Artificial Intelligence in Agriculture

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ABSTRACT

Artificial Intelligence is one of the emerging technologies in the field of agriculture which tries to simulate human reasoning in intelligent systems. It is making a revolution in agriculture by replacing inefficient traditional methods with more efficient AI-based methods. AI is used in agriculture in various ways such as automation, robots, drones, soil and crop monitoring, and predictive analytics. This paper provides various applications of AI tools in agriculture.

KEYWORDS: artificial intelligence, artificial intelligence in agriculture

INTRODUCTION

Agriculture (or farming) is a key economic sector of any nation. It provides food required for human survival. From labor employment to contribution to national income, agriculture contributes immensely to the economy. Agriculture is the second largest industry after Defense. Figure 1 shows the lifecycle of agriculture [1]. The traditional methods used by the farmers are inadequate to meet the increasing demand for food by a soaring global population.

Digital transformation is disrupting the agricultural world. The application of artificial intelligence (AI) in agriculture has been widely considered as one of the most viable solutions to address food inadequacy. In essence, AI is a technology which functions like a human brain. This technology is based on mimicking how human brain thinks, how humans learn, make decisions, and work while solving a problem. The goals of artificial intelligence include learning, reasoning, and perception.

AI is making a huge impact in all sectors of the economy. It has penetrated business, healthcare, engineering, education, agriculture, industry, security, military, etc. Some of the areas of applications of AI are illustrated in Figure 2 [2]. Scientists have used AI to develop self-driving cars and chess-playing computers, and now in agriculture. The AI-powered technologies can assist the agriculture sector to yield healthier crops, control pests, and monitor soil. Farmers use AI for in various areas such as precision agriculture, crop monitoring, soil composition, and temperature control in growing areas.

OVERVIEW ON ARTIFICIAL INTELLIGENCE

The term "artificial intelligence" (AI) was first used at a Dartmouth College conference in 1956. AI is now one of the most important global issues of the 21st century. AI is the branch of computer science that deals with designing intelligent computer systems that mimic human intelligence, e.g. visual perception, speech recognition, decision-making, and language translation. The ability of machines to process natural language, to learn, to plan makes it possible for new tasks to be performed by intelligent systems. The main purpose of AI is to mimic the cognitive function of human beings and perform activities that would typically be performed by a human being. Without being taught by humans, machines use their own experience to solve a problem.

AI is stand-alone independent electronic entity that functions much like human expert. Today, AI is integrated into our daily lives in several forms, such as personal assistants, automated mass transportation, aviation, computer gaming, facial recognition at passport control, voice recognition on virtual assistants, driverless cars, companion robots, etc. AI is not a single technology but a range of computational models and algorithms. Some forms of AI that are most commonly used in electrical and computer engineering include the following [3,4]:

➢ **Expert systems:** They solve problems with an inference engine that draws from a knowledge base equipped with information about a specialized domain, mainly in the form of if-then rules. Expert systems are the earliest and most extensive, the most active and most fruitful area.

➢ **Fuzzy logic:** This makes it possible to create rules for how machines respond to inputs that account for a continuum of possible conditions, rather than straightforward binary.

➢ **Neural networks:** These are specific types of machine learning systems that consist of artificial synapses designed to imitate the structure and function of brains. They are similar to the human brain. They are made up of artificial neurons, take in multiple inputs, and produce a single output. The network observes and learns as the synapses transmit data to one another, processing information as it passes through multiple layers.

➢ **Machine learning:** This includes a broad range of algorithms and statistical models that make it possible for systems to find patterns, draw inferences, and learn to perform tasks without specific instructions. Machine learning is a process that involves the application of AI to automatically perform a specific task without explicitly programming it. ML techniques may result in data insights that increase production efficiency. Today, artificial intelligence is narrow and mainly based on machine learning. Some applications of ML in the agri-food space are illustrated in Figure 3 [5].

➢ **Deep learning:** This is a form of machine learning based on artificial neural networks. Deep learning architectures are able to process hierarchies of increasingly abstract features, making them especially useful for purposes like speech and image recognition and natural language processing.

➢ **Natural Language Processors:** For AI to be useful to us humans, it needs to be able to communicate with us in our language. Computer programs can translate or interpret language as it is spoken by normal people. In natural language processing,

➢ **Robots:** These are computer-based programmable machines that have physical manipulators and sensors. Sensors can monitor temperature, humidity, pressure, time, record data, and make critical decisions in some cases. Robots have moved from science fiction to your local hospital. In jobs with repetitive and monotonous functions they might even completely replace humans. Robotics and autonomous systems are regarded as the fourth industrial revolution.

These AI tools are illustrated in Figure 4 [6]. Each AI tool has its own advantages. Using a combination of these models, rather than a single model, is recommended. AI systems are designed to make decisions using real-time data. They have the ability to learn and adapt as they make decisions.

AI IN AGRICULTURE
Although the integration of artificial intelligence in agriculture has been relatively recent, its role in agriculture has been much significant than in any other field. AI is transforming agriculture in many ways. Farmers are relying on AI technology in their crop production. Some companies are leveraging computer vision and deep learning algorithms to process the data captured by drones. Machine learning algorithms are used to identify the sense of strengths and weaknesses in soil. Food producers are using AI to sort products and reduce labor.

The major factors driving the growth of the AI in agriculture market include [7]:

➢ the growing demand for agricultural production owing to the increasing population

➢ rising adoption of information management systems and new advanced technologies for improving crop productivity

➢ increasing crop productivity by implementing deep learning techniques

➢ growing initiatives by worldwide governments supporting the adoption of modern agricultural techniques

➢ crop selection, where AI-based solutions are ideal for selecting crops

➢ crop monitoring, where data can be collected using technologies like IoT, drones, and satellite imaging, from the fields

The combination of the Internet of things (IoT) and artificial intelligence technologies, such as machine learning, computer vision, and predictive analytics, allow farmers to analyze real-time data of weather conditions, temperature, soil moisture, plant health, and crop prices in real time.

APPLICATIONS OF AI IN AGRICULTURE
AI tools have taken modern agriculture to a different level. They have enhanced crop production and improved real-time monitoring, harvesting, processing, and marketing. The various ways in which AI has contributed in the agricultural sector include the following [8].

➢ **Robots:** Automated systems using agricultural robots and drones have made a tremendous contribution in agriculture. Farmers are using robots that can easily perform multiple tasks. Some robots are designed for harvesting. Typically, a robot is trained to control weeds and harvest crops at a faster pace than humans.

➢ **Drones:** A drone is an unmanned aerial vehicle (UAV) that is used in farming to help increase crop production and monitor crop growth. Drones are based on the innovations of sensors and microcontrollers. They are used for spraying and crop-monitoring. They are effective in the situations of cloudy climate and inaccessibility to a field of tall crops. They are capable of capturing far more land in much less time than humans. Using drones, AI-powered cameras can take images of the entire farm. Typically, the drone captures data from fields and transfers the data to a computer so that experts can analyze it.

➢ **Chatbots:** These are basically conversational virtual assistants who automate interactions with end users. AI-powered chatbots can help users understand natural language and interact with users in a more personalized way.

➢ **Precision Farming:** AI systems are helping to improve the overall harvest quality and accuracy, known as precision agriculture. AI applications in agriculture have developed applications and tools which help farmers by providing them proper guidance on water management, crop rotation, timely harvesting, type of crop to be grown, etc. Precision farming will optimize the processes of monitoring the state of soil and crops. AI-enabled technologies can predict weather conditions, temperature, precipitation, and wind speed. Microsoft precision agriculture attempts to democratize AI for farmers around the world.

➤ **Monitoring:** This allows farmers to monitor soil and crop conditions. Farmers leverage sensors and various IoT-based technologies to monitor crop and soil health. Satellites can be used for monitoring crop health and sustainability. AI also allows farmers to monitor the health of animals and manage the number of livestock. Smart devices can help control their movement and track feed requirements.

➤ **Weather Forecast:** Agriculture across the world is dependent on climate. Weather tracking and forecasting are important applications of AI in agriculture. They involve collecting up-to-date information of prevailing weather conditions such as temperature, rain, wind speed and direction, and solar radiation. Various devices such as handheld instruments, sensors, GPS and on-field weather stations are used for tracking weather.. The availability of real-time information helps farmers in making timely decisions.

➤ **Predictive Analytics:** This is one of the most promising areas for the farming industry. It is used in a variety of ways. These include solutions that predict crop yields using ML algorithms and AI algorithms can evaluate the creditworthiness of farm borrowers. The crop yield prediction is beneficial for marketing strategies and crop cost estimation. Advances in AI-based data analytics help farmers protect natural resources like land, air, and water, and reduce the amount of inputs needed for successful harvests.

Other areas of applications include indoor farming, weed management, disease management. detection of pests, intelligent irrigation, labor efficiency, crop diversity, supply chain management, precision farming, and food manufacturing.

BENEFITS
The main benefits of AI in agriculture are its flexibility, high performance, accuracy, and cost-effectiveness. AI-based technologies help to improve efficiency in all the areas, while the conventional farming machineries lack in efficiency. With AI-based solutions, farmers can meet the world's need for increased food without depleting natural resources. AI technology will improve the way we think, the way we explore new horizons, whether space or the ocean. AI and machine learning are gradually replacing outdated ways of planning and forecasting.

Some advantages of implementing AI in agriculture include [9]:

➤ AI provides more efficient ways to produce, harvest, and sell essential crops.

➤ AI implementation emphasis on checking defective crops and improving the potential for healthy crop production.

➤ The growth in artificial intelligence technology has strengthened agro-based businesses to run more efficiently.

➤ AI is being used in applications such as automated machine adjustments for weather forecasting and disease or pest identification.

➤ Artificial intelligence can improve crop management practices and help many tech businesses invest in algorithms that are becoming useful in agriculture.

➤ AI solutions have the potential to solve the challenges farmers face such as climate variation, an infestation of pests and weeds that reduces yields.

CHALLENGES
While AI has brought a lot of promise, it has also brought some challenges. Agriculture is one of the most uncontained environments to manage. The agricultural industry faces many tremendous challenges such as lack of effective irrigation systems, issues with plant monitoring due to crop height, extreme weather conditions (global warming), worry due to price fluctuation of the crop, omnipresent uncertainty, and the need to produce more food using fewer resources. These challenges are driving farmers and agro companies to find ways that are more efficient than the traditional methods. As a result, AI is emerging and promising to help farmers solve these challenges and get more from the land while using resources more sustainably.

AI is far from a silver bullet. Securing access to AI on a global level may pose some challenges. There is a gap between farmers and AI engineers. The cost of technology such as drones has made it unavailable to an average farmer. AI solutions in agriculture will require new, common terminologies to be agreed upon globally. AI will replace jobs in factories and in agriculture such as hand harvesters.

Other challenges of the application of AI-based techniques in agriculture include [10]:

➤ Possible uneven future distribution of mechanization

➤ Discrepancies between control experiments and actual implementation

➤ Security and privacy

THE FUTURE OF AI IN AGRICULTURE
Artificial intelligence is a solution for the future. It will be a powerful tool that can help organizations cope with the increasing amount of complexity in modern agriculture. AI is finding new applications in the areas of gardening and farming sector. Through robots, monitoring of soil, and by making data supported predictions, AI is emerging in the field of agriculture. Scientists at Microsoft are revolutionizing conventional farming by sowing, growing, and harvesting seeds under controlled temperatures powered by AI. With the help of AI, vegetables, fruits, flowers, mushrooms, herbs, etc. can be grown under the favorable combination of blue, red; and white light. Since enough food will be produced locally, nations will not need to import food products internationally.

The presence of many agriculture technology providers such as IBM, Microsoft, John Deere, Granular, Autonomous Tractor Corporation, Fendt, and Blue River Technology in US is driving the growth of the North American AI in agriculture market. These companies are pushing the boundaries of technology when it comes to AI's role in agriculture. China is growing at a swift pace when it comes to AI. AI can drive agricultural revolution at a time when the world must produce more food using less natural resources. The future promises more food with less consumption of natural resources [11].

CONCLUSION
With the widespread use of artificial intelligence across all industries, it is not surprising that AI is gradually transforming agriculture. Artificial Intelligence has brought

an agriculture revolution. It is already at work in agriculture industry and is here to stay. Through AI technology, farmers are well equipped to tackle the huge challenges of a growing global population and world hunger. For more information about artificial intelligence in agriculture, one should consult the book in [12] and the following related journal: *Artificial Intelligence in Agriculture*.

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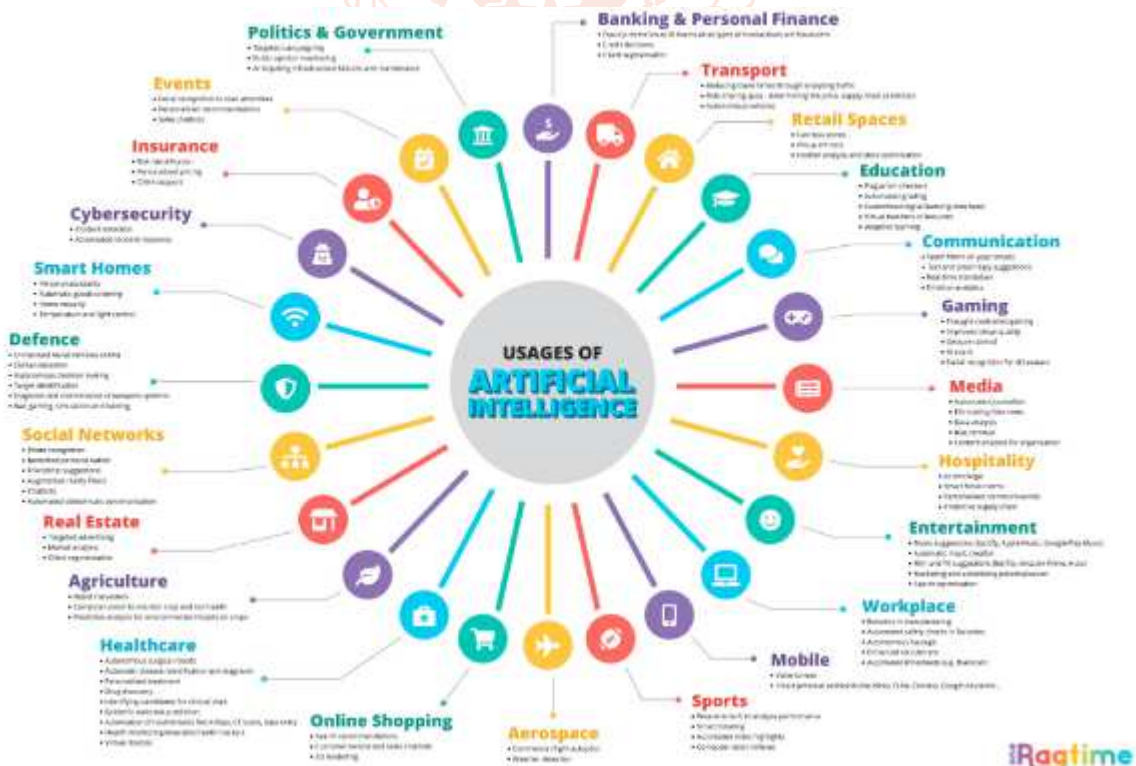
Figure 1 Lifecycle of agriculture [1].

Figure 2 Some areas of applications of AI [2].
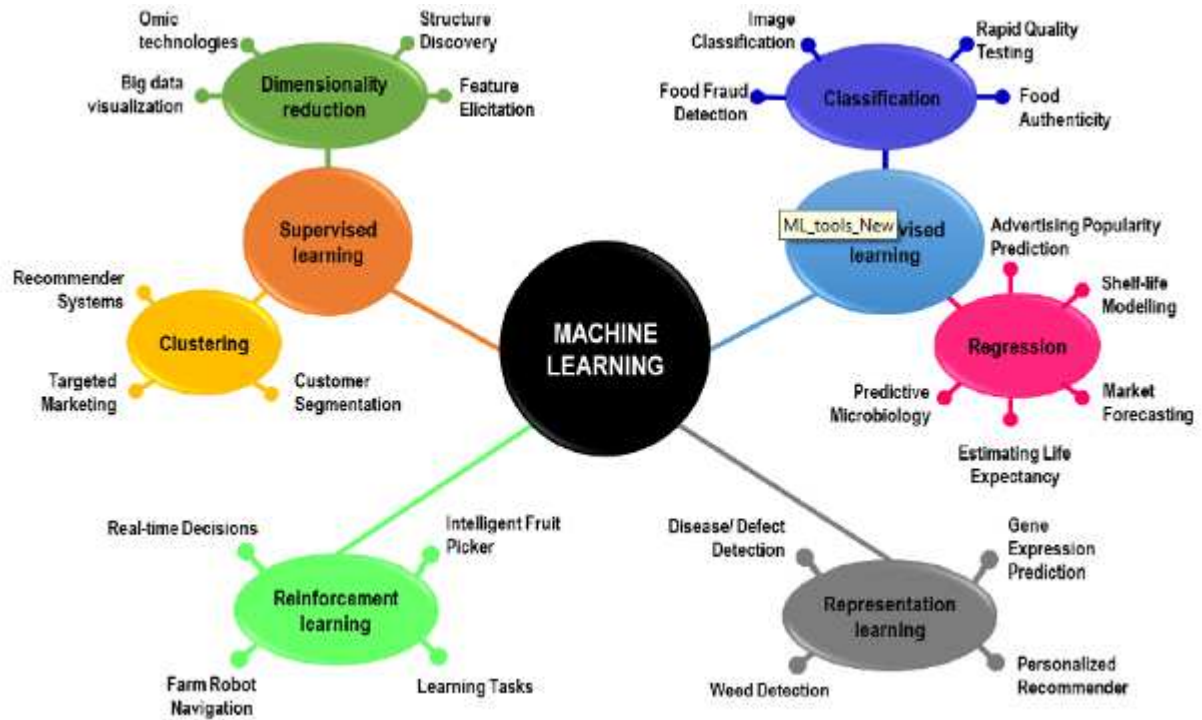
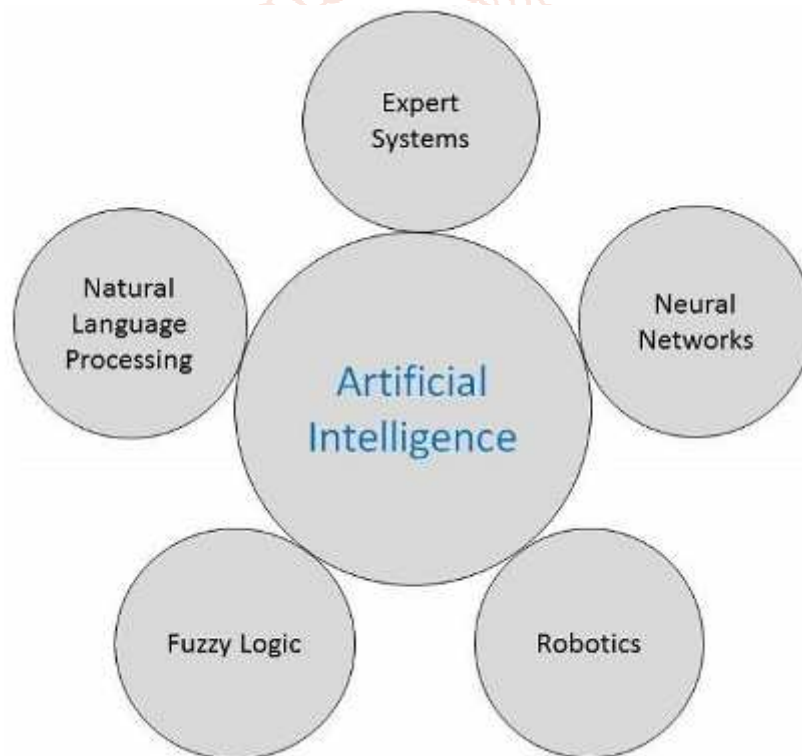**Figure 3 Some applications of machine learning in agriculture [5].**

Figure 4 Branches of artificial intelligence [6].