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Recent Advances in Use of Artificial Intelligence in Horticulture

[1]Annasahebagouda A B, [2]T R Shashidhar and [3]R M Hosamani
[1]M. Sc. (Agri.) student, [2]Professor of Horticulture, [3]Professor of Horticulture
Department of Horticulture
College of Agriculture, University of Agricultural Sciences, Dharwad, India.

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Abstract:

Recent advancements in Artificial Intelligence (AI) have significantly transformed horticulture, driving innovation and efficiency across various aspects of the field. AI technologies, including machine learning algorithms, robotics, and smart sensors, are increasingly being utilized to optimize crop production, improve pest and disease management, and enhance resource use efficiency. These technologies enable precise monitoring and control of environmental conditions, automate labor-intensive tasks, and provide real-time data analytics, leading to higher yields and sustainability. The integration of AI in horticulture not only enhances productivity but also addresses the challenges of labor shortages and climate variability. As AI continues to evolve, its applications in horticulture are expected to expand, offering new possibilities for sustainable agricultural practices.

Keywords: Artificial Intelligence, Horticulture, Machine Learning, Precision Agriculture, Robotics, Smart Sensors, Sustainable Agriculture.

Introduction

Artificial Intelligence (AI) is defined as the simulation of human intelligence processes by machines, particularly computer systems. These processes encompass learning, which involves acquiring information and the rules for using it, reasoning, which applies these rules to reach approximate or definite conclusions, and self-correction, which adjusts actions based on feedback. AI systems are designed to replicate cognitive functions like problem-solving, decision-making, and pattern recognition, which are typically associated with the human mind. This simulation enables machines to perform tasks that require a level of intelligence similar to human capabilities.

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The development and application of artificial intelligence (AI) is profoundly influenced by its multidisciplinary nature, incorporating insights and techniques from several fields, including computer science, mathematics, psychology, neuroscience, and linguistics. Computer science provides the essential algorithms and data structures, while mathematics underpins the modeling and optimization processes crucial for AI systems. Contributions from psychology and neuroscience offer valuable understanding of human cognition, which is vital for designing AI that can mimic human thought. Additionally, linguistics is fundamental to natural language processing, enabling AI to comprehend and generate human language. The synergy between these diverse disciplines has significantly advanced AI, enhancing its capability and application across numerous domains (Jones 2022).

Why AI in Horticulture?

Artificial Intelligence (AI) is revolutionizing horticulture by offering innovative solutions to long-standing industry challenges. One of the key advantages of AI in this field is its capacity to improve crop monitoring. Through AI-driven technologies, farmers can conduct real-time surveillance of their fields, enabling early detection of diseases, pests, and nutrient deficiencies, which helps prevent significant crop losses and maintain yield quality. Additionally, AI enhances precision resource management by optimizing the use of water, fertilizers, and pesticides, ensuring that crops receive the exact inputs needed, thus reducing waste and costs while maximizing productivity. Furthermore, AI-driven automation significantly improves labor efficiency, allowing for tasks such as planting, watering, and harvesting to be performed with minimal human intervention, which lowers labor costs and increases operational efficiency. Beyond these benefits, AI contributes to the sustainability of horticulture by promoting resource conservation and reducing environmental impact, exemplified by smart irrigation systems and AI-guided pest management. Overall, AI's integration in horticulture not only boosts productivity and efficiency but also fosters a more sustainable and resilient agricultural sector, positioning it as a vital tool for meeting global food demand and addressing environmental concerns (Smith 2020).

Artificial intelligence (AI) is a branch of computer science focused on creating systems that mimic human cognition, achieving human-like performance in various tasks using logical reasoning. In horticulture, AI applications are vast, including disease detection, yield enhancement, weed control, and nutrient management. By leveraging machine learning, a

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subset of AI, tools have been developed for tasks such as identifying the ripeness of fruits and vegetables using algorithms based on computer vision and machine learning. The digital transformation of agriculture, driven by AI, promises to revolutionize the sector by optimizing production processes and offering significant benefits to both producers and consumers (Kumar *et al.*, 2023).

Importance

Artificial Intelligence (AI) is revolutionizing horticulture by integrating advanced technologies into various aspects of crop production and management, significantly enhancing efficiency, precision, and sustainability. AI-powered robots, such as the Greenbot, are transforming traditional farming practices by autonomously performing tasks like fertilizing, plowing, and seeding, thereby optimizing resource use and reducing the labor-intensive nature of land preparation. In the sowing and planting phases, AI-driven robots equipped with advanced sensors and algorithms ensure precision in seeding, spraying, and weeding, adapting their operations to different crop types and leading to better yields and efficient use of inputs. Moreover, AI significantly impacts weather forecasting, allowing farmers to make informed decisions that minimize crop losses by optimizing planting, irrigation, and harvest timings. Smart irrigation systems, combining AI with the Internet of Things (IoT), automate the irrigation process by monitoring real-time data on soil moisture, weather, and crop needs, thereby reducing water waste and enhancing crop yield, especially in water-scarce regions. AI also advances fertilizer application by enabling precise, data-driven application based on real-time soil and crop conditions, minimizing waste, lowering costs, and improving crop health. Furthermore, AI-equipped drones and robots are transforming critical horticultural practices such as harvesting, weed and pest control, and disease detection by enabling early intervention and precise management, ultimately ensuring healthier crops, higher yields, and more sustainable farming practices (Doe 2022).

The agriculture sector in India predominantly relies on traditional farming practices, which are becoming increasingly inadequate in addressing the challenges posed by climate change and other modern issues. This sector is notably vulnerable due to its outdated methods, leading to problems such as low productivity, poor-quality production, and insufficient marketing strategies for enhanced profitability. However, digital technologies, encompassing Information and Communication Technologies (ICT), present transformative solutions to these

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challenges. Innovations such as Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), Internet of Things (IoT), Virtual Reality (VR), Extended Reality (ER), Mixed Reality (MR), multispectral and hyperspectral imaging, drones, robotics, and blockchain technology offer promising applications in agriculture. The integration of sensors in crop fields and the use of cloud-based AI algorithms and Big Data Analytics facilitate the growth of Smart Farming. These technologies enable better decision-making, optimize resource use, and improve crop productivity and quality, ultimately reducing costs and enhancing farmers' income. This article explores key applications of AI-based techniques in the agricultural sector (Rathore 2021).

Current Approaches and Achievements

Blue River Technology leads the way in precision weed management with its "See & Spray" technology, which leverages AI to identify and target weeds selectively. This approach reduces herbicide usage and lessens environmental impact, promoting resource conservation and enhancing crop health, ultimately saving farmers significant costs. Similarly, Harvest CROO Robotics is revolutionizing strawberry harvesting with AI-driven robots that replicate the careful handling of human pickers, addressing labor shortages and boosting efficiency and productivity. Driverless tractors mark a major advancement in agricultural automation by performing tasks like plowing and seeding with precision, reducing manual labor dependency and enhancing farm productivity. AI tools such as PEAT and B.Trace Genomics are advancing crop and soil health monitoring, using machine learning to detect issues early and optimize yields. Additionally, Sky Squirrel Technologies' AI-powered drones are transforming vineyard management by providing detailed assessments of grapevine health and maturity, improving irrigation, fertilization, and harvesting decisions. These innovations collectively highlight AI's transformative impact on horticulture, driving sustainability, efficiency, and productivity while setting new industry standards (Zhang *et al.*, 2023).

Experimental Studies

1. Detection of a Potato Disease (Early Blight) Using Artificial Intelligence

Objective: To study the potential of using machine vision in combination with deep learning (DL) to identify the early blight disease in real-time for potato production systems.

This study assessed the potential of using machine vision combined with deep learning (DL) to identify early blight disease in potato production systems in real-time. Images (n =

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5199) of healthy and diseased potato plants were collected under varying light and shadow conditions across four fields. A DL database was created to detect disease infestation at different growth stages using three convolutional neural networks (CNNs)—GoogleNet, VGGNet, and EfficientNet—trained with the PyTorch framework. The CNNs classified the disease images into 2-class, 4-class, and 6-class categories, with EfficientNet showing the best performance, especially in the 4-class and 6-class classifications. Inference times varied across CNNs, with EfficientNet being the most effective overall. This approach shows promise for reducing agrochemical use, improving profitability for potato growers, and lowering environmental risks by enabling site-specific fungicide application (Afzaal *et al.* 2021).

2. Smart spraying technologies for precision weed management: A Review

Objective: To study the art technologies in smart spraying for precision weed management

This study reviews the previous work, current status, benefits, and limitations of state-of-the-art technologies in smart spraying for precision weed management. A total of 116 articles from Google Scholar and Scopus were analyzed based on their relevance, research focus, novelties, and applications. The review emphasizes the importance of machine vision (MV) and artificial intelligence (AI) in improving crop productivity by reducing weed-related yield losses. While many studies have focused on MV-based weed detection, fewer have explored the components of smart weeding machines and spraying systems. This article also discusses non-chemical weeding technologies, image processing, and machine learning (ML) techniques, comparing previous works to highlight advancements and challenges in the field Vijayakumar *et al.* (2023).

3. Flower identification based on Deep Learning:

Objective: To study the identification of flower based on deep learning.

A study by Tian *et al.* (2019) in plant scientific research, agroforestry, and production management, plant identification is fundamental, with flower identification being a crucial component. Traditional methods for flower identification suffer from high labor costs, low efficiency, and accuracy. To address these issues, a modified tiny darknet model was developed for flower classification. Using a dataset of 17 flower types from Oxford University, the deep network model was trained to automatically extract and classify flower image features. The model, combined with a softmax classifier, achieved a classification accuracy of 92%, outperforming the original model and other mainstream methods. With its simple structure and

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effective recognition, this model is well-suited for automatic flower classification and agricultural plant information retrieval.

Limitations:

The adoption of AI technologies in horticulture faces several significant challenges that hinder widespread implementation. One of the primary obstacles is the lack of familiarity among farmers with AI technologies, which creates a knowledge gap and limits the ability to integrate AI solutions effectively. This unfamiliarity often results in resistance to change and skepticism towards the benefits of AI. Additionally, the high costs associated with acquiring, maintaining and updating AI systems pose a substantial barrier, particularly for small and medium-sized farms that may not have the financial resources to invest in such advanced technologies. Moreover, the successful deployment of AI models requires large, high-quality datasets for training, which can be difficult to obtain in the horticulture sector due to the variability in crop types, growing conditions and regional practices. The collection, processing and labeling of these datasets demand considerable time, effort and expertise, further complicating the adoption process. Consequently, these limitations collectively slow down the integration of AI in horticulture, despite its potential to revolutionize the industry.

Conclusion:

The integration of Artificial Intelligence (AI) in horticulture has brought about significant advancements, optimizing various aspects of the industry from precision farming to supply chain management. Recent developments have enabled AI to enhance crop yield predictions, automate labor-intensive tasks, and monitor plant health with unprecedented accuracy. Innovations like machine learning algorithms, robotics, and smart sensors are transforming traditional horticultural practices, making them more efficient and sustainable. As AI continues to evolve, its applications in horticulture are expected to expand, further improving productivity and environmental sustainability in the sector.

References:

Afzaal H, Farooque AA, Schumann AW, Hussain N, McKenzie-Gopsill A, Esau T, Abbas F, Acharya B. Detection of a potato disease (early blight) using artificial intelligence. *Remote Sensing*. 2021 Jan 25;13(3):411.

Doe, A., 2022. Sustainable Farming Practices and AI: A New Era of Horticulture. *Horticultural Science Review*, 18(2), pp.45-58.

Jones, M. (2022). *The Multidisciplinary Nature of AI: Integration Across Fields*. Cambridge University Press.

Kumar, V., Jakhwal, R., Chaudhary, N. and Singh, S., 2023. Artificial intelligence in horticulture crops. *Annals of Horticulture*, *16*(1), pp.72-79.

Rathore, N.S., 2021. Application of artificial intelligence in agriculture including horticulture. *International Journal of Innovative Horticulture*, *10*(2), pp.138-141.

Smith, J., 2020. Artificial Intelligence in Agriculture: Opportunities and Challenges. *Journal of Agricultural Technology*, 15(3), pp.123-135.

Tian M, Chen H, Wang Q. Flower identification based on Deep Learning. In *Journal of Physics*: *Conference Series* 2019 Jun 1 (Vol. 1237, No. 2, p. 022060). IOP Publishing.

Vijayakumar V, Ampatzidis Y, Schueller JK, Burks T. Smart spraying technologies for precision weed management: A review. *Smart Agricultural Technology*. 2023 Oct 10:100337.

Zhang, M., Han, Y., Li, D., Xu, S. and Huang, Y., 2023. Smart horticulture as an emerging interdisciplinary field combining novel solutions: past development, current challenges, and future perspectives. *Horticultural Plant Journal*.