ARTIFICIAL INTELLIGENCE IN AGRICULTURE

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Abstract:

Artificial intelligence (AI) is a term used to describe a system that simulates or replicates human intelligence in computers that have been designed to think and behave like people. Developing intelligent agents that are capable of carrying out tasks that generally require human intelligence, such as problem-solving, reasoning, learning, perception, language understanding, and decision-making, is the main objective of AI. Two major categories can be used to categorize AI:

• Narrow AI (Weak AI): This kind of AI is made to carry out specified tasks or address specific issues. Virtual personal assistants (like Siri and Alexa), recommendation systems (like Amazon Prime suggestions), and chatbots are examples of narrow AI systems that are widely used today. They are experts in their particular fields, yet they are unable to generalize past their assigned jobs.

• General AI (Strong AI): General AI is artificial intelligence with capabilities akin to human intelligence, including the capacity to comprehend, acquire, and apply knowledge across a variety of tasks. It is sentient and capable of carrying out any intellectual job that a human is capable of. General AI is still only a theoretical idea and is not yet a reality.

AI technologies cover a wide range of methods and strategies, including:

• Machine Learning: A branch of artificial intelligence that entails instructing algorithms to gain knowledge from data without explicit programming. Unsupervised learning, reinforcement learning, and supervised learning are all included.

• Natural Language Processing (NLP): Allows computers to comprehend, decipher, and produce human language, facilitating communication between people and machines.

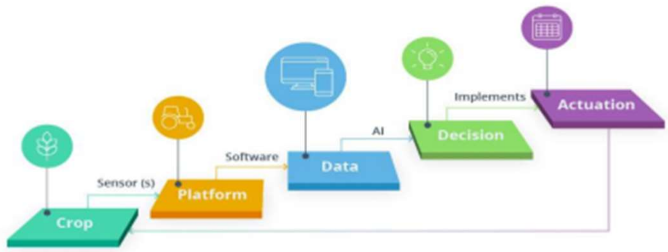
• Computer vision focuses on giving robots the ability to comprehend and interpret visual data from the outside world similarly to human eyesight.

• Robotics: Combines AI and robotics to create intelligent machines that can carry out physical activities and communicate with their surroundings.

Applications of AI are becoming more and more common in a variety of sectors, including agriculture, healthcare, finance, manufacturing, transportation, and entertainment. Researchers, decision-makers, and business leaders are always working to enhance AI technology ethically and assure its usage in a way that maximizes benefits and reduces risks.

Keywords:

Agriculture, Artificial intelligence, Plant robotics, Drones, IOT and sensory layout, Robots.



Role of A.I. in agriculture information management cycle

Background:

Agriculture is the basis for the sustainability of any economy. It plays an important role in long-term economic growth and structural change; however, it may differ internationally.

In today's world, technology and agriculture coexist. Due to technological advancements in recent years, such as those involving sensors, metals, machines, and development, exercise and land cultivation now function more dramatically than they did a few decades ago. Modern agricultural practices include the use of robotics, temperature and moisture sensors, airborne photographs, and GPS advancements. These push-up devices, together with the precision of agricultural and manufacturing systems, allow organizations to continuously gain advantages, grow stronger, gradually be protected, and even rise above ground by neighbours. Numerous new data opportunities have arisen as a result of the growth of e-commerce investments and related heads.

Today's agriculture faces significant new problems. As a result, the agricultural sector's sustainability is essential to providing food security and reducing poverty for the world's expanding population. In the upcoming years, there will be many issues related to the weather, climate change, sustainable water management, and water scarcity. These factors make the creation of a plan to shift from the current conception of agricultural product development to agricultural sustainability vitally necessary. The adoption of sustainable agriculture practices is a crucial decision, especially when using digital technologies like the Internet of Things (IoT), artificial intelligence (AI), and cloud computing. Expecting efficient solutions and assisting farmers and stakeholders in making better decisions is also critical. Additionally, local intelligence technology has been merged with subsets of AI (machine and deep learning algorithms) (Kaushal et al., 2023).

Introduction:

John McCarthy first proposed a study based on the idea that "every aspect of learning or any other feature of intelligence can, in principle, be so precisely described that a machine can be made to simulate it" at the 1955 Dartmouth Conference, which is where the term "Artificial Intelligence" was first used. Agriculture used to be solely concerned with growing plants and food. However, it has developed over the last 20 years to include the processing, production, marketing, and distribution of agricultural and livestock goods. Agriculture is currently a major source of employment, GDP growth, national trade, unemployment reduction, provision of manufacturing resources to other industries, and improvement of the global economy. Currently, agricultural operations are a major source of income, a driver of GDP, a facilitator of international trade, a means of lowering unemployment, a supplier of industrial inputs to other sectors of the economy, and an engine of growth for the world economy.

Artificial intelligence (AI) has enormous potential for addressing complex issues in agriculture. Some of the major sub-fields of AI include Natural Language Processing (NLP), Robotics, Machine Learning (ML), Automated Reasoning, Knowledge Representation, Expert Systems, Computer Vision, Speech Recognition, Automated Data Analytics, Virtual Reality, Augmented Reality, Internet of Things (IoT), Cloud Computing, Statistical Computing, Deep Learning, etc.

In a recent discussion paper, the NITI Aayog outlined its vision for AI solutions in several important industries, including agriculture. The use of AI computers in agriculture has enormous potential to tell farmers about soil quality, when to plant, where to apply herbicide, and where to anticipate pest infestations. Thus, India might experience a farming revolution if AI systems can advise farmers on better methods. However, scaling up such a futuristic scenario to include the full value chain while keeping things like capacity expansion and cost reduction in mind is a daunting challenge (Bhar et al., n.d.).

Application of Artificial Intelligence in Agriculture

Around the world, AI-driven technologies are emerging to support improvements in market and supply chain efficiency, weather forecasting, predictive agricultural analytics, and crop and soil monitoring efficiency. The development of digital agriculture is made possible by the use of cloud computing infrastructures, data ecosystems, the Internet of Things (IoT), and artificial intelligence (AI). This empowers farmers to practice smart farming, smart irrigation, smart fertilizer application, and smart disease/pest diagnosis/ detection, spraying, and harvesting. It is common practice worldwide to use machine learning and soft computing techniques with pattern recognition through image and video (drone cameras, satellite imagery) data processing to monitor and manage various farm operations and predict the occurrence of disease and pests, weather forecasts, the best time to apply and dose of chemical sprays, the time of harvest, and life spans (Gangwar, 2023).

i. **Smart agriculture:** Processes are used in agri-food production systems, and the variables that affect those processes (such as the inherent unpredictability of biological processes, soils, and climate) are quite varied. In addition, society has expectations regarding the environment in which production takes place, the materials used, and the Caliber of the results. Additionally, this makes it necessary to record and log the activities. A management concept called "smart agriculture" directs actions to protect or boost agricultural productivity and food security in the face of shifting physical and chemical constraints, a changing climate, and rising demands for and expectations of transparency from all participants in the agri-food chain. Smart agriculture may use artificial intelligence (AI) as a tool to accomplish goals that are beyond the capacity of humans. One of the problems for the future is digesting a vast amount of data and turning it into useful information.

ii. **Precision Farming:** Drones and satellites that use AI to collect and analyse data on agricultural growth, soil health, moisture levels, and pest infestations. With the use of this knowledge, farmers can apply water, herbicides, and fertilizers exactly when and where they are needed, maximizing resource use and raising crop yields.

iii. **Pest and Disease Management:** Using deep learning-based picture identification technology, we can now identify plant diseases and pests. Using picture classification, detection, and segmentation techniques, this method creates models that can "keep an eye" on plant health. Monitoring, detection, and management of insect pests and plant diseases are made simpler and more environmentally benign by employing AI approaches.AI-based models are able to anticipate and spot probable pest and disease outbreaks in particular areas. With the use of this knowledge, farmers can take preventative actions and use dangerous pesticides less frequently.

iv. **Crop and Soil Health Monitoring:** Using either a deep learning-based tool or image capture with a camera recognition tool, artificial intelligence (AI) and machine learning (ML) technologies have made it possible to track crop characteristics as well as soil characteristics in farms, such as quality, fertility, microorganism and nutrient deficiency, as well as flora pattern. Early identification enables farmers to take prompt action, limiting the requirement for broad-spectrum pesticides and lowering the risk of crop loss.

v. **Autonomous Farming Machinery:** Planting, harvesting, and weeding operations can be completed by AI-enabled autonomous tractors and robotic farm equipment without the need for human interaction. These devices run precisely and effectively, increasing productivity and lowering labour expenses.

vi. **Predictive Analytics:** In order to give farmers predicted insights, AI can analyse both historical and current data, including weather patterns, market trends, and soil conditions. Making informed decisions about planting times, crop selections, and market timing is aided by this.

vii. **Smart Irrigation:** Intelligent irrigation systems use weather forecasts and sensors to keep track of soil moisture levels. Farmers may save water resources and avoid water waste by providing the proper amount of water at the appropriate time.

viii. **Livestock Monitoring:** A good example of an agricultural business that used AI first is Cattle Eye. Utilizing cameras and unmanned aerial vehicles (UAVs) for data collecting helps with cowshed management. Using overhead cameras and computer vision algorithms, it is simple and accurate to track animal health and behaviour, spot aberrant behaviour, and keep an eye on significant behaviours like giving birth. With the help of this technology, feeding regimens may be optimized and animal welfare as a whole is improved.

ix. **Supply Chain Management:** AI improves logistics, inventory control, and transportation to streamline the agricultural supply chain. By ensuring prompt produce delivery to markets, this lowers food spoilage and waste.

x. **Plant Breeding:** By analysing genetic data and locating desirable features in crops, artificial intelligence (AI) streamlines the plant breeding process. This aids in the creation of novel cultivars that are more tolerant of pests, diseases, and environmental stresses.

xi. **Weather and price forecasting:** The weather has a significant impact on agricultural planning and decision-making. Farmers might be able to get meteorological data through artificial intelligence technology, which would be useful for timely planting, harvesting, spraying, and other agronomic procedures, enhancing crop output and revenues by lowering crop danger. The management of pests can also benefit from weather forecasts; taking measures by implementing practices on schedule lowers input costs and yield loss. In order to optimize profit, farmers might use price forecasting to acquire a better understanding of crop prices in the upcoming weeks.

xii. **Market Analysis and Price Forecasting:** In order to give farmers precise price estimates, AI systems may analyse market trends, consumer behaviour, and global commodity prices. This aids farmers in making knowledgeable choices regarding what to plant and when to sell their harvest.

The internet of Things (IoT)

It is a technology that aims to link all intelligent items together in one network. includes all computer technology, including a) Hardware (such as smart boards and sensors) and b) Software (such as cutting-edge operating systems and artificial intelligence (AI)) algorithms.

The development of device applications is the major goal in order to facilitate monitoring and control of a certain domain. It is commonly used in agriculture for managing agricultural goods using data acquired in real-time, in addition to:

Tracing, being cautious, controlling, managing, testing, and performance are all aspects of the supply chain. (Kaushal et al., 2023)

Robots: These are created and crafted to undertake fundamental agricultural tasks (such as harvesting crops) considerably more quickly and powerfully than human labour. See and Spray, a robot for weed management, and CROO harvesting, a robot for agricultural harvesting, are two examples of robot uses. Milking robots in particular have the potential to be significant AI applications.

Fertilization: Nitrogen, phosphorus, calcium, and potassium are some of the many nutrients that are naturally present in soil. When plants have poor nutritional content, they are unable to operate correctly and generate high-quality food. Once the plants are harvested, the soil's natural level of nutrients needs to be raised by adding additional nutrients. Fertilizers have been used since the dawn of agriculture, but it is now widely understood that, if not properly controlled, their overuse can affect the ecosystem. Soil samples are scanned and tested using IoT sensors by farmers for basic testing so that fertilizer may be added using accurate data. Maintaining sustainable agricultural production systems involves fertilization.

Irrigation / Water: Pressure to maintain the availability of water sources is growing as the need for water in agriculture grows globally and particularly in the Mediterranean countries. As a result, innovative and successful techniques should be the emphasis of smart, sustainable agriculture operations.

In the context of agriculture, the Internet of Things (IoT) and sensory layout have the potential to revolutionize the industry by making farming more efficient, sustainable, and productive. IoT devices equipped with various sensors can be deployed throughout farmlands to collect real-time data about soil conditions, weather, crop health, water usage, and more. This data can then be analysed and used to make informed decisions to optimize agricultural practices. Here's how IoT and sensory layout can benefit agriculture:

Soil Monitoring: IoT sensors can be embedded in the soil to measure essential parameters like soil moisture, pH levels, and nutrient content. This data can help farmers determine the right amount of irrigation and fertilizer needed, thus reducing water waste and improving crop yields.

Weather Monitoring: Weather stations equipped with IoT sensors can provide accurate and localized weather data. This information helps farmers anticipate changes in weather patterns, such as rainfall, temperature, and humidity, enabling them to adjust their planting and harvesting schedules accordingly.

Crop Health Monitoring: Drones equipped with cameras and sensors can fly over the fields and capture high-resolution images of crops. By using image recognition and data analysis, farmers can detect early signs of pests, diseases, or nutrient deficiencies, allowing them to take timely action to prevent or mitigate crop losses.

Precision Agriculture: IoT devices can be integrated with farm equipment, such as tractors and irrigation systems, to enable precision agriculture. This involves using GPS data and real-time information from sensors to optimize planting, fertilizing, and spraying, resulting in reduced resource wastage and improved productivity.

Livestock Management: IoT sensors can be used to monitor the health and behaviour of livestock. For example, wearable devices can track the activity levels of animals, helping farmers identify signs of illness or stress. Automated feeding systems can also be implemented based on individual animal needs.

Water Management: IoT sensors in irrigation systems can monitor soil moisture levels and weather conditions to optimize water usage. Farmers can implement smart irrigation systems that automatically adjust watering schedules based on real-time data, conserving water resources and reducing costs.

Remote Monitoring and Control: Farmers can remotely monitor and control various aspects of their farm operations through IoT-enabled mobile applications or web portals. This allows them to make data-driven decisions without the need for physical presence on the farm at all times.

Data Analytics and Insights: The data collected from IoT sensors can be processed and analysed using advanced analytics tools. This provides farmers with valuable insights and trends over time, helping them fine-tune their farming practices and make more informed decisions for increased efficiency and profitability.

In agriculture, the successful implementation of IoT and a well-designed sensory layout can lead to sustainable farming practices, reduced resource wastage, increased crop yields, and improved overall farm management. By harnessing the power of IoT, farmers can embrace modern technology to address the challenges of feeding a growing global population while promoting environmental conservation. (Kaushal et al., 2023)

Fig: - General implementation of AI in Agriculture

Artificial Intelligence	Uses	Implementation
Robots	◦ Fruit picking ◦ Weeding ◦ Driverless tractor ◦ Shearing of sheep's ◦ Harvest Automation	◦ Robots use photos and maps to find the fruits, pick them up, and store them based on their size. ◦ Using a specially made wheel, you can disturb weed seeds as they germinate and cut them if any of them manage to sprout. ◦ An automated farm vehicle called a driverless tractor provides a high tractive effort at a slow speed for tillage and other agricultural tasks. ◦ Shearing sheep is made easier by robots with mechanical arms and trimmer sets. ◦ Using computer vision, robots can locate and locate fruits on trees, as well as recognize fruits that are shaded by other fruits and collect them.
Drones	◦ Soil and fields analysis ◦ Crop monitoring ◦ Plantation ◦ Livestock management ◦ Crop spraying	◦ Agriculture drones can be used for field and soil studies for effective field planning. They can also be used to mount sensors that measure the moisture levels in the soil. ◦ Crop monitoring is the process of keeping track of a crop's development from the time the seeds are sown until the crop is ready to be harvested. ◦ AI can be effective in plantations to replace labour-intensive large tractors that create hazardous emissions and save on fuel.

		° Drones are useful for handling large amounts of livestock because their sensors contain high-resolution infrared cameras that can quickly identify sick animals and take appropriate action. ° In contrast to the conventional way, Agro-drones can be useful for chemical spraying because they contain reservoirs that can be filled with fertilizers and pesticides.

Challenges of AI in field crop production (European Parliament. Directorate General for Parliamentary Research Services., 2023)

a. **Necessary infrastructure resources:** Important human and technological resources are needed for the successful integration of AI approaches into field operations on a regular basis. Many AI methods are impractical either because to the high processing requirements or the demand for an unavailable high supply of field data. In the majority of rural locations, where crops are normally cultivated and 5G or the internet, if available, can be inconsistent, the real-time transfer of field data to the cloud is not guaranteed. A practical method for reducing the need for expensive infrastructure while preventing the loss of important field data is on-board computing and data storage. Because of this, technical resources may be difficult to obtain, yet affordable solutions are already available.

b. **System difficulty:** Some AI-related problems in agriculture can be viewed from a system-wide perspective, which refers to systemic qualities that should apply to the entire system as a whole rather than just one layer of its architecture. These include characteristics like the solutions' scalability and flexibility, or the ability to swiftly and effectively adjust to shifting situations or requirements. These factors, together with the service layer's real-time capacity, are essential for navigating the real-time and constantly shifting dynamics of the global economy. Finding strategies to control this complexity is crucial because as the system develops and adapts, it may also get more complicated.

c. **Dynamic systems and ongoing improvements**: The idea of continual improvement and its relationship to this system dynamics is a crucial topic. Engineering, which is made possible by the system's real-time data and learnability and adjust using AI. In order to improve system performance and, more importantly, to at least maintain it, new approaches should make use of data that is acquired in real-time. Despite these changing circumstances that are a part of real-world contexts. In the context of machine learning applications, this involves managing issues like idea drift, which describes situations in which the data distributions may differ from those with which models were initially trained. As a result, it is important to investigate integrated methods for automated, seamless monitoring, adaption, and validation of implemented solutions.

d. **Concept drift:** Concept drift may be lessened through the application and modification of cutting-edge deep learning (DL) techniques like the various Autoencoder (AE) variants or Generative Adversarial Networks (GANs). In order to overcome this, the training set can be supplemented with data produced by the aforementioned DL models that have the potential to be processed in a way that introduces distracting parameters or noise and broadens the distribution of the training set.

e. **A convincing reliability:** Farmers are concerned about the machines' dependability, both in terms of their proper operation and dependable mechanics and electronics. In fact, they are concerned that a malfunction at a crucial period throughout the season, such as during harvest, could endanger the entire crop or a portion of it. Sandbox testing for combined mechanical, electronic, and AI systems helps boost trust in this area.

Future prospect of AI in Agriculture

Let's continue by speculating on how AI will benefit the average person/ famers in the future. Technology has grown so quickly that what has been accomplished in the roughly 15 years from the early 2000s is significantly more than what has been accomplished throughout the previous the 1970s, 30 years ago. Some of the AI-based ideas Microsoft is working on include helping farmers raise agricultural yields, detecting dangerous diseases, lowering accident risks, and anticipating customer behaviour. AI is advancing quickly, with examples including Microsoft's Cortana, Apple's Siri, IBM's Watson, and self-driving automobiles. Thanks to the omniscient Google Baba, we now have computers in our pockets that are connected to the Internet, providing us a wealth of alternatives like streaming movies and music directly from our smartphones at any time! Let's extrapolate this amazing innovation leap to the advancement of AI. Around the world, AI-driven technologies are emerging to support improvements in market and supply chain efficiency, weather forecasting, predictive agricultural analytics, and crop and soil monitoring efficiency. The development of digital agriculture is made possible by the use of cloud computing infrastructures, data ecosystems, the Internet of Things (IoT), and artificial intelligence (AI). This empowers farmers to practice smart farming, smart irrigation, smart fertilizer application, and smart disease/pest diagnosis/ detection, spraying, and harvesting.

With the goal of developing an international Agri-commodity standard that will facilitate trustworthy trading across national borders, AI-based automatic grading and sorting for fruits and vegetables are already being done at the national level. In order to digitize food quality, deep learning and cutting-edge image processing algorithms are utilized to view photographs and pictures. However, scaling up the usefulness to include more things and to cover more areas requires millions more of these kinds of photographs. If no such photographs are gathered, digitized, and annotated, this would seem a bit far-fetched. Since the government holds the majority of agricultural data, it is completely their responsibility to annotate and make that data useful. Therefore, the effectiveness of deep learning is directly related to both quality and quantity. Deep learning also requires data collected over a long period of time in order to estimate power generation in certain other situations, such as solar or energy power planning.

It is common practice worldwide to use machine learning and soft computing techniques with pattern recognition through image and video (drone cameras, satellite imagery) data processing to monitor and manage various farm operations and predict the occurrence of disease and pests, weather forecasts, the best time to apply and dose of chemical sprays, the time to harvest, the shelf life of produce, etc. Artificial Neural Networks (ANNs), the algorithms used in deep learning, are modelled after the structure and operation of the brain. Because increasingly complicated models are utilized in these situations, which enable significant parallelization, deep learning may tackle more complex problems, particularly those with a large number of features. Deep on image data, segmentation using learning approaches produces disease/variety identification, crop yield estimation, and prediction with a great deal higher accuracy.

Another area where AI might be useful is in precision farming, which can also help farmers make the most of the available space and be more knowledgeable about the sorts of crops, weather patterns, and the best times and locations for growing crops. The best thing that

AI can do for agriculture is to eliminate the tediousness and monotony of many agricultural processes so that we can invest our time and energy in more productive ways to discover a wide range of inventive AI advances that will outperform human capabilities (Bhar et al., n.d.).

Conclusion

Applications of AI will undoubtedly greatly assist agriculture. AI can be used to build intelligent systems into machines that can function faster and more accurately than humans while yet being receptive to user input like humans. The Internet of Things (IoT), sensor technology, and AI together can be a major enabler for precision agriculture. In the widespread adoption of climate smart agriculture, AI can be just as important as remote sensing technology. Some AI techniques, such as mobile-based recommender systems and expert systems, can significantly speed up the adoption of agricultural technologies, such as high-yielding or disease-resistant varieties and cutting-edge farm tools, enhancing farmer revenue. The millions of farmers in our nation may benefit from a paradigm shift away from location-based advising services toward personalized and context-specific advice thanks to these AI capabilities. With the help of AI, automation, sensors, drones, IoT, solar power, and other technologies, businesses and entrepreneurs now have new potential to provide farmers cutting-edge solutions as a service at competitive costs.

Since AI can rewire its own thinking to get better with repeated instructions and experiences, advancement in AI should proceed much more quickly at this rate. Since everything has two sides, including artificial intelligence, it is important to remember that scientists are continuously figuring out ways to design safeguards to ensure that AI, which on the one hand enables innovations, on the other hand does not destroy our daily lives by altering the lives all around us, with the most obvious application standing out being the robot. Nowadays, it doesn't seem so far-fetched that people have begun to casually discuss AI in everyday conversations and a lot of general pieces have been published in publications. People did discuss climate change earlier, and that had a significant influence in what caused practical measures to be made to avert it. AI is currently the topic of discussions, which will eliminate any concerns about it. Therefore, if we want to take action, it would be wise to begin by carefully discussing AI with more people (specially farmers) (Bhar et al., n.d.).

Declarations

Author contribution statement

All authors listed have significantly contributed to the development and the writing of this article.

Data availability statement

No data was used for the research described in the article.

Interest declaration statement

The authors declare no conflict of interest.

References:

Bhar, L. M., V, R., Arora, A., Marwaha, S., & Prasad, R. (n.d.). *Era of Artificial Intelligence: Prospects for Indian Agriculture*.

European Parliament. Directorate General for Parliamentary Research Services. (2023). *Artificial intelligence in the agri-food sector: Applications, risks and impacts.* Publications Office. https://data.europa.eu/doi/10.2861/516636

Gangwar, P. (2023). Artificial Intelligence in Agriculture. *Just Agriculture Multidisciplinary E-Newsletter*, *3*(8), 579–582.

Kaushal, S., Kumar, S., & Tabrez, S. (2023). Artificial Intelligence in Agriculture. *International Journal of Science and Research (IJSR)*, *11*, 1682–1688. https://doi.org/10.21275/SR22524180634