UNIVERSITY OF WOLVERHAMPTON

HERALD COLLEGE KATHMANDU

Literature Review (Draft)
Disease and Pest Detection in Agriculture using AI – Driven Tools (Complex System)

Name: Bristina Prajapati

Group: L6CG13

University Id: 2330707

Lecturer: Deepson Shrestha

1. Literature Review

1.1. Traditional Methods of Pest and Disease Detection

The traditional methods of detecting the plant disease and pests often involved visual inspection and manual monitoring which consumed a lot of time and effort. It required skilled people and the inspections were also prone to human errors. Field surveys and laboratory tests for pathogens like fungi, bacterial and fungi were carried out but, those were costly and also required several days or weeks for result. This lengthy process also made it difficult for farmers to act quickly and protect the crops.

It is also found that the traditional agricultural production is not sustainable from economic or environmental point of view. It is also necessary to optimize the use of resources such as soil and water to enable high yield of crops. And, the crop output is also threatened by diseases and insects. It is estimated that between 20% to 40% of yearly crop production is lost due to plant diseases and insect assaults and it also costed the global economy of $220 billion and $70 billions. (Tiago Domingues, 2022) However, to overcome this more accurate AI-driven tools are being used which offers faster and cost-effective solutions and more precise methods for detecting and diagnosing disease in crops.

1.2. AI in Disease and Pest Detection in Agriculture

The integration of AI driven tools in agriculture has played a major role in revolutionizing the agricultural field. It has majorly improvised the pest and disease detection offering unprecedented accuracy and efficiency. Deep learning models like Convlutional Neural Networks (CNNs) and studies using UAV based systems with YOLOv5s modifications achieved precise detections for pest like ants, shield bugs and so on. (Wang, 2021) Similarly, AI enabled frameworks capturing image data has shown precise identification of disease and pests.

Despite all of the achievements, it is also facing several challenges. There are limited datasets and uneven distribution of data which has lead difficulties in model training. However, to mitigate this issue, data augmentation and transfer learning have been applied where the pre-trained models are fine-tuned with specific agricultural datasets. As per the research, DenseNet ‘a convolutional neural network architecture designed

to enhance feature reuse and efficient parameter usage', is found to excel in small scale and in complex agricultural conditions while combined with attention mechanism. It has achieved near perfect accuracy for crop disease and pests. (Wang, 2021)

1.3. AI-Driven Tools in Pest and Disease Detection

The AI- driven technologies including the deep learning (DL), computer vision and Machine learning (ML) has been increasingly adopted for pest and disease detection in agriculture. These technologies allows automated analysis of large datasets for accurate results/solutions. It uses images from drones and IOT sensors to detect and classify pest and diseases. Following are the various AI-driven approaches as per the recent researches.

1.3.1. Convolutional Neural Networks (CNNs) for Image Classification

Convolutional Neural Networks (CNNs) is a deep learning architecture which is highly effective in image based classification for pest and disease detection. It analyses images of crops and automatically extract relevant features eliminating the need for manual involvement. CNNs has also been used in several studies for pest and disease detection by processing images from various sources like cameras, smartphones and drones. Its use has significantly improved accuracy and efficiency of detection system by identifying multiple pests and diseases within a single image.

A study also showed that the use of CNN-based real time object detection system 'YOLOv5 model' for pest detection showed excellent performance in detecting pests such as wasps, grasshoppers, ants with the average precision of 96% and a mean average of (mAP) 95%. It also used the UAV (Unmanned Aerial Vehicle) technology for the detection. (Asma Khan, 2024)

1.3.2. Drones and UAV Technology for Data Acquisition

Drones equipped with high resolution cameras and sensors are used to gather data for AI- driven pest and disease detection. Drones were integrated with deep learning technologies to create a pest disease recognition system. This utilized CNNs and wireless data transmission for pest and disease detection.

The pest and disease recognition system designed for agricultural drones was structured into three-tier architecture. It consisted of sensing layer, transmission layer, and application layer. The sensing layer include drone system, ground monitoring station and mobile client, while the transmission layer ensured the secure and stable transfer of data. And, the application tier processes the image data through deep learning algorithms. Its effectiveness was also validated through experiment using a grape leaf image with an accuracy of 93.5%. (Wenqi Li, 2024)

1.3.3. Use of Visual Sensor Data

The use of sensors has played a vital role in enhancing the AI driven pest and disease detection system. The detection process involves installing of sensors in agricultural field to capture plant images, and image processing and segmentation to extract data for machine learning (ML) algorithms. It collects environmental data such as temperature, humidity, soil moisture etc. which can then be analysed along with the visual data. They are then processes and analysed and are distinguished into healthy and diseased leaves.

Automated disease detection systems rely on ML and DL algorithms including decision trees, k-nearest neighbours, support vector machines and artificial neural networks. As per the experiment these models are valuable for crops like tomato, which are prone to fungal, bacterial and pest-related diseases. As per the research Deep Neural Neworks(DNN) like VGG-16 and ResNet have demonstrated accuracy in diagnosing plant diseases like Verticillium wilt and powdery mildew in crops like tomatoes. It has achieved accuracy of over 90%. (Abbas Jafar, 2024)

Those AI applications were also applied to other crops like chillies, cucumber, potatos etc. where disease like cerospora and Dowm Curl were detected. For instance, the use of architectures like VGG-16 and Xception on disease detection in tomato achieved accuracy rate of 99.25%. (Abbas Jafar, 2024)

1.3.4. AIoT Based Pest Detection System

The system includes AI for the pest identification and IOT for gathering the real time data from the environment. For example, it gathers weather information to predict the pest occurrence. It uses deep learning model, YOLOv3 (You Only Look Once) for

detecting pest in images. To improvise the system performance, the environmental data is analysed with Long Term Short Term Memory (LSTM) networks which helps to predict the pest behaviour. As per the research the disease detection accuracy is found to be 90%. (Chen, 2020) This has also played a vital role to reduce the use of pesticides, minimize environmental harm, and minimize the need for manual work in pest control.

The report also compares models for pest detection. Here, two-stage object detection model like Faster R-CNN identifies the particular region of interent in an image and delivers the high accuracy. But, this requires high computational power. However, one stage method like YOLO works faster by detecting pests in a single step. YOLOv3 detects pests accurately in real time scenario through advance techniques like multi-scale fusion. (Chen, 2020)

This system has allowed the farmers to get notified early about the pest activity. Allowing them to use pesticides only in the places where its needed. This hs prevented crop loss, reduce the waste and minimize harm to the environment. Therefore, the combination of AI and IOT has paved the way for more sustainable and efficient farming practices.

Reference

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