The Future of Farming: Integrating AI Technologies in Agricultural Systems

Dr. S. Ranjini[1], Dr Srividhya Mouli[2], Mr.R.P.Kabilan[3]

1. *Assistant Professor, Department of Commerce (Computer Applications), Rathnavel Subramaniam College of Arts and Science (Autonomous), Sulur, Coimbatore. India E-Mail ID: ranjiniprabhu4@gmail.com*
2. *Associate Professor, Melville School of Business, Kwantlen Polytechnic University, Canada E-Mail ID: srividhya.mouli@kpu.ca*
3. *, Assistant Professor, Department of English, KPR College of Arts Science and Research, Coimbatore - 641407, Tamil Nadu, India. E-Mail ID: rpkabilan08@gmail.com*

ABSTRACT

Artificial intelligence is based on the idea that human intelligence can be described in such a way that a computer can simply duplicate it and carry out activities. A large sector of the economy that is crucial to a nation's economy is agriculture. Technology is currently more necessary than fertilizers due to population expansion, food quality requirements, and other environmental considerations. The best technical option to deal with the expanding population and the changing climate of the world is artificial intelligence. Artificial intelligence in agriculture will contribute to resolving these practical issues by reducing time commitment and virtually eliminating labour-intensive tasks. Artificial intelligence in agriculture aids in pest management, data organisation, healthier crop production, workload reduction, and many other tasks. The ability to address needs with cutting-edge solutions like robotics, smartphone applications, and imagery technology is crucial. Numerous businesses are attempting to advance agricultural technology development so that it can be used to preserve crop output from environmental changes and population expansion in addition to introducing automated ways. This research paper analyses the applications of Artificial intelligence in different domains of Agriculture

Keywords — Agriculture, Artificial intelligence, farming, Technology, Applications, Machine Learning

INTRODUCTION

Artificial intelligence is based on the idea that human intelligence can be described in such a way that a computer can simply duplicate it and carry out activities, from the basic to the most complicated (Talaviya et. al, 2020). One of the oldest and most important professions in the world is agriculture and farming. In the economic sense, the agriculture sector is essential for the growth of the country. By 2050, it is predicted that there would be nearly 9 billion people in the globe. To meet this demand, agricultural production needs to be increased by 70 per cent (Bannerjee et. al., 2018). This is because as the world's population rises, land, water, and other resources become scarce, threatening to disrupt the demand-supply chain. People desire to become more creative and environmentally conscious about how agriculture is performed as the world's population continues to grow and land becomes scarce. This might necessitate employing less acreage to cultivate more plants while increasing productivity and yield. In addition, Indian agriculture suffers from some difficulties such as over-dependence on the monsoon, a strong reliance on natural resources, erioration he land and a lack of soil fertility, and irregular yields per hectare etc. In this context, artificial intelligence can play a catalytic role in improving crop productivity despite having weather fluctuations, population increase, employment issues, and food safety issues (Khandelwal and Chavhan, 2019). Artificial intelligence in agriculture would contribute to resolve these practical issues by reducing time commitment and virtually eliminating labour-intensive tasks.

Agriculture-based economies benefit greatly from artificial intelligence, which plays a key role in advancing agriculture and farming. Emerging technologies like AI-based Automated Robotic Systems can be used in agriculture to improve irrigation, crop monitoring, farming, automate spraying, and pesticide and herbicide application. There are numerous smartphone apps available that use artificial intelligence to help farmers by providing a range of services, from improved trading options to regulating and increasing the field's productivity.

REVIEW OF LITERATURE

Artificial intelligence (AI) is increasingly integral to agriculture, offering innovative solutions to optimise farming processes through data analysis and automation. Early applications of AI, such as those developed by McKinion and Lemmon (1985), introduced expert systems like GOSSYM, which simulated cotton crop growth under varying conditions. This pioneering work established a foundation for integrating AI into agricultural practices [7].

The need for AI in agriculture has grown in response to the escalating global population. The Food and Agriculture Organization (2020) reports that to feed a projected population of 9 billion by 2050, agricultural production must increase by 70% [5]. AI technologies are crucial in meeting this challenge by enhancing efficiency and productivity across various agricultural domains.

AI's impact on soil management is significant, with technologies like soil sensors and machine learning algorithms improving the assessment of soil health and nutrient levels. Eli-Chukwu and Ogwugwam (2019) emphasise that AI enhances precision in soil management, thereby optimising crop yields [13]. Similarly, in weed management, AI-driven computer vision systems combined with machine learning can distinguish between crops and weeds, facilitating automated weeding and reducing manual labour. Partel et al. (2019) discuss the development and effectiveness of low-cost AI technologies for precision weed management [15].

The integration of AI with Internet of Things (IoT) devices has revolutionised data collection and analysis in agriculture. IoT technologies, such as sensors and drones, provide real-time data that AI algorithms use to make informed decisions, thereby improving operational efficiency and data accuracy. Tzounis et al. (2017) highlight the transformative potential of IoT in agriculture, emphasising its role in enhancing data-driven decision-making [17].

AI technologies contribute extensively to various aspects of agricultural management, including crop and soil monitoring, pest and disease detection, and intelligent pesticide application. Michael and Fuetc (2016) note that advancements in AI have significantly improved productivity and resource management, which are vital for addressing global food security concerns [3].

However, the adoption of AI in agriculture is not without challenges. High initial investment costs are a major barrier, as indicated by Gertsis et al. (1997), who reported the financial difficulties associated with implementing AI technologies in agriculture [8]. Additionally, the lengthy technology adoption process can hinder widespread use, requiring considerable time and resources for farmers to adapt to new systems [2].

Data privacy and security are also critical issues, given the extensive data collection involved in AI applications. Nilsson (2014) emphasizes the need for robust cybersecurity measures to safeguard sensitive agricultural information [12]. Furthermore, the potential for job displacement due to automation poses socioeconomic challenges, as discussed by Kok et al. (2002) [9].

Looking forward, the development of agricultural robots and advanced AI systems holds promise for further advancements in the field. Innovations such as autonomous robots for pesticide spraying and flexible grippers for apple harvesting illustrate the potential of AI to enhance farming efficiency and precision. Warwick (2011) underscores the future prospects of these evolving technologies, which are expected to drive significant improvements in agricultural practices [10].

Objectives of the study:

- To analyse the applications of Artificial Intelligence in the domain of agriculture
- To understand the challenges in using AI in agriculture

APPLICATIONS OF AI IN AGRICULTURE

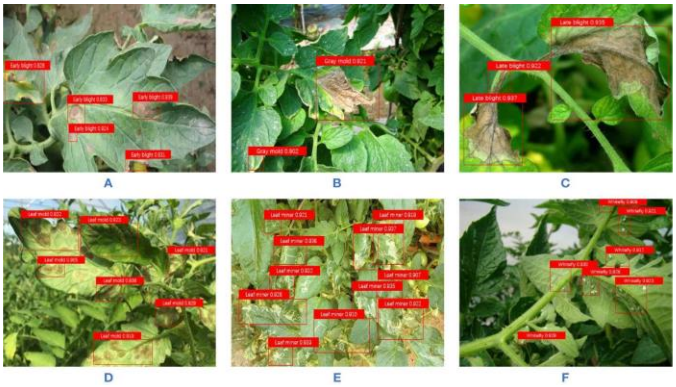
1. AI in irrigation system

AI plays a crucial role in detecting leaks in irrigation systems. By analyzing data, algorithms can identify patterns and anomalies that indicate potential leaks. Machine learning (ML) models can be trained to recognize specific signatures of leaks, such as changes in water flow or pressure. Real-time monitoring and analysis enable early detection, preventing water waste together with potential crop damage. AI also incorporates weather data alongside crop water requirements to identify areas with excessive water usage. By automating leak detection and providing alerts, AI technology enhances water efficiency helping farmers conserve resources.

2. Crop and soil monitoring

The wrong combination of nutrients in soil can seriously affect the health and growth of crops. Identifying these nutrients and determining their effects on crop yield with AI allows farmers to easily make the necessary adjustments. While human observation is limited in its accuracy, computer vision models can monitor soil conditions to gather accurate data necessary for combatting crop diseases. This plant science data is then used to determine crop health, predict yields while flagging any particular issues. Plants start AI systems through sensors that detect their growth conditions, triggering automated adjustments to the environment. In practice, AI in agriculture and farming has been able to accurately track the stages of wheat growth and the ripeness of tomatoes with a degree of speed and accuracy no human can match.

3. Detecting disease and pests



As well as detecting soil quality and crop growth, computer vision can detect the presence of pests or diseases. This works by using AI in agriculture projects to scan images to find mould, rot, insects, or other threats to crop health. In conjunction with alert systems, this helps farmers to act quickly in order to exterminate pests or isolate crops to prevent the spread of disease. AI technology in agriculture has been used to detect apple black rot with an accuracy of over 90%. It can also identify insects like flies, bees, moths, etc., with the same degree of accuracy. However, researchers first needed to collect images of these insects to have the necessary size of the training data set to train the algorithm with.

4. Monitoring livestock health

It may seem easier to detect health problems in livestock than in crops, in fact, it's particularly challenging. Thankfully, AI for farming can help with this. For example, a company called CattleEye has developed a solution that uses drones, cameras together with computer vision to monitor cattle health remotely. It detects atypical cattle behaviour and identifies activities such as birthing. CattleEye uses AI and ML solutions to determine the impact of diet alongside environmental conditions on livestock and provide valuable insights. This knowledge can help farmers improve the well-being of cattle to increase milk production.

5. **Intelligent pesticide application**

By now, farmers are well aware that the application of pesticides is ripe for optimization. Unfortunately, both manual and automated application processes have notable limitations. Applying pesticides manually offers increased precision in targeting specific areas, though it might be slow and difficult work. Automated pesticide spraying is quicker and less labor-intensive, but often lacks accuracy leading to environmental contamination. AI-powered drones provide the best advantages of each approach while avoiding their drawbacks. Drones use computer vision to determine the amount of pesticide to be sprayed on each area. While still in infancy, this technology is rapidly becoming more precise.

6. Yield mapping and predictive analytics

Yield mapping uses ML algorithms to analyze large datasets in real time. This helps farmers understand the patterns and characteristics of their crops, allowing for better planning. By combining techniques like 3D mapping, data from sensors and drones, farmers can predict soil yields for specific crops. Data is collected on multiple drone flights, enabling increasingly precise analysis with the use of algorithms.These methods permit the accurate prediction of future yields for specific crops, helping farmers know where and when to sow seeds as well as how to allocate resources for the best return on investment.

7. Automatic weeding and harvesting

Similar to how computer vision can detect pests and diseases, it can also be used to detect weeds and invasive plant species. When combined with machine learning, computer vision analyses the size, shape, and colour of leaves to distinguish weeds from crops. Such solutions can be used to program robots that carry out robotic process automation (RPA) tasks, such as automatic weeding. In fact, such a robot has already been used effectively. As these technologies become more accessible, both weeding and harvesting crops could be carried out entirely by smart bots.

8. Sorting harvested produce

AI is not only useful for identifying potential issues with crops while they're growing. It also has a role to play after produce has been harvested. Most sorting processes are traditionally carried out manually however AI can sort produce more accurately. computer vision can detect pests as well as disease in harvested crops. What's more, it can grade produce based on its shape, size, and colour. This enables farmers to quickly separate produce into categories — for example, to sell to different customers at different prices. In comparison, traditional manual sorting methods can be painstakingly labour-intensive.

9. Surveillance

Security is an important part of farm management. Farms are common targets for burglars, as it's hard for farmers to monitor their fields around the clock. Animals are another threat — whether it's foxes breaking into the chicken coop or a farmer's own livestock damaging crops or equipment. When combined with video surveillance systems, computer vision and ML can quickly identify security breaches. Some systems are even advanced enough to distinguish employees from unauthorised visitors.

CHALLENGES OF USING AI IN AGRICULTURE

1. High Initial Investment

Implementing AI technologies in agriculture demands a substantial initial investment. Purchasing and integrating AI-driven systems, machinery, and infrastructure might financially burden small-scale farmers.Farmers might need to invest in sensors, drones, AI-driven machinery, and infrastructure upgrades to adopt these technologies effectively. Additionally, the costs associated with training and hiring skilled personnel capable of managing these sophisticated systems can further strain budgets.

2. A Long Technology Adoption Process

Implementing AI in agriculture can encounter a drawback due to the sometimes-lengthy technology adoption process. This transition requires time for farmers to adapt to modern technologies, understand their functionality, and incorporate them effectively into existing systems. Additionally, the complexity of some AI solutions might necessitate a learning curve, further prolonging the adoption process.

3. Data Privacy and Security

AI systems rely heavily on data collection and analysis. Concerns arise regarding the privacy and security of sensitive agricultural data. The storage and management of this data present potential vulnerabilities to cybersecurity threats, such as unauthorised access, data breaches, or malicious attacks. Farmers and agricultural businesses must safeguard sensitive information from theft, manipulation, or exploitation.This aspect requires robust cybersecurity measures, ethical data handling practices, and stringent privacy regulations to safeguard sensitive agricultural data.

4. Job Displacement

The automation and mechanisation of AI technologies in farming could lead to job displacement for agricultural workers. As tasks become automated, there may be a decrease in the demand for manual labour, potentially impacting rural employment.AI-powered machinery and robots can increasingly manage tasks such as harvesting, planting, and monitoring, leading to a decreased demand for manual labour in farming. This shift could adversely affect the livelihoods of agricultural workers, particularly those in routine and repetitive job roles.

5. Environmental Concerns

While AI optimises resource use, excessive reliance on AI-driven farming practices might have unintended environmental consequences. Overuse of technology can lead to increased energy consumption, waste generation from outdated systems, or even the neglect of traditional sustainable practices.

Technological Dependence

Over reliance on AI for decision-making and farm management may lead to a technological dependence among farmers. Farmers relying extensively on AI systems may face challenges if these technologies malfunction, experience downtime, or encounter technical issues. Additionally, the need for continuous updates, maintenance, and tech support can create dependencies on external entities or suppliers are some of the disadvantages of digital agriculture.

CONCLUSION

This review presents an overview of the application of AI technology in agriculture. Corresponding to the current social situation of decreasing manual labour, limited usable agronomic land and a greater gap between total food produced and the world population, AI has been regarded as one of the most feasible solutions to those problems and has been developed and improved for years by scientists worldwide. In this review, the definitions of AI are first introduced, in which the highlight is the Turing Test. Then two subfields that AI has been playing an important role in are demonstrated, which are in soil management, weed management, and Internet of Things (IoT), a useful data analysis and storing technology that has wide application in agriculture, is introduced. This review also points out three major practical challenges of AI in agriculture: first, due to certain geographical, social or political reasons, the distribution of modern technology is uneven, which foreshadows that the application of AI will have its limitation in certain areas; secondly, despite significant improvements made in the past years, to transfer AI-based machines and algorithms from control experiments to real agricultural environment requires much more studies and research, and to be able to handle large sets of data and to interpret them accurately and quickly are two main challenges that need to be addressed in order to enable the application; finally, the security of devices used in open spaces of agricultural environment and the privacy of data collected are also problems to address. Then this review specifically introduces the development of agricultural robots. First, a couple of examples of robots designed to tackle different tasks in the agricultural industry are listed. There are autonomous mobile robots that can spray pesticides in greenhouses, tractors that use GPS and machine vision and have a travelling path pre-programmed, apple picking robots that use a Cartesian coordinate system to locate objects, two types of robots that manage weed problems and innovate in several directions, such as physical mobility and the ability to distinguish between crops and weeds, an apple harvesting

machine that has an innovative flexible gripper, etc. Then the review indicates challenges of applying agricultural robots, basically circulating around the question of the unpredictability in real environments, but underscores the considerable development and a promising prospect in this field.

REFERENCES

[1] McCarthy J, Minsky ML, Rochester N, Shannon CE. A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence, 1955, 27(4):12-12..

[2] G.Banerjee, U. Sarkar, S. Das, I. Ghosh. Artificial Intelligence in Agriculture: A Literature Survey[J]. International Journal of Scientific Research in Computer Science Applications and Management Studies, 2018, 7(3):1-6.

[3] Michael, C, Fuetc. Google DeepMind's AlphaGo[J]. Or/ms Today, 2016.

[4] "Hunger and Food Insecurity." Food and Agriculture Organization of the United Nations, Food and Agriculture Organization of the United Nations, 2020, www.fao.org/hunger/en/.

[5] "2050: A Third More Mouths to Feed." Food and Agriculture Organization of the United Nations, Food and Agriculture Organization of the United Nations, 2020, www.fao.org/news/story/en/item/35571/icode/.

[6] Popa, Cosmin. Adoption of Artificial Intelligence in Agriculture[J]. Bulletin of the University of Agricultural Sciences & Veterinary, 2011.

[7] Mckinion J M, Lemmon H. E. Expert systems for agriculture[J]. Computers & Electronics in Agriculture, 1985, 1(1):31-40.

[8] Gertsis AC, Galanopoulou-Sendouca S, Papathanasiou G, Symeonakis A. USE OF GOSSYM-A COTTON GROWTH SIMULATION MODEL-TO MANAGE A LOW INPUT COTTON PRODUCTION SYSTEM IN GREECE. In First European Conference for Information Technology in Agriculture, 1997.

[9] Kok J N, Boers E J W, Kosters W A, et al. ARTIFICIAL INTELLIGENCE: DEFINITION, TRENDS, TECHNIQUES, AND CASES[C]. International Symposium on Southeast Asia Water environment. 2002.

[10] Kevin Warwick. Artificial Intelligence: The Basics[M]. Routledge, 2011.

[11] Dobrev, D. (2012). A Definition of Artificial Intelligence. arXiv preprint arXiv:1210.1568, 2012.

[12] Nilsson, Nils J. Principles of artificial intelligence. Morgan Kaufmann, 2014.

[13] Eli-Chukwu N, Ogwugwam E C. Applications of Artificial Intelligence in Agriculture: A Review[J]. Engineering, Technology and Applied ence Research, 2019, 9(4):4377-4383.

[14] Elijah O, Member S, IEEE, et al. An Overview of Internet of Things (IoT) and Data Analytics in Agriculture: Benefits and Challenges[J]. IEEE Internet of Things Journal, 2018, PP(99):1-1.

[15] Partel V, Charan Kakarla S , Ampatzidis Y . Development and evaluation of a low-cost and smart technology for precision weed management utilizing artificial intelligence[J]. Computers and Electronics in Agriculture, 2019, 157:339-350.

[16] Diego Inácio Patrícioa, Riederb R. Computer vision and artificial intelligence in precision agriculture for grain crops: A systematic review[J]. Computers and Electronics in Agriculture, 2018, 153:69-81.

[17] Tzounis A, Katsoulas N, Bartzanas T, et al. Internet of Things in agriculture, recent advances and future challenges[J]. Biosystems Engineering, 2017, 164:31-48.