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Intelligent detection and classification of insects in agricultural farm

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Abstract : The agricultural sector has a huge capacity to address food needs and provides wholesome, nutritious food. Insects damage a significant portion of the crops and degrade their quality, making finding agricultural insects challenging for farmers.The primary cause of crop quality decline are insects. And decrease harvest efficiency. It's critical to keep track of insects and assess useful and harmful insects. Early detection of insect attacks in agriculture is essential. Which will help farmers plan pest control and action against harmful insects. A computer vision and image analysis-based system can detect and classify crop insects more accurately and quickly at an early stage, assisting farmers to increase the yield of crop. This paper proposes a Yolov5 model architecture that detects and categorizes insects on crops. The objective is to solve the problem of identifying and classifying insects present in agricultural crops. To extract more properties of insects, we use multiscale training with a fully convolutional network.

Keywords: **Insect classification, insect detection, Yolov5, image processing,Machine learning**

INTRODUCTION

In the current situation, agricultural land has been decreasing as it is turned into residential areas due to the, rapid population increase. However,on the other hand, the population is increasing at a similar rate. In addition to this climate change also affects crops in the fields. In any farm the biggest problem for farmers are insects which damage the crops completely and which leads to the loss of crops. These insects come in various varieties, and certain plants are affected by insect attacks. The type of pest depends on the weather and its impact. Due to this, farmers cannot use one kind of pesticide for all crops, and if they use the wrong pesticide for some crops, it won't give effective results and will lead to economical loss and crop yield. Another issue is bugs are responsible for crop quality degrade and reduce yield efficiency. As a result, it's critical to examine and evaluate insect harm to identify agriculture attacks as soon as possible.

The soil quality is determined, and the reason for soil degradation is found. A sample of soil is collected, dried, and further chemical testing is performed. From the outlier soil detection method toxicity of soil, quality content, moisture, dead creatures in soil are calculated and detected [1].

According to our study, the type and duration of fertilization treatment significantly impacts crop yield. When the quantity of long stretches of preparation expanded after the nine preparation medicines, the crop yield initially diminished. According to our study, harvest yield and C: N: P stoichiometric proportion in soil were greatly affected by the span of nine treatment medicines for millet in parched and semi-dry regions [2].
In addition to their widespread availability, N composts have a remarkable capacity to increase yields compared to other natural manures, making it one of the most commonly used practices to increase crop yields. This was determined using remote detection (RS) systems. For crop development, water is crucial. However, water in paddy and water-logged fields stands out as a breeding site for insects, making it easier for them to lay eggs in fields and increasing the number of hazardous insects. In the paddy field, the number of insects, their species, and the damage they do is recorded. Additionally, it's crucial to understand and monitor water quality, as well as the temperature of water and the quantity of water to be given to particular crops is imperative [3].

Weather conditions are also important factors in leaf health. Leave object is detected based on crop leave. If the moisture is more than usual, the leaf will swell; if the humidity is less, it will drain. Based on humidity content, rice crop images predict leaf attacks[4].

We know that when a field is attacked by insects, the farmer realizes it too late, but the damage has already taken place. Due to that, less goods reach the market and it affects the economic situation. In this situation, we will implement a project to alert the farmer in advance so that appropriate actions can be taken and measurements can be taken. Insects not only harm the crop field products but also cause harm to the seeds when not stored in proper conditions and cautions. Necessary and regular measures are difficult for large farm holders. Visiting the large farms physically on daily basis is not feasible and economical. It is in such circumstances that the proposed model can be used by farmers to keep regular check on the insect insertion in their fields. When more insect count is detected the alert message gives an alarm to the farmer for taking appropriate actions immediately. The process is automated to increase accuracy, reduce costs, and help farmers respond quickly to sensor responses. Installed in the farms. Crop quality and yield can be increased by early insect detection. As a result, they can gain more profit from the market after harvesting and selling. As well care is required to be take while storing the crops and while transporting them.

The paper then goes on to present a literature review on methods that can be used to detect attacks based on parameters like soil, leaves, fertilizer, and weather conditions along with their limitations and potential uses. Then a proposed methodology depicts the module's working process flow. The paper concludes with the conclusion.

LITERATURE SURVEY

Yang, Wentao, et al. [5] The proposed hybrid approach can be used to estimate unknown soil pollution concentrations. It comprises three main steps: spatial outlier detection, spatial regression and interpolation for normal datasets, and prediction with a combination of the two methods. This paper has been verified by an environmental dataset from Huizhou in China which recorded heavy metal Cd and as concentrations. Results showed that this method had a lower mean square error (MSE) than other models tested as comparison - 0.028 for Cd concentration predictions; 3.834 for As concentration predictions – indicating its feasibility and effectiveness when applied practically to similar data sets with outliers present. The experiments in this paper were conducted using an environmental dataset from Huizhou, China which recorded heavy metal Cd and As concentrations. This data was used to verify the performance of the proposed hybrid approach for estimating unknown soil pollution concentrations.

Liu, Qiang, Hongwei Xu, and Haijie Yi [2] suggest the effectiveness of long-term fertilization in enhancing crop output, soil fertility, and C: N: P stoichimetry. It also indicates that in dry or semi-arid environments, a single application of an organic fertilizer or a blend of organic and nitrogen fertilizers may alleviate nitrogen limitations. The findings of this study may be useful for farmers who want to increase yields while maintaining sustainable agricultural practices. This paper shows that regular fertilization can increase soil fertility, crop productivity, and the C: N: P stoichimetry. Furthermore, applying organic fertilizer only once or combining it with nitrogen fertilizers could reduce nitrogen limitation in arid/semi-arid areas.

Sethy, P. Kumar, et al [3] To count insects in a farm field and detect them with a camera and image-processing software, a prototype for a fully autonomous device was constructed. The system the authors used involves identifying regions of interest and representing them as SIFT descriptors. It also involves construction of code books which map the descriptors into a fixed length vector in histograms using SVM. The authors took 20 classes of paddy field insect pests from Google Images and classified them. According to the author, the HOG descriptor and SURF features together produce 90% classification accuracy. SVM and the Bag of Words technique were utilized in the detection and classification system to identify and categorize the pests in the collected image. The proposed prototype can identify and detect five different pests.

To identify plant disease infections, Dr. Srikanthan C, Dr. M. Senthil Kumar [4] implemented K-means clustering and GLCM (grey level cooccurrence matrix). It includes Image Acquisition, where leaves were photographed. The next step was picture pre-processing, which enhances image quality by removing unwanted distortions. This K-mean segmentation methodology, which divides and clusters the image using a hue estimation method, does image segmentation by dividing the image into sub-images.

Barbedo, Jayme Garcia Arnal [6] provides an overview of the research done on Machine learning and nearby digital photos are applied for automatic pest detection. Automatic pest detection based on digital images and machine learning. It also identifies gaps in current knowledge, which can be used to guide future research efforts towards more effective solutions for remote monitoring of potential infestations. The findings from this article could help farmers develop better strategies for managing pests on their farms. This is done by providing them with a comprehensive understanding of existing technologies and techniques available to detect pests remotely.

The experiments in this paper use proximal digital images and machine learning techniques to detect pests. These data sources are used to train algorithms, which can then be applied to existing datasets for accurate detection of potential infestations. This paper shows that combining proximal digital images with machine learning techniques can be an effective way to remotely monitor potential infestations. It also provides a unified overview of the research carried out so far. As well as pointing out gaps in current knowledge, it suggests possible topics for future research. Table 1 indicates the different methods of image processing for classification and detection of insects.

Table1**.** Shows the comparison of different papers

sr.no	Title	Results and Discussion	Limitations
1	(2017) Image Processing Techniques for Insect Shape Detection in Field Crops [7]	Insect image against backdrop segmented using ANN in MATLAB techniques.	Detection and classification of type of crop insects in a shortest period.
2	(2020) Detection and Identification of Stored-Grain Insects Using Deep Learning: A More Effective Neural Network [8]	RPN, CNN Find the insects and the grain (particles). Make distinctions based on characteristics including body size, number of legs and feet, and wing size and shape.	Inefficient for very small size insects. to segregate based on some cases such as features like count of feet(legs) and antenna
3	(2021) Insect Detection and Counting Based on YOLOv3 Model [9]	The YOLOv3 model-based target detection network allows for the detection of numerous targets.	The average accuracy of the model can reach 91%, but there are still many short comings in this paper
4	(2020) Insect classification and detection in field crops using modern machine learning techniques [10]	Compare NB, SVM, ANN, CNN, and KNN. The CNN model produced the greatest classification rates of 91.5% and 90% for the nine and 24 class of insects, respectively.	Proposed CNN required more computation time for classification.
5	(2020) Detecting and Classifying Pests in Crops Using Proximal Images and Machine Learning [6]	Automatic insect recognition and counting utilizing nearby digital photos and machine learning is accomplished using ANN, SVM, and K-means clustering algorithms.	Not predicted whether it is a harmful insect attack or a beneficial insect attack
6	(2021) Prediction of insects-herbivory- damage and insect-type attack in maize plants using hyperspectral data [11]	It is analysed and divided into two classes: undamaged plants and herbivory damaged plants using KNN, SVM, NB, and DNN.	It adopts the proposal presented only on maize plants not herein for other types of cultivars and cultures.
7	(2020) Plant Disease Detection using Image Processing [4]	A program developed to distinguish between healthy and disease-affected plants using k-means, CNN GSLM.	By increase the number of images present in the predefined database it takes more time and gets low accuracy when dataset is larger.
8	(2019) Predictive Soil Pollution Mapping: A Hybrid Approach for a Dataset with Outliers [5]	Analyzing the soil contamination outliers with spatial regression and the FTSOD algorithm.	To estimate the unknown values at the normal area, and the grid size was not considered, which may lead to not very high precision of the results.
9	Pest Detection for Rice Using Artificial Intelligence [12]	Using ANN, FCM, and MATLAB algorithms, it forecasts disease attacks on plants based on the parameter of humidity.	It gives only the disease on the leaf. It does not get actual attack on it.
10	Early Detection of Aphid Infestation and Insect-Plant Interaction Assessment in Wheat Using a Low-Cost Electronic Nose (E-Nose), Near- Infrared Spectroscopy and Machine Learning Modeling [13]	Use of UAV technology makes insect detection simple. Low cost and simple to use.	Changes results due to abiotic factors like heat waves, Frosts, smoke etc. Unable to work effectively when changes in abiotic factors and changing natural conditions

METHODOLOGY

This paper proposes a Yolov5 model architecture that detects and categorizes insects in crops. To extract more insect properties from this network, we employ a fully convolutional network and a multiscale training technique.

To diagnose insect attacks, the proposed model is used. A farmer can use the model to classify and predict insect attack. Pest classification is based on color, shape, and size. The knowledge representation stage is carried out once the characteristics have been gathered.
Following fig.1 shows the system architecture

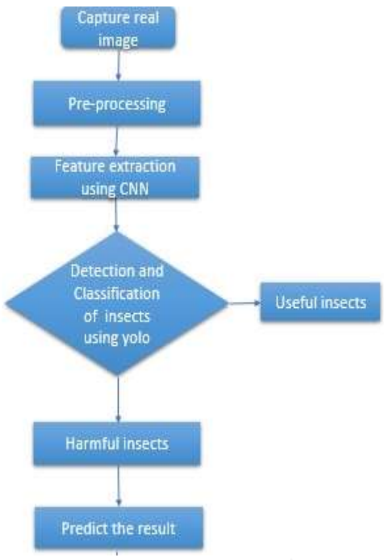


Fig.1 Work Flowchart

In the first stage, as illustrated in Figure 1, historical data on insect and pest attacks in the region is collected to determine whether they are beneficial or harmful. Historical data must be accurate to achieve accuracy. Next, current weather conditions are obtained, and the past week's weather data is analyzed to assess the vulnerability of the current situation to pest attacks. To make accurate predictions, different machine learning algorithms such as Yolov5 can be employed. It is necessary to train all historical data using machine learning algorithms. Once the algorithm is trained, it can accurately predict potential insect or pest attacks.

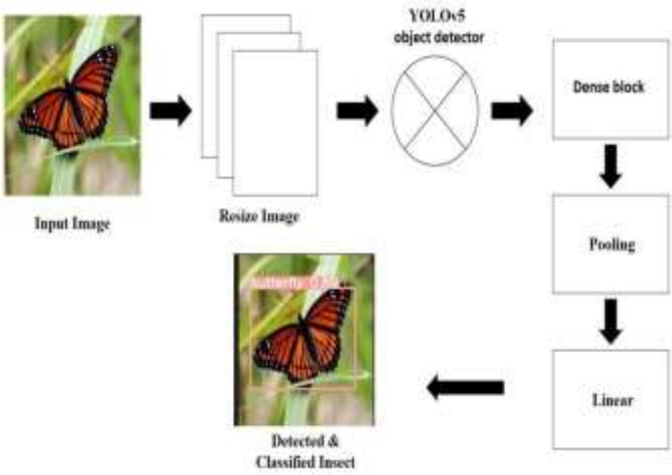


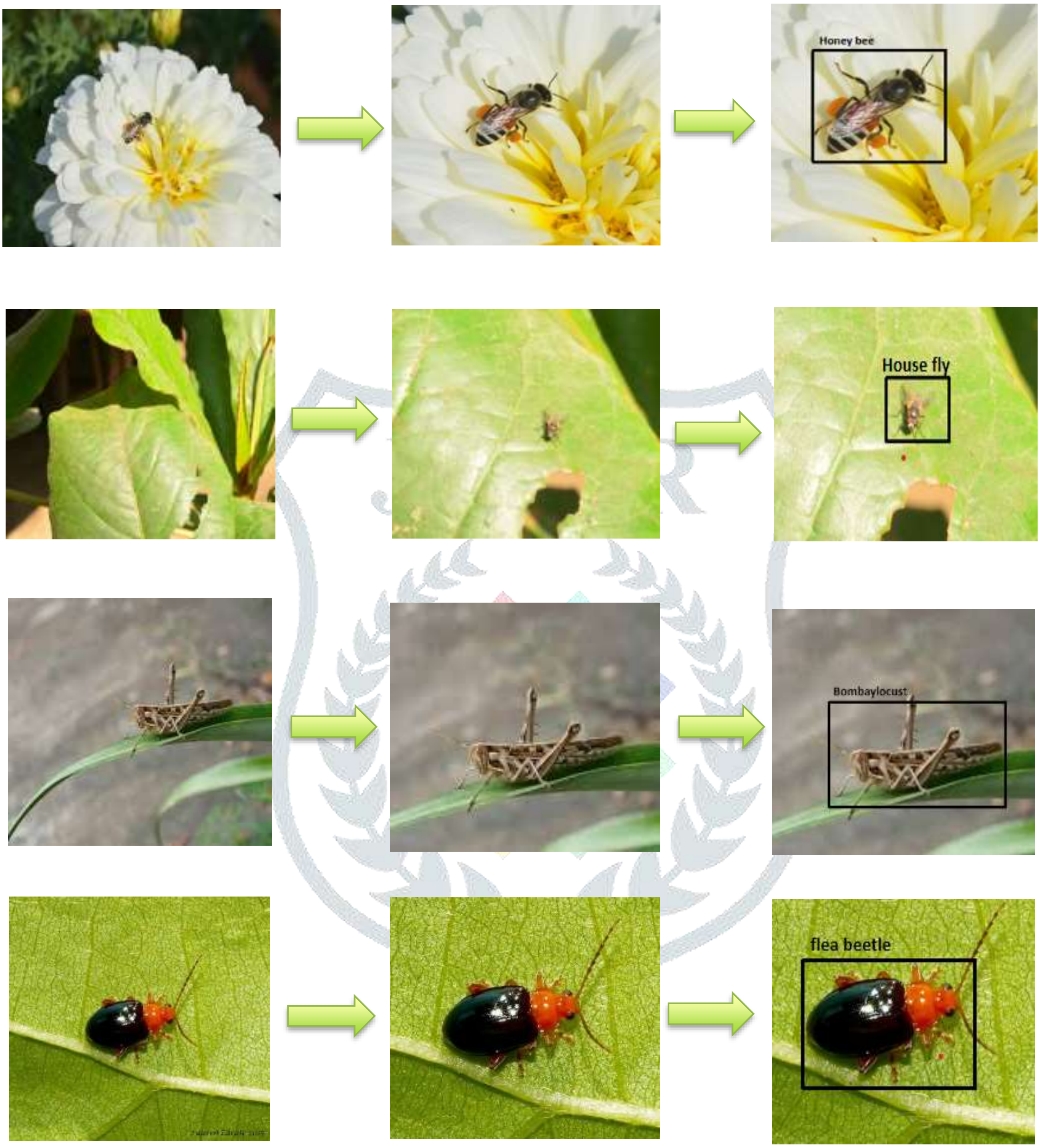
Fig.2 YOLO Architecture

YOLOv5 is an object detection algorithm that detects insects in images. As illustrated in Fig.2, in YOLOv5, a dense block is used to extract features from the input image. The pooling layer is used to reduce the size of the feature maps and down sample the image. This makes detection faster and more efficient. Finally, a linear layer is applied to make the final classification decision based on the extracted features. YOLOv5 classifies the detected object as an insect. This is based on the features extracted from the dense block and pooling layer.

IMAGE PROCESSING

The practice of applying different techniques to an image in order to enhance it or extract useful information from it is known as image processing. It is a form of signal processing in which a picture serves as input. The output may be another image, features, or characteristics associated with the input image. Image processing involves three steps: 1) importing the image using image acquisition software; 2) analyzing and altering the image; and 3) producing a report or altered image as a result of the analysis.
The two categories of image processing are analog and digital. Hard copies like prints and images can use analog image processing. When applying these visual techniques, image analysts employ several interpretation principles. Digital image

processing tools make digital picture alteration possible. When employing digital techniques, all forms of data must pass through three general phases: pre-processing, augmentation, and presentation; and information extraction.



EXECUTION FLOWCHART

A flowchart of the Experimental Process is shown in figure 4; the study begins with Dataset Creation, which includes establishing an image capture setup. The second step involves processing the images and manually labeling the images. The third step stage, which includes training an algorithm that turns out in Analysing the algorithm's accuracy and performance. Further, the process involves creating an application, which is the platform for the user to make use of the proposed features. In the fifth layer, testing of the model and application is carried out on the dataset created in the First stage of the Process. The last step is to predict the results for the real time images.

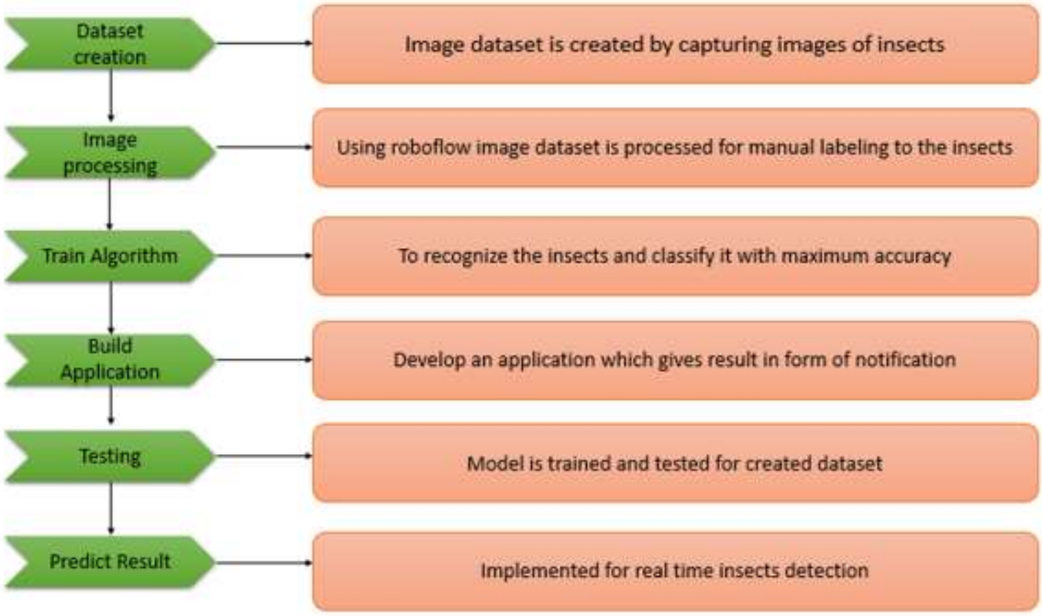


Fig.4: Experimental Process flowchart

RESULT AND DISCUSSION

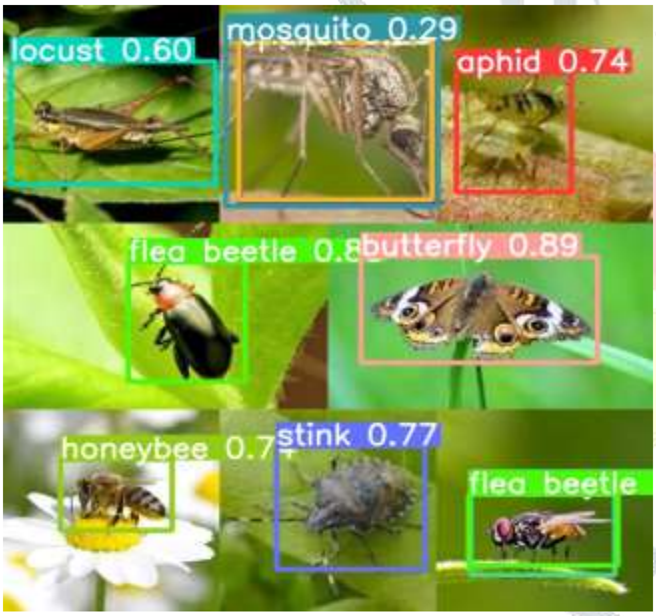
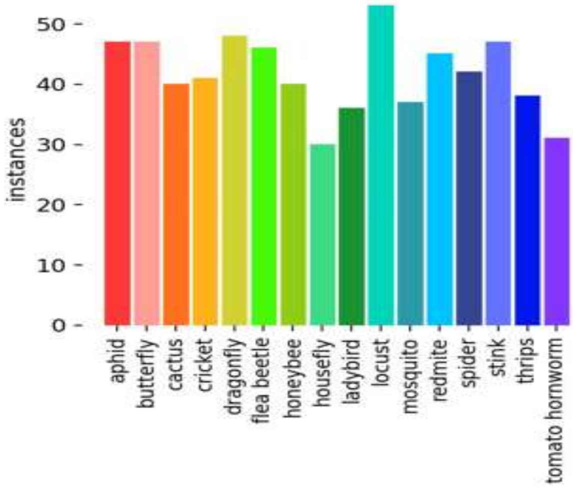


Fig.5 (a)Result with 50 epochs Fig.5 (b)Result with 150 epochs

Fig. 5(a) illustrates the outcomes achieved after running the model for 50 epochs. In this model insects of various types are detected and highlighted with different colored bounding boxes based on their classification accuracy. The graph provides an overview of the model's performance in accurately identifying and categorizing different insects present in the dataset.

Fig.5(b) presents the model's performance after running for 150 epochs, showing an improvement in accuracy over the results obtained after 50 epochs. The graph indicates that the model's accuracy improves with the number of epochs trained. Increasing the number of epochs may also increase training time and resource requirements, so it is important to balance the trade-off between model performance and computational cost.

Fig.6 illustrates insect detection and classification accuracy as a function of instances. The graph highlights how accuracy varies with the number of instances analyzed, providing insight into the model's performance for different amounts of data. The graph showcases the relationship between the model's accuracy and the amount of data it is trained on. This highlights the potential trade-off between accuracy and data quantity.



Precision is the ratio of true positives (TP) to the total number of predicted positives (TP + FP). A high precision value indicates that the model makes accurate positive predictions.

$$\text{Precision} = TP / (TP + FP) \qquad (1)$$

Recall is the ratio of true positives (TP) to the total number of actual positives (TP + FN). A high recall value indicates that the model can correctly identify most positive cases.

$$\text{Recall} = TP / (TP + FN) \qquad (2)$$

Fig.7 illustrates the Precision-recall curve for our insect detection model.

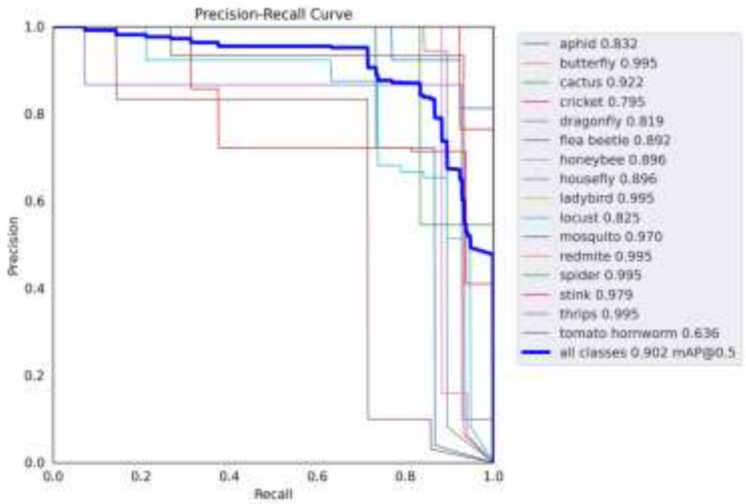


Fig.7 Precision-Recall Graph

CONCLUSION

In this proposed system, the classification and detection of various insect datasets using machine learning and insect pest detection algorithms was done, and the results were compared. To extend the dataset and boost accuracy, every bug image was rescaled, pre-processed, and enhanced. Accomplishing bug characterization with high accuracy in the continuous field is a difficult issue due to the presence of shadows, leaves, soil, branches, and bloom buds, etc. Field crops are a significant part of the farming industry.

Any of these methods will help to reduce insect attacks and farmers to avoid harmful chemical pesticides in their fields, which in turn will reduce soil and water pollution as well. In India, the use of these latest technologies will certainly lead to smart agricultural evolution. In this way, we have seen some methods for pest attack management. Despite using different implementations, datasets, and approaches, these methods have the same goal of reducing insect and pest attacks.

In the future, deep learning techniques will be utilized to identify multiple types of insects in videos captured at different stages of crop growth in agriculture. The algorithm for insect detection will be implemented using a deep convolutional neural network model. This model will be trained to recognize and classify different types of insects within larger datasets.

Insect monitoring and control in the agricultural industry may be revolutionized by deep learning techniques for detecting insects in videos. In the end, both farmers and consumers will benefit from greater crop yields and a reduction in harmful pesticides.

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