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IMAGE PROCESSING BASED SMART SERICULTURE SYSTEM USING IOT

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Abstract
Rearing of silkworm is highly dependent on environmental variations. To have a healthy cocoon production, it is necessary to have a proper temperature and humidity controlled house for silkworm rearing. Temperature, humidity and fresh air should be managed to get a wonderful silk product. An ideal temperature of 23°C to 28°C and humidity in between 65% to 85% is to be maintained. IoT based silkworm rearing house consists of sensors and actuators, which are interfaced with a low power controllers. The Sericulture unit can be equipped with a wireless sensor node to sense the real time Temperature and Humidity [1], also necessary actuators to control these environmental parameters. The color change in the body of the worms indicates the different stages and the light yellowish indicates that they have reached to the cocoon stage and the morphological changes in silkworm structure can be used to detect abnormal worms[2].The proposed framework introduces an Internet of Things (IoT) empowered Wireless Personal Area Network (WPAN) system. The received image is first segregated into two classes as diseased or healthy by analyzing the histogram of the background removed image based on thresholding. Again the diseased class will be sub classified into 2 diseases as either Flacherie or Pebrine by applying suitable mask for extracting worm and obtaining the histogram of the worm and analyzing it. The result will be sent to the farmer via E-mail. The proposed system could be a probable solution for productivity in silkworms.

***Keywords**:* Morphology, Thresholding, Histogram, Feature extraction, Sensors, WPAN, IOT.

1. Introduction
The art of production of silk by rearing silkworm is the science known as sericulture. The silk is known as queen of the fabric by its various properties like elegance, smoothness, glittering luster, tensile and durability. The silk is preferred over all other types of fibers due to its remarkable properties like water absorbency, heat resistance, dyeing efficiency, and luster. Silk is an animal protein fiber secreted by the silkworm larva for spinning of the cocoon. India is the second largest producer of the silk in the world and Karnataka is the largest producer of silk in India. But still sericulture is carried out by using traditional methods in India which causes huge loss to the farmer. According to the economical statistics provided by ministry of textiles Indian raw silk exports has been reduced by 16.1% to 20.93 billion INR in the FY 2016-17 from previous 24.95 billion INR. Hence there is need of modernizing the Sericulture Industry in India.
In India 4 traits of silkworms will be reared namely Mulberry, Muga, Oak Tasar and Eri. There are four stages of development in silkworm namely egg, larva, pupa and moth The mulberry silkworm which is a traditional silkworm trait reared in India passes through 4 moults and 5 instars stages in 20-30 days to complete its lifecycle. The growth and development of silkworm is greatly influenced by environmental conditions. The seasonal weather changes affect the genotypic of warm in the form of phenotypic output resulting in variation in shell weight, cocoon weight and shell ratio of cocoon. Silkworms are highly prone to diseases in their early instars hence accurate inspection needs to be carried out and appropriate measures should be taken. The temperature and humidity required for the instars of the silkworm are as represented in the Table 1.

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Table 1: Temperature and Humidity required at various stages of silkworm development

Environmental factors	Incubation	I instar	II instar	III instar	IV instar	V instar	Spinning	Cocoon preservation
Temperature	25°C	28°C	27°C	26°C	25°C	24°C	25°C	25°C
Relative humidity	75–80%	85–90%	85%	80%	70–75%	65–70%	70%	80%

To have a sustainable production of cocoon, a major emphasis should be given on management of relative humidity and temperature which are undergoing lot of changes in last decade due to environmental variations. Temperature, humidity and fresh air should be managed to get wonderful silk product. Smart Sericulture system based on IoT and Image processing could be the solution for the above mentioned problem. The IoT based silkworm rearing house consists of sensors and actuators, which are interfaced with battery operated controllers. Sensors provide the real time data of the stages of the silkworm and Blynk app is used to send the instar of the silkworm to controller. Based on these readings, decision will be taken by the controller and actuation is performed. Image Processing system includes collecting images and creating a database, background elimination using mask, color image processing, feature extraction and classification. Identification of diseased worm and its disease by estimating color change and its pattern on the body of the silkworm. The farmer will be informed about these diseases through E-mail. The flow of the paper is as follows:

Section 1: Methodology
Section 2: Design and Implementation
Section 3: Result Analysis
Section 4: Conclusion of the proposed work
Section 5: Future scope

2. Methodology:

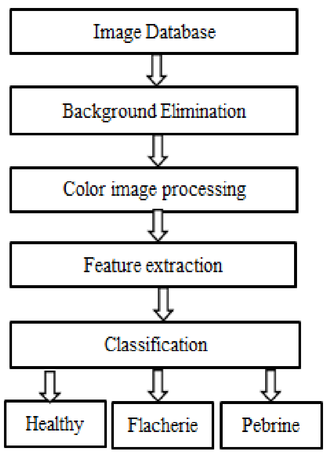

Fig 2: Flow chart of Image processing section for sericulture

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Image processing section as shown in Fig 2 consists of following procedure:

- **Image Database:** The images of the silkworm will be captured by using digital camera from the sericulture unit and will be stored in the database. These images will be processed using MATLAB. The silkworm image should have the same background and the worm should not overlap with each other.
- **Background elimination:** The background of silkworm image capture which is stored in the database will be eliminated by creating a binary mask and applying this to the RGB image for passing only the pixels corresponding to the silkworm by making the other background pixels as 0.
- **Color image processing:** The histogram of the R-layer of silkworm image which is obtained after background elimination will be used to plot the histogram. By using histogram we can clearly distinguish between the healthy and diseased worm.
- **Feature extraction:** The mean of the histogram will be calculated for each worm will be calculated and a threshold value will be estimated which will clearly classify the worms.
- **Classification:** The silkworm images will be classified into healthy and diseased by comparing mean value with the threshold value. The original images of diseased worm will be again applied with a separate mask as the body color of the silkworm will be different from the healthy one .The procedure of background elimination to classification will be again followed to classify the diseased images into Flacherie and Pebrine. If the diseased worm is detected them an E-mail will be sent to the farmer which will indicate the disease detected.

3. Design and Implementation

The IoT system for maintaining the climatic conditions of silkworms at different instars by using Node MCU ESP8266, DHT11, I^{2}C LCD, Relays, Heater, Humidifier, DC fan, ThingSpeak, Blynk app, is as shown in the Fig 3

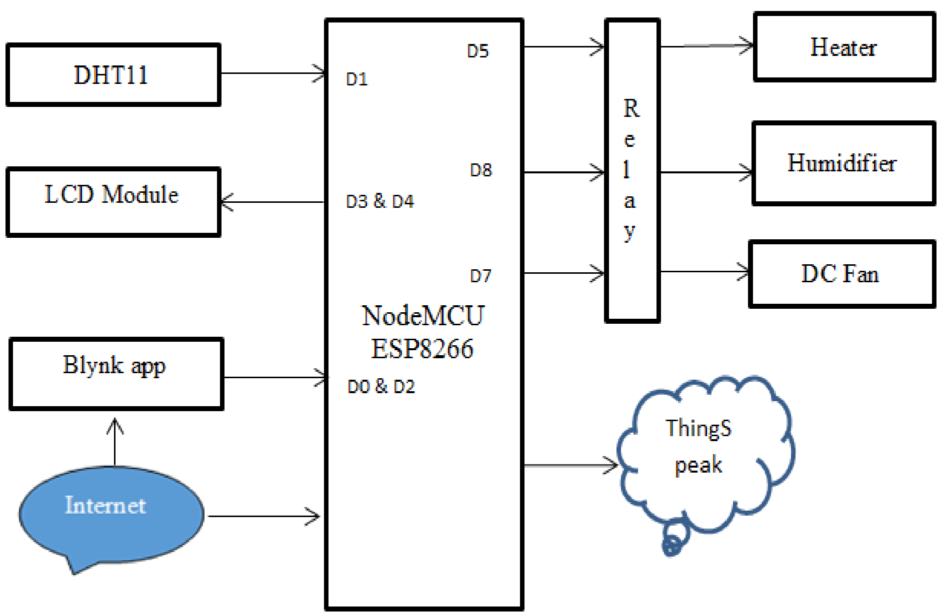

Fig 3: Block Diagram of IoT System

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The IoT system involves, choosing a microcontroller (i.e. NodeMCU ESP8266), sensors and actuators which are compatible with each other and best suitable for the application. NodeMCU ESP8266 is chosen because it is a low power controller which is best suitable for IoT applications. The sensor used is DHT11 for measuring temperature and Humidity of sericulture unit. For lowering the temperature we use cooling fan and for increasing the temperature we are using heater, also to maintain the humidity in the desired range humidifier is used. To meet the power requirement of these interfaces and to switch these devices we use 3 relays. The NodeMCU will be powered using USB cable which also used to program it. To program the NodeMCU we use Arduino IDE platform which is a user friendly IDE. The data sensed by sensor will be displayed on the LCD and will be also stored on to the Thing Speak cloud using HTTP protocol by NodeMCU. The Blynk app will be used to send the stage of development of the silkworm to NodeMCU ,so that corresponding climatic conditions will be maintained at each stage.

4. Result Analysis

A prototype of wireless sensor node which monitors and control temperature and humidity parameters of the sericulture unit as shown in Fig 4.1 .These environmental parameters will be stored on to cloud. The stage of development of larvae and diseased silkworm will be identified by image processing techniques. Notifying the farmer about the condition of the silkworm using GSM module.

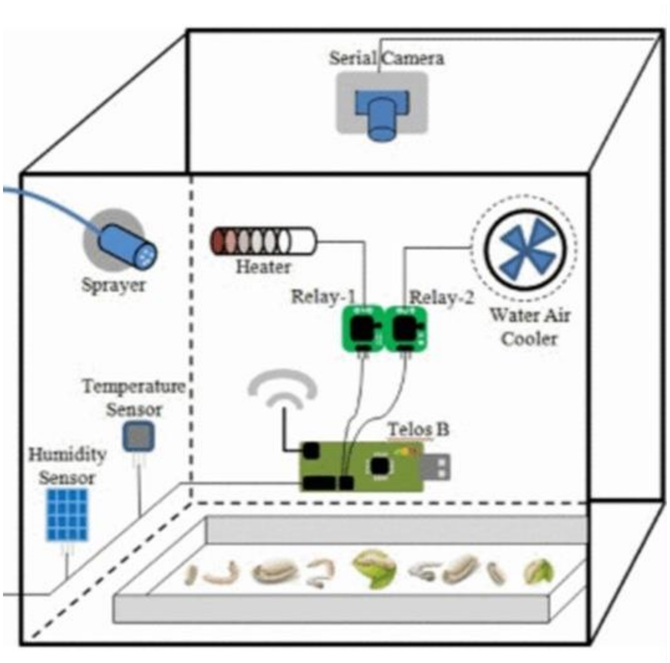

Fig 4.1: Prototype of the Smart Sericulture system.

The temperature and humidity parameters sensed by DHT11 sensor will be posted on to the ThingSpeak platform as shown in Fig 4.2.The values are posted on two fields in the channel “smart sericulture” which has been created in the user account. The x-axis represents time of data posting and the y-axis represents the amplitude/value of the data being posted.

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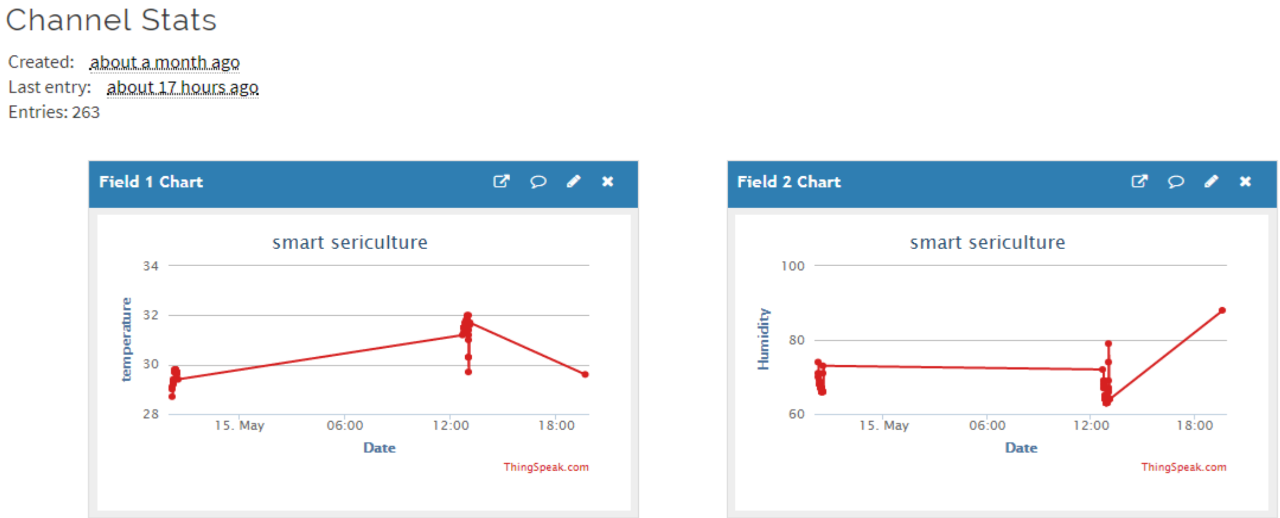

Fig 4.2: Temperature and Humidity values stored in ThingSpeak Channel

The stages of the silkworm will be sent to the NodeMCU ESP8266 by using Blynk app. Two switches switch1 and switch 2 will be used which acts as multiplexer where 00 is instar 3, 01 is instar 4 and 10 is instar 5 as shown in the Fig 4.3.

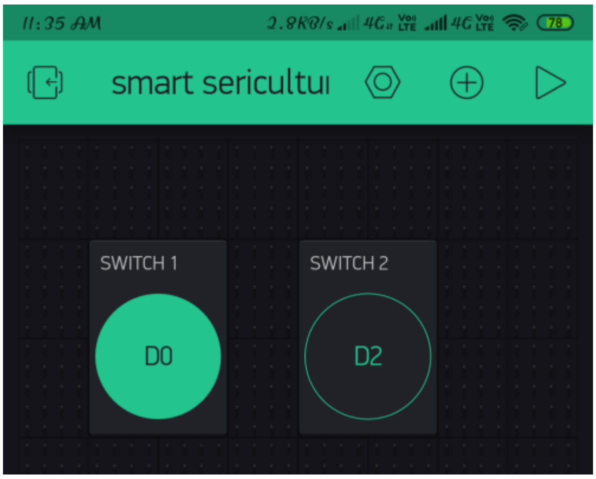

Fig 4.3: Smart sericulture System GUI in Blynk app

Healthy worm detection based on histogram thresholding as shown in the Fig 4.4. Here the silkworm image which has been taken from database will be background eliminated to get the image of only silkworm as shown. The histogram of the silkworm will be taken as shown in below figure which implies that the most number of pixels are nearer to white pixel value hence the detected worm is healthy. By comparing the average of the histogram with previously set threshold value the image will be identified as healthy worm images by displaying on a dialog box.

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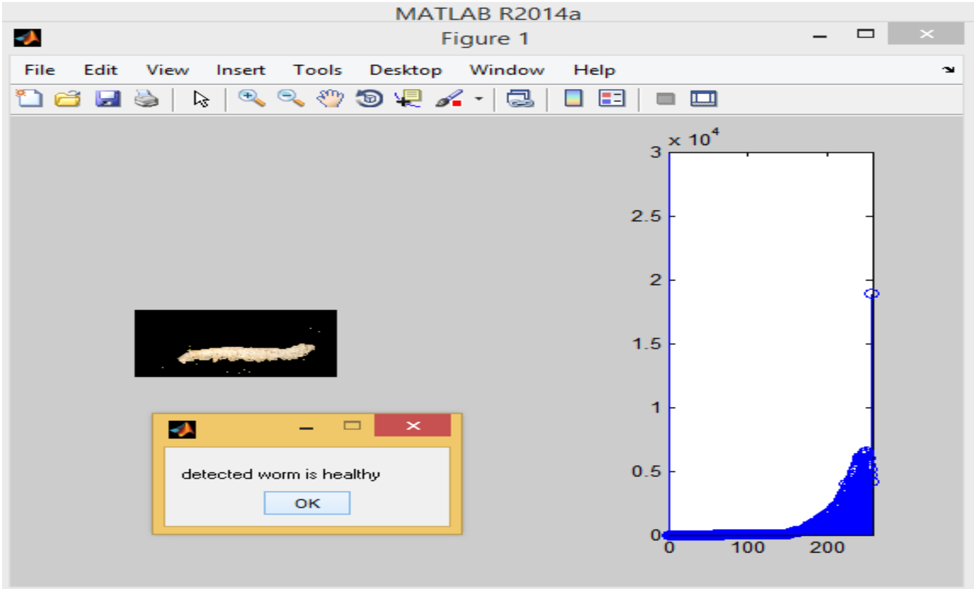

Fig 4.4: Healthy worm is detected

Flacherie diseased worm detection based on histogram thresholding as shown in the Fig 4.5. Here the silkworm image which has been taken from database and will be classified into diseased based on thresholding and further it will be classified to identify the disease. The background elimination technique will be applied to the diseased class silkworm to obtain only the diseased image. The histogram of the silkworm will be taken as shown in above figure which implies that the most number of pixels are nearer to black value. By comparing the average of the histogram with previously set threshold value the image will be identified as flacherie diseased worm images by displaying on a dialog box. The E-mail will be sent to the farmer saying that Flacherie disease is detected.

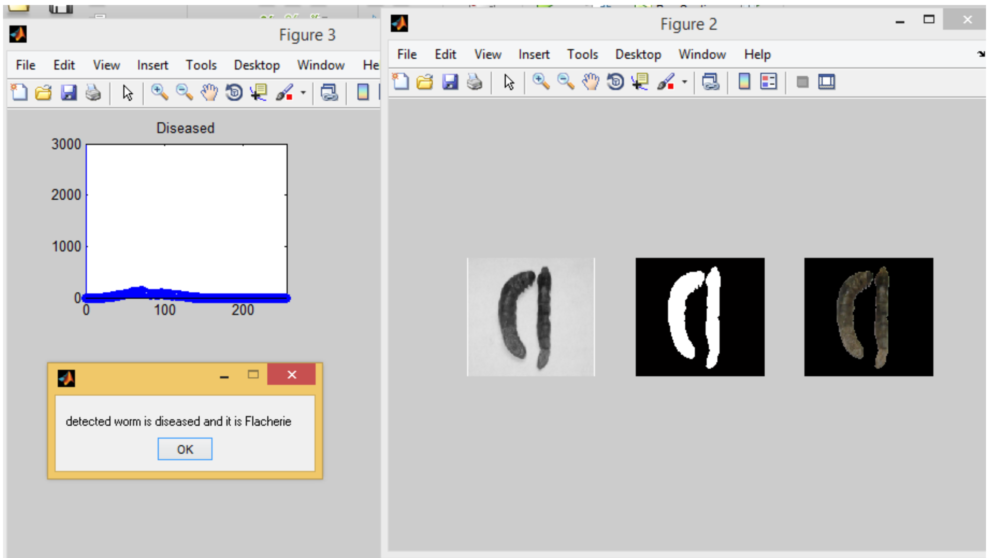

Fig 4.5: Flacherie disease is detected

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Pebrine diseased worm detection result is as shown in the Fig 4.6.Here the silkworm image which has been taken from database and will be classified into diseased based on thresholding and further it will be classified to identify the disease. The black spot will be identified as shown in the figure. If the black spot has been identified on silkworm it will be identified as pebrine diseased silkworm by displaying on a dialog box. The E-mail will be sent to the farmer saying that pebrine disease is detected.

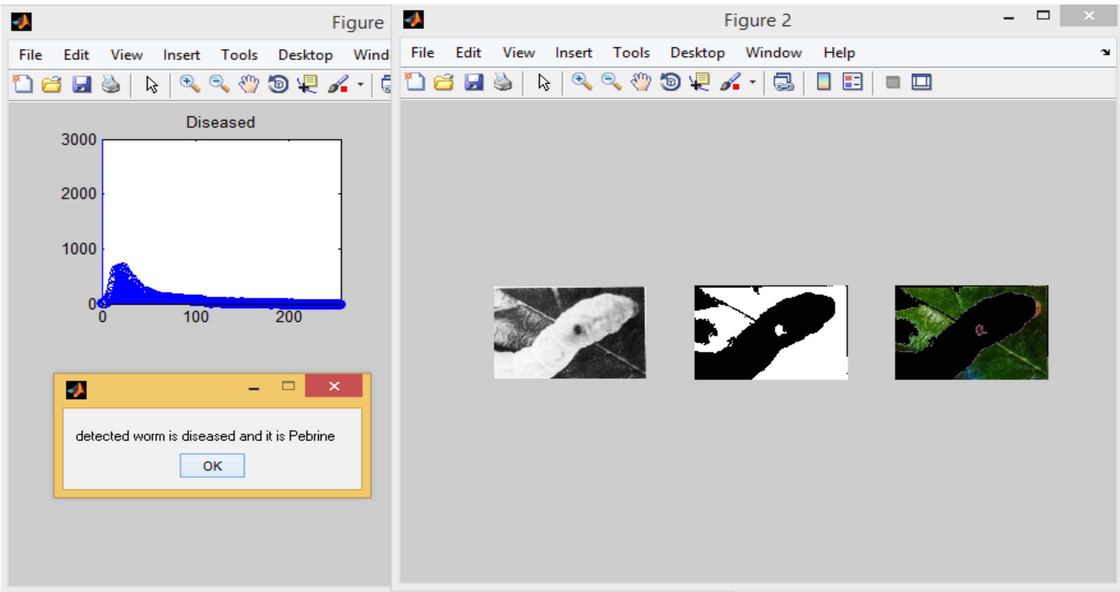

Fig 4.6: Pebrine disease is detected

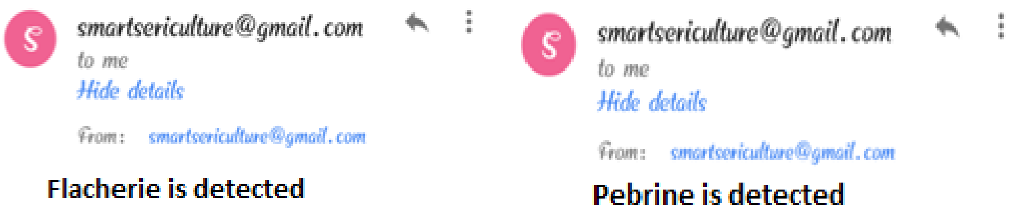

Fig 4.7: Email received by the farmer

The farmer will be notified if any diseased silkworm is detected by in the sericulture bed using the send mail function. Send mail function will be previously specified with the senders and receivers email address and SMTP server. The Emails informing about Flacherie and Pebrine disease detection is as shown in the Fig 4.7.

Conclusion

This paper presents a prototype design of sericulture unit based on IoT and image processing techniques. The prototype will operate in real time for monitoring the parameters and to control the condition inside the deployed environment and has several advantages in term of remote monitoring, automated actuation to suitable condition inside the system. Image processing will classify the worms as healthy and diseased by

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identifying the disease using colour change and texture analysis which involves masking the image using binary mask to obtain the silkworm, applying the colour thresholding for the histogram of the silkworm, classifying them into three classes as healthy, Flacherie infected and Pebrine infected and notifying the sericulturist about the diseased worm detected and also the disease of the silkworm using send mail function of the MATLAB.

Future Scope:

The proposed system can be further enhanced for the real images of silkworm that would be captured by digital camera for processing. The detected silkworm will be separated from other worms by a robotic arm as soon as it is detected. The stages of development of the silkworm that is detected by image processing system and will be sent to IoT for maintaining the climatic conditions accordingly. Hence, making the system dynamic and efficient compared to the proposed solution.

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