Keynote Speech

Agriculture 5.0: Smart Agriculture, AI, Iot, Society 5.0, Big Data Analytics, Blockchain, Digital Twins, Robotics, Drones and Immersive Reality

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Abstract
Agriculture is transforming due to Agriculture 5.0, including smart agriculture, AI, IoT, Society 5.0, big data analytics, blockchain, digital twins, robotics, drones and immersive reality, and digitally delivered services and apps. There are numerous examples at various points in the agriculture value chain: traceability technologies and digital logistics services have the potential to streamline agri-food supply chains while also offering consumers reliable data, information, knowledge; remote satellite data and in-situ sensors increase accuracy and lower the cost of crop growth and water or land quality monitoring; automated farm equipment allows for fine-tuning of inputs and decreases the need for manual labour. The development and application of mobile technology, distributed computing, and remote sensing services are now enhancing smallholders' admittance to data, information, knowledge, financing, markets, and education in the agriculture. Digital technologies are creating new opportunities to include smallholders in a digitally driven agriculture. The entire agriculture chain will shift as a result of digitalization. It is possible to achieve highly optimal, customized, intelligent, and anticipatory resource management throughout the real-time and hyperconnected system. Traceable and coordinated value chains will be more precisely, allowing for managing various farms, crops, and animals according to their unique ideal prescriptions. Digital agriculture will result in highly productive, proactive, and responsive systems to changes like those caused by climate change. This could result in improved sustainability, profitability, and food security. The technologies employed frequently draw on the ideas of the Internet of Things and include sensors, communication networks, unmanned aerial systems (UAS), artificial intelligence (AI), robotics, and other cutting-edge gear. Digital agriculture can increase productivity, consistency, and resource and time usage. This has significant advantages for farmers as well as global social gains. Creating new, disruptive opportunities allows organizations to share data, information, knowledge, across conventional industry borders. According to our research, the following development in Agriculture 5.0 research, recent developments, policy, and practice need to be reflected: smart agriculture, AI, IoT, Society 5.0, big data analytics, blockchain, digital twins, robotics, drones and AR/VR/immersive reality.

Keywords: Smart agriculture, Artificial Intelligence (AI), Internet of Things (IoT), Society 5.0, Big data analytics, Blockchain, Digital twins, Robotics, Drones, Immersive reality

Introduction

Agriculture is the backbone of many economies worldwide. In recent years, the application of technology in agriculture has become increasingly prevalent, leading to the emergence of Agriculture 5.0. Agriculture 5.0 refers to the use of smart agriculture, Artificial Intelligence (AI), Internet of Things (IoT), Society 5.0, big data analytics, blockchain, digital twins, robotics, drones, and immersive reality in agriculture. These technologies have the potential to revolutionize the agriculture industry, making it more efficient and sustainable. In this paper, we will explore the various technologies that make up Agriculture 5.0 and their potential impact on agriculture.

Smart Agriculture

Smart agriculture is an emerging concept that involves the use of various technologies such as AI, IoT, big data analytics, and drones to optimize agricultural production. The goal of smart agriculture is to enable farmers to make more informed decisions by providing them with real-time data on crop health, soil moisture, and weather conditions. Smart agriculture can also help farmers reduce water usage, fertilizer and pesticide application, and increase crop yields. One example of smart agriculture is precision agriculture, which involves the use of sensors and GPS technology to map fields, track crop growth, and monitor soil health. Another example is smart irrigation systems, which use real-time weather data and soil moisture sensors to optimize irrigation scheduling. Smart agriculture has the potential to revolutionize the agricultural industry by making it more efficient, productive, and sustainable. According to a report by the Food and Agriculture Organization of the United Nations, smart agriculture has the potential to increase crop yields by up to 70%, reduce water usage by up to 50%, and reduce fertilizer usage by up to 30%. However, the widespread adoption of smart agriculture will require significant investments in technology and infrastructure, as well as education and training for farmers to effectively use these tools (FAO, 2019).

Artificial Intelligence (AI)

Artificial intelligence (AI) is a key technology that is increasingly being used in agriculture to improve crop yields, reduce costs, and increase efficiency. AI can be used in a variety of ways in agriculture, including crop monitoring, disease detection, and yield prediction. AI algorithms can analyze large amounts of data from sensors, satellite imagery, and weather stations to provide farmers with real-time information on crop health, soil moisture, and weather conditions. This information can help farmers make more informed decisions about irrigation scheduling, fertilizer application, and crop management. One example of AI in agriculture is the use of computer vision algorithms to identify plant diseases. Researchers have developed AI algorithms that can analyze images of crops to identify signs of disease, allowing farmers to take action before the disease spreads. Another example is the use of machine learning algorithms to predict crop yields based on weather patterns and soil moisture levels. AI has the potential to revolutionize agriculture by enabling farmers to make more informed decisions and optimize their operations. According to a report by the International Data Corporation, the market for AI in agriculture is expected to grow from $214 million in 2019 to $816 million in 2024 (IDC, 2020).

Internet of Things (IoT)

The Internet of Things (IoT) is a technology that enables the connectivity and exchange of data between physical devices and systems over the internet. In agriculture, IoT can be used to improve crop monitoring, precision farming, and resource management. IoT sensors can be deployed throughout fields to collect data on soil moisture, temperature, and other environmental factors. This data can be analyzed in real-time to inform decisions on irrigation scheduling, fertilization, and crop management. IoT can also be used to optimize equipment and machinery, reducing downtime and increasing productivity. For example, IoT sensors can be used to monitor the health and performance of tractors and other farm machinery, allowing farmers to schedule maintenance and repairs before they break down. The use of IoT in agriculture is growing rapidly. According to a report by MarketsandMarkets, the global market for IoT in agriculture is expected to grow from $9.06 billion in 2018 to $26.76 billion by 2023 (MarketsandMarkets, 2018). However, the widespread adoption of IoT in agriculture will require significant investments in technology and infrastructure, as well as education and training for farmers to effectively use these tools.

Society 5.0

Society 5.0 is a concept introduced by the Japanese government that envisions a society where technology, including AI, IoT, and other advanced technologies, is used to solve social problems and create a more sustainable future. In the context of agriculture, Society 5.0 envisions the use of technology to improve food security, reduce waste, and promote sustainable agriculture practices. Society 5.0 emphasizes the importance of collaboration and partnerships between different sectors of society, including government, academia, and industry. In agriculture, this means bringing together farmers, researchers, and technology companies to develop and implement innovative solutions that address the challenges facing the industry. One example of Society 5.0 in agriculture is the development of precision agriculture technologies, such as smart irrigation systems and crop monitoring tools, that use data and analytics to optimize crop yields while minimizing environmental impact. Another example is the use of blockchain technology to improve transparency and traceability in the food supply chain, ensuring that consumers have access to safe, high-quality food. The Society 5.0 concept is gaining traction around the world, with governments and organizations recognizing the importance of using technology to address social and environmental challenges. In 2019, the United Nations launched the Society 5.0 Global Initiative to promote the use of technology for sustainable development (United Nations,2019).

Big Data Analytics

Big data analytics refers to the process of analyzing large and complex data sets to uncover patterns, trends, and insights. In agriculture, big data analytics can be used to inform decisions on crop management, resource allocation, and risk management. One example of big data analytics in agriculture is the use of satellite imagery and weather data to predict crop yields and identify areas that are vulnerable to drought or other environmental risks. This information can be used to inform decisions on irrigation, fertilization, and other crop management practices. Big data analytics can also be used to optimize supply chain management and reduce waste in the food system. By tracking data on crop yields, transportation, and storage, farmers and food companies can identify inefficiencies in the system and develop more efficient and sustainable practices. The use of big data analytics in agriculture is expected to grow significantly in the coming years. According to a report by ResearchAndMarkets, the global market for big data analytics in agriculture is expected to grow from $864.4 million in 2018 to $2.3 billion by 2023 (ResearchAndMarkets, 2018). However, the widespread adoption of big data analytics in agriculture will require investments in technology and infrastructure, as well as education and training for farmers to effectively use these tools.

Blockchain

Blockchain is a distributed ledger technology that allows for secure and transparent transactions without the need for intermediaries. In agriculture, blockchain technology can be used to improve supply chain transparency and traceability, as well as reduce food fraud and increase food safety. By using blockchain technology, farmers and food companies can track the movement of food products from farm to table, allowing for greater transparency and accountability in the supply chain. This can help to build trust between consumers and food producers, and ensure that consumers have access to safe and high-quality food. In addition, blockchain technology can be used to reduce food waste by providing real-time information on food products, including their origin, quality, and freshness. This can help to reduce waste in the supply chain and ensure that food products are delivered to consumers in a timely and efficient manner. The use of blockchain technology in agriculture is still in its early stages, but there are several initiatives underway to explore its potential. For example, IBM has partnered with Walmart and other companies to develop a blockchain-based system for tracking the movement of food products through the supply chain (IBM, 2019).

Digital Twins

Digital twins are virtual models that replicate the physical characteristics and behavior of a real-world object or system. In agriculture, digital twins can be used to create a virtual representation of a crop or livestock system, allowing farmers to monitor and optimize their production processes in real-time. By using digital twins, farmers can simulate different scenarios and test the effects of different management practices on crop yields, water usage, and soil health. This can help to improve crop productivity and reduce the use of resources, such as water and fertilizers. In addition, digital twins can be used to monitor and optimize livestock production systems, such as animal health, feed efficiency, and waste management. This can help to improve the overall efficiency and sustainability of the livestock industry. The use of digital twins in agriculture is still in its early stages, but there are several initiatives underway to explore its potential. For example, Microsoft has partnered with the European Space Agency to develop a digital twin of a wheat farm, which can be used to optimize irrigation and fertilizer use (Microsoft, 2020).

Robotics

Robotics has been increasingly used in agriculture to automate labor-intensive tasks such as planting, harvesting, and weeding. Agricultural robots are equipped with sensors and cameras that can detect and analyze data on soil moisture, crop health, and yield, allowing farmers to make data-driven decisions to optimize their production processes. In addition, robots can be used to reduce the use of chemicals and pesticides in agriculture, as they can accurately apply chemicals only to areas where they are needed, minimizing waste and environmental impact. They can also work around the clock, which can help to increase crop yields and reduce labor costs. Some examples of agricultural robots include the LettuceBot, which can thin and weed lettuce crops, and the Agrobot, which can pick strawberries. The use of robotics in agriculture is expected to grow in the coming years, as farmers seek to increase productivity, reduce labor costs, and improve sustainability (Doraiswamy et al., 2019).

Drones and immersive reality technologies

Drones and immersive reality technologies are being increasingly used in agriculture to enhance crop monitoring and management. Drones equipped with sensors and cameras can collect high-resolution images of crops and fields, providing farmers with data on crop health, yield, and soil moisture levels. This data can then be analyzed using big data analytics to optimize crop management strategies and increase yields. Immersive reality technologies, such as virtual and augmented reality, can be used to create immersive experiences for farmers, allowing them to visualize and manipulate data in new and interactive ways. For example, virtual reality can be used to simulate different growing scenarios and test the impact of different management strategies on crop yield. The use of drones and immersive reality technologies in agriculture is expected to continue to grow as farmers seek to improve crop yields, reduce costs, and increase sustainability (Garcia-Santillan et al., 2020).

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