International Journal of Research, Science, Technology & Management
ISSN Online: 2455-2240, Volume 20 Issue II, August 2020

OPTIMIZING YIELD OF SILK BY ZONE BASED INTELLIGENT CONTROL SYSTEM

Nayan Rastogi, Krishna Ekapure

ABSTRACT

Analysis of the current sericulture practices shows a clear need of automation. Strict control of optimum values of abiotic factors, like temperature, humidity and so on will contribute towards a significant change in the yield of silk. In view of this hypothesis, an Intelligent Sericulture plant automation system, using zone-based cascade control of physical parameters is proposed in this paper. With ideal parameter values and a data repository of past implementations, the system intelligently implements the desirable changes using Artificial Intelligence techniques. The system comprises of a Data Acquisition Unit, a Computation Unit and an Actuation Unit. The DAU gathers data from respective zones in the rearing unit and channels it to the CU. The CU uses training data to determine the optimum yield curve using gradient descent algorithm. A shortest path from the observed parameter values to the optimum curve is calculated, which is the necessary change. The AU is responsible for triggering suitable actuators to implement this corrective action. This system has an edge over current sericulture practices as it ensures saving of time, optimal resource usage by the virtue of zones, lesser exposure to harmful conditions in the sericulture rearing unit and tighter control without expensive setup.

Index Terms: *Artificial Intelligence, Sericulture, shortest path, gradient descent, Zone-based.*

1. INTRODUCTION

Sericulture is a traditional occupation in India. Despite providing livelihood to a considerable population, the total yield does not meet the expectations. Lack of technological advancement can be identified as the major reason for this. It has been observed that environmental parameters significantly affect the yield of silk. With stringent control of several abiotic factors, namely, temperature, relative humidity, light, air flow and air quality during the lifecycle of a silkworm, improvement in quality and quantity of silk can be assured. It should be noted that every moult i.e. growth stage of a silkworm requires a certain set of values of environmental parameters to achieve an optimum yield. This requirement varies from moult to moult. For e.g. early stages of silkworm require relatively higher temperature as they are highly active and eat vigorously. The role of each of these parameters that affect the yield of silk are described as follows:

A. Temperature:
Temperature is a key player in determining the quantity and quality of the silk produced. It is important that in the course of rearing silkworms, the temperature should not fall below 20˚C or rise above 30˚C.

B. Relative Humidity :
Humidity plays a vital role in silkworm rearing and its role is both direct and indirect. The combined effect of both temperature and humidity largely determines the satisfactory growth of the silkworms and production of good-quality cocoons. The recommended relative humidity is in the range of 70-90%.

C. Air Flow :
Depending upon the environmental conditions air current is required to build quality cocoons. During rainy season more than recommended air current is a must to remove the accumulated humidity in the mounting hall and vice versa during summer and winter. The rearing room should have enough fresh air to avoid accumulation of Carbon-di-oxide etc. Carbon-di-oxide in the rearing room should not exceed 1% and this can be achieved by proper ventilation.

D. Light:
Larvae prefer dim light of l5-30 lux. It is better to avoid keeping the cocooning frames in strong and bright light. Farmers therefore usually cover the trays containing larvae with wax coated sheets to avoid contact with bright light.

The parameter values or ranges required to achieve optimum yield are mentioned as follows:

Table 1: Parameter requirements

PARAMETER	RECOMMENDATION
Temperature	20ºC TO 30ºC
Humidity	70% TO 90%
Light Intensity	15 TO 30 LUX(dim light)
Air Flow	Well ventilated room
Air Quality(Carbon Dioxide)	Not more than 1%

Moreover, the required parameter values vary for each lifecycle stage for a silkworm. By using principal component analysis, temperature and relative humidity are identified as the most dominant factors affecting the yield of silk. The temperature and relative humidity requirement for each stage can be tabulated as:

Table 2: Temperature and humidity Requirements

Life Cycle Stage	Temperature in ºC	Relative Humidity (%)
Incubation Stage	25	75-80
1	28	85-90
2	27	85
3	26	80
4	25	70-75
5	24	65-70

From the above facts, it can be inferred that each stage has different set of requirements of physical parameters. Hence, the concept of 'Zoning' is proposed. The sericulture plant is divided into several zones, partitioned using inexpensive plastic sheet separators to ensure environment regulation. Stages in the lifecycle of silkworm having similar requirements of parameters are grouped together and placed in the same zone.

The Zones can be as follows:

Table 3: Parameters for various zones

Life Cycle Stage	Temperature in ºC	Relative Humidity (%)
Incubation stage + Stage 4	25	75
Stage 1 + Stage 2	27.5	85
Stage 4 + Stage 5	24.5	70

Zoning can be illustrated as shown in the following figure:

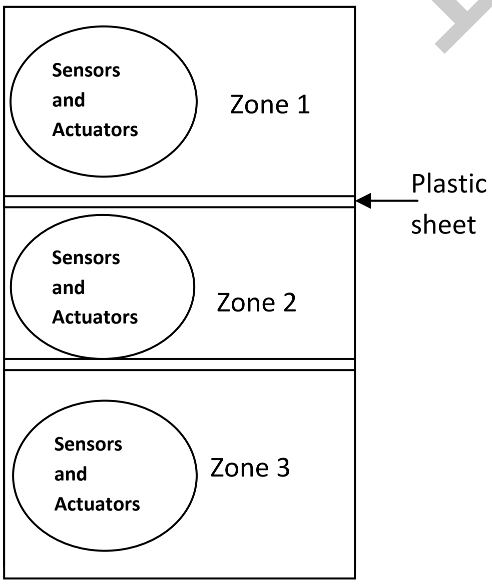


Figure 1: Proposed Zoning

2. SYSTEM ARCHITECTURE

The proposed system, at a larger level, comprises of three units, namely, data acquisition unit, computation unit and actuation unit. Suitable interfaces for communication between each of these units are designed. Further, the architecture of each of these units is described as follows:

2.1 Data Acquisition Unit

The data acquisition unit primarily consists of sensors suited to detect the said parameters. Each zone has its own set of sensors installed. The sensors are serially connected to the master microcontroller like PIC 18F4550. Desired signal processing is carried out at this level. Thus microcontrollers with in-built ADCs and sensors providing calibrated outputs are preferred. The sensors detect the respective parameters at a predefined interval and send the data to the computation unit via the microcontroller in real time. The microcontroller can be serially interfaced with the Computation unit, i.e. computer with MATLAB facility.

2.2 Computation Unit

This is essentially a Matlab setup for selecting a suitable corrective action. The data acquired through sensors is stored in an excel file. This data is extracted from the excel file into Matlab for further processing using multivariate regression algorithm. A data repository is maintained specifying the parameter values for optimum yield.

2.3 Actuation Unit

The corrective action determined using the error calculated in Matlab is fed to a Master controller. The controller directs this action to appropriate slave controllers in respective zones. The slave controllers trigger inexpensive actuators such as bulbs and fans. The master controller also drives a display unit to show the current status. A series of bulbs can be installed out of which only a number of bulbs is used for required temperature change.

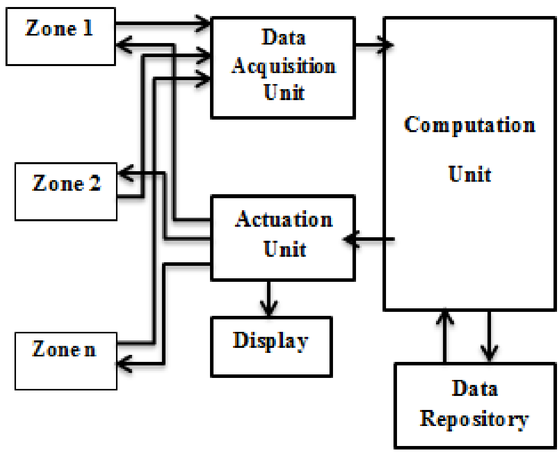
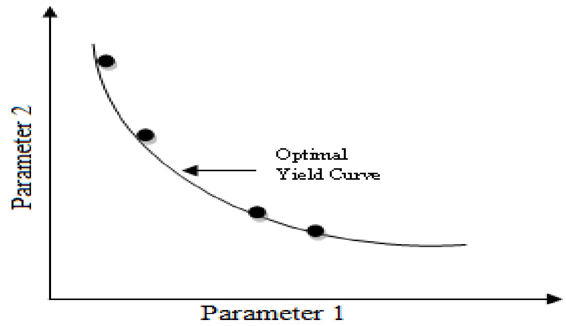


Figure 2: System Block Diagram

3. SYSTEM DESCRIPTION

The data received from various sensors is tabulated in excel files. This data is then imported into Matlab. There exists a data repository mentioning ideal parameter values for optimum yield. Now the received values of parameter of a particular type are compared with the ideal parameter values required for the particular lifecycle stage of the silkworm. Further, a curve of optimum parameter values against the optimum yield is plotted using linear regression algorithm. If the recorded value by the sensor varies from the optimum parameter value, a series of processes are carried out to determine the error which is nothing but the cost function. Firstly, the difference between the actual and observed parameter value is calculated. In case, there is a variation in two or more parameter values, the most dominant factor is identified using principal component analysis. Thus, we can find a shortest path to reach the nearest point on the optimal yield curve by minimizing the cost function using gradient descent.



Step 1: Plotting an optimal curve through the training data.

Hypothesis function for optimum yield is given as:

$h_\theta(x) = \theta_0 x_0 + \theta_1 x_1 + \theta_2 x_2 + \theta_3 x_3 + \theta_4 x_4$

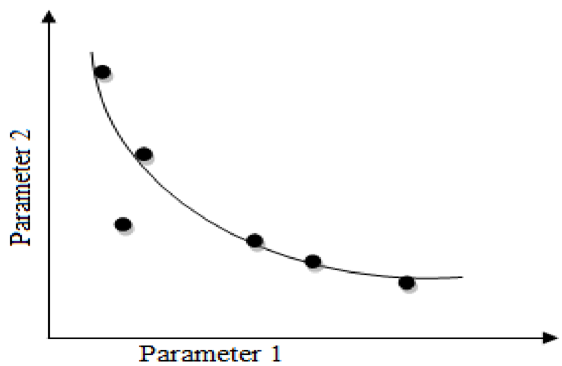
Here x_0, x_1... are the environmental parameters and θ_0,$\theta_1$are the constants to be calculated.

Using this Hypothesis function, the cost function is determined as:

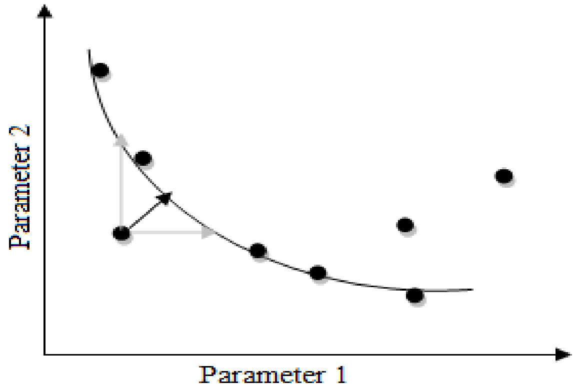
$$J(\theta) = \frac{1}{2m} * \sum_{i=1}^{m} (h\theta(x^i) - y^i)2$$

$$\theta j = \theta j - \alpha * \frac{1}{m} \sum_{i=1}^{m} \left(h\theta(x(i) - y(i)) * xj(i) \right)$$

Here, J is the cost, m is the number of training samples and $y^i$is the yield calculated by substituting instantaneous parameter values. The change in theta values suggested by the gradient descent algorithm after a predetermined number of iterations is estimated and optimum curve is plotted.



Step 2: Plotting of real-time recorded parameter values.



Step 3: Calculation of Shortest Path

The highlighted path is the shortest path. The shortest path to curve is straight line joining the coordinates of observed values to the nearest point on optimum curve. This action is instructed to the actuation unit. This data is fed as training data back to the system to make the system more learned. This implies that, if such a situation were to occur in the future, it would get automatically stored in the repository, increasing the efficiency of the system as a whole.

This control signal is signaled to the actuation unit using serial communication. On receiving the input from the computation unit, the actuation unit is responsible for the implementation of the corrective action. The master controller is responsible for directing the action towards the slave controllers located in different zones. Only those slaves are triggered where there is a need for rectification in the parameter values. Each slave is further connected to actuators such as fans, bulbs, water sprinklers, etc. For example, if there is a drop in the temperature as compared to the optimum temperature value, bulbs are turned on. The bulbs dissipate heat which contributes in raising the temperature of the zone. Being a closed loop system, these changes in temperature values are constantly recorded by the sensors. The actuators remain on until the parameters do not reach their optimum values. Once the optimum values are achieved, the actuators are turned off.

The system also consists of a display unit. It can be a simple LCD. It shows the current status of the system and also gives appropriate notifications to the sericulturist.

4. ADVANTAGES

The proposed system provides a cost effective solution involving the use of cheap and readily available actuators. These actuators are turned on only when needed. This contributes in a big way in achieving power efficiency. The power efficiency increases furthermore by virtue of creation of zones. This automatic system provides real time surveillance and control. This system reduces the sericulturists' prolonged exposure to the rearing unit, thereby reducing the possibility of developing lung cancer.

5. CONCLUSIONS AND FUTURE SCOPE

The intended system incorporates Artificial Intelligence (machine learning) techniques in optimizing the yield of silk. The system being power and cost efficient is well suited for installation in Sericulture plants. The actuators being fans and bulbs, are cheap solutions both during installation and use. Moreover, the flexibility of this system can be enhanced if the user is allowed to feed the parameter values as set-points in any environment for monitoring any parameter.

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to Dr. Bhooshan Kelkar and Mrs. Mrudul Dixit for their valuable suggestions. A special thanks to BAIF, Urulikanchan, and Sericulture unit.

REFERENCES

[1]. "Sericulture Development in Non-traditional Areas", proceedings of National workshop, Pune, 2012, BAIF.

[2]. "Management of Climatic Factors for Successful Silkworm (Bombyx mori L.) Crop and Higher Silk Production" V.K Rahmathullah, Psyche, vol (2012), article id 121234

[3]. "Studies on the influence of temperature and humidity on biological traits of silkworm" M. Hussain, African Journal of Biotechnology vol 10(57)

[4]. "Correlation and regression Analysis to study the variables affecting the technological gap in Sericulture production" - Dakhani, Sanase, Hake.

[5]. www.coursera.edu/ml-005

[6]. www.mathworks.in

[7]. Central Silk Research Institute (CSRTI), Mysore. http://silk.csrtimys.res.in/technologies