Ai and Vision Reality

AI-Based Crop Disease Detection: Challenges and Ethical Considerations

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Abstract

The integration of Artificial Intelligence (AI) in agriculture particularly in crop disease detection, has garnered significant attention due to its potential to enhance agricultural productivity and food security. This paper critically evaluated the present literature and technological advancements in AI driven crop disease detection. It investigates historical methods, recent advances, and emerging issues in the field. The study adds to a thorough knowledge of AI's role in agriculture by combing insights from diverse sources, and it emphasizes the significance of resolving ethical concerns technological limits for sustainable farming practices.

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1. Introduction

The integration of Artificial Intelligence (AI) in agriculture has been gaining significant attention especially in the sector of crop disease detection, Agriculture being one the biggest industry in the world is the main backbone for many countries and, due to the growing population, there is a constant demand for food. To satisfy the pressing need. It is of importance to improve agricultural potency and protect crops. Crop diseases can decrease productivity of agricultural production by 10% to 95% ensuing notable decrease in the quality and quantity (Orchi, et al., 2021). AI emerging technologies offer effective solutions to enhance agricultural productivity by enabling early and accurate identification of crop diseases.

For instance, AI driven techniques have demonstrated effectiveness in combating agricultural disease like early blight in potatoes, highlighting the potential algorithms and image analysis. However, a thorough evaluation uncovers uncertainties surrounding the potential of AI solutions in various agricultural environments. (Haasan, et al., 2021).

Furthermore, as agriculture progressively embraces AI technology, it is crucial to evaluate the wider consequences for sustainability and farming practices. This integration in traditional agricultural methods aim to reduce waste, enhance sustainability, and enhance farmers to make informed decisions (Vasiliki, et al., 2023).

To maintain global food security and sustainability, it is imperative that AI based crop detection be investigated. Therefore, this paper aims to critically examine the use of AI in crop disease detection, by scrutinizing current literature and technological developments.

2. Literature review

2.1 Introduction

Crop diseases are caused by insects, pests, bacteria, fungi, and viruses, which are found and can spread in all parts of the plant. Historical methods and recent methods of crop disease detection are being reviewed to understand the transition and technological improvements over the years.

2.2 Historical Methods in Crop Disease Detection

For ages, crop diseases have been identified through visual observation this longstanding traditional method of crop disease detection is obtained by solely relying on the naked eye inspection and accumulated knowledge and experience (Singh, 2020). Expert farmers in this sector rely on the plant height, color, leaf shape, leaf density on the branches, changes in the root system to make diagnosis. Through this tentative diagnosis of the primary pathogenesis of a nematode, fungus, bacterium are made (Khakimov, et al., 2022).

This outdated method of relying on the eyes, limits the accuracy and reliability of diagnosis, as it may overlook underlying complexities and variations in disease pathology, emphasizing the requirement for more advanced diagnostic approaches (Singh, 2020).

Hence microscopy came to being. As times improved, plants wounded are taken to laboratories to undergo microscopic observation, in anticipation of an accurate diagnosis. With the aid of stereomicroscope analysts can zoom in on specific plant components to identify certain disease symptoms (Khakimov, et al., 2022). Since 1999, farmers and quadrative inspectors can take very specialized using this method (Mahlein, 2016).

These time-consuming methods require skilled personals with advanced abilities in diagnosis and illness identification, making the susceptible to human prejudice (Mahlein, 2016).

2.3 Emergence of AI in Agriculture

Introduction of AI technologies: The advent of AI in recent years has led to significant advancements in agriculture, providing novel answers to long standing objectives. It has revolutionized traditional agricultural procedures and increased efficiency.

By emulating human cognitive functions, AI holds the potential to revolutionize traditional farming practices and enhance overall efficiency and productivity. (Dharmaraj & Vijayanand, 2018).

Additionally, AI technology has the capability to analyze vast amount of data quickly and accurately allowing farmers to make more informed decisions. This approach can significantly reduce the need for harmful chemicals but rather promoting more sustainable farming practices.

Applications of AI in Agriculture: AI integration is revolutionizing agriculture and promises transformative advancements in soil analysis, insect control, crop monitoring, yield predictions, water management, disease control, weed management and crop forecasting (Bal, 2023).

Lately, we have technologies such as robotics automate fruit harvesting for apples and litchi while smart technologies like cloud services and internet of things (IOT) improve supply chain management. Also, blockchain technology facilitate prompt payments and effective business dealings while ensuring transparency and throughout the entire agricultural process (Bal, 2023).

2.4 Recent Advances in AI-driven Crop Disease Detection

AI-driven crop disease detection has advanced significantly in recent years, changing agricultural practices, and providing effective means of identifying and managing diseases. The following are the AI technologies used in crop disease detection.

I. Machine Learning Algorithms
   a. Support vector machines (SVM): A supervised learning algorithm used in crop disease detection, trained on labeled data sets of crop images. Despite their high accuracy and robustness in identifying complicated patterns in crop images, SVMs may have limitations in handling large scale datasets. (Sharada , et al., 2016).
   b. Convolutional neural networks (CNNs) deep learning algorithms inspired by the human visual system, are used in crop disease detection by training on large datasets of crop images to learn discriminative features demonstrating remarkable accuracy and scalability (Sharada , et al., 2016). CNNs can automatically learn intricate patterns and features from. Tea leaf images, aiding in precise disease identification.

II. Image processing techniques
   a. Image segmentation: This is a technique that entails the division. of images into separate segments for enhances analysis. The algorithms are used to separate crop photographs based on pixel intensity, color texture or other attributes into sections. This enables precise localization and identification of diseases symptoms thus facilitating greater accuracy (Fuentes, 2017).
   b. Feature extraction: This entails finding and extracting pertinent aspects from crop photos that are suggestive of disease symptoms (Fuentes, 2017). Extracted features like color histograms and texture descriptors provide valuable information for classification (S. Hossain, 2018).

The process of segmenting a picture involves breaking it up into meaningful portions, and feature extraction is the process of finding and extracting pertinent properties from these segmented areas. In image analysis jobs, picture segmentation is usually the first stage, followed by feature extraction to retrieve important data for further processing and decision making (Fuentes, 2017).

All these processes work with each other and interweave, for better perception, consider the detection of tea leaf disease detection.

To detect tea leaf diseases using SVM, high resolution images of tea leases are first captured using a Niko D5600 camera, followed by preprocessing steps including contrast enhancement and image normalization to enhance image quality and prepare them for further analysis (S. Hossain, 2018). The processed images are segmented to isolate regions of interest such as diseased areas like brown light and alali infections from healthy areas (S. Hossain, 2018). Feature extraction is then done by taking features such as color, texture, and shape. The extracted features are then utilized in classification algorithms like SVM to accurately identify and classify tea leaf diseases (S. Hossain, 2018). This process allows for efficient and accurate identification of teal leaf diseases, aiding in timely intervention and management strategies to maintain health of tea crops.

This method of identifying diseases in tea leaf diseases has achieved 93% success rate in accurately identifying classifying three types of diseases, including brown laugh and algal infections/ The system also reduced the number of features without compromising the classifier’s success rate, allowing for a 300ms reduction in identification time per leaf image (S. Hossain, 2018).

To sum up, the use of advanced imaging technology and machine learning algorithms can significantly improve overall productivity and quality of production.

3. Methodology

3.1 Introduction

AI-Based Crop Disease Detection have made a significant progress in the agricultural sector, but the implementation remains limited due to ethical concerns and obstacles. Data quality, ethical dilemmas, challenges, and technology limitations are some of the issues that hinder the integration of this system and addressing them is crucial for sustainable agricultural practices. The methodology chapter will go through the literature selection criteria, analysis methods and limitations.

3.2 Literature Selection Criteria and Data Analysis Methods

This literature utilized resources focused on peer reviewed articles, research reports from 2010-2024. Credible academic resources such as google scholar, Kaggle, ResearchGate where the main resources used where accessed by filtering using terms such as ‘ethical considerations in AI based crop disease detection’ and ‘Crop disease detection’. Mind mapping and Lists were carefully used to select and filter papers aligning with the aim and goals of the literature. The approach aimed to explore the complexities of Ai driven methods, addressing moral dilemmas.

An analytical approach was implemented to narrow down, critically analyze and extract data from approved papers. This method used themes like data quality, bias, interpretability, and transparency to analyze data.

3.3 Limitations

4. Reflections/Discussions

In reference to the group activity that led to the innovation of a crop/human fault detector, combing of ‘computer vision & AI for autonomous vehicle’, ‘AI based crop disease detection’ and ‘AI in healthcare’ fields, that uses sensors to detect specific entities like humans and crops, autonomously navigating its surroundings and generating outcomes, this shows how diverse and applicable AI based crop disease detection devices can be.

It is paramount to evaluate this to understand the possibilities of benefits and drawbacks. AI-based agricultural disease detection has significant effects on farmers and rural communities. These technologies have the potential to increase food security, lower economic losses, and boost agricultural output.

4.1 Challenges, Ethical Dilemmas and Considerations in AI-based Crop Disease Detection

Ai based crop disease detection has several challenges, such as interpretability of the models, scalability and data quality and bias (Soltani, 2020). Furthermore, verifying the interpretability of models is vital in comprehending the logic underlying AI generated results, thus augmenting confidence and approval among interested parties (Soltani, 2020). Also, strong infrastructure and resources to handle varied agricultural landscaped and technological adoption levels are needed to achieve scalability in Ai systems for crop disease detection.

Data privacy, algorithm bias, and equal access to technology are the main ethical conundrums to be considered for AI based crop disease detection (Dwivedi, 2024). The formulation of ethical frameworks is required as issues regarding accountability and transparency in decision making processes arise (Manoj Ram Tammina, 2024). Thoroughly addressing these concerns is crucial for the proper application of AI in crop disease detection.

4.2 Gaps in current research

Current research gaps indicate differences in ML approaches used for remote pest surveillance. Despite attempts being made to combine ML with proximate digital photographs, an in depth understanding of the subject matter is hindered by the variation of species and circumstances (Barbedo, 2020).

Moreover, disease outbreaks are a serious concern in places like Morocco where agriculture is a major economic factor. Possible solutions are provided by automated disease identification methods while issues including the requirement for reliable detection algorithms and data harmonization still exist (Houda Orchi, 2021)

5. Conclusion

Ultimately, the adoption of AI in crop disease detection presents both opportunities and challenges for the agricultural sector. While AI powered technologies offer promise in enhancing productivity and, reducing crop losses, ethical dilemmas and technological limitations must be carefully navigated. The critical analysis of historical approaches, contemporary advances and emerging challenges emphasizes the necessity for robust ethical frameworks and scalable technology solutions. By addressing these concerns, stakeholders can harness the transformative potential of AI to boost global food security and sustainable agricultural practices in the face of evolving agricultural landscapes.

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