LITERATURE REVIEW

Agriculture is increasingly benefiting from innovations such as Artificial Intelligence (AI) technology, Internet of Things (IoT), and Computer Vision to address problems such as crop diseases, low crop yields, and inefficient use of resources. Many authors have proposed intelligent systems that can automate crop health monitoring and detection of diseases.

1. AI-Based Crop Disease Detection

There are some research works focused on applying deep learning models for crop disease identification from leaf images. The conventional image processing approach utilized hand-crafted features like color, texture, and shape. However, the results demonstrated lower accuracy when applied in practical scenarios.

Recently, the efficiency of Convolutional Neural Networks (CNN) for plant disease classification has been highlighted. CNN-based approaches automatically learn features from the image and are quite accurate when trained with a sufficient number of images. Nonetheless, they are mostly crop specific and demand a large number of labeled images.

More sophisticated architectures like FourCropNet show improvement regarding multi-crop disease recognition tasks using generalized features. However, such models face difficulties while being implemented in real fields owing to variations in illumination levels, background noises, and overlapping leaves.

2. Object Detection Models for Agriculture

YOLO (You only look once) object detection methods, like YOLO, are used for disease detection applications requiring real-time processing. Recently, efficient and accurate disease spot localization strategies, namely YOLOv11 and C2PSA Attention Mechanisms, are used in the proposed system.

Because they are capable of live monitoring, these models can be applicable in the field. Nevertheless, according to the literature, YOLO-based approaches are computationally-intensive, requiring GPUs or edge computing equipment, which could be costly to small farmers.

3. Vision Transformers for Agriculture Use Cases

Vision Transformers or ViTs are relatively new additions to the realm of plant disease segmentation. These differ significantly from CNNs, as they can observe the whole image simultaneously by using self-attention. It has been found that ViTs work satisfactorily even in complex settings like unbalanced illumination and obscured leaves.

Surveys on Vision Transformers in agricultural settings have progressed with increased accuracy and robustness levels compared to traditional CNN models. Despite this, the model is still faced with limitations when it comes to large-scale agricultural applications mainly due to its increased computational cost and lack of model interpretability.

4. IoT-Based Smart Agriculture Systems

IoT has a great role to play in the monitoring of environmental and soil parameters, such as temperature, humidity, soil moisture, and pH. Many researchers have presented IoT-based systems that continuously collect field data and send it to cloud platforms for processing.

Such systems help farmers understand environmental conditions, which affect the development of diseases. Literature reports various issues with the systems, including power supply, network connectivity problems, calibration errors on sensors, and maintenance within rural areas.

5. AI-IoT Integration

Recent research focuses on the amalgamation of AI-based image analysis with data from IoT sensors to provide comprehensive crop monitoring. AI models detect visible symptoms of diseases, whereas IoT sensors give early signals of stress conditions before the appearance of clear visual symptoms.

According to research, such integrated systems provide better precision in decision-making and reduce the consumption of pesticides and other chemicals. This is a well-known approach to precision farming. However, most of these existing solutions are intended for single-crop environments and suffer from major scaling issues.

6. Mobile-and Cloud-Based Agricultural Platforms

Various authors suggest mobile and web-based dashboards to provide disease alerts and recommendations to farmers. These channels enhance access and allow for real-time communication.

However, the literature indicates limitations like poor internet penetration, the absence of the local language, and user interfaces that are not user-friendly.

7. Key Observations from Literature

- Based on the reviewed papers, it can be observed that:
- Almost all models of AI are hungry for large amounts of quality data, of which very little exists in agriculture.
- Laboratory models may not work well in the real field.
- There are cost-related issues, power consumption issues, and connectivity issues in the realm of the IoT.
- Current approaches are more crop-specific, which is difficult to scale.
- A lack of model interpretability makes it difficult for the farmer to trust AI results.

8. Research Gap Identified

- From the literature review, the gaps identified are the following:
- Requirement for a Multi-Crop and Multi-Disease Detection System.
- Requirement for real-time integration of AI and IoT data.
- Requirement for scalable, economic, and farmer-friendly solutions.
- Absence of systems integrating Early Warning, Real-Time Alerting, and Sustainability Agenda.

Conclusion of Literature Review

There is evidence in the literature that AI and IoT have immense potential for transforming the agricultural sector. But the present solutions have certain limitations in terms of scalability, affordability, and applicability. This leads to the objectives of this research proposal, which will combine AI solutions for disease detection with environmental monitoring systems using IoT for offering an efficient, sustainable, and pragmatic solution for agricultural requirements.