lowering the need for manual inspection. This technical improvement not only simplifies the sericulture process but also improves the quality and efficiency of silkworm production, indicating a significant advancement in the field of sericulture.

Our Convolutional Neural Network is made up of a succession of linked layers that are meant to extract progressively complicated characteristics from silkworm photos. It starts with convolutional layers, which recognize fundamental patterns like edges and textures. Following these are pooling layers that downsample the feature maps, lowering computing complexity while keeping critical information. Following that, we have fully linked layers that conduct the real classification process by balancing the extracted characteristics. The employment of these convolutional, pooling, and fully connected layers combined enables our CNN to distinguish complex properties in silkworm photos, permitting precise classification between healthy and ill silkworms with outstanding precision and efficiency.

A vital stage in every image classification effort is the creation of a strong and appropriate dataset. In our study, we diligently gathered a specialized collection of around 200 photos of both healthy and unhealthy silkworms. This dataset is the foundation of our research since it has been rigorously developed to include the unique visual properties of silkworms in various health conditions. Each photograph was obtained skillfully, assuring high-quality depictions of both healthy and sick silkworms under various environmental situations. The rigorous annotation and organization of this unique dataset demonstrates the precision and attention with which our research was carried out. It underlies the dependability and accuracy of our Convolutional Neural Network model, allowing it to perform remarkable silkworm classification.

IV. Result

The whole completed setup of the project will look as in Fig.3, all the sensors and the relays which will trigger on parameter decreasing less than the pre-defined set value. Likewise, a specific relay getting triggered will compensate the change in the particular parameter.

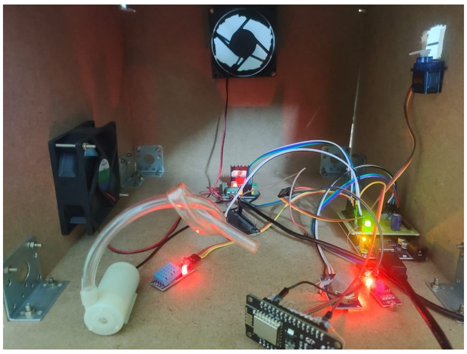

Figure 3. Working Hardware Setup

The parameters will be updated continuously in the cloud channel of ThingSpeak where the user can monitor 24/7 from anywhere. The view of the parameter updation will be as in Fig.4.

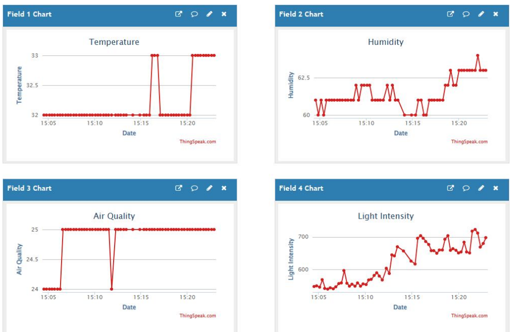

Figure 4. Parameters updating in ThingSpeak Channel

The farmer can use the command from the mobile application which will result in powering up the servo motor which is cause of opening and closing movement of windows, The interface of the application is shown in Fig.5, and the opened window is shown in Fig.6.

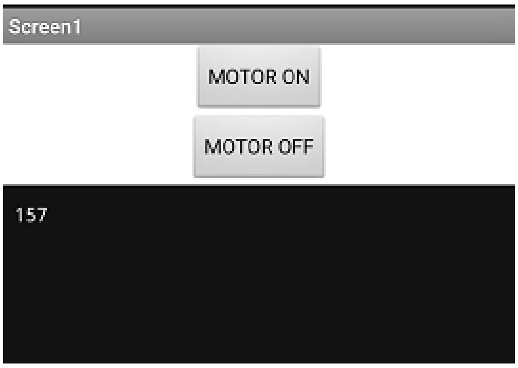

Figure 5. Mobile Application UI for Window Opening/Closing

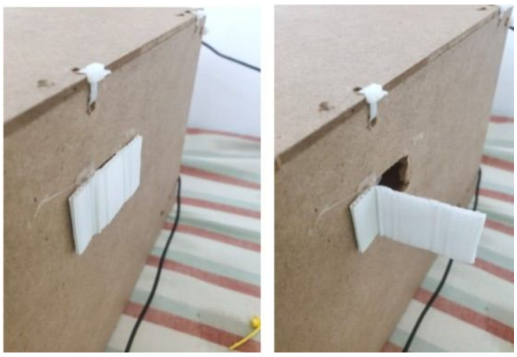

Figure 6. Window open vs Window Closed Position

Figure 7. Healthy Silkworm as Input image

Figure 8. Prediction given by the Model for Healthy input

The Image identification done with the CNN also showing near accurate prediction of Healthy and Diseased Silkworms from the given image. The input image is shown in Fig.7 and its accuracy is as in Fig.8 for Healthy Silkworm and for Diseased they are depicted in Fig.9, Fig.10.The Conf in Fig.8,10 represent the confidence of the prediction by the Model.

Figure 9. Diseased Silkworm as Input image .

Fig. 10. Prediction given by the Model for Diseased input.

V. FUTURE WORK

As we reflect on the accomplishments and breakthroughs described in this research, it becomes clear that there are attractive areas for future work in the field of sericulture and automated silkworm health evaluation. First and foremost, the scalability and usability of our program should be investigated in various sericulture situations and geographies. This may include customizing the program to local variables and conditions in order to secure widespread acceptance. Furthermore, the inclusion of new environmental characteristics and sensor data might improve our system's accuracy and adaptability. We also see prospects for real-time data analysis and predictive Modeling, which might help sericulturists manage their silk output more proactively. Finally, ongoing cooperation with specialists and sericulture practitioners will be critical for improving and expanding our methods.

VI. CONCLUSION

Finally, our study path has brought us to a pivotal point in the field of sericulture. We have not only reinvented the evaluation of silkworm health via the creation and deployment of our advanced software solution, but we have also tackled the critical elements of monitoring and control in sericulture. We are able to give an accurate and automatic approach for discriminating between healthy and ill silkworms because to the successful integration of Convolutional Neural Networks with a rigorously curated bespoke dataset.

Furthermore, our program goes beyond health evaluation. It recognizes the crucial need of environmental monitoring and management in the sericulture process. By monitoring and analyzing critical factors such as temperature, humidity, and air quality, our technology guarantees that the silk production environment remains optimum for silkworm well- being and, ultimately, high-quality silk output. The real-time data updates to the Thing Speak channel give sericulturists with crucial insights, allowing them to adapt proactively to changing circumstances.

This research journey has shown that technology and tradition can coexist peacefully, with our software improving both the quality and efficiency of silk production while respecting sericulture's age-old traditions. As we imagine a future in which sericulture evolves with the digital era, our software serves as a tribute to the inventive spirit and collaborative efforts that will ensure the industry's future. We believe that our study will be remembered as a lasting contribution to the sericulture community, motivating future innovation in the sector and establishing a precedent for the monitoring and management of critical parameters in sericulture activities.

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