Automative SericultureFarm

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Abstract—

Through the use of cutting-edge automation technology, the "Automation Sericulture Farm" initiative seeks to transform conventional sericulture practices by expediting the processes of mulberry planting, silkworm rearing, cocoon harvesting, and silk processing. Automated mulberry plantation systems, Internet of Things-based climate and environment management for silkworm rearing buildings, robotic cocoon harvesting, and sophisticated silk reeling technology will all be beneficial to this labor-intensive sector. These developments offer lower labor costs and more production, quality, and efficiency, opening the door for a profitable, sustainable, and modernized future for sericulture.

I. INTRODUCTION

The lifecycle of a silkworm involves a transformative journey, starting from the larval stages and culminating in the butterfly stage. During this process, the silkworm constructs a cocoon to undergo metamorphosis (see Fig. 1). The larval stage is crucial as it significantly impacts the quality of silk produced, with environmental factors such as humidity and temperature playing vital roles in the health of the larva [1-2]. To effectively monitor these parameters, an automated system is essential [3-5].

In addition to environmental factors, biological threats such as fungi and bacteria can also impact the worm's health. To address these challenges, the system includes a disinfection mechanism. This ensures that medicines and chemicals can be delivered to the worm without adversely affecting its life cycle.The system is constructed using readily available electronics equipment, designed to tackle maintenance issues (see Fig. 2). It is designed with features like portability and the ability to easily add additional functionality. In terms of power management, the system includes a backup power supply to mitigate power loss situations and protection against power surges.

The system also incorporates real-time data monitoring and analysis for precise control and optimization of the silkworm's habitat.

II. LITERATURE REVIEW

[1] Sumriddetchkajorn, S., Kamtongdee, C., &Chanhorm, S. (2015). Fault-tolerant optical-penetration- based silkworm gender identification. *Computers and Electronics in Agriculture*, *119*,201-208.

The papers cover various silkworm research areas: gender identification, cocoon classification, image processing for silkworm pupae, and genetic studies. Sumriddetchkajorn et al. (2015) introduced an optical method for gender identification using ROIs to reduce noise. Mahesh et al. (2017) developed a system to classify cocoons based on physical parameters. Liu (2019) proposed a computer vision-based gender classification method. Raj et al. (2019) designed a multi-sensor system for gender classification. Tao et al. (2019) presented an image restoration technique for accurate sex identification. Ma et al. (2019) discussed genome editing in silk production. Sakai et al. (2014) identified crucial sex determination stages. Luan et al. (2018) analyzed genes influencing silk yield. Kamtongdee et al. (2013) improved gender identification efficiency. These papers advance silkwormresearch significantly, covering gender ID methods to genetic investigations impacting silk quality
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[2] Liu, L. (2019). Automatic Identification System of Silkworm Cocoon Based on Computer Vision Method. RevistaCientífica,29(4).

Silk, often dubbed the 'Queen of Textiles,' is highly esteemed globally for its natural luster and is a product of labor-intensive sericulture. This industry encompasses a range of activities from mulberry cultivation to silk production processes like reeling and weaving. Grainage centers play a crucial role by supplying silkworm eggs for farming. Computer vision, involving camera-computer systems, aids in tasks like image processing and pattern recognition.

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Gender classification of silkworm cocoons is pivotal for silk industry success, and our proposed non-destructive classification system integrates image features for accurate sorting. This system utilizes cost-effective imaging technologies and machine learning algorithms to enhance accuracy and streamline operations in grainage centers.

[3] Liu, L. (2019). Automatic Identification System of Silkworm Cocoon Based on Computer Vision Method. *RevistaCientífica*,*29*(4).

As image recognition technology improves, researchers are focusing on identifying the gender of silkworm cocoons. Existing methods have struggled due to inaccuracies and inefficiencies, hindering the development of a flawless identification system. To address this, the paper proposes a multi-resolution local Gabor binary pattern (MLGBP) feature extraction technique using computer vision. This method aims to thoroughly describe the intricate patterns in silkworm cocoons for accurate and efficient gender recognition.

The experimental outcomes indicate that MLGBP achieves high accuracy, ranging from 95% to a maximum of 98.8% in gender classification. The paper introduces a gender classification approach based on computer vision, which involves using cameras and computers to identify, track, and measure targets. Computer vision encompasses image processing, pattern recognition, spatial shape descriptions, geometric modeling, and cognitive processes, enhancing image suitability for human observation or instrument detection. Image recognition techniques assist in identifying targets and objects across various modes.

[4] Raj, J., Noel, A., Sundaram, R., Mahesh, V. G., Zhuang, Z., & Simeone, A. (2019). A Multi-Sensor System for Silkworm Cocoon Gender Classification via Image Processing and Support Vector Machine. *Sensors*, *19*(12),2656.

In their 2019 study, Raj, Noel, Sundaram, Mahesh, Zhuang, and Simeone introduced a groundbreaking multi-sensor system for classifying silkworm cocoons by gender. This system, integrating image processing and Support Vector Machine (SVM) techniques, was designed to address challenges in the labor-intensive sericulture industry. By collecting weight and image data from individual cocoons, extracting shape-related features, and utilizing SVM for classification, the system can accurately separate male and female cocoons. The use of air blowers and a conveyor system further streamlines the process, contributing to improved efficiency and productivity in sericulture.

[5] Tao, D., Wang, Z., Li, G., &Qiu, G. (2019). Radon transform-based motion blurred silkworm pupa image restoration. *International Journal of Agricultural and Biological Engineering*, *12*(2), 152- 159.

This study focuses on using machine vision to identify and sort silkworm pupae based on their sex. However, capturing clear images of live pupae can be challenging due to their writhing motion, leading to motion blur that affects the accuracy of sex identification. To overcome this challenge, a three-stage approach was proposed.

First, in the image prediction stage, sharp edges were obtained using filtering techniques, and an initial blur kernel was computed using Gaussian prior. Next, the Radon transform was used in the kernel refinement stage to estimate a more accurate kernel. Finally, a TV-L1 deconvolution model was applied in the final restoration step to improve image quality.

Experimental results demonstrated that this approach effectively reduced motion blur, resulting in clearer images with more textures, thus aiding in sex identification. The method's applicability extends beyond silkworm pupae sorting and can be useful in other areas as well.

[6] Ma, S. Y., Smagghe, G., & Xia, Q. Y. (2019). Genome editing in Bombyx mori: New opportunities for silkworm functional genomics and the sericulture industry. *Insect science*, *26*(6),964-972.

Genome editing has revolutionized life sciences, particularly with CRISPR technology's simplicity and efficacy. In Bombyx mori, genome editing has expanded research possibilities, offering insights into insect biology and pest management. This review explores genome editing's progress in silkworms, focusing on functional genomics and genetic material creation.

Bombyx mori is crucial for silk production and insect studies, benefiting from various biotechnological tools like transgenics and RNA interference. Challenges persist in precise DNA fragment insertion despite using genome editing techniques like ZFN and TALEN. Enhancing homologous recombination (HR) efficiency by targeting ku70, involved in repairing DNA breaks, could improve genome editing outcomes in Bombyx mori.

[7] Sakai, H., Aoki, F., & Suzuki, M. G. (2014). Identification of the key stages for sex determination in the silkworm, Bombyx mori. *Development genes and evolution*, *224*(2),119-123.

Understanding the timing of sex determination in Bombyx mori is crucial for unraveling its sex determination mechanism. Researchers focused on key stages by studying the expression patterns of Bmdsx and BmIMP genes, essential in the sex determination cascade of B. mori. Through reverse transcription PCR (RT-PCR) analysis, they discovered that male-type Bmdsx expression occurred in females at 27 and 29 hours after oviposition (hao) but disappeared by 32 hao. Additionally, BmIMP mRNA, crucial for male-specific splicing of Bmdsx, was expressed in these females at levels comparable to male-type Bmdsx mRNA. This indicates that sex determination in B. mori happens between 29 and 32 hao, corresponding to specific developmental stages. Bmdsx plays a crucial role in sex determination by encoding male-specific (BmDSXM) and female-specific (BmDSXF)DSX proteins. Dysregulation of Bmdsx expression can lead to abnormal genital organ differentiation in females or affect gene expression related to female characteristics.

[8] Luan, Y., Zuo, W., Li, C., Gao, R., Zhang, H., Tong, X., ... & Dai, F. (2018). Identification of Genes that Control Silk Yield by RNA Sequencing Analysis of Silkworm (Bombyx mori) Strains of Variable Silk Yield. *International journal of molecular sciences*, *19*(12), 3718.

In this study, we analyzed the transcriptomes of multiple silkworm strains with varying silk yields. We identified 22 common genes related to metabolic pathways and validated seven significant ones using qRT-PCR. These genes, including BGIBMGA003330 and BGIBMGA005780, are linked to cocoon shell weight and play roles in silk gland development or silk protein synthesis. Our findings suggest that modern breeding has a stronger influence on silk yield traits than domestication, leading to the aggregation of genes related to silk production.

[9] Kamtongdee, C., Sumriddetchkajorn, S., & Sa-ngiamsak, C. (2013, June). Improvement of light penetration based silkworm gender identification with confined regions of interest. In *ICPS 2013: International Conference on Photonics Solutions* (Vol. 8883, p. 88830H). International Society for Optics andPhotonics.

Our research focuses on improving silkworm gender identification using light penetration. We noticed that optical noise near the pupa and support can lead to errors, so we added a small rectangular hole to the support. This hole acts as a region of interest (ROI), blocking unwanted noise and helping locate the abdomen for easier processing. We also added a smaller ROI within the image to speed up processing. Using only the external ROI, we achieved 86% accuracy in identifying gender with an average processing time of 38 ms for 120 pupae. Combining both ROIs increased accuracy to 95% with a faster 18 ms processing time.

We placed the silkworm pupa on a transparent support under LED lights, with a thin sheet and rectangular hole acting as the external ROI. A 2-D camera captured images, controlled by an electronic unit adjusting light intensity automatically. Female pupae showed a shadow region indicating optimal light intensity, while male pupae triggered maximum intensity during examination.

[10] McAndrew, A. (2004). An introduction to digital image processing with matlab notes for scm2511 image processing. *School of Computer Science and Mathematics, Victoria University of Technology*, *264*(1),1-264.

Humans heavily rely on vision to understand the world, quickly identifying faces, discerning colors, and processing visual data rapidly. However, even static objects can change appearance due to lighting variations and shadows.

We mainly focus on static images or snapshots representing various subjects like people, animals, landscapes, or technical components. Image processing aims to modify images to improve human interpretation or make them more suitable for machine analysis.

Our discussion centers on digital image processing using computers. It's crucial to note that while enhancing images for human viewing is essential, it may not align with machine perception, which prioritizes simplicity.

In essence, image processing serves both human interpretation and machine perception, with distinct considerations for each aspect.

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III. IMPLEMENTATION DETAILS

A. Requirements and Specifications

Hardware Component Description

The most common set of requirements defined by any operating system or software application is the physical computer resources, also known as hardware, a hardware requirements list is often accompanied by a hardware compatibility list (HCL), especially in case of operating systems. An HCL lists tested, compatible, and sometimes incompatible

hardware devices for a particular operating system or application. The requirements of the system are:

Methodology:

The overview of the system is depicted in the Figure below, illustrating the various modules essential for constructing the system. Raw data is initially captured by sensors and a camera, providing a comprehensive input dataset. The relevant parameters from this raw data are then filtered to extract crucial information, which is subsequently fed into the sensor fusion module for further decision-making processes. Leveraging the output from sensor fusion, the system can effectively detect and classify diseased silkworms, facilitating their recovery while also regulating the temperature to suit the specific needs of the worms. This real-time application is presented and monitored through a display monitor, providing real-time insights and control over the system's operations.

The system configuration encompasses sensors, an Arduino controller, and actuators. The sensor circuit includes four analog sensors: temperature, humidity, light, and CO2, along with a digital fire sensor. The Arduino controller is meticulously programmed to incorporate threshold values and the necessary monitoring and control capabilities, ensuring efficient and accurate system operation.programmed in such a way that it will have the threshold values and the capacity to monitor and control the system.

Controlling fan and bulb:

This system for controlling a fan and bulb utilizes the DHT11, a digital temperature and humidity sensor, which outputs a calibrated digital signal. The DHT11 is integrated with a high-performance 8-bit microcontroller. Both the fan and bulb, along with the DHT11, are connected to a power supply and the Arduino UNO, an open-source microcontroller development board capable of reading sensors and controlling actuators like motors and fans. The data from the DHT11 sensor is transmitted to the Arduino UNO for processing. Based on this processed data, the bulb and fan are either turned on or off. The system maintains an optimal temperature range between 22 to 26 degrees Celsius, activating the bulb if the temperature falls below or rises above this threshold. Additionally, the system adjusts humidity within a confined space using the fan. If the humidity surpasses or falls below the specified range of 75-80%, the fan is either turned on or off, respectively, to regulate humidity levels.

A.Preprocessing and segmentation:

Image processing is necessary for image enhancement. During preprocessing RGB image is converted into grayscale. The brightness of the pixel isrepresented with a single number for all grayscale images. Every image lies between the values 0 to 255 where 0 indicates black and 255 indicates white. All images are stored as an 8 bit image. Image segmentation is basically performed to locate the Silkworm object in image.

Feature Extraction: Feature Extraction stage is necessary because certain features has to be extracted so that they are unique for each Silkworm. After the decision is made that a Silkworm-Diseases and Non- Diseases is present, then the last frame is taken into consideration and features. Finally the Feature Extraction is extract the features (Size, Pixels,Labels) in all Image(Silkworm) dataset are store in 'Support Vector Machine Model', best on train data.

Fig. Healthy Silkworm

Fig. Diseased Silkworm

Image:Image(Silkworm) dataset are store in 'Support Vector Machine Model', best on train data.

Descriptions about Modules:

Raspberry Pi

ARM11 Raspberry Pi 3board

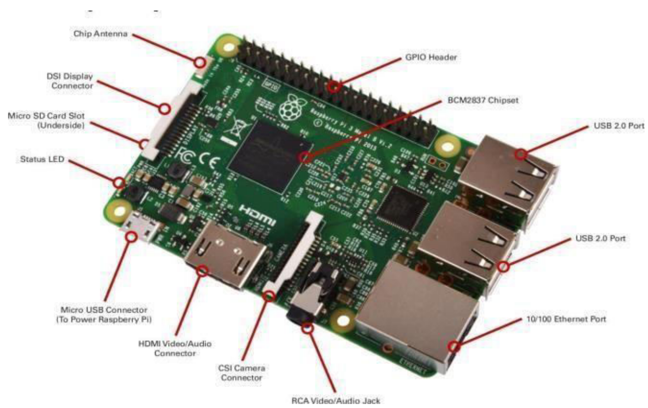


Figure 4.1: Specification of Raspberry pi

The Raspberry Pi is a small computer board featuring a Broadcom BCM2835 system-on-chip with a 700 MHz ARM1176JZF-S processor. Originally equipped with 256 MB of RAM, newer models have 512 MB. Storage is facilitated by an SD card, and connectivity options include HDMI, USB ports, Ethernet, and GPIO pins. More recent versions offer dual-band wireless LAN, Bluetooth, and Power-over-Ethernet capability. It supports various operating systems like Debian and Arch Linux ARM, along with programming languages such as Python, BBC BASIC, C, Java, and Perl. Its compact size, affordability, and diverse functionalities make it widely used in educational and DIY projects.

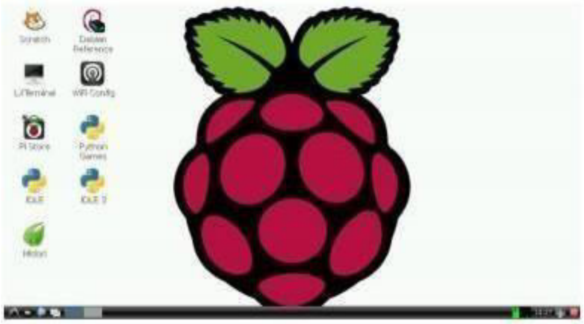
Raspberry pi 3 model b+

The Raspberry Pi 3 Model B+ is an improved version of the Raspberry Pi computer board. It features a quad-core 64-bit processor running at 1.4GHz, 1GB LPDDR2 SRAM, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE, faster Ethernet up to 300Mbps, and Power-over-Ethernet capability with a separate PoE HAT. These enhancements make it ideal for designers, developers, and engineers integrating Pi systems into their projects.

Boosts All Around

Spec	Raspberry Pi 3 B	Raspberry Pi 3 B+
CPU type/speed	ARM Cortex-A53 1.2GHz	ARM Cortex-A53 1.4GHz
RAM size	1GB SRAM	1GB SRAM
Integrated Wi-Fi	2.4GHz	2.4GHz and 5GHz
Ethernet speed	10/100 Mbps	300Mbps
PoE	No	Yes
Bluetooth	4.1	4.2

Raspberian OS:



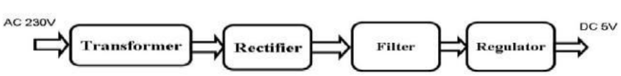
Raspbian OS is a customized version of Debian Wheezy armhf designed to run on the Raspberry Pi. It features optimized "hard float" code for improved performance, particularly for applications using floating-point arithmetic operations. The desktop environment of Raspbian is similar to Windows, with a menu bar, web browser, file manager, and pre-installed applications. Raspbian has been developed primarily by Mike Thompson and Peter Green, with contributions from the Raspberry Pi community aimed at maximizing performance on the Raspberry Pi device.

Regulated power supply:

A regulated power supply consists of a transformer and a rectifier. The transformer transfers electrical energy from one circuit to another using inductive coupling without changing the frequency. It induces a varying electromotive force (EMF) in the secondary winding when a varying current flows in the primary winding. This allows energy transfer from the primary to the secondary circuit.

The rectifier, on the other hand, converts alternating current (AC) to direct current (DC) using diodes. It rectifies the AC waveform, ensuring that current flows in one direction only. Rectifiers are crucial components in power supplies, ensuring a steady and reliable source of DC power for various electronic devices and systems.

Regulated Power supply



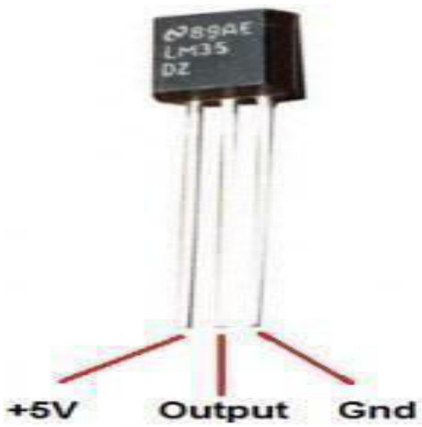
Jumper Wires

A jump wire, also referred to as a jumper, jumper cable, DuPont wire, or DuPont cable, is an electrical wire or a set of wires within a cable. It typically has a connector or pin at each end, although it may sometimes be "tinned" without connectors. Jump wires are commonly used to connect components on a breadboard or in prototype circuits without the need for soldering. They facilitate internal connections within circuits or connections with external equipment or components during testing or prototyping processes.

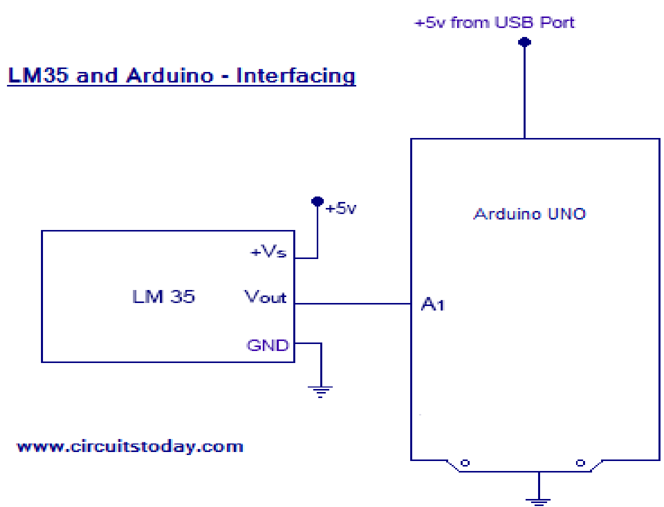
LCD

An LCD (Liquid Crystal Display) is a flat panel display technology that uses liquid crystals to produce images or text. It consists of multiple layers, including a liquid crystal layer sandwiched between two transparent electrodes and two polarizing filters. When an electric current is applied, the liquid crystals align to allow or block light, creating the desired display

Temperature Sensor:



A temperature sensor is an electronic device that measures the temperature of its surroundings and converts it into a numerical value that can be read or processed by a computer or microcontroller. These sensors are widely used in various applications such as climate control systems, industrial processes, medical devices, and consumer electronics



The LM35 is an IC temperature sensor that provides an electrical output directly proportional to the temperature in Celsius (°C). Compared to thermistors, the LM35 offers higher accuracy and does not require external calibration. It maintains an accuracy of +/-0.4°C at room temperature and +/-0.8°C over a range of 0°C to +100°C. Additionally, it has a low power consumption of only 60 microamps and minimal self-heating.

The LM35 comes in various packages such as TO-92, TO-46, and SO-8, making it versatile for different applications. It operates as an analog sensor, so it needs an Analog to Digital Converter (ADC) to interface with microcontrollers like Arduino. However, modern microcontrollers often have built-in ADCs, simplifying the integration process.

To connect the LM35 to an Arduino Uno, the +5V pin of the LM35 is connected to the +5V pin of the Arduino, the ground pin of the LM35 is connected to the ground (GND) pin of the Arduino, and the analog output pin (Vout) of the LM35 is connected to any analog input pin (e.g., A1) of the Arduino. The LM35 is available in different series (LM35A, LM35C, LM35D) with variations in temperature measurement range.

DHT 11 Sensor:

This DHT11 Advanced relative moistness and temperature sensor module is pre-adjusted with resistive sense innovation combined with NTC thermistor, for the exact perusing of the relative mugginess and encompassing temperature DHT11 break-out board is an exceptionally famous, minimal expense sensor from Aosong, the breakout gives simple establishment of the DHT11 sensor module. The total course of action makes the gadget an optimal detecting arrangement to be snared straightforwardly to any sort of microcontroller sheets like Arduino's. The board is extra highlighted with locally available Drove, a detour capacitor among Vcc and Gnd and a draw up resistor across the information line and Vcc

Figure 4: DHT11

LDR :

It is a resistance decrease with increasing incident light intensity. It is also called as photodetector and made up of high resistance semiconductor

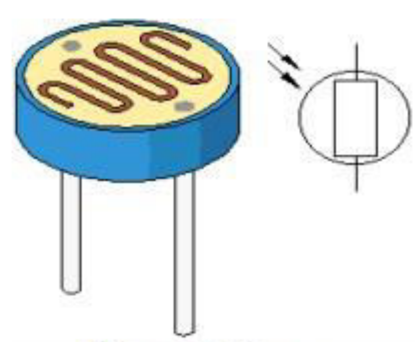


Figure.3. LDR sensor

Water Pump:

The Micro DC 3-6V Micro Submersible Pump is a compact and cost-effective water pump suitable for DIY projects such as fountains, garden mini water circulation systems, and more. It operates on a power supply ranging from 3 to 6 volts and can pump up to 120 liters of water per hour. Despite its high flow rate, it has a low current consumption of only 220mA.

To use the pump, simply connect a tube pipe to the motor outlet, submerge it in water, and power it up. It's important to ensure that the water level remains higher than the motor to prevent dry running, which can damage the motor and cause noise due to overheating.

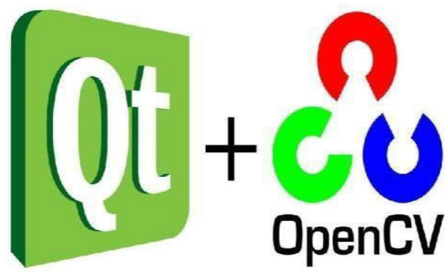
Software Requirement Specification

A Software Requirements Specification (SRS)

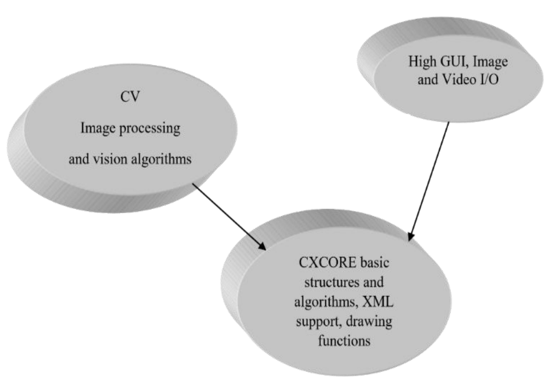
– a requirements specification for a software system – is a complete description of the behavior of a system to be developed. In addition to a description of the software functions, the SRS alsocontains non- functionalrequirements. Software requirements are a sub-field of software engineering that deals with the elicitation, analysis, specification, and validation of requirements for software.

1. Open CV
2. Raspbian OS
3. Python

1..OpenCV (Open Source Computer Vision Library) is an open-source computer vision and machine learning software library. It provides a wide range of functions for real-time computer vision applications, including image and video processing, object detection and recognition, and machine learning algorithms. OpenCV is widely used in academia, research, and industry for various applications such as robotics, augmented reality, and image processing.



2. Raspbian is a free operating system based on Debian optimized for the Raspberry Pi hardware. It is the official operating system for the Raspberry Pi single- board computers. Raspbian provides a user-friendly interface and a suite of software tools and utilities, making it easy to set up and use the Raspberry Pi for various projects, including home automation, media centers, and educational purposes.



3. Python is a high-level, interpreted programming language known for its simplicity and readability. It supports multiple programming paradigms, including procedural, object-oriented, and functional programming. Python is widely used in various fields such as web development, scientific computing, data analysis, artificial intelligence, and automation. It has a large standard library and a vibrant community, making it a popular choice for beginners and experienced developers alike.

Advantages and Applications

Advantages

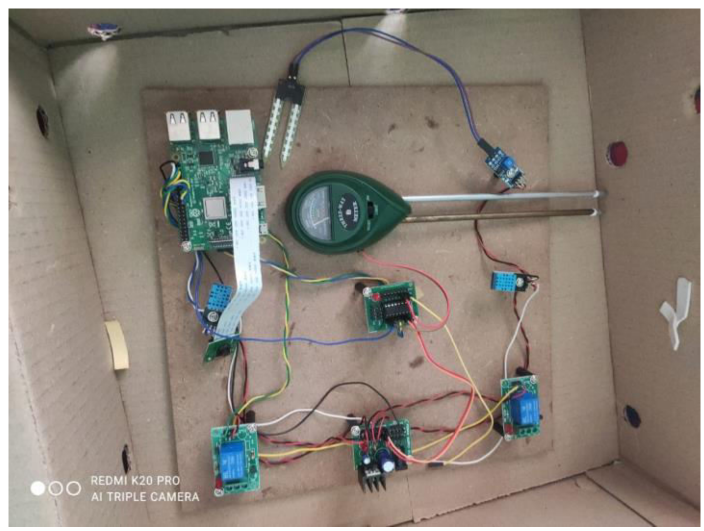
- It recommends financially affordable and power effective organization.
- Efficient wireless sensor network with IOT technology to monitor and control the temperature, humidity and light intensity present in silkworm rearing house.
- The proposed system reduces the man power and reduces the chance of errors.
- The model is easy to implement and use.
- Data collection.
- All data can be collected with the help of installed sensors Reduction of risks Business goes automated Livestock monitoring Monitoring climate conditions.

Applications

1. Farmers Can Best Utilize it
2. Silk Industries

Snapshot:

The automated sericulture arm system combines a Raspberry Pi microcontroller, Python programming, and a camera module to revolutionize silk production processes. The Raspberry Pi serves as the central hub, orchestrating image capture, color analysis using the ColorLabeler class, and data communication with the user interface. Python scripts running on the Raspberry Pi employ advanced image processing algorithms to extract color data, analyze silkworms and cocoons, and provide real-time insights to users regarding silk production metrics such as color distribution and cocoon quality. This integration of hardware and software components ensures efficient and accurate monitoring of sericulture operations, enhancing quality control measures and facilitating informed decision-making for silk producers.



CONCLUSION

IoT is widely used in connecting devices and used to gather information. The system is designed to remotely monitor the applied parameters such as humidity, temperature, and accumulation of harmful gases, this information collected can be used to automate the climatic conditions within the closed environment. The worms are monitored by using a camera that collects data in form of pictures at equal specified intervals. The data collected here is used determine if the worm is healthy or diseased. If the worm is found to be diseased, an automated pump will dispense the medicine. Thus, the system will help the farmers to limit physical labor involved in silk production, and to increase the yield as well as the silk quality. This is done by maintaining précised parameters such as humidity, temperature, and gases as well as monitoring and classification in the controlled environment with the help of IoT.

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