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AgriSentinel: Deep Learning Framework for Automated Monitoring and Advisory System

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ABSTRACT :

Agricultural pest infestations significantly affect crop quality and productivity, leading to substantial losses in agricultural production. Traditional pest detection methods rely primarily on manual inspection, which is time-consuming, labor-intensive, and less efficient for large-scale farming. AgriSentinel introduces a deep learning-based framework for automated pest monitoring and advisory support to improve early pest identification and agricultural decision-making.

The proposed system utilizes deep learning techniques, including Convolutional Neural Networks (CNN) and YOLO, to detect and classify pests from crop images. Implemented using Python and Streamlit, the system processes uploaded images using a model trained and tested on the IP102 dataset. It identifies pests and provides relevant advisory information, including symptoms, preventive measures, and treatment suggestions. The system aims to facilitate early pest detection, reduce crop losses, minimize excessive pesticide usage, and promote sustainable agricultural practices. AgriSentinel provides a foundation for intelligent pest monitoring and decision support, with potential for further enhancements in detection accuracy and real-time agricultural advisory services.

Keywords: AgriSential,Deep learning,Pest Detection,YOLO,CNN,IP102 Dataset,Pest Advisory System**.**

Introduction

Agricultural pest infestation is a major challenge to crop quality and productivity, particularly in developing regions where agriculture plays an important role in food security and economic stability. Pests can cause significant crop losses and affect the overall efficiency of farming. Traditional pest detection methods mainly depend on manual field inspections and expert knowledge, which are time-consuming, labor-intensive, and less efficient for large-scale agricultural fields.

Existing pest detection approaches often require manual identification and may not provide timely information about the type of pest and appropriate control measures. These limitations can delay pest management and lead to excessive pesticide usage. With advancements in Artificial Intelligence, Machine Learning, and Deep Learning, image-based pest detection has emerged as a promising approach for improving agricultural monitoring and decision-making. Techniques such as Convolutional Neural Networks (CNNs) and You Only Look Once (YOLO) can be used to identify and classify pests from agricultural images.

To address these challenges, the proposed system, AgriSentinel, introduces a deep learning-based framework for automated pest monitoring and advisory support. The system processes uploaded crop images using a model trained and tested with the IP102 dataset to detect and identify pests. It provides relevant advisory information, including symptoms, preventive measures, and treatment suggestions, through a user-friendly interface developed using Python and Streamlit. The proposed system aims to support early pest detection, reduce crop losses, minimize unnecessary pesticide usage, and promote sustainable agricultural practices

Literature Review

2.1 Title of the Paper: Deep Learning-Based Real-Time Detection of Small Pests in Field Crops Using YOLOv8

Authors and Year: **S. Khalid, M. Asif, and A. Rahman — 2023**

This paper presents a real-time agricultural pest detection system using the YOLOv8 object detection model. The system identifies pests in field images and localizes them using bounding boxes, making it suitable for automated agricultural monitoring. The approach supports fast detection and potential deployment on mobile and edge devices. However, its performance depends on the availability of sufficiently annotated training data, and detecting very small or overlapping pests in complex backgrounds remains challenging.

2.2 Title of the Paper: Plant Diseases and Pests Detection Based on Deep Learning: A Review

Authors and Year: J. Liu and X. Wang — 2021

This review examines deep learning techniques for detecting plant diseases and agricultural pests. It discusses Convolutional Neural Networks (CNNs), region-based detection methods, and image segmentation techniques. The study highlights the benefits of automated feature extraction and compares datasets and evaluation metrics used in agricultural research. However, limited labeled data, poor generalization across different crops, and high computational requirements remain important challenges. The authors emphasize the need for lightweight and scalable detection systems.

2.3 Title of the Paper: Deep Learning Based Agricultural Pest Monitoring and Classification

Authors and Year: S. M. Venkateswara and J. Padmanabhan — 2025

This paper proposes a CNN-based approach for automated agricultural pest monitoring and classification. The system uses agricultural image datasets to identify different pest categories and reduce dependence on manual inspection. The study highlights the potential of automated pest monitoring to improve agricultural productivity and reduce crop losses. However, detection performance depends on the quality and diversity of the training data. The absence of integrated real-time advisory and recommendation features also limits its practical usefulness for farmers.

2.4 Title of the Paper: Advances in Deep Learning Applications for Plant Disease and Pest Detection: A Review

Authors and Year: Shaohua Wang et al. — 2025

This review discusses recent developments in deep learning for plant disease and pest detection using image-based and remote sensing approaches. It covers CNNs, transfer learning, and object detection models, along with the use of drones and satellite imagery for large-scale agricultural monitoring. The study highlights the potential of deep learning to improve detection accuracy and scalability. However, dataset imbalance, environmental variations, and challenges in real-time deployment remain unresolved. The review also identifies the potential of integrating artificial intelligence with the Internet of Things (IoT) for improved agricultural monitoring.

2.5 Title of the Paper: A Deep Learning Model for Predicting Risks of Crop Pests and Diseases

Authors and Year: S. Lee and C. M. Yun — 2023

This study proposes a deep learning-based approach for predicting crop pest and disease risks using environmental factors such as temperature, humidity, and rainfall. The system supports early warning and preventive pest management by estimating potential infestation risks. Incorporating environmental information can support more informed agricultural decisions. However, the approach depends on continuous environmental data collection and may be difficult to deploy in areas with limited sensor infrastructure. Furthermore, it focuses on risk prediction rather than directly identifying pest species from crop images.

Research Methodology

➢ *Dataset Collection*

- Use the IP102 dataset containing labeled images of agricultural pests for model training and evaluation.
- Organize the dataset into appropriate training, validation, and testing sets, according to the dataset and model configuration.
- Use the pest images and corresponding annotations to support pest identification and localization.

➢ *Data Preprocessing*

- Load and process agricultural pest images using Python-based image-processing libraries.
- Resize images to the dimensions required by the selected deep learning model and normalize image data where applicable.
- Verify image quality and annotation consistency before using the data for model training and evaluation.

➢ *Deep Learning Model Development*

- Use deep learning techniques for automated pest detection and classification.
- Employ the YOLO object detection model to identify pest categories and locate detected pests using bounding boxes.
- Use CNN-based techniques where applicable for feature extraction or classification, depending on the implemented model architecture.

➢ *Pest Detection and Classification*

- Accept an uploaded agricultural image as input to the system.
- Process the image using the trained detection model to identify the pest category and its location.
- Display the detected pest, bounding box, and confidence score through the application interface.

➢ *Pest Advisory Generation*

- Provide relevant advisory information based on the identified pest category.
- Present available information about pest symptoms, preventive measures, and suitable treatment suggestions.
- Support farmers in understanding the detected pest and selecting appropriate pest-management measures.

➢ *Backend Development and Integration*

- Implement the application logic using Python.
- Integrate the trained deep learning model with the image-processing and pest-advisory components.
- Connect the backend functionality with the user interface to process uploaded images and display detection results.

➢ *Dashboard Development and Visualization*

- Develop an interactive user interface using Streamlit.
- Provide image-upload functionality and display pest detection results with bounding boxes and confidence scores.
- Present the associated advisory information in a clear and accessible format for users.

➢ *System Evaluation and Analysis*

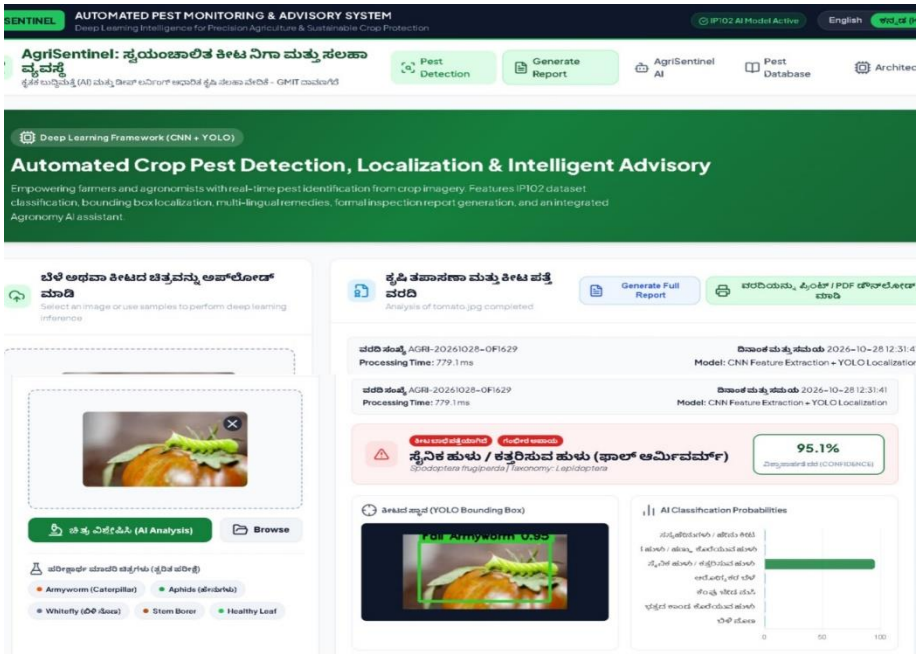
- Evaluate the pest detection model using appropriate performance metrics, such as precision, recall, mean Average Precision (mAP), and inference time, where applicable.
- Analyze detection performance across the pest categories represented in the evaluation dataset.
- Assess the usability of the interface and the relevance of the advisory information to identify areas for future improvement.

Objectives of the Study

- To develop a machine learning–based system for automatic pest detection using images.
- To accurately classify different types of pests affecting crops.
- To provide advisory information such as pest details, damage symptoms, and control measures.
- To reduce dependency on agricultural experts for pest identification.
- To support farmers in making timely and informed pest management decisions.
- To minimize crop loss and promote sustainable agricultural practice.

5. Results and Discussions

Fig 5.1: Interactive Website of Agrisential Crop Pest Detection.



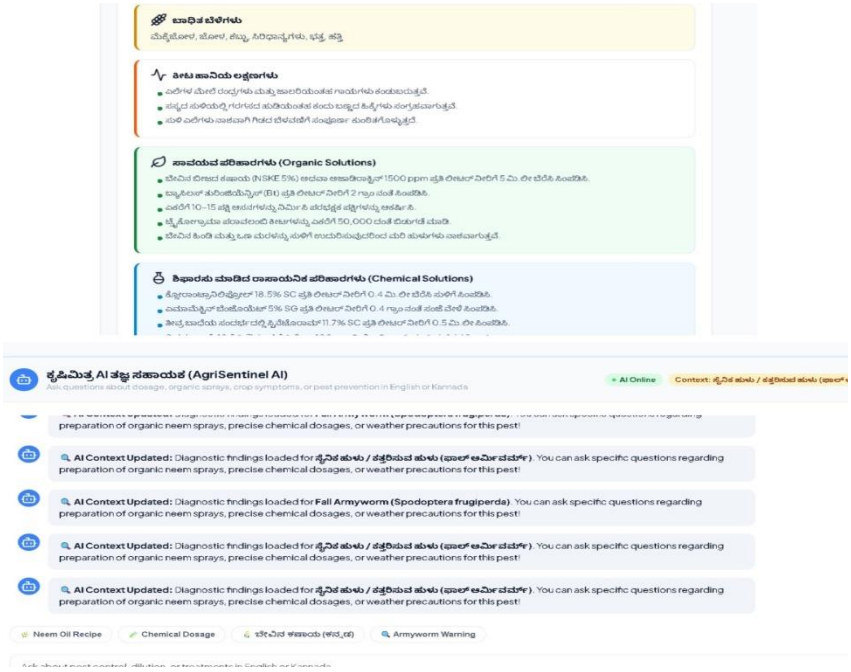


Fig 5.2: Information of the pest, symptoms, suggestions ,chemical solution and AI Assisstent

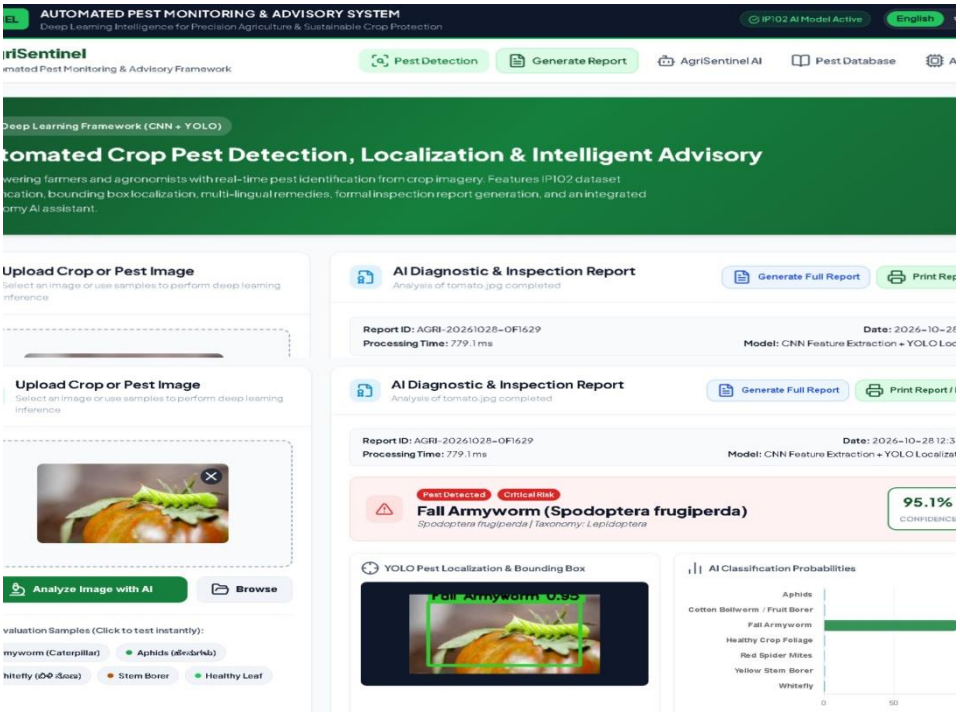


Fig 5.3: The English Language version

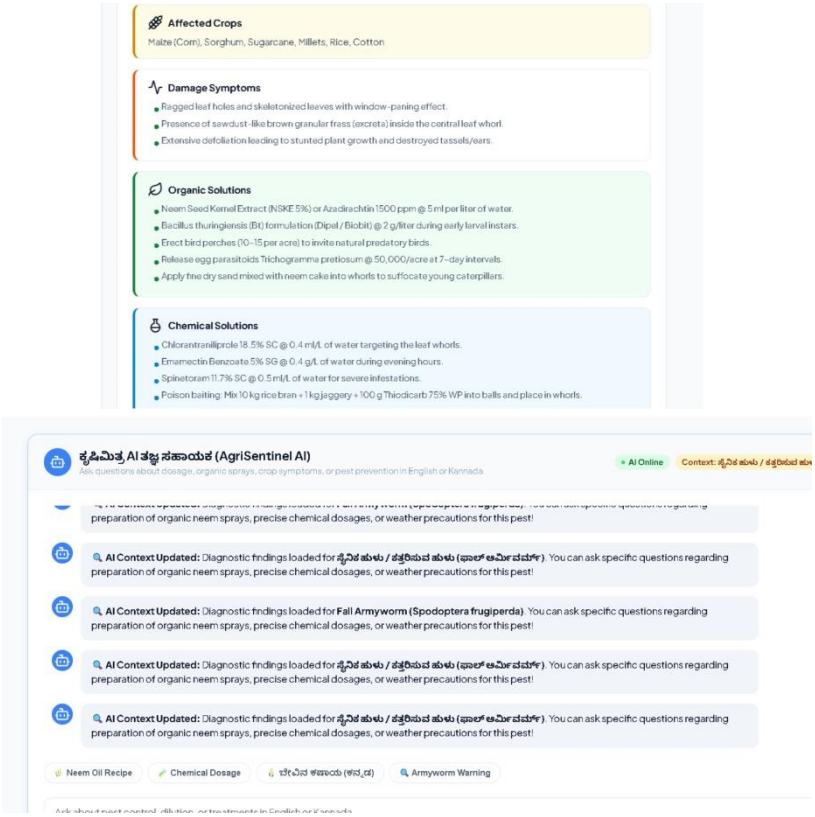


Fig 5.4:Information Of affected crops,damage symptoms,Solutions,Chemical Solutions

The AgriSentinel system was developed to detect and localize crop pests using CNN-based feature extraction and the YOLO object detection model. As shown in the output, users can upload crop or pest images, view the analysis results, and generate AI-based inspection reports. The system displays the report ID and processing time and supports PDF report generation, multilingual interaction, and an AI agricultural assistant. The displayed processing time for the example is 779.1 ms. These results demonstrate the integration of pest detection, report generation, and agricultural advisory features into a single platform [5.1], [5.2], [5.3], [5.4].

6. Conclusion

AgriSentinel presents a deep learning-based framework for automated agricultural pest monitoring and advisory support. The system uses a trained YOLO model to detect and classify pests from uploaded crop images and displays the detection results using a Streamlit-based interface. By providing bounding boxes, confidence scores, and relevant advisory information, the proposed system helps users identify pest infestations and understand suitable preventive and treatment measures.

The integration of image processing, deep learning, and an interactive dashboard aims to make pest identification easier, faster, and more accessible to farmers. Early identification of pests can help farmers take timely action, reduce potential crop losses, and support more informed pest management decisions. In the future, the system can be enhanced by including more pest categories, expanding the dataset, improving detection performance, and validating the advisory recommendations under real agricultural conditions. Overall, AgriSentinel aims to support smarter, technology-driven, and sustainable agricultural practices.

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