Survey on AI based system in agricultural field

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Abstract:

Agriculture plays a significant role in a country's economy; however, the industry faces various challenges such as climate changes, natural calamities, and limited resources. One way to address these challenges is by implementing Artificial Intelligence (AI) technology in the agricultural sector. This paper aims to explore the potential benefits of AI-based systems for agriculture and provide an overview of the existing research. The study is based on an extensive literature review of academic journals, research papers, and industry reports. The paper provides an in-depth insight into how AI can revolutionize the agriculture sector by addressing various challenges that the industry faces. The research identifies AI-based systems that can help farmers increase productivity, reduce costs, and improve agricultural output quality. The use of machine learning algorithms can help predict the weather, soil moisture level, and pest infestation, enabling farmers to make better-informed decisions about crop production. AI-based tools can help detect crop diseases earlier, allowing for early treatment and faster response time. AI-based systems can also optimize the processing and distribution of agricultural products through automated systems that can adjust for supply chain factors such as demand, warehousing, and logistics. Furthermore, this paper identifies several challenges in adopting AI in the agricultural sector, such as a lack of awareness, cost, and limited access to technology. The research also suggests solutions that can help overcome these challenges, such as government support, subsidies, and partnerships with tech companies. This paper concludes that AI-based systems can significantly benefit the agriculture sector by improving crop yield, reducing costs, and addressing safety issues. While AI implementation requires significant investment, the long-term economic and social benefits are substantial. The paper also emphasizes the need for continued research, development, and adoption of AI-based systems in the agriculture sector.

Keywords:

AI-based systems, agriculture, crop yield prediction, crop disease detection, precision farming, sustainable farming practices, deep learning, big data analytics, autonomous farming systems.

Introduction:

Agriculture plays a crucial role in the growth and development of the economy of any country. With the continuous increase in population growth, the need for food production has become more important than ever. To achieve this, modern farming techniques have been introduced that rely on the use of artificial intelligence (AI) systems. These systems allow farmers to optimize their agricultural practices, resulting in improved crop yield and quality while reducing resource consumption. In this survey paper, we will study the role of AI-based systems in agriculture, specifically in the improvement of agricultural sites and the production of crops. We will provide a comprehensive literature review of the research done in this field, highlighting the benefits, challenges, and future prospects of AI in agriculture.

Literature Review:

AI-based systems in agriculture have been extensively studied in recent years. One of the significant areas of research is crop yield prediction, which utilizes machine learning algorithms to forecast yield based on various data sources such as weather information, soil data, and crop growth history. Raji and Balaraman (2020) utilized machine learning and big data analytics to predict the yield of soybean crops. The authors achieved high accuracy in predicting the yield, indicating that their model could be used to optimize farming practices. Another area of research is crop disease detection. AI systems have been developed to detect and diagnose crop diseases using image recognition techniques. Wang et al. (2019) proposed a deep learning algorithm for the detection of cucumber diseases. The authors reported high accuracy in the identification of diseases, providing farmers with an efficient tool for early detection and timely intervention.

AI can also be used for crop irrigation management. An AI-based irrigation system can monitor various environmental factors such as temperature, humidity, and soil moisture and provide the optimal amount of water required by the crops. Yu et al. (2021) developed an intelligent irrigation system based on a neural network algorithm that significantly improved water use efficiency while maintaining optimal crop growth conditions. Another promising application of AI in agriculture is precision farming, which allows farmers to optimize their agricultural practices based on real-time data. Zhou et al. (2021) proposed an AI-based system for greenhouse crop production. The system utilized an intelligent monitoring system that collected data on various environmental factors and used a decision-making model to suggest appropriate farming practices. The authors reported significant improvements in crop yield and quality, indicating the potential of AI in precision farming.

Data-Driven Management for Modern Agriculture:

It is necessary to effectively process the raw measurements of important crop metrics so that data can be reliably derived from numbers or images. Although crop management based on field data had already advanced thirty years prior to the invention of Precision Agriculture, the current digital information era has undoubtedly changed it. Field management traditionally, and in places where technology has not yet arrived, is visually examining the development of crops to make a diagnostic that helps farmers decide and implement offering their crops various treatments. This strategy is based on facts seen through the eyes of farmers and field experience. Associated growers may also abide by the advice of cooperative technicians or engineers employed by the organisation to which they belong. According to the operational cycle depicted in Figure 1, field management differs in farms that have adopted modern technology. The actual crop to manage is the first step in this management method, which capitalises on the crop's inherent variability, both spatially and temporally. The platform is the actual tool used to gather data, and the sensors are the particular components by means of which objective data are gathered. Data is any information that has been directly obtained from parameters that have been monitored in the crop, soil, or environment. There are many ways to retrieve the sensor data, including using software applications that are synced to the Internet or plugging a pen drive into a USB port to access the files. Filtering procedures and AI algorithms are used at the intersection of the data and decision stages to obtain only the relevant data and support the grower in making informed decisions. Last but not least, actuation describes the actual physical carrying out of an action ordered by the decision system. This is often done by sophisticated machinery that can take commands from a computerised control unit. The cycle begins and ends at the crop level as each operation is performed over the crop; the response of the crop is then tracked by specialised sensors, and the loop is repeated repeatedly until harvest, which denotes the conclusion of the crop life cycle. [24]

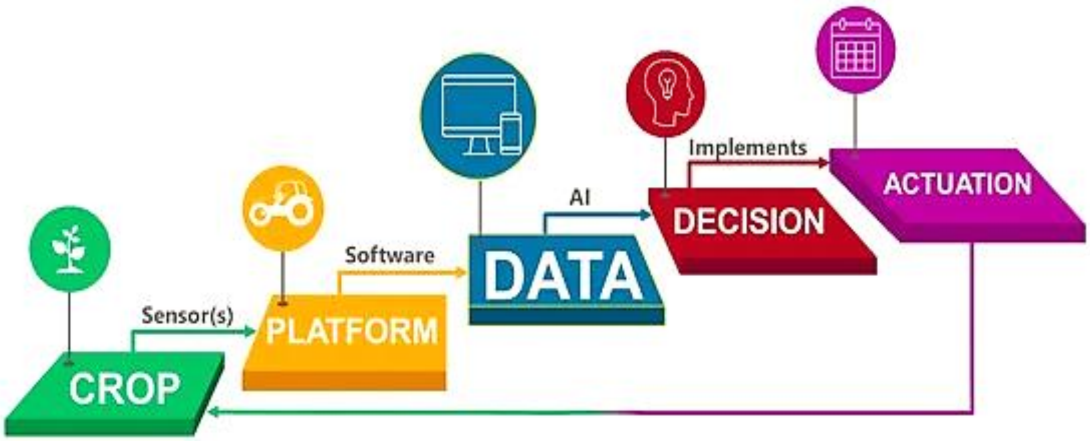

Figure 1: Data-Driven Management for Modern Agriculture [35]

Benefits of AI-based Agriculture systems:

1. Precision Farming: AI-based precision farming aims to optimize agricultural operations by gathering and analyzing real-time data using sensors and Machine Learning algorithms. This data includes various information such as weather patterns, soil conditions, crop growth, and nutrient levels. AI algorithms then analyze this information to provide actionable insights to farmers that can help them make informed decisions about their farming practices. AI-based precision farming allows farmers to monitor their crops constantly, enabling them to identify potential issues early on, such as pest infestations or nutrient deficiencies, and take appropriate action. [3] [4] AI algorithms also enable farmers to optimize planting and harvest schedules based on weather patterns and other environmental factors, reducing waste and increasing yield. One of the key advantages of AI-based precision farming is increased efficiency and cost savings. By automating data collection and analysis, farmers can save time and resources by identifying and addressing issues before they become major problems. Additionally, AI can help farmers reduce the use of pesticides, fertilizers, and water, minimizing environmental impact and lowering costs. Another important benefit of AI-based precision farming is increased sustainability. By optimizing farming practices and reducing waste, AI can help farmers produce more crops without harming the environment, ensuring long-term viability and profitability. AI-based precision farming represents a major breakthrough in agriculture by utilizing technology to optimize farming practices and increase sustainability, enabling farmers to produce more crops with fewer resources and less environmental impact. [6] [11]

Figure 2: Precision Farming [32]

2. Machine Learning in agriculture: Machine learning, a subset of artificial intelligence, enables computers to learn from data and enhance their performance without being explicitly programmed. This technology can revolutionize farming and crop production in numerous ways, from increasing crop yield to improving food safety. In this essay, we will explore some of the future aspects of machine learning in farming and crop production. One of the fundamental ways in which machine learning can help farmers is by predicting weather patterns and soil health. Through machine learning algorithms, farmers can better predict crop yield and plan their farming strategies accordingly. [5] [7] By analyzing historical data on weather and soil conditions, machines can predict the best time to plant, water and harvest crops. This can lead to higher crop yields, more efficient usage of resources, and ultimately increased profitability for farmers. Another area in which machine learning can significantly impact farming is through precision agriculture. Farmers can use machine learning algorithms to create precise maps of their fields, identifying problem areas that require additional fertilization or irrigation. They can then develop precise plans to address these issues in a targeted way, leading to less waste, more efficient resource usage, and better crop yields. This can potentially lead to the reduction of costs, maximization of profits and better environmental impact. Machine learning can also benefit the agricultural industry by helping to improve food safety. By monitoring food production processes in real-time, machine learning can detect and prevent contamination, ensuring safer, healthier food products. Additionally, farmers can use machine learning to track inventory and monitor product quality, improving supply chain processes and reducing the risk of food waste and ecological impact. Another exciting aspect of machine learning in agriculture is the potential to automate many farming processes. With the help of sensors and cameras-equipped drones, machines can perform tasks such as crop monitoring and picking, pruning of plants and automated weed identification. This will not only save time and energy for farmers but also reduce the need for manual labor and minimize human error. [8] [10]

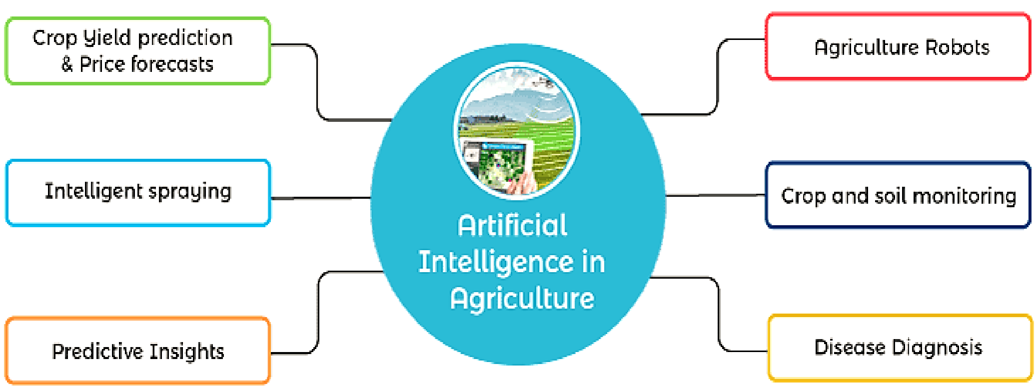

Figure 3: Machine learning in agriculture [34]

3. Computer vision: Computer vision has several applications in agriculture. Some of them are:

Crop Monitoring: Computer vision algorithms can analyze images of crops to monitor their growth and detect any signs of disease or pests. By using drones equipped with cameras or fixed cameras in fields, farmers can collect data on crop health and growth patterns. This helps them make informed decisions about when to irrigate, fertilize or spray pesticides. [12] [29]

Yield Estimation: Computer vision algorithms can also be used to estimate crop yield by analyzing images of fields. By analyzing the size and density of crops, the algorithms can predict the potential yield of the crop. This helps farmers plan their harvesting schedule and estimate their profits. [9]

Fruit and Vegetable Sorting: Computer vision can be used to sort fruits and vegetables according to size, shape, color, and defects. This can help reduce the amount of manual labor required in sorting and grading of produce. It also ensures that only high-quality produce is sent to market, reducing food waste and increasing profits. [27]

Livestock Monitoring: Livestock monitoring is another area where computer vision can be used. By using cameras equipped with computer vision algorithms, farmers can analyze animal behavior, detect signs of illness, and monitor feeding and watering patterns.

Land Management: Computer vision can also be used for land management. By analyzing satellite imagery or drone images, farmers can analyze the condition of the soil and crops in different areas of their fields. This helps them optimize their planting strategies and improve their overall crop yields. [26]

Computer vision has the potential to revolutionize the way that farmers manage their crops and livestock. By analyzing data in real-time, farmers can make more informed decisions that help maximize their profit while minimizing their environmental impact. [13]

4. Automation: Automation in farming is the use of technology and robots to automate various agricultural tasks and processes. This includes everything from planting, watering, and harvesting crops to monitoring crop health, using precision agriculture techniques, and managing livestock. There are various types of automation technologies used in agriculture such as drones, autonomous tractors, robotic harvesters, GPS-enabled equipment, and sensors for monitoring soil moisture, temperature, and other environmental factors.

The use of automation in farming has several potential benefits. It can improve efficiency and productivity, reduce labor costs, enhance crop yields and quality, and increase sustainability by using resources more efficiently. Automation also allows farmers to monitor their crops more closely and proactively respond to issues like weather changes or pest attacks. [28]

One of the primary areas where automation is already making a significant impact is precision agriculture. Precision agriculture involves using data and technology to manage agricultural land more efficiently, with a focus on identifying disparities in crop health and optimizing nutrient and water usage. The use of automation in precision agriculture allows farmers to apply the right amount of inputs at the right time and in the precise area where they are needed, reducing waste and enhancing the quality of the crop. [23]

Automation in farming is a growing trend that holds enormous potential for improving agriculture efficiency, sustainability, and profitability. With the increasing demand for food globally, the deployment of automation is expected to play a vital role in meeting the growing food need. [25]

Figure 4: Automation in agriculture [33]

5. Data Analytics: From its traditional roots in the past, agriculture has gone a long way. It has developed as an industry from a period where it just relied on advice from other farmers to a contemporary, data-driven endeavour. Today's farmers can use historical data and insights to do a thorough analysis of the crop to plant and the cultivation technique to apply. Data analytics is now permeating centuries-old agricultural processes to eliminate inconsistencies and boost productivity in perishable foods handling, irrigation, harvesting, supply chain management, and logistics. AI-based systems can help farmers make informed decisions based on data insights obtained from previous years' crop yields, soil productivity, weather patterns, and much more. [16] [17]

6. IoT-enabled solutions: IoT smart agricultural solutions are made to assist in crop field monitoring using sensors and irrigation system automation. As a result, farmers and related brands can quickly and hassle-free monitor field conditions from anywhere. By using robots, drones, sensors, and computer imagery together with analytical tools to gather data and monitor the farms, precision agriculture utilises IoT in agriculture. By placing physical equipment on farms, data is monitored and recorded, and this information is subsequently used to get insightful knowledge. Also, IoT devices such as weather sensors, soil moisture monitors, and other internet-connected sensors can provide real-time information that can be analyzed by AI systems to create more accurate decision-making models and provide better insights. [1] [2]

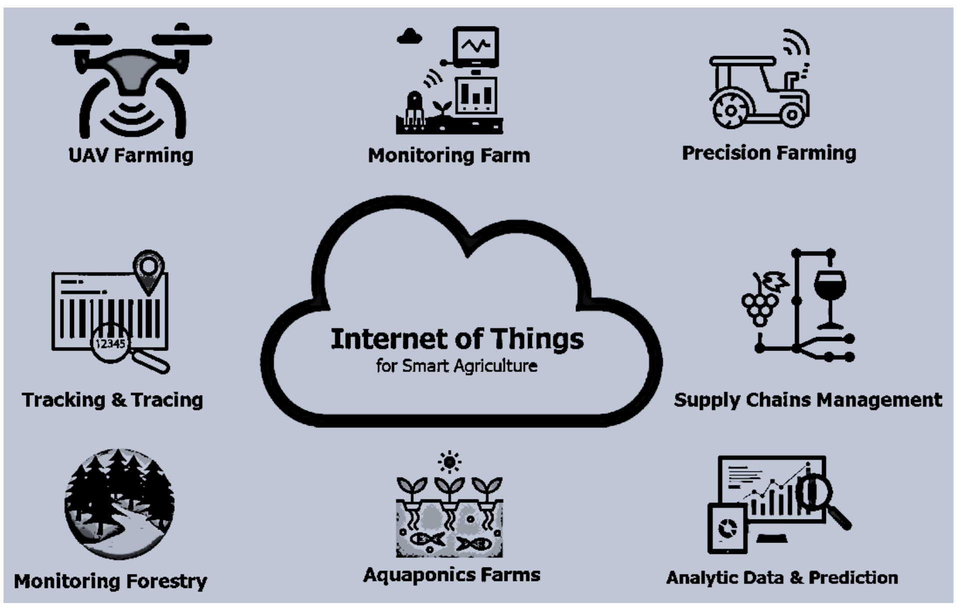

Figure 5: IOT for smart agriculture [31]

7. Sustainability: Sustainability in AI farming involves the use of sustainable agricultural practices and minimizing negative environmental impacts. AI technologies can help farmers use resources more efficiently by providing them with real-time data and analytics that enable them to optimize crop growth, reduce water usage, and minimize the use of harmful chemicals. Precision agriculture is a major area where AI technology can be deployed to promote sustainability. Through the use of sensors and machine learning algorithms, AI can collect and analyze data on soil moisture, temperature, and nutrient levels in real time. This data can then be used to precisely and efficiently distribute water and fertilizer to crops, which reduces waste and helps improve crop yields. [15] [30]

Another emerging area of AI farming is robotic farming, which involves the use of autonomous machines for tasks such as planting, harvesting, and weeding. Robotic farming can help reduce labor and increase efficiency, which can contribute to sustainability by reducing the use of fossil fuels and minimizing the carbon footprint of agricultural operations. [20]

Additionally, AI can aid in predicting climate changes and weather patterns that could affect crop yield, allowing farmers to adapt their planting strategies and crop choices accordingly to mitigate risks. Although AI-based farming methods are still in their early stages, they have the potential to greatly benefit the environment and promote sustainability in agriculture. By leveraging AI technology, farmers can enhance their ability to produce food while minimizing their environmental impact. [19]

Challenges:

Despite the benefits of AI in agriculture, some challenges need to be addressed. One significant obstacle is the accessibility of data, which is essential for the development of AI models. Data collection from remote or rural agricultural areas can be challenging and expensive, limiting the development of AI-based systems in these regions. Another challenge is the lack of technical expertise and awareness among farmers, preventing them from utilizing AI-based systems to their full potential. [18]

1. Data Management: One of the biggest challenges of AI in farming is data management. Collecting and processing data from various sources, such as weather stations, soil sensors, drones, and satellite imagery, can be a complex and time-consuming process. In addition, the data needs to be accurate, relevant, and updated in real-time. [21]

2. Adaptation to Local Conditions: Farming practices and conditions differ greatly across different regions and geographies. AI applications, therefore, need to be adapted to these local conditions to ensure optimum results. Agricultural practices can vary even within a single farm or field, requiring AI tools to be flexible enough to adapt to these variations.

3. Cost and Accessibility: Implementing AI in farming can be expensive and may not be accessible to all farmers. Many small farmers do not have access to the necessary technology, expertise, or funding to implement AI applications.

4. Ethical and Legal Concerns: As AI tools continue to become more advanced, there are growing concerns about the ethical and legal implications of their use in farming. Concerns center around data privacy, potential bias in decision-making, and the use of AI to replace human labor in agriculture.

5. Lack of Interoperability: The use of multiple AI applications from different providers can lead to a lack of interoperability between platforms, making it difficult to integrate data and achieve seamless collaboration between different systems.

6. Dependence on Technology: The adoption of AI may lead to a greater dependence on technology, which may not always be reliable or accessible, and can be a cause of concern for farmers in developing countries or those in remote locations.

Future prospects:

AI-based systems in agriculture have enormous potential for the development of sustainable farming practices. With advancements in AI technologies such as deep learning and big data analytics, we can expect more efficient and accurate models for crop yield prediction, disease detection, and other applications. The integration of AI with drones and robotics can also lead to the development of autonomous farming systems, reducing labor costs and increasing productivity. [22, 36-37]

Conclusion:

This survey paper provides a comprehensive review of the research done in the application of AI systems in agriculture. The review presents the benefits, challenges, and future prospects of using AI in agriculture. Based on the literature review, it can be concluded that AI-based systems can significantly improve agricultural practices, leading to improved crop yield and quality while reducing resource consumption. However, the challenges of data accessibility and technical expertise need to be addressed to realize the full potential of AI in agriculture.

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