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Leveraging artificial intelligence for advancements in agriculture: A review

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Abstract

The introduction of Artificial Intelligence (AI) technology has caused a revolutionary paradigm change in the agricultural sector in recent years. The technologies have emerged as powerful tools for addressing various challenges in agriculture, offering innovative solutions to enhance productivity, sustainability, and efficiency in food production. This paper explores the application of AI across different domains of agriculture and discusses its potential for revolutionizing traditional farming practices. Specifically, we examine how AI techniques such as machine learning, computer vision, and data analytics are being utilized in crop management, precision agriculture, livestock monitoring, pest detection, yield prediction, and supply chain management. Additionally, we discuss the benefits, challenges, and future prospects of integrating AI into agricultural systems, highlighting the importance of interdisciplinary collaboration and scalable solutions for maximizing the impact of AI technologies in advancing global food security and sustainability.

Keywords: AI, agriculture, sustainability, machine learning

Introduction

The foundation of any economy's sustainability is agriculture. (Kekane, 2013) ^[10]. The agriculture sector faces a myriad of challenges, including the need to meet the growing global demand for food, mitigate the impacts of climate change, and ensure sustainable resource management. In this context, the integration of artificial intelligence (AI) technologies holds immense promise for revolutionizing traditional farming practices and addressing these pressing challenges. Artificial intelligence refers to the replication of human intellect in computers that are engineered to think, behave, and learn like humans do, including solving problems and learning new things. (Dutta *et al.*, 2020) ^[5]. AI encompasses a range of techniques, including machine learning, computer vision, and data analytics, which have demonstrated remarkable capabilities in transforming various industries, including agriculture.

The application of AI in agriculture, often referred to as "AgriTech" or "AgTech," encompasses a wide array of technologies and methodologies aimed at optimizing agricultural processes, enhancing productivity, and promoting sustainability. In this article, we explore the uses of artificial intelligence in agriculture.

AI Applications in Crop Management

Crop management is one of the main areas where AI is progressing significantly. Through the use of remote sensing techniques, AI algorithms can analyze satellite imagery and drone data to monitor crop health, identify areas of stress, and predict yield outcomes. Machine learning models trained on historical data can provide insights into optimal planting times, irrigation schedules, and fertilization strategies, thereby maximizing yields while minimizing resource inputs.

Utilising a variety of soil and atmospheric characteristics, crop prediction methodology is used to forecast the most beneficial crop. Variables such as soil type, depth, temperature, rainfall, humidity, PH, nitrogen, phosphate, potassium, organic carbon, calcium, magnesium, sulphur, manganese, copper, and iron are used (Snehal and Sandeep, 2014) ^[17]. With two cameras for recording and a GPS sensor for navigation, Demeter is a computer-controlled speed-rowing

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device. It can plan harvesting procedures for an entire field and then carry out those activities by repositioning itself in the field, cutting crop rows and spotting unforeseen obstructions (Pilaraski *et al.*, 2002) ^[14]. AI is being used to harvest cucumbers by utilising separate hardware and software components of the robot, such as the autonomous vehicle, manipulator, end-effector, two computer vision systems for fruit detection and 3D imaging, and a control scheme that creates motions for the manipulator that minimise collisions during harvesting (Henten *et al.*, 2002) ^[8].

Precision Agriculture

Precision agriculture is another domain where AI is driving transformative change. Farmers are able to make accurate management decisions that are suited to particular field conditions by using real-time data on crop health, weather patterns, and soil conditions obtained by IoT sensors, drones, and AI algorithms. Autonomous machinery equipped with AI capabilities further enhances precision in planting, harvesting, and spraying operations, leading to increased efficiency and reduced labor costs.

Drones provide real-time, high-quality imagery that is combined and analysed using algorithms. In a way that makes it easier to identify and track crops, evaluate their growth and health, and decide when they are ready to be harvested. Drone technology helps in cost reduction as well as in improving the crop yield (Khan *et al.*, 2021) ^[11].

Internets of Things (IoT) technology have been progressively incorporated into agriculture, according to Gubbi *et al.*, (2013) ^[7], changing conventional farming methods into more data-driven and effective systems. The Internet of Things (IoT) in agriculture refers to the use of networked sensors, equipment, and devices to gather and share data in real-time, allowing farmers to monitor and regulate different parts of their operations from a distance.

Livestock Monitoring and Management

In the realm of livestock management, AI-powered systems enable continuous monitoring of animal health, behavior, and productivity. Wearable sensors and RFID technology facilitate individual animal tracking, while predictive analytics algorithms identify patterns and anomalies, allowing for early detection of health issues and optimization of feed formulations.

Chaudhry *et al.*, 2020 ^[4] made multi-sensor board will be used to record several physiological indicators, such as skin temperature, heart rate, and rumination in relation to ambient temperature and humidity. Additionally, a camera will be used for image processing to detect various behavioural patterns. Wi-Fi/GSM technology will be used to direct the measured data to the server, where machine learning (ML) models will be used for data analytics to identify sick animals and forecast cattle health over time in order to provide prompt and appropriate medical care.

The system proposed by Ahmed *et al.* (2023) ^[2] aims to intelligently identify cattle in real-time or in still images or videos. To achieve this, an image dataset of cattle must be trained to enable the system to recognise the face, head, and nose of cattle, which resolves cattle identification issues. This helps livestock insurers validate legitimate claims by precisely identifying the insured animal.

Pest and Disease Detection and Management

Furthermore, AI plays a crucial role in pest and disease detection and management, offering rapid and accurate identification of

pests and diseases through image recognition and sensor networks. Artificial Intelligence (AI) reduces the need for chemical pesticides and allows for targeted interventions by forecasting insect outbreaks and infestation patterns. This reduces the impact on the environment and promotes sustainable pest management techniques. Text-to-speech (TTS) converters are used in many applications to provide text-to-talk user interfaces. It offers a very powerful interactive web UI for real-time communication (Kolhe *et al.*, 2011) ^[12].

According to a study by Selvaraj *et al.*, 2019 ^[15], the DCNN is a reliable and practical method for detecting pests and diseases in digital bananas. We performed deep transfer learning (DTL) on a pre-trained disease detection model to generate an accurate prediction-making network. The model is a helpful early disease and pest detection tool because of its very high success rate.

A model built by Mallick *et al.*, in 2023 ^[13] has effectively identified six distinct mung bean diseases and four types of pests from leaves that were collected over several seasons, both healthy and diseased. They suggested smartphone-based deep learning model for mung bean pest and disease detection has an average accuracy of 93.65%, according to the conducted experiments.

Yield Prediction and Forecasting

Crop cost estimation and marketing methods both greatly benefit from the crop yield projection. Furthermore, prediction models can be used in the era of precision agriculture to analyse pertinent aspects that have a direct impact on production. Various artificial neural network models are used to predict yield from different parameters related to production (Bannerjee *et al.*, 2018) ^[3]. Integration weather forecasts and satellite imagery used for accurate yield forecasting. Application of AI in optimizing harvest schedules and supply chain management.

A recommendation system was presented by Shah *et al.*, in 2021 ^[16]. It uses a variety of machine learning and statistical algorithms like XGBoost, Gradient Boosting to not just forecast crop yield but also extract trends by evaluating various parameters such as NDVI Rainfall, Temperature, Air Quality Index (AQI) etc.

AI in drone technology

AI in drone technology is revolutionizing agriculture by providing farmers with valuable insights and tools to optimize crop management, increase yields, and reduce resource usage. Drones equipped with AI-powered sensors and software can collect high-resolution aerial imagery and data, which is then analyzed to provide actionable insights for precision agriculture.

One of the key applications of AI in agriculture drones is crop monitoring and analysis. By utilizing computer vision and machine learning algorithms, drones can identify crop health issues, detect pests and diseases, and assess plant growth and vitality. This allows farmers to target interventions such as irrigation, fertilization, and pest control more precisely, optimizing resource allocation and minimizing environmental impact. Furthermore, AI-powered drones enable farmers to perform field mapping and surveying with unprecedented accuracy and efficiency. By generating detailed maps of terrain, soil types, and crop health indicators, drones help farmers make informed decisions about land management, crop rotation, and planting strategies. Another important application is yield estimation and prediction. By analyzing aerial imagery and data collected throughout the growing season, AI algorithms can accurately forecast crop yields, allowing farmers to anticipate market trends, optimize harvest schedules, and make informed

decisions about crop marketing and distribution.

Overall, AI in drone technology is empowering farmers with advanced tools for precision agriculture, enabling them to maximize productivity, minimize input costs, and promote sustainable farming practices. As the technology continues to evolve, the integration of AI and drones holds great promise for transforming the agricultural industry and addressing the challenges of food security and environmental sustainability. Numerous authors like Ganesh *et al.* 2023^[6], etc. worked and researched the same about the use of AI in drone technology in agriculture.

Challenges of AI Adoption in Agriculture

Despite the numerous benefits that AI brings to agriculture, there are also challenges and barriers to adoption that must be addressed. These include issues related to data quality and availability, technological infrastructure, and farmer acceptance. Moreover, ethical considerations surrounding data privacy, algorithmic bias, and socioeconomic impacts warrant careful attention. The major limitations include response time and accuracy, requirement of huge data for performing of any applications, method of implementation, flexibility and high data cost.

Conclusion

This paper provides a comprehensive overview of how artificial intelligence is transforming agriculture, discussing the diverse applications of AI techniques and their potential to drive advancements in agricultural productivity, sustainability, and resilience. By examining the benefits, challenges, and future prospects of AI adoption in agriculture, this paper aims to inform policymakers, researchers, and industry stakeholders about the transformative potential of AI technologies in addressing global food security challenges and promoting sustainable agricultural practices.

References

1. Ahmad M, Abbas S, Fatima A, Ghazal TM, Alharbi M, Khan MA, *et al.* AI-driven livestock identification and insurance management system. *Egyptian Informatics Journal*. 2023;24(3).
2. Ahmed A, Mogahid F, Musab A, Abdul-Wahid AS. Optimal altitude range for image collection drone from agricultural areas with image resolution and power consumption constraints. 20th International Multi-Conference on Systems, Signals & Devices (SSD). 2023. p. 689-693.
3. Bannerjee G, Sarkar U, Das S, Ghosh I. Artificial intelligence in agriculture: A literature survey. *Int J Sci Res Comput Sci Appl Manag Stud*. 2018;7(3):1953.
4. Chaudhry AA, Mumtaz R, Hassan Zaidi SM, Tahir MA, Muzammil SH. Internet of Things (IoT) and Machine Learning (ML) enabled livestock monitoring. *IEEE 17th International Conference on Smart Communities: Improving Quality of Life Using ICT, IoT and AI (HONET)*. Charlotte, NC, USA; 2020. p. 151-155.
5. Dutta S, Rakshit S, Chatterjee D. Use of artificial intelligence in Indian agriculture. 2020;1:65-72.
6. Ganeshkumar C, Arokiaraj D, Jeganathan GS, Manjunath S. Application of drone technology in agriculture. In: *Applying Drone Technologies and Robotics for Agricultural Sustainability*. 2023. p. 50.
7. Gubbi J, Buyya R, Marusic S, Palaniswami M. Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*. 2013;29(7):1645-1660.
8. Henten EJ, Hemming J, Tuijl BAJ, Kornet JG, Meuleman J, Bontsema J, *et al.* An autonomous robot for harvesting cucumbers in greenhouses. Springer; c2002.
9. Jagadeesh G, Sahana SA, Sneha M, Shanmugasundaram H, Kukreja V, Vasantha SV. Improving precision agriculture by appropriate measurement of fertilizers with drones. *International Conference on Advances in Computation, Communication and Information Technology (ICAICIT)*. 2023. p. 425-431.
10. Kekane MA. Indian agriculture-status, importance and role in Indian economy. *Int J Agric Food Sci Technol*. 2013;4(4):343.
11. Khan YM, Kumar S. Applications of artificial intelligence in agriculture. *Int Res J Modernization Eng Technol Sci*. 2021;3(1):1398.
12. Kolhe S, Kamal R, Saini HS, Gupta GK. An intelligent multimedia interface for fuzzy-logic based inference in crops. *Expert Syst Appl*. 2011;38(12):14592-14601.
13. Mallick MT, Biswas S, Das AK. Deep learning-based automated disease detection and pest classification in Indian mung bean. *Multimed Tools Appl*. 2023;82:12017-12041.
14. Pilarski T, Happold M, Pangels H, Ollis M, Fitzpatrick K, Stentz A. The Demeter system for automated harvesting. Springer; 2002.
15. Selvaraj MG, Vergara A, Ruiz H. AI-powered banana diseases and pest detection. *Plant Methods*. 2019;15:92.
16. Shah A, Agarwal R, Baranidharan B. Crop yield prediction using remote sensing and meteorological data. In: *International Conference on Artificial Intelligence and Smart Systems (ICAIS)*. Coimbatore, India; 2021. p. 952-960.
17. Snehal SS, Sandeep SV. Agricultural crop yield prediction using artificial neural network approach. *Int J Innov Res Electr Electron Instrument Control Eng*. 2014;2(1):683-686.