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Role of Modern technology (Internet of things and Artificial Intelligence) in Agriculture: An Analytical Study

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Abstract

With the increasing demand for food globally, farmers are looking for ways to increase yields while reducing costs and improving sustainability. One solution to this challenge is the use of precision agriculture techniques. These cutting-edge technologies can be utilized to enhance crop productivity, optimize resource usage, and improve overall efficiency in farming practices. Two of the most important modern technologies are artificial intelligence (AI) and the internet of things (IoT), that can help farmers achieve these goals. IoT sensors can be used to collect real-time data on weather, soil moisture, and plant growth, which can then be analysed by AI algorithms to provide farmers with insights and recommendations for improving crop yields. AI-powered robots and drones can also be used to perform everyday and mundane tasks such as planting, weeding, and harvesting. These technologies have the potential to revolutionize agriculture by reducing labour costs, increasing efficiency, and improving sustainability. However, there are also concerns about the ethical and societal implications of AI and IoT in agriculture, such as the potential for job loss and the impact on small-scale farmers. This paper aims to analyses various aspects of the implementation of AI and IoT in modern agriculture.

Keywords- Modern technology, artificial intelligence (AI), internet of things (IoT), precision agriculture, improved crop productivity.

Introduction

"Artificial Intelligence" can describe electronic environments that are designed to be sensitive and responsive to human presence. In an ambient intelligence world, various devices work in harmony to provide support for people's daily activities in a natural and effortless way, by utilizing the vast amount of information and intelligence that is hidden within networked devices. The main features of this technology are that it is embedded in many devices, context-aware, personalized, adaptive, and anticipatory. The Internet of Things (IoT) is a global interconnected network of hardware devices, vehicles, home appliances, and other products that are surrounded with electronics, software, sensors, and network connectivity, enabling these objects to collect and exchange information. These IoT devices rely on the internet to communicate with each other and with other systems, such as cloud platforms and applications (Madakam, Ramaswamy, & Tripathi, 2015).

Everyday new technology takes the market by storm and radically changes the way we perform tasks. Modern technology has interdigitated itself into every nook and cranny of industrial applications. Food security and distribution depends heavily on the agricultural industry which also borrows modern technology to its own benefit. As King (2017) has stated that modern technology has the potential to revolutionize agriculture and make it more sustainable and productive. Pest management, automatic harvesting, farm animal tracking, and soil remediation are some of the recommended applications of modern technology such as precision agriculture, data analytics and biotechnology. However, it is important to carefully weigh the costs against the benefits of these technologies and ensure that they are accessible to all farmers, regardless of their location or scale of operation. Due to the same reason, there also exists a discrepancy between developing and developed nations as the latter have a clear upper hand in terms of availability of resources and time to invest in disruptive technologies like the ones mentioned above. However, looking at how smart AI has gotten, with more research, these issues can be solved. The humans involved in agriculture practices need not be completely replaced by AI tools and technologies, but these can definitely act as an added supplement. Figure 1 presents some of the popular technological advancements in the area of IOT and agriculture:

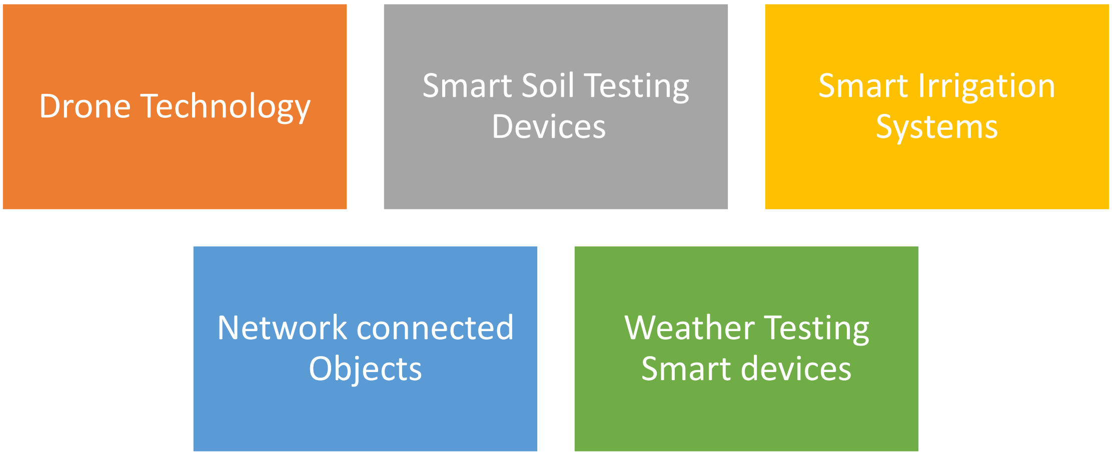

Figure 1 IOT innovations in Agriculture

Literature Review

Throughout history, agriculture has undergone several revolutions that have drastically transformed the way we produce food. The first agricultural revolution marked the transition from hunting and gathering to use of advanced tools in settled agriculture, while the second revolution occurred during the 18th century in Britain. The third revolution consequently led to productivity increase associated with mechanisation and the Green Revolution in developing countries. Despite the presence of technological innovation in agriculture for centuries, we are currently experiencing a new era of transformation with the emergence of innovative technologies such as the Internet of Things, robotics, and artificial intelligence. This paradigm technological shift has been labelled ‘Agriculture 4.0’, and it is poised to bring forth a new era of agricultural productivity and efficiency. (Rose and Chilvers, 2018). Not only that, but Agriculture 4.0 is expected to address some of the major tests facing agriculture such as climate change, food security, and sustainability. With the help of these innovative technologies, farmers can make informed decisions, reduce waste, and optimise their resources for maximum output.

Role of Artificial Intelligence in Agriculture

Bannerjee et al. (2018) have mentioned certain major aspects of agriculture which can be benefitted by artificial intelligence. According to them, these are — general crop management, integrated pest management and control of diseases, weed management, product monitoring and storage, soil and irrigation, and productivity and yield. These ideas, along with applications like that of “autonomous farming:” use of AI to control farm machinery, such as tractors and harvesters, autonomously, have been reinforced by Rose and Chilvers (2018). This can improve utility and reduce labour costs. The same authors also talk about ‘harvest prediction’ or the use of to forecast when crops will be ready for harvest, allowing farmers to plan their harvest activities more efficiently and effectively. This also reduced the burden of the dependency on environmental cues which are easily recognisable only after several decades of experience in the field.

Using machine learning algorithms, crop growth models, and weather data, AI-based systems can accurately predict crop yields. This technology can help farmers make conversant decisions about planting, fertilising, and reaping crops, leading to increased efficiency and higher yields. Additionally, AI-based systems can also help identify potential issues with crops early on, allowing for quicker intervention and mitigation of crop loss. As Bergez et al. (2010) have explained, a general AI model should mimic the biophysical system and allow for human-like decisions. Moreover, changing parameters such as the environmental conditions in terms of agriculture should also be taken into account. Such simulation models need to be better trained to account for biotic components— flora like weeds and fauna like earthworms, pollinators, etc. By following these key points, robust and interactive systems can be engineered to work seamlessly with existing practices. Chen, & Mcnairn (2006) have applied the use of neural networks in rice monitoring. These networks, trained on historical data to learn the relationships between environmental factors and crop growth, can detect subtle changes in rice growth and development that are difficult for humans to detect. By analysing patterns in the data, neural networks can predict rice yield, identify areas of poor crop growth, and detect diseases and pests that could impact yield.

Intelligent AI apps can allow a user to simply scan the pest or disease-related symptom and then detect, monitor, and control the pathogen in a more successful manner. These systems use image recognition, data analysis and machine learning algorithms to identify and track pests, as well as to predict their behaviour and potential outbreaks. By analysing data on pest behaviour and environmental conditions, AI systems can help to identify the most effective and least harmful ways to control pest populations, such as using natural predators or biological control agents (Singh, 2018). The fast processing of a large amount of data can allow illiterate or educationally unqualified farmers to also benefit from this quick assistance. With time, it would allow their knowledge to grow with the application. AI can play a critical role in precision farming by enabling real-time monitoring of soil conditions, crop growth, and water usage. This data can be used to innovate predictive models that can help farmers make decisions about irrigation scheduling, fertilizer application, and other management practices in a jiffy and without stuggle. By optimizing these practices, farmers can reduce water usage, minimize fertilizer waste, and improve crop yields. This can lead to a more sustainable and efficient agricultural system, benefiting both the environment and the economy. Additionally, the use of predictive models can also help mitigate the effects of climate change on crop production. For example, these authors used neural networks and fuzzy logic to optimize irrigation scheduling, resulting in 20% reduction in water usage while maintaining or improving crop yields (Tsang, & Jim, 2016).

Role of Internet of Things in Agriculture

The Internet of Things (IoT) has become a significant buzzword in recent years, and its applications are diverse, including agriculture. One of the main advantages of IoT in agriculture is its ability to optimise crop management and increase efficiency. By using sensors and other IoT devices to monitor environmental conditions like temperature, humidity, and soil moisture, farmers can make more informed decisions about irrigation, fertilization, and pest control. This can lead to higher crop yields and lower costs. Sensors and other IoT devices can also track the movement of goods from farm to market, so farmers can ensure that their products are delivered in a timely and efficient manner. This can help reduce waste and improve profitability (Elijah et al., 2018). The same idea of supply chain management, or as the authors have called it, the journey of crops from "far, to fork," has been reinforced by Nukala et al. (2016). Techniques like radio frequency identification (RFID), wireless sensor networks (WSN), cloud computing, and data analytics are all part of the process and help to systematically change resource management, supply chain management, and other aspects of current agricultural practices. RFID can especially help in tagging and monitoring perishable food products, which often suffer terrible losses during transportation and distribution. Furthermore, WSN can sense the state of these products and provide real-time monitoring inputs.

Another way IoT makes agriculture intelligent is with the use of drones. Drones engineered with sensors and cameras can be used to monitor crop growth and identify potential issues such as pest infestations and nutrient deficiencies. This allows farmers to take proactive measures to address these issues before they become more serious. IoT can also be used to automate various tasks in agriculture, such as seeding, fertilizing, and harvesting. For example, autonomous tractors equipped with GPS and sensors can be used to plant and fertilize crops with precision, reducing waste and increasing yields. Similarly, automated harvesting machines can be used to harvest crops more efficiently and with less labour (Li, Gu, & Yuan, 2016). Soil moisture sensors can detect the water level in the soil i.e, water holding capacity and transmit this data to the farmer. Additionally, weather sensors can provide real-time data on weather patterns, enabling farmers to adjust their irrigation schedules based on the weather forecast. IoT devices such as smart irrigation systems can be used to automate the irrigation process, allowing for precise and efficient water usage. These systems can be programmed to water crops at specific times and in specific amounts based on data collected from sensors, reducing water waste and increasing crop yields. By collecting and analysing data on crop water use and irrigation practices, farmers can identify inefficiencies and adjust and optimise their water usage. This data analysis can also be used to forecast future water needs, allowing farmers to plan for droughts or other water shortages (Ram et al., 2015).

Challenges faced by AI and IoT in agriculture

While AI has the potential to improve efficiency and profitability in agriculture, it is important that farmers can easily understand and use these systems. AI systems need to be designed to take these local variations into account, as well as the different practices and knowledge of farmers in different regions. There is also a need for policy frameworks to make sure that AI is used in an ethical and responsible manner. This includes ensuring that the benefits of AI are shared fairly across all stakeholders, as well as mitigating any potential negative impacts on the environment or social structures (Weersink, 2018).

One of the primary challenges is the lack of infrastructure in rural areas. Many farms in remote areas do not have access to reliable internet connectivity, which is essential for IoT devices to function. This hinders the widespread adoption of IoT in agriculture. The high cost of implementing IoT devices is also compounded by the need for additional equipment, such as sensors, gateways, and data storage systems. Moreover, the lack of standardisation in IoT devices and platforms can also pose a challenge for farmers (Tzounis et al., 2017).

Conclusion

With the advancements in artificial intelligence and the advent of internet of things, every industry has undergone radical change. The agricultural industry is also not oblivious to this change. As has been discussed in detail, AI and IoT have transformed agriculture by making it more intelligent, efficient, and sustainable. By using sensors, drones, automation, and data analysis, farmers can optimise their farming practices and improve their yields while reducing waste and environmental impact. Moreover, AI and IoT can also help farmers make more informed decisions about crop selection, pest management, and irrigation. This can lead to better resource management and increased profitability for farmers. As the technology continues to evolve, we can expect to witness even more innovations in the field of intelligent agriculture while also keeping in mind the challenges that need to be resolved. The world is changing, and with it, agricultural transformation is expected to reach new zeniths.

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