



Agri Articles

(e-Magazine for Agricultural Articles)

Volume: 04, Issue: 05 (SEP-OCT, 2024)

Available online at <http://www.agriarticles.com>

© Agri Articles, ISSN: 2582-9882

AI Technology in Agriculture and Its Applications

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Artificial intelligence (AI) holds vast potential to advance agriculture services in the coming years. The intersection of AI and agriculture has yielded unprecedented opportunities to address modern farming's complex demands. This paper explores AI technologies' transformative potential in revolutionizing agricultural practices, including precision farming, crop management, supply chain optimization, and decision-making processes. AI-powered solutions provide farmers with real-time insights into crop health, soil conditions, and weather patterns, enabling precise interventions. Machine learning algorithms analyze vast data amounts, including satellite imagery, drone footage, and sensor data, to generate field-tailored recommendations. By leveraging predictive analytics, AI systems forecast crop yields, disease outbreaks, and market trends, empowering farmers to make informed decisions and optimize resource allocation.

Introduction

Artificial intelligence (AI) operates on the principle that machines can mimic human intelligence, enabling them to perform tasks ranging from simple to complex. AI goals include learning, thinking, and perception. Examples of AI applications include self-driving cars, visual recognition systems, recommendation engines that suggest products based on past purchases, and virtual assistants like Siri on Apple iPhones. AI has a significant impact on various industries, including agriculture, which is one of the oldest and most crucial professions globally. Agriculture is a \$5 trillion industry worldwide, and with the world's population expected to exceed 9 billion by 2050, agricultural production needs to increase by 70% to meet demand. However, limited land, water, and resources make it challenging to sustain the supply chain. Therefore, a smarter and more efficient approach to farming is necessary to meet the growing demand.

AI is ubiquitous, from mobile face recognition apps to self-driving cars. While other industries have seen significant productivity gains from AI systems and ML skills, it's hard to imagine agriculture undergoing a digital transformation. However, AI is bringing one of the oldest industries into the future. AI has numerous agricultural applications, enabling precision agriculture. AI can assist farmers with watering, crop rotation, harvesting, crop selection, planting, and pest control using ML data (Shadrin et al., 2019; Linaza et al., 2021). AI's foundation is the assumption that human intelligence can be described in a way that allows computers to replicate and perform tasks of all sizes. AI goals include learning, reasoning, and perception. AI is making a significant impact across industries, with every sector looking to automate specific jobs using intelligent machinery. This occurs when human intelligence is defined in a way that a machine can understand. Moreover, AI technology in agriculture has the potential to revolutionize the world. It can perform tasks ranging from simple to complex,

with goals including learning, reasoning, and perception. AI aids in automating jobs across industries, simplifying various tasks (Sharma et al., 2022; Bolandnazar et al., 2020).

Artificial intelligence in agriculture

Crop yield prediction and price forecasts: Identify the output yield of crops and forecast prices for the next few weeks will help the farmer to obtain maximum profit.

Intelligent spraying: AI sensors can detect weed affected areas and can precisely spray herbicides in the right region reducing the usage of herbicides.

Predictive insights: Insights on “Right time to sow the weeds” for maximum productivity. Insights on the impacts created by the weather conditions.

Mechanization and Farm Equipment: Plows, harvesters, tractors, and other farm equipment are essential for various agricultural operations, including planting, harvesting, transporting, and soil preparation. Mechanization enhances productivity and reduces labor requirements in farming operations.

Accurate Farming: Precision agriculture utilizes technologies like GPS (Global Positioning System), GIS (Geographic Information System), and remote sensing to collect data on crop health, soil variability, and environmental factors. By leveraging this data, farmers can optimize inputs such as water, fertilizer, and pesticides, leading to increased yields and improved resource efficiency.

Irrigation Systems: Modern irrigation techniques, including center pivots, drip irrigation, and sprinkler systems, enable crops to receive water efficiently while minimizing water waste and optimizing plant growth. Additionally, sensor-based irrigation systems can adjust watering schedules in real-time based on data from sensors, further enhancing water efficiency.

Genetic Engineering and Biotechnology: Genetic engineering techniques like CRISPR-Cas9 enable the development of crop varieties with desirable traits, such as resistance to pests and diseases, tolerance to environmental stresses, and enhanced nutritional value. Additionally, biotechnology employs other methods like marker-assisted breeding and tissue culture to further improve crops.

Crop Protection: To manage pests and diseases, various technologies are employed, including chemical pesticides, biological control agents, and integrated pest management (IPM) techniques. Furthermore, technological advancements in crop monitoring, remote sensing, and predictive modeling enable farmers to detect and respond to pest and disease outbreaks more efficiently.

Digital farming: Digital farming involves the utilization of technologies to assist farmers in collecting, analyzing, and managing data related to crop yields, weather forecasts, market prices, and farm operations. Examples of these technologies include farm management software, mobile applications, and sensor networks. These digital tools enhance farm productivity and facilitate data-driven decision-making.

Vertical farming and hydroponics: Indoor soilless crop-growing methods utilize nutrient solutions, artificial lighting, and controlled environments to cultivate crops. These technologies offer several advantages over traditional farming techniques, including year-round production, enhanced crop yields, and significantly reduced water consumption.

Automation and Robotics: The adoption of drones and agricultural robots is on the rise, transforming various farming processes such as planting, weeding, spraying, monitoring crop health, and data collection. By leveraging automation and robotics technologies, farmers can significantly boost productivity, reduce labor costs, and minimize the reliance on chemical inputs in their agricultural operations.

Blockchain and Traceability: The implementation of blockchain technology in supply chain traceability enables the transparent and secure tracking of agricultural products from farm to

fork. This technology has the potential to enhance food safety, ensure product authenticity, and foster trust between consumers and producers.

Smart sensors and Internet of Things (IoT): This device is utilized in agriculture to monitor various parameters in real-time, including environmental conditions, equipment performance, soil moisture levels, and meteorological data. These tools enable precise resource management and provide farmers with valuable insights to inform their decision-making and take prompt action.

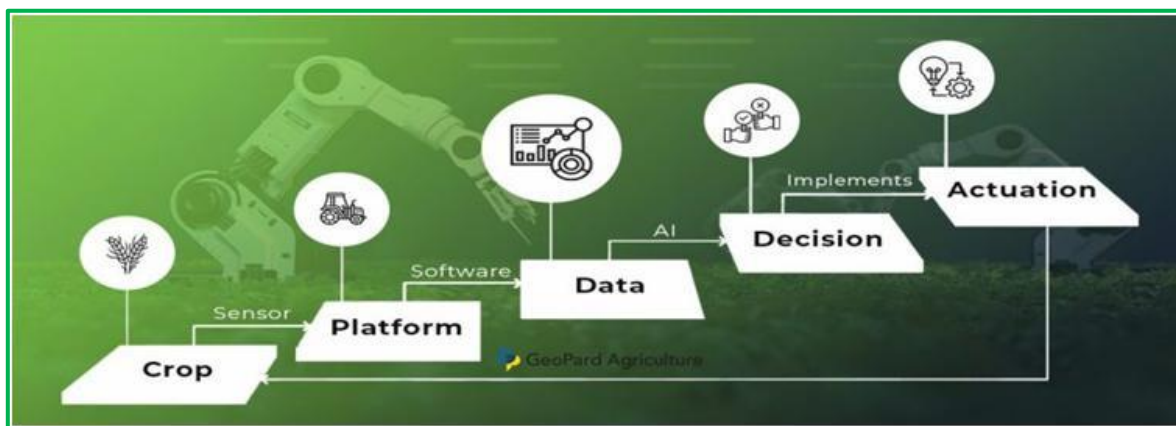


Fig 1: Role of AI in Agriculture

Agriculture applications of AI and machine learning: Artificial intelligence (AI) and machine learning (ML) are revolutionizing various aspects of farming practices, with numerous applications transforming the agriculture industry. Some key applications include:

Precision Agriculture: AI and ML analyze data from various sources, including sensors, drones, satellites, and more, to assess field variations in soil qualities, moisture levels, and crop health. By leveraging this insights, farmers can optimize the application of inputs such as herbicides, fertilizers, and water, leading to improved resource utilization, increased yields, and more efficient farming practices.

Crop Management and Monitoring

Yield Prediction: Machine learning models utilize historical data, weather forecasts, soil parameters, and other factors to make accurate predictions about crop production. These precise yield forecasts enable farmers to optimize planting schedules, determine the ideal harvest time, and make informed decisions regarding marketing and sales strategies.

Pest and Disease Detection: Artificial intelligence (AI) and machine learning (ML) techniques are employed to detect early signs of insect infestation, disease outbreaks, and nutrient deficiencies in crops. By analyzing sensor data, images, and environmental factors, machine learning (ML) algorithms can identify patterns that may indicate the presence of pests or diseases, enabling early detection and intervention.

Weed Management: AI-powered systems utilize machine learning and image analysis to accurately distinguish between weeds and crops. This enables precise application of herbicides or mechanical weeding, minimizing crop damage and reducing chemical usage.

Smart Irrigation: AI-based irrigation systems optimize irrigation schedules by analyzing data from soil moisture sensors, weather forecasts, and crop water requirements. Using machine learning algorithms, these systems can adjust watering levels in real-time, ensuring effective water consumption and avoiding over-irrigation or water stress.

Conclusion

In conclusion, the integration of artificial intelligence (AI) in agriculture is a significant breakthrough with the potential to revolutionize the sector. AI has diverse applications in agriculture, including supply chain optimization, decision support systems, precision

agriculture, and crop monitoring. By leveraging real-time data, farmers can enhance production, sustainability, and resource efficiency, leading to increased yields, reduced waste, and minimized environmental impact. AI-driven solutions enable precise management of inputs like water, fertilizer, and pesticides, while early detection and intervention capabilities help manage pests and diseases, reducing crop losses and ensuring food security. Although challenges remain, AI holds immense potential in agriculture. By embracing AI-driven innovations and fostering collaboration among stakeholders, the agriculture industry can address global food security concerns, promote sustainability, and create a more resilient and productive agricultural sector.

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