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AI Integration with Agriculture

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A B S T R A C T

AI is an ever developing field of machines and robotics capable of performing tasks that require human limbic functions. Machine Learning(ML) is a type of AI which permits computers to automatically gain new knowledge from existing data without being specifically programmed to do so. The constraints of modern agriculture-perpetually mounting demand, while resources become increasingly scarce-call for leverage AI and ML techniques which optimize resource utilization by analysing relevant data. Nowadays farming has been transformed by the AI predicting numerous input parameters, and forecasting the crop's post-harvest lifecycle. The present chapter highlights the various AI and ML techniques that have been developed and employed across different stages of the agriculture life cycle. This chapter has a vast scope of domain in agriculture that needs AI and ML integration. It incorporates soil and irrigation management alongside diseases management as well. The significance of AI application in the area of Plant Phenomics is also included in this chapter.

In this chapter, the likely application of GIS along with remote sensing integrated with AI is examined. Keywords Artificial intelligence (AI); Machine learning (ML); Agriculture; Recommender system; Phenomics; Geographic information system (GIS); Remote sensing.

Keywords:AI in agriculture, precision farming, crop monitoring, yield prediction, smart farming, automation in agriculture.

1. Introduction

The Artificial Intelligence (AI) deals with the efforts made using various tools and technologies to accomplish activities that Human Intelligence does. These are diverse and include natural language comprehension, understanding, generation, vision, decision, etc. Machine learning and deep learning are the two most popular approaches to AI. Breakthrough technologies of AI have transformed modern life and each facet of it, including agriculture. Major challenges with respect to agricultural production are crop production decision making, crops diseases pest infestation, weather forecasting, yield prediction, advisory systems for enhanced crop productivity, etc. Steak on the fire while green earth is agriculture productivity. Temperature, fertility of soil, water and its quality are the largely influence parameters. To make these predictions, improved AI techniques are being developed. While the latest technological boom has brought some comforts, prospects for small or marginal farmers still appears to be bleak.

Unlike other technologies, AI can reach out to individual farmers more easily and efficently which can result in significant lifestyle improvement for farmer. This world consists of two life cycles of immense consideration, farmers and agriculture. The agriculture cycle starts with land preparation, followed by seed sowing, irrigation, weeding, fertilizer application, pest and disease control, harvesting, post harvesting processing, storage, and marketing. AI has the potential to impact all the phases of the life cycle and certain aspects of it are available while others still require a bit of time. In a smart ecosystem, farmers are guided by artificially intelligent assistants that based on the GIS and remote sensing data of a certain area, determine the most ideal and suitable methods and dates to prepare land. In an enabled supply chain, farmers can collect quality seeds through blockchain after land preparation. Low-cost smart weed controllers can handle scheduled weeding along with fertigation. Pest and disease identification along with management can be dealt by AI-powered mobile applications.

The precision-marketing buyer selection will be done using the predicted yield of the market as calculated through the smart drone application.

Il2. Methodology of AI in Agriculture:

2. Methodology of AI In Agriculture

2.1 Data gathering methods:

- Remote Sensing: Taking satellite images using drones, and other sensors for data capture and remote crop monitoring.

- Internet of Things (IoT): Real-time data collection using IoT sensors from the farm such as soil moisture, temperature, and others.
- Big Data Analytics: Making decisions by analyzing the available sensor data, weather forecasts, and historical yield data makes a lot of sense.

2.2 Machine Learning (ML) and Deep Learning (DL) Approaches:

- Supervised Learning: A category of learning with set guidance where certain identification tasks, such as identifying crop diseases, predicting crop yield, and pest detection.
- Unsupervised Learning: Clustering and anomaly detection to form an alternative approach to trend or pattern detection in crop performance.
- Reinforcement Learning: Taught in precision farming where depending on the environment, irrigation, fertilization, and pesticide use gets optimized.

2.3 AI Algorithms and Models:

- Convolutional Neural Networks (CNNs): Used to recognize images like disease or pest infested crops, and other important plant health assessment images.
- Support Vector Machines (SVM): Identification of different plants for species classification or particular crops for diagnosing various plant diseases fall under the classification approach.
- Random Forests: Selection of features for use in crop classification and prediction of crop yields are some of its purposes.

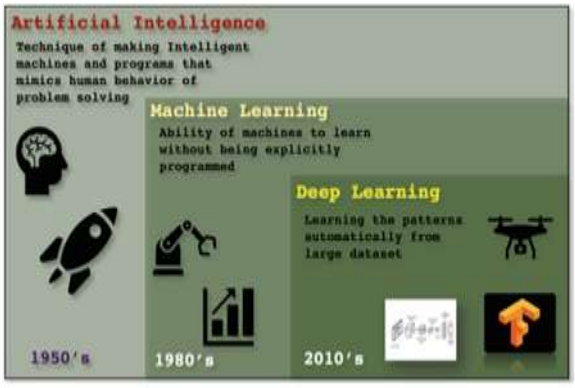

Fig. 21.2 Chronology of artificial intelligence, machine learning, and deep learning concepts

3. Literature Survey:

In this subsection, focus will be directed towards available studies, research papers, and other works done concerning the use of AI in agriculture.

It is possible to classify it in terms of AI applications under Ai Subsections:

Crop Management:

AI has enabled the development of many new methods to increase and reduce crop damage. Often selecting the right crop to harvest is very crucial and directly relates to the health of the crop. Big data seed selection technologies may assist in ecosystem and offshore region selection. Remote sensing methods such as hyperspectral photography and 3D laser scanning can efficiently construct crop matrices on hundreds of square miles of farmland[15]. Monitoring plant development is essential for crop health. Crops as such require 17 most important elements for growth [16]. Different types of computer vision techniques are used to measure and predict agricultural yield. Different techniques have been devised for monitoring most types of agriculture crops. For the case of cotton these include COMAX and COTFLEX[17,18]. In real life COMAX is regarded as the very first expert system developed back in 1986. For soybeans there is other expert system developed based on fuzzy logic [19]. ANN algorithm is crop councilor and crop predictor [20]. Here it is assumed that farmer will propose to apply fertilizer if they wish to grow the crop which is read.

Soaking Software and hyperspectral frame cameras are utilized for observing the nitrogen content of the rice leaf. AI powered sensors and satellites are used extensively to monitor the health of the crop. Monitoring Agriculture is ultimately linked to the health of the crop, numerous sensors powered by AI are utilized. Sensors such as MQ4 and MQ7 are also used to detect carbon monoxide and natural gas respectively. Data obtained from crop dusters can also be utilized to measure temperature and humidity. Artificial neural networks can also predict the yield from the crop based on several parameters such as temperature, rainfall and humidity.

●Pest and disease detection

No diseases leads to abundant crops, but the quality and quantity drastically decreases when a crop is facing some type of issue. These diseases end up costing farmers a lot of money. AI is able to assist with the management of these overpowering diseases. The capture and treatment of a disease can be easily done by farmers. A strengthened focus on precisely classifying leaf wounds has been achieved to aid the integration of CNNs. A Segmentation Based CNN algorithm is able to detect and solve diseases from the serving vegetables leaves. CNN is an example of deep learning algorithm which helps in the identification of diseases. The dataset includes numerous images of healthy and sick plants. in deep learning, cnn models can undergo training and testing on datasets. Computer Vision (CV) technology also approaches the detection of crop disease.

SVMs use machine learning algorithms to identify and categorize diseases using color, texture, and shape of the leaves. All types of pests cause significant damage to crops, including gastropod mollusks, mites, nematodes, and insects. There are two main categories associated with crop damage: external damage and internal damage. The removal of pests is done through the application of AI technology. Identification and target treatment of pests 140 is an AI-based application of image recognition technology. The pest is identified and categorized using the AI algorithm YOLOv3, which uses CNN for this purpose and classifies him as a pest. With minimal effort from a person, CCNN determines the number of pests on a plant using image processing tools [47]. Technologies such as meteorology, computer meteorology, machine learning, and deep learning predict pestilences by studying various weather conditions [48]. Farmers fumigate their crops with pesticides to prevent pest intrusion. Abuse of pesticides is detrimental to the environment. Integrated pest management (IPM) is an environmentally safe method of pest control. Chemical control approaches are often considered less effective in the long term. Managed biopesticides are another option for farmers instead of chemical pesticides. Natural pest control substances that are deemed safe are termed eco-friendly biopesticides. Below is a list detailing the role of AI in weeding, disease identification, and pest management.

● Precision Agriculture:

o AI field management: automated tractors, precise sowing, and fertilization.

The implementation of AI for smart systems of irrigation, as well as for the optimal usage of fertilizers and pesticides.

- Yield Prediction:

The AI techniques used for predicting the yield of crops through the analysis of weather data, soil conditions, and the crop’s history.

The application of deep learning in forecasting production trend.

- Environmental Sustainability:

Application of AI models in optimizing the usage of resources like water and energy in agricultural activities.

The role of AI in sustainable agriculture by minimizing the waste, carbon footprint, and the overall footprint of land usage.

Article	Area	Technique/ Application	Objective	Proposition
Knowledge mapping of machine learning approaches applied in agricultural management—A scientometric review with citespace [64]	Agriculture management	Machine learning	To identify recent research based on machine learning methods in agricultural management Presented in a visualised and quantitative format.	Integrated research of more methods in material management.
Citizen science for sustainable agriculture–A systematic literature review [65]	Sustainable agriculture	Citizen science	To identify emerging trends in citizen-science studies	Increase sample size and make research more stakeholder oriented (Ex. Farmers)
A review of applications and communication technologies for internet of things (IoT) and unmanned aerial vehicle (UAV) based sustainable smart farming [66]	Communication technologies, sustainable smart farming	IoT & UAV based sustainable farming	Identify advantages and usages of IoT and UAV in advanced farming methods, IoT, network functions and network essentials for smart farming	Research required in the areas of resource management, hardware maintenance, security issues arising from connected systems, large scale data maintenance
Research advances and applications of bio-sensing technology for the diagnosis of pathogens in sustainable agriculture [55]	Pathogens detection in sustainable agriculture	Bio-sensing	A review of bio-sensor methods for disease identification in food production and the agricultural industry	Further integration of other techniques in increasing sensitivity of autonomous detection bio-sensors
Integrated technologies toward sustainable agriculture supply chains: missing links [67]	Supply chain	Information communication technology	Finding the missing links in the study of utilizing integrated enabling technologies to achieve sustainable, circular agriculture supply chain	Study the technologies enabling further advancement in reaching UN sustainable development goals
Scientometric analysis of the application of artificial intelligence in agriculture [68]	Agriculture	Artificial Intelligence	Scientometric review to identify the academic collection of the application of artificial intelligence in agriculture	Further research specifically focused on precision farming application of artificial intelligence
Automatic identification of diseases in grains crops through computational approaches: A review [69]	Disease identification	Artificial Neural Network	Review of 109 peer-reviewed articles on early stage detection of diseases on maize, rice, wheat, soybean, and barley to improve production. The article provides an integrated taxonomy of grain plant leaf diseases	Additional accurate classification may be improved by integrating optimization processes or techniques based on fuzzy set theory, rough set theory by utilizing classification algorithms in existing literature
A review of autonomous agricultural vehicles (The experience of Hokkaido University) [70]	Agriculture process automation	Robotics	Review of autonomous agricultural vehicles (AAV), their components and their advantages and disadvantages	Continued development of robotic AAV for the benefit of stakeholder in agriculture
A review of remote sensing applications in agriculture for food security: Crop growth and yield, irrigation, and crop losses [71]	Food security	Remote-sensing	Overview of utilization of satellite remote sensing information in analysis and agriculture management in ecohydrology	Development of algorithms that ascertain the yield in heterogeneous agricultural systems
A systematic literature review on machine learning applications for sustainable agriculture supply chain performance [35]	Supply chain performance	Machine learning	Systematic review of 93 research papers on machine learning (ML) solutions in agricultural supply chain process	Use of ML in transforming present production procedures into data-driven smart manufacturing systems and developing customer focused applications based on consumer purchase behaviour

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4. Conclusion:

Without a doubt, the application of AI technologies have revolutionized the agricultural sector. The advancement of food sustainability, proactive responses to climate change, and proper resource allocation are just some of the benefits provided by smarter AI technologies in farming. Yet there is still a lot of comprehensive study needed in order for AI technologies to be convenient, scalable, and modified for farming communities from all over the world. The promise of optimized socioprogressive SDS in farming lies in the development of AI technologies paired with the set of tools guiding resource conservation and population growth towards vibrant agricultural innovation.

What stands out in the farming sector undergoing evolution is the accelerated focus on integrating diverse domains, coupled with collaboration on enhancing data access along with emphasis on the scalability of solutions driven by AI to ensure Universal access, especially to marginalized smallholder farmers residing in developing regions.

It is apparent that through various methods AI can have profound impacts in regard to the agricultural industry on a global scale by improving the economy and protecting nature.

5.Future Directions:

□Precision and intelligent agriculture

□AI for climate-wise sustainable farming

Edge AI and affordable technologies

Farmers-centered explainable AI

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