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Artificial Intelligence in Agriculture

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Abstract

Artificial intelligence (AI) involves the construction of intelligent machines that can perform tasks that traditionally require human intelligence. To feed the rising world population, food production needs to increase. Data intensive methods in artificial intelligence can be us ed to increase agricultural productivity. AI could transform agricultural techniques such as soil management, water requirement analysis, precise modelling of fertiliser, pesticide, insecticide, and herbicide requirement, yield projection, and overall crop management for increasing the global agricultural productivity.

Keywords: Artificial Intelligence, Crop management, Machine learning, Sensors

Introduction

The global economy is largely dependent on the agricultural sector. With the rise in world population the pressure on the agriculture system also increases. Artificial Intelligence (AI) has emerged as a new scientific discipline that uses data-intensive methods to increase agricultural productivity with reduced environmental pollution. AI is spreading quickly due to its wide range of applications, rapid technological improvement, and capacity to handle issues that are particularly difficult for people and conventional computing systems to address well.

What is Artificial Intelligence?

Artificial intelligence is a branch of computer science concerned with building smart machines which can perform tasks that typically require human intelligence. Traits of human intellect are used for development and implementation as computer-friendly algorithms. AI is widely used in different fields to make life easier.

History of AI dates back to 1956 and was first described during a workshop at Dartmouth College in the United States. Alan Mathison Turing is considered as a pioneer in the field with his idea that the human brain operates essentially like a computer. He proposed the concept of self-learning and self-instructed machines that learn from their own experiences as a human being does.

Internet of Things (IoT)

"Smart farming" is a general term for the use of modern technologies in agriculture. An extensive network of electronically interconnected devices and items is referred to as the "Internet of Things." The devices, or "things," in this case, are digitally connected to one another via the internet. IoT allows for reliable connectivity between the physical and digital worlds. Sensors are the devices that gather data from the external environment and replace it with a signal that both people and machines can recognise. Sensors can help in crop assessment thereby leading to increase in productivity. A wide variety of sensors, such as soil sensors, humidity sensors, light sensors, air sensors, temperature sensors, and CO_2 sensors are utilised in smart agriculture. Low altitude airborne hyperspectral photography and the use of sensors to track farm conditions could revolutionize agriculture. Gathering data on temperature, precipitation, humidity, wind speed, pest infestation, and soil composition are examples of IoT applications in agriculture. This information can be used by automated farming methods to make wise decisions that will increase crop quality and quantity, reduce waste and danger, and reduce manual work load management (Linaza *et al.*, 2021).

Unmanned vehicles systems are mobile Aerial or Terrestrial platforms which provide numerous advantages for the

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execution and monitoring of farming activities. The combination of unmanned aerial vehicles with advanced cameras, sensors and GPS technologies can help to discern specific weeds, pest and disease infestation and also provide geographical information for field mapping, and can help in precisely monitoring of large farm areas within a short span of time.

Applications of Artificial Intelligence in Agriculture

Artificial Intelligence can be applied in the agricultural field for automation of irrigation, soil monitoring, automated harvesting, diagnosis of pest and diseases, weed management *etc*. (Figure 1).

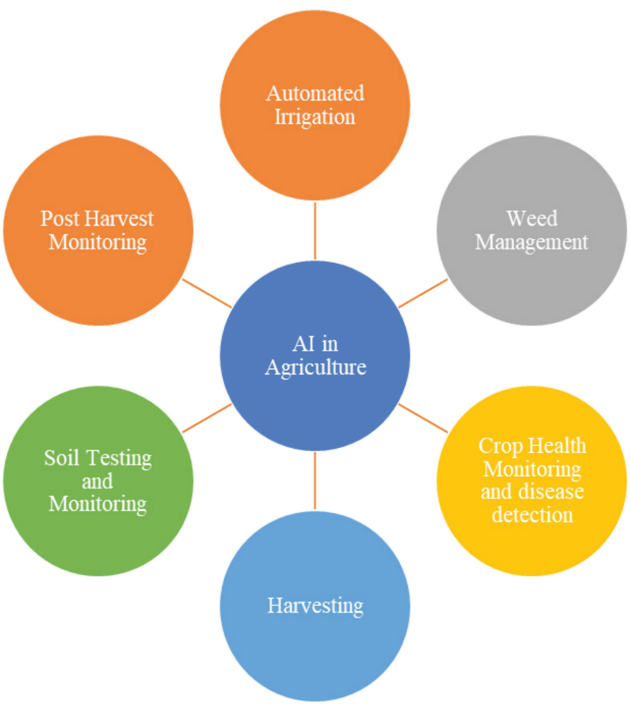

Figure 1: Applications of artificial intelligence in agriculture

Automated Irrigation

Crop output is significantly influenced by irrigation, which is mostly dependent on topological, climatic, and geographic factors. Irrigation based on just observation of the field by the farmer is highly inefficient and inconsistent. It is necessary to have an irrigation system that the farmers can rely on permanently, one that can adapt to the local climate and properly estimate how much water the crops would need in real time to ensure efficient use of water resources and improved agricultural yield. AI based intelligent systems based on local rainfall pattern, weather parameters, soil humidity assessment sensors *etc*. can be used for irrigation that can predict the quantity of water needed for irrigation in order to minimize wastage and increase the crop yield.

Weed Management

In modern agriculture, herbicides are often sprayed freely across the farmland to control weeds. Often overuse of herbicides leads to severe environmental pollution. One method to reduce expenses and adverse impacts on the environment is to use the appropriate amount of herbicide at the appropriate time and place. With very high spatial resolution and at a reasonable cost, precision agriculture systems may capture images of the entire agricultural area. Unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs) can provide quick and efficient data collection since they quickly acquire the complete crop area with a very high spatial resolution and at a low cost. The herbicide can be sprayed accurately on the precise location where the weeds are present to avoid unnecessary wastage of herbicide chemicals.

Crop Health Monitoring and Disease Detection

Machine learning algorithms applied to image datasets and including environmental variables can be used in data analysis systems to produce insights on a variety of indices important to crop development and quality. AI can be effectively used for tracking crops throughout their lifecycle and generate reports in the event of anomalies. Healthy plants often reject majority of the infrared spectrum whereas the diseased plants absorb it. This information is useful for figuring out whether a plant is infected, deficient in nutrients, or too dry. The amount of nitrogen is usually linked to the chlorophyll content of the crops and in turn the greenery of the field. Infestation by pests, disease incidence, weed cover, water logging, yield vegetation index etc are used as indices for the purpose.

Spraying pesticides evenly across the crop field is the commonly used method of controlling pests and diseases. Despite being ineffective, this method leads to high economic loss and environmental pollution. Remains of the pesticide in agriculture products, consequences of ground water contamination, effects on local animals and eco-systems, and other things can have an impact on the environment. With the aid of various Machine Learning and Deep Learning (DL) techniques, various systems for the autonomous detection of plant diseases are also being proposed.

Harvesting

Efforts are undertaken to use advances in DL and AI algorithms to automate and improve the current agricultural harvesting processes. Manual labour involved in harvesting can be decreased by using automated fruit harvesting robots.

Identification and localisation of the fruit on the trees using appropriate sensors and collection of the fruit using robotic arms without hurting the target fruit and tree are done with specialised techniques that use colour, spectral, or thermal cameras. Often, it is challenging to identify a fruit that is cast in shadow by another fruit when using a spectral camera (Onishi *et al.*, 2019). Thermal cameras work based on the temperature difference between the fruit and the background for identification of fruits.

Soil Testing and Monitoring

Natural resource soil is heterogeneous and has difficult-to-understand complex processes and systems. Soil parameters are used to comprehend how agriculture affects ecosystem dynamics. A precise assessment of the state of the soil can result in better soil management. Numerous machine learning (ML) applications exist for predicting and identifying the characteristics of agricultural soil, including estimations of the soil condition, temperature, and moisture content.

For an accurate examination of a region's eco-environmental conditions and the effects of climate change, soil temperature plays a crucial role. It is a crucial meteorological variable that regulates the interactions between the atmosphere and the earth. In addition, crop yield variability is significantly influenced by soil moisture. However, soil measurements are typically time-consuming and expensive, therefore using computer analysis based on ML approaches can result in a low cost and dependable solution for the precise assessment of soil. Soil mapping, remote sensing, and environmental data are used to estimate some SQI (Soil Quality Index) (Sankey *et al*., 2021).

Post-Harvest Monitoring

Agricultural packaging industry can make use of AI-based fruit monitoring and grading systems to replace traditional manual inspections. Sorting and grading of fruits are done based on calibrations for parameters such as colour, size, shape, mass, and defects. Unstructured features of fruits and environmental complexities along with machine vision challenges often lead to the requirement of advanced AI detection systems for effective monitoring and grading.

Challenges Faced by AI

Although AI offers tremendous potential for agriculture applications, there is currently a lack of understanding of cutting-edge high-tech machine learning solutions in farms all over the world. In order to develop their algorithms and produce precise forecasts and predictions, AI systems also require a large amount of data. When there is a huge quantity of agricultural land, collecting spatial data is easy; but, collecting temporal data is more challenging. Often the data can be collected only during the cropping season. As databases need time to grow, creating a trustworthy AI machine learning model requires a lot of time.

Conclusion

The ability of a machine to mimic the capabilities of living systems, notably the intelligence of a person, is one of the greatest achievements that have been witnessed. One essential aspect of biological systems is the capacity for object recognition and decision-making. Many of the cognitive and perceptual capabilities of living systems are presently used by AI to detect objects and make judgements. Robotics and Autonomous Systems (RAS) are destined to change global industry. Large economic sectors with poor productivity, like the agro-food sector, will be greatly impacted by these technologies (food production from the farm to the retail shelf).

AI intervention can play a very significant role in revolutionising different agricultural practices such as soil management, water need analysis, precise modelling of fertilizers, pesticides, insecticides and herbicides requirement for better overall crop management. Effective use of AI in farm management system can improve agricultural productivity. Agriculture, and bio-based companies, will be tremendously benefitted by applying AI capabilities.

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