KARNATAKA STATE COUNCIL FOR SCIENCE AND TECHNOLOGY

Student Project Programme - 46th Series

PROJECT SYNOPSIS

1. **Project Proposal Reference No**: 46S_BE_0858

2. **Project Title**: An AI Driven End-to-End Sericulture Management System

3. **Name of the College**: Ramaiah Institute of Technology, Bangalore

4. **Department**: Electronics and Communication Engineering.

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7. **Keywords:** silkworm disease identification, machine and deep learning, sensor network, actuation system, cloud database

8. **Introduction**

- Sericulture is an agrarian activity that contributes significantly to the GDP of the country. But this industry faces serious consequences in the rearing and cultivation of silkworms that is a major reason for economic losses to farmers.
- Current methods adopted for cultivation and rearing of silkworms require manual supervision and intervention that is not feasible in the long run.
- Due to inefficiency in manual methods and other environmental factors, silkworms are prone to numerous diseases that are left unattended and cause a huge loss to farmers.
- The methods adopted currently for disease identification and classification in silkworms are laboratory intensive biological processes that are time

consuming and require technical expertise which is highly unfeasible in a rural setup.

- These traditional methods do not have provisions to predict the diseases in silkworms before they could occur or at an early stage.
- There are no methods available to continuously monitor the silkworm rearing chambers and alert the farmers of any unfavourable environmental conditions.
- There is no evidence of adoption of intelligent systems that can autonomously take corrective actions if the environmental conditions in the rearing chambers cross a particular threshold.
- There are also no methods to automatically identify the diseased silkworms, apply the required disinfectants and sort them out from the healthy worms in order to curb the spread of the diseases.

9. **Objectives**

- To alleviate the problems faced by sericulture farmers and help reduce their economic losses with the aid of state-of-the-art AI enabled technologies.
- Extensively evaluate machine learning and deep learning algorithms based on several metrics and select the most robust model for disease identification in silkworms.
- Implement the above AI models on Raspberry Pi processor with camera and sensor integration for real-time disease identification and monitoring of environmental conditions in silkworm rearing chambers.
- Provide real-time data to farmers remotely enabled by a cloud powered database that is accessible through a user-friendly app called SeriMitra.
- Build a stand-alone autonomous actuation system that can take intelligent corrective actions based on the data obtained from the sensor network and hence ensure that optimum silkworm rearing conditions are always maintained. This system also helps in automatic segregation of diseased and healthy silkworms to prevent the spread of the disease.
- To reduce manual intervention in the silkworm rearing houses and hence help farmers increase productivity in cultivation of silkworms.

10. **Methodology**

a. **Real Time Disease Identification**

- *Dataset:* Consists of 3000 silkworm images, divided into healthy and diseased classes.

- *Data Pre-processing*: Images are resized, cropped, and annotated as per the requirements of the algorithms. Data is further split into train (70%) and test (30%) sets.
- *Evaluation Metrics*: Accuracy, Precision, Recall, F1 score, Intersection over Union (IoU) score and frames per second (fps) are calculated to select the most robust model. A trade-off between accuracy and inference speed is considered to ensure hardware compatibility of the model.
- *Implementation:* Model is deployed on Raspberry Pi core, connected to a camera for real time capturing of images and videos of the rearing chambers and hence enabling real time disease identification in silkworms.

b. Sensor and Actuation System

- Temperature and humidity sensors along with actuation elements such as fan, motor, and pump work in synchronization to achieve the desired actions.
- The actuation system integrates a disinfectant system, responds autonomously based on sensor data, takes corrective actions if the environmental conditions such as temperature and humidity cross the threshold and hence ensures that optimum conditions are maintained throughout. The system also autonomously separates out healthy and diseased silkworms.

c. **Real Time Data Storage and SeriMitra App**

- The data from the sensor network and the camera is remotely stored on Firebase which is a cloud powered database and this is available to the farmers via the developed app called SeriMitra which also alerts them of any anomalies in the silkworm rearing chambers.

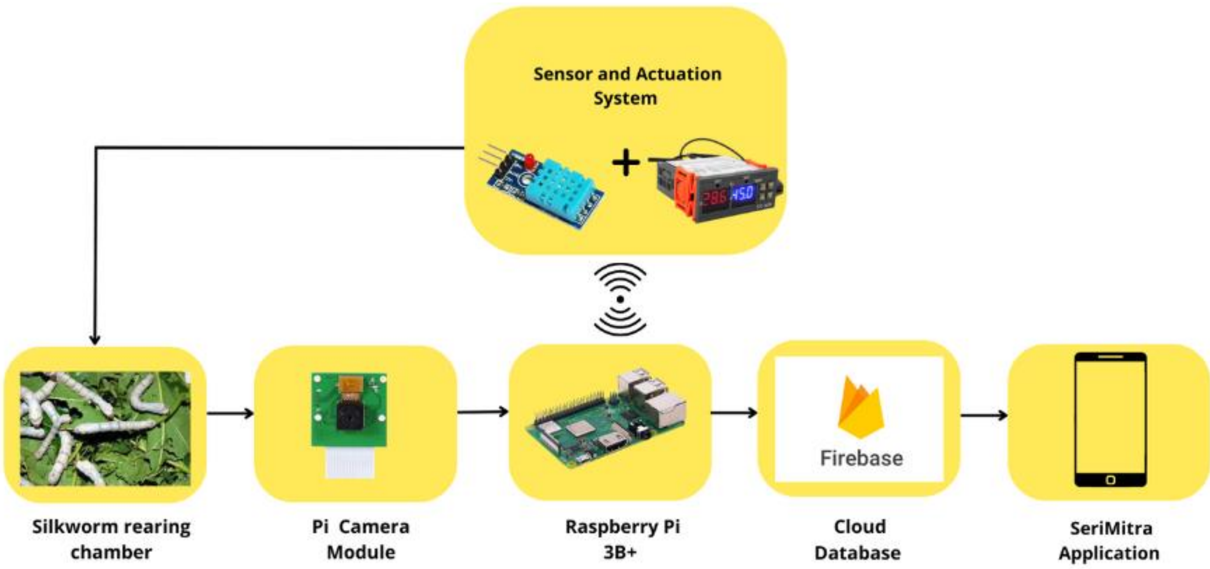

Fig 1: Overall Methodology Adopted

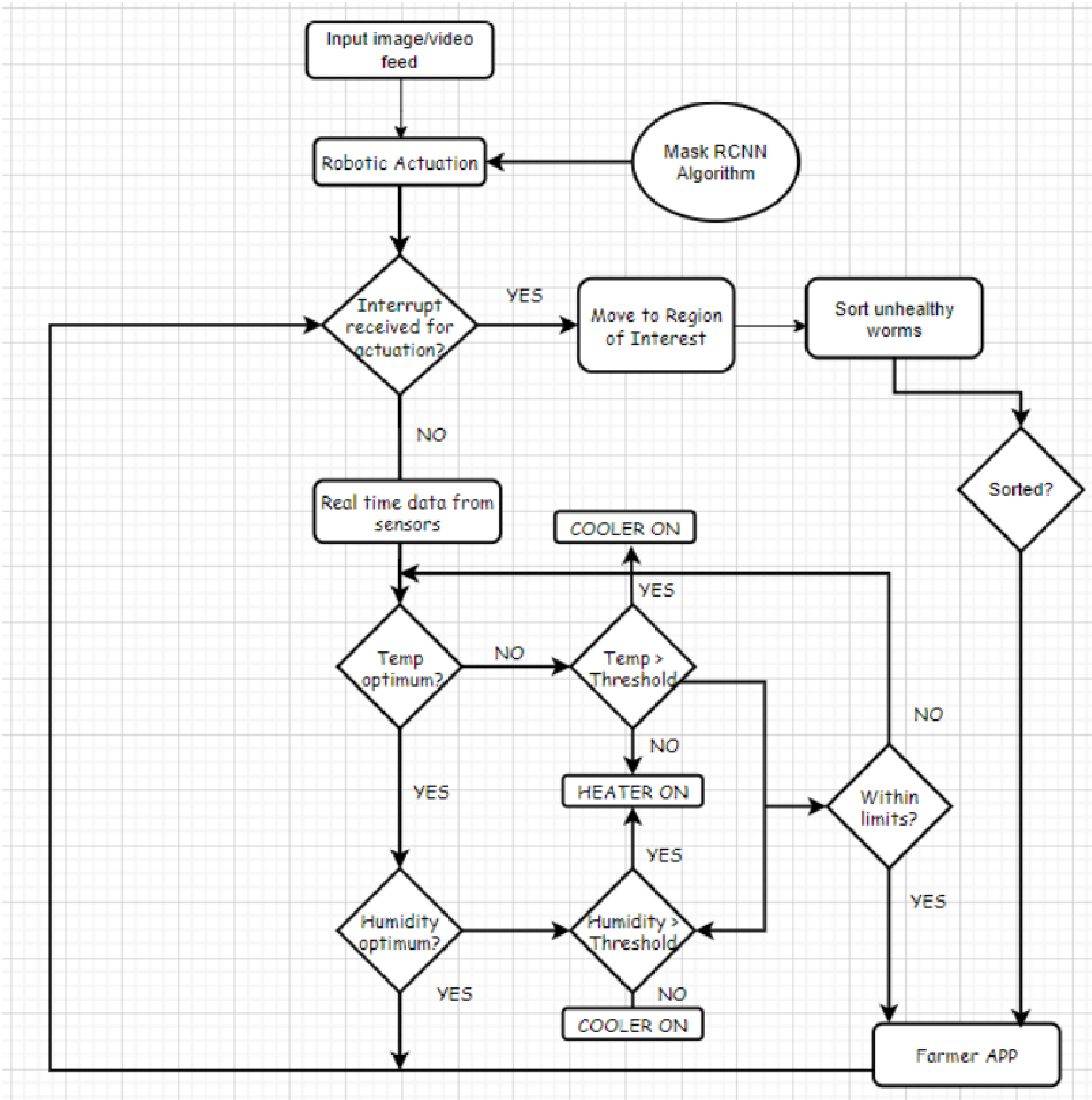

Fig 2: Sensor and Actuation System Flowchart

11. Results

a. Machine Learning Results: Various binary classifiers such as Random Forest, Decision Tree, Support Vector Machine, k Nearest Neighbours, Gradient Boost and AdaBoost classifiers were compared and evaluated on several metrics such as accuracy, precision, recall and F1 score. The analysis and results are depicted in Table 1 to Table 4.

Table 1: Comparison of Machine Learning algorithms

Algorithm	Accuracy
Random Forest Classifier	83.9506%
Decision Tree Classifier	75.3086%
Support Vector Machine Classifier	77.7777%
K Nearest Neighbors	74.0740%
Gradient Boost Classifier	79.6296%
AdaBoost Classifier	75.3086%

Table 2: Precision Comparison

Name of the algorithm	**Precision**
Random Forest Classifier	0.843
Decision Tree Classifier	0.811
Support Vector Machine Classifier	0.810
K Nearest Neighbors	0.907
Gradient Boost Classifier	0.81
AdaBoost Classifier	0.7956

Table 3: Recall Comparison

Name of the algorithm	**Recall**
Random Forest Classifier	0.905
Decision Tree Classifier	0.863
Support Vector Machine Classifier	0.810
K Nearest Neighbors	0.621
Gradient Boost Classifier	0.8526
AdaBoost Classifier	0.7789

Table 4: F1 Score Comparison

Name of the algorithm	**F1 Score**
Random Forest Classifier	0.873
Decision Tree Classifier	0.836
Support Vector Machine Classifier	0.810
K Nearest Neighbors	0.7375
Gradient Boost Classifier	0.830
Ada Boost Classifier	0.787

From the above tables it can be inferred that, Random Forest classifier outperforms the other machine learning algorithms in terms of accuracy, precision, recall and F1 score. Hence, it proves to be the best machine learning algorithm for classifying healthy and diseased silkworms. Figure 3 depicts the confusion matrix of the Random Forest classifier that summarizes its performance and indicates the number of true positives, true negatives, false positives, and false negatives.

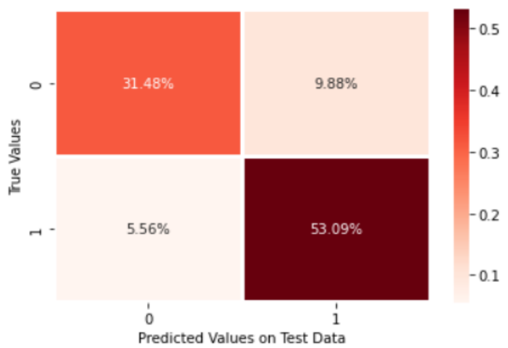

Fig. 3: Confusion matrix of Random Forest Classifier

Fig. 4: Performance of Random Forest Classifier with input as healthy class and detection window

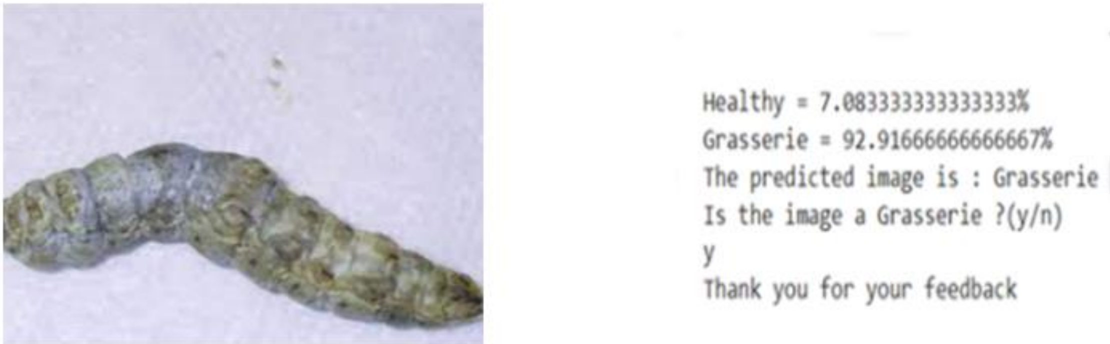

Fig. 5: Performance of Random Forest Classifier with input as diseased class and detection window

Figure 4 and Figure 5 depict the inference obtained with the Random Forest classifier in the cases where the input to the algorithm belongs to the healthy class and the diseased class respectively.

b. **Deep Learning Results**: In cases where healthy and diseased worms were found with a particular region of interest in the same image, machine learning algorithms failed to localize the diseased worms effectively. In such cases, deep learning-based object detection algorithms were found to outperform other algorithms in terms of effective localization of healthy and diseased worms. The performance of three object detection algorithms (YOLOv3, YOLOv4 and EfficientDet) are shown in Figure 6.

(a) **(b)** **(c)**

Fig. 6: Inference of deep learning algorithms (a) YOLOv3 (b) YOLOv4 (c) EfficientDet

c. **Instance Segmentation Results:** To effectively localize healthy and diseased silkworms in cases when they are overlapping, instance segmentation algorithms are adopted. The performance of two segmentation algorithms is compared and the results are tabulated in Table 5 where YOLOv8 is found to show the most robust performance. The localization capability of YOLOv8-based segmentation algorithm is shown in Figure 7.

Fig. 7: Instance segmentation algorithm results

Table 5: Comparison of Instance Segmentation Algorithms

Parameter	YOLOv5	YOLOv8
Precision (Box)	0.923	0.949
Recall (Box)	0.840	0.853
mAP Score (Box)	0.897	0.994
Precision (Mask)	0.911	0.949
Recall (Mask)	0.840	0.853
mAP Score (Mask)	0.899	0.994
fps (CPU)	23	30
fps (GPU)	56	98

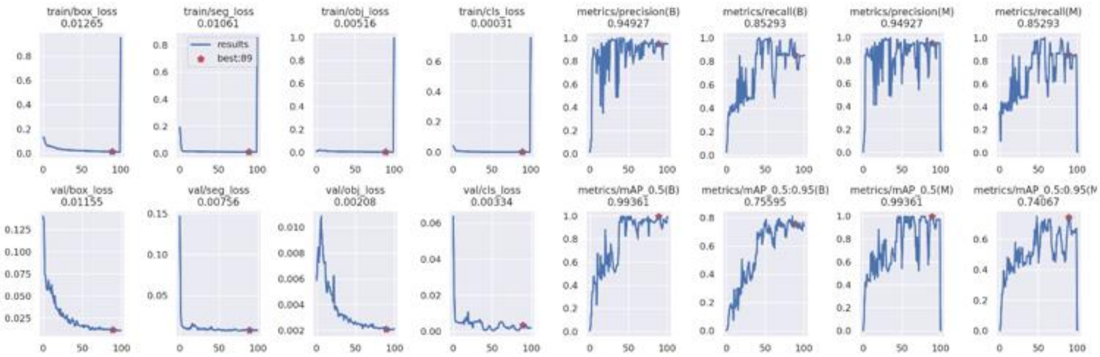

Fig. 8: Performance analysis of YOLO8 segmentation algorithm

The performance metrics of YOLOv8 algorithm is depicted in Figure 8. It also depicts the variation of training loss, validation loss and mean average precision (mAP) values over 100 epochs.

d. **Cloud Database and SeriMitra App:** The data from the sensor network and the camera is stored in a cloud database powered by FireBase. This data is remotely accessible in real time via the user interface developed as a part of this project which is called SeriMitra. Figure 9 and Figure 10 denote the remote data storage on FireBase and the SeriMitra app respectively.

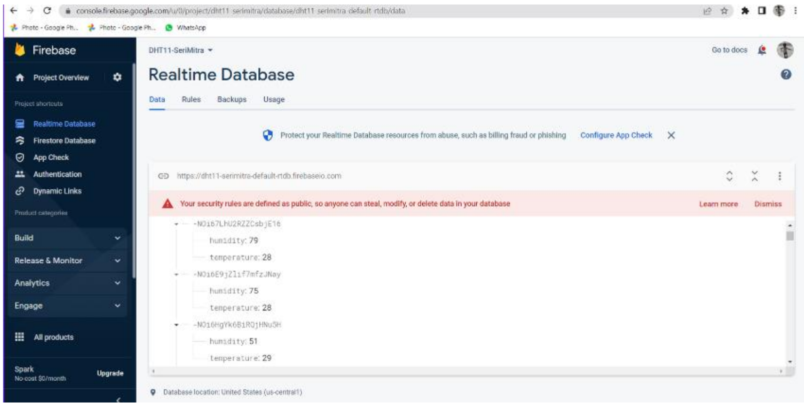

Fig. 9: Remote data storage using FireBase

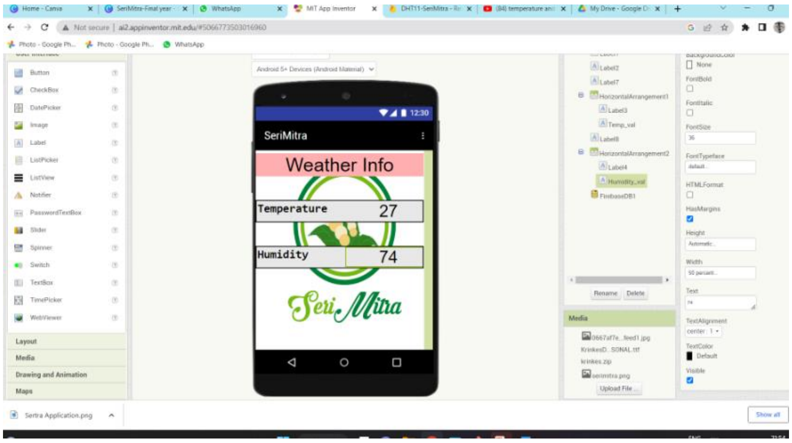

Fig. 10: SeriMitra app

e. **Sensor and Actuation System:** The sensor and actuation system is depicted in Figure 11 that is built to monitor real time environmental conditions like temperature and humidity, has a coupled disinfectant system for spraying pesticides on a timely basis and also separates out healthy and diseased worms.

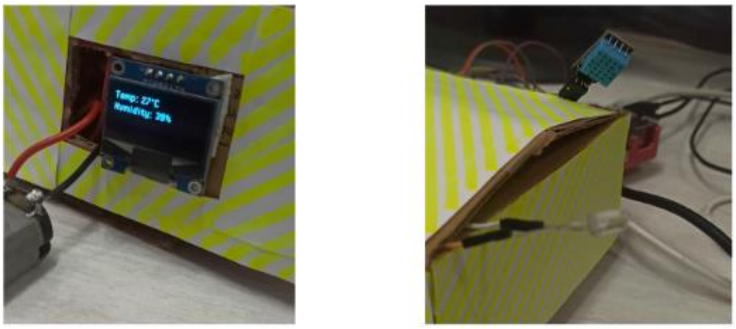

Fig. 11: Sensor and actuation system

12. **Innovation**

- The project provides an end-to-end solution for real time identification of diseases in silkworms and remote monitoring of the silkworm rearing chambers along with provisions to send real time updates to the farmers via the developed user interface called SeriMitra.
- The project is first of its kind since the stand-alone device achieves a variety of tasks efficiently while being cost effective, user friendly and reliable.
- The project aims to bridge the gap between the traditional methods adopted in the silkworm rearing houses with state-of-the-art technological interventions.
- Currently, the methods adopted for disease identification is invasive and laboratory intensive which is not feasible for farmers to adopt. Through this project, the aim is to build deep learning algorithms for robust disease identification in silkworms which is currently not prevalent.
- Currently there are no provisions to monitor the environmental conditions in real time, take corrective actions to adjust the parameters that are suitable for rearing of silkworms, separate out healthy and diseased worms and at the same time provide real time updates to the farmers remotely. Through the project work, a solution has been proposed for these problems and hence the project is innovative and novel.

13. **Conclusion and Future Work**

- The proposed product is first of its kind that provides an end-to-end solution to the Sericulture farmers. The product consists of an inbuilt vision system, sensor, and an actuation system to monitor the health of the silkworms as well as the environmental conditions and take autonomous actions in case of unfavourable conditions.
- The developed autonomous system is a boon to the Sericulture sector and is designed to improve the productivity and efficiency in cultivation of silkworms.
- The developed methodology can also be extended to other areas of Agriculture thus helping in an overall profitable yield.
- The prime stakeholders of our product are the farmers themselves, hence an optimal cost model has been developed making it affordable to the rural people.
- The proposed stand-alone system is environment friendly, does not involve the emission of harmful gases and does not use harmful plastics that contaminate the environment.

- The product can be commercialized and can be deployed in rural areas that practice Sericulture.

OUTCOMES OF THE PROJECT

RESEARCH PUBLICATIONS

1. C G Raghavendra and Dharini Raghavan, "Grasserie Disease Identification in Bombyx Mori Silkworm using Ensemble Learning Approach," International Journal of Electronics Signals and Systems, Vol. 4, Iss. 3, Article 6, pp. 1-7, 2022.
2. Ajey Kalagi, Dharini Raghavan, C. G. Raghavendra, Supreet Bajannavar and V. S. Bhavani, "Sericulture Technology Towards Sustainable Management, " 2022 IEEE International Conference on Distributed Computing and Electrical Circuits and Electronics (ICDCECE), pp. 1-5, 2022.
3. Dharini Raghavan, C. G. Raghavendra, "Methods for Effective Disease Recognition in Silkworms - A survey", International Conference on Multidisciplinary Research and Innovative Practices. (ICMRIP-2021), pp. 142-145, 2021.

PATENT FILED

Title of the invention: “A System and a Method for Autonomous Sorting of Healthy and Diseased Silkworms"

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