POTENTIAL OF ARTIFICIAL INTELLIGENCE TO COMBAT CHALLENGES IN TRANSFORMING AGRICULTURE

Abstract

The agricultural industry has many difficulties in the twenty-first century, such as issues with food security, sustainability and rising demand brought on by population increase. To tackle these issues, artificial intelligence (AI) has emerged as a game-changing tool with enormous potential. This essay examines how artificial intelligence (AI) could revolutionize agriculture by improving production, resource management and decision-making. Precision farming, which uses AI-powered sensors, drones and machine learning algorithms to assist farmers in enhancing crop yields, minimizing waste and optimizing resource use, is a significant component of AI's impact on agriculture. AI also helps with disease outbreak prediction, task automation and monitoring soil conditions, all of which increase productivity and lower labour costs. AI-driven data analytics also promote sustainable practices and guarantee food security by enabling better-informed decisions, from crop selection to market forecasts.

Keywords: Artificial Intelligence, Agriculture, Precision Farming, Sustainability, Resource Management, Crop Yields, Food Security

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I. INTRODUCTION

It is estimated that by 2050, there will be approximately 10 billion people on the planet, which will result in a 50% rise in agricultural demand from 2013 levels, even with very moderate economic growth (FAO, 2017). When John McCarthy proposed a study project based on the notion that machines might mimic every facet of human learning and intellect in 1955, the term 'Artificial Intelligence' was first used. The first use of AI in agriculture was in 1985 when McKinion and Lemmon created GOSSYM, a model for simulating cotton crops that used expert systems to improve cotton production by considering a variety of variables including climate, weed control, irrigation, and fertilization. The Turing Test, a game created to answer the question of whether a machine can think like a person, was proposed by Alan Turing in the 1950s (Zha, J. 2020). Bostrom (2014) defines artificial intelligence as the imitation of human intellect by robots that have been taught to reason rationally and behave similarly to people. It's also important to note that smart drip irrigation has been shown to save a substantial amount of water, saving roughly 41.5% when compared to traditional flood irrigation and 13% when compared to standard drip irrigation techniques (Barkunan *et al*., 2019).

Figure 2: How AI Technology Is Revolutionizing Agriculture

Agriculture is one of the most important sectors of the economy, and there is a growing global interest in automating agricultural activities. The need for food and work possibilities is rising due to the considerable expansion in the global population. Farmers used to rely on traditional farming methods, but these days they can no longer fulfill the increasing demands. As such, novel automated techniques have been presented to tackle this problem. These contemporary methods create jobs for billions of people in addition to satisfying the needs for food production. A revolution in agriculture has been sparked by artificial intelligence (AI), which has revolutionized industry. Crop yields have been

successfully shielded by this technology from a number of threats, such as shifting climatic conditions, population increase, labor shortages, and worries about food security.

Across the globe, agriculture is the backbone of many economies, providing food security and supporting the livelihoods of countless people. However, this sector faces a number of challenges, including population growth, resource scarcity, soil erosion, and climate change. Currently, technology is a major tool for addressing these issues. Artificial Intelligence (AI) is one of these technologies that has the most potential to change agriculture significantly. It is a powerful instrument.

But what Exactly is Artificial Intelligence?

AI constitutes a field within computer science that harnesses machine and deep learning algorithms, among other techniques, to acquire knowledge from data and make inferences, emulating human intelligence. In essence, AI involves the emulation of human thought processes and actions through the programming of machines to think logically and replicate human behavior. There are several approaches to achieving AI, some of which are outlined as follows:

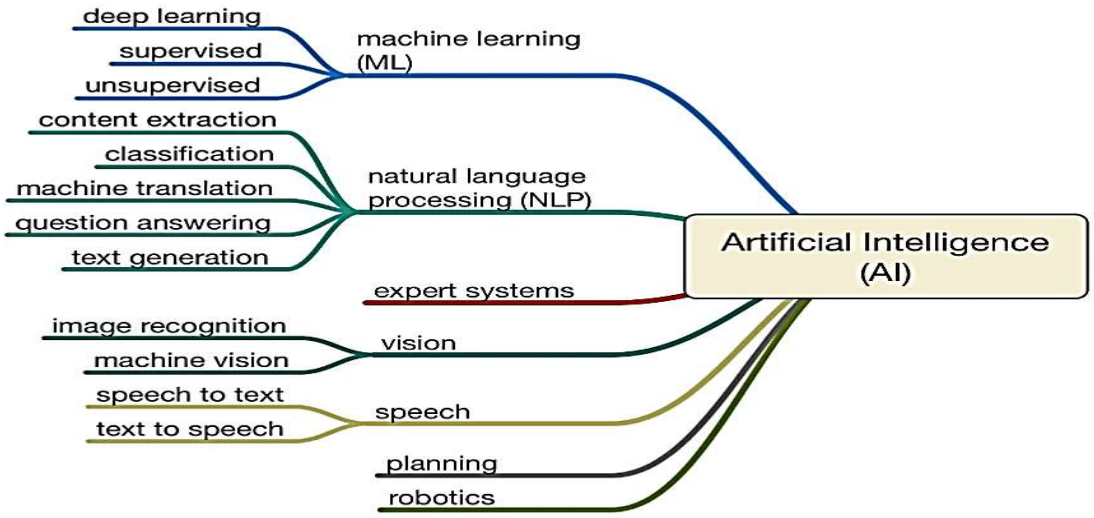

Figure 2: Sub domains of Artificial Intelligence

II. CATEGORIES OF ARTIFICIAL INTELLIGENCE

1. **Artificial Narrow Intelligence (ANI):** All too often called "Weak AI," artificial intelligence (ANI) refers to the early stages of the field, when robots are able to do a small number of very particular jobs. Machines today are limited to performing preprogrammed tasks and are incapable of any kind of cognitive processing. Instances of Weak AI include humanoid robots such as Sophia, self-driving cars, the Alpha-Go programme, virtual assistants such as Siri and Alexa, and numerous AI systems developed to date.

2. **Artificial General Intelligence (AGI):** Alternatively referred to as "Strong AI," artificial general intelligence (AGI) represents a higher level in the development of artificial intelligence at which machines will be able to think and act like humans. Though there are no examples of Strong AI at this time, it is expected that humans will soon be able to create computers with intelligence on par with that of humans.

3. **Artificial Super Intelligence (ASI):** Artificial Super Intelligence denotes the ultimate stage of Artificial Intelligence, where computer system's capabilities surpass those of human beings. ASI remains a theoretical concept, as portrayed in movies and science fiction literature, where machines have gained supremacy over the world.

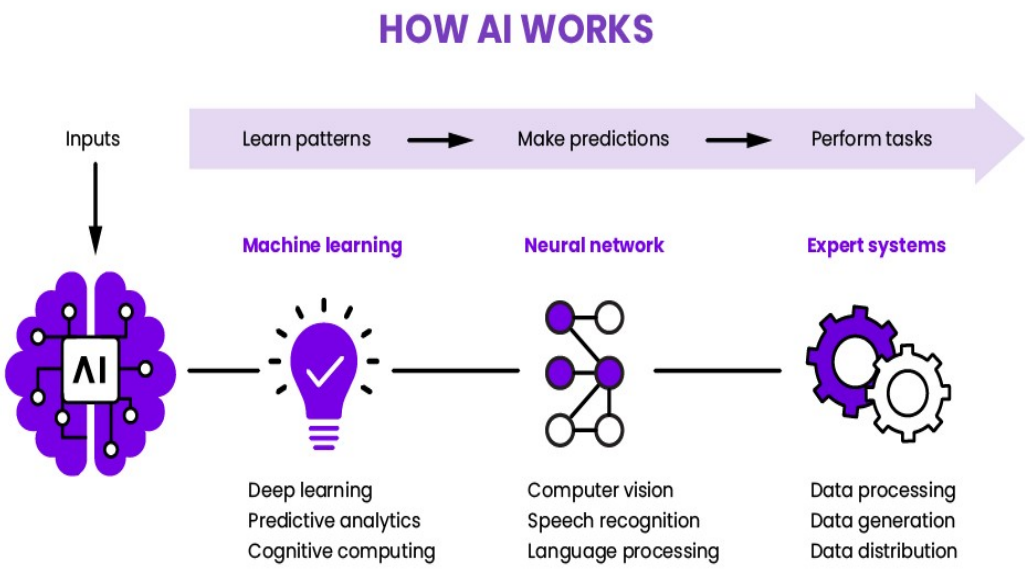

Figure 3: How AI works?

III. AI APPLICATIONS IN AGRICULTURE

Applying five key principles, AI has the potential to greatly increase agricultural output. These include the use of precise nutrient supplementation (minimizing input costs), sensible crop variety selection (resistant to heat, drought, and stress), intelligent water management (such as drip or sprinkler irrigation), conservation tillage (reducing moisture and soil loss), and the revolutionary use of farm management software (Zhang *et al*., 2021). Precision farming use artificial intelligence (AI) to detect pests, plant illnesses, and nutrient shortages on agricultural properties. Drones equipped with AI-powered cameras are able to virtually instantly take and process photos of entire farms, allowing for the detection of problems and the recommendation of possible fixes. Robots, for example, can increase productivity while lowering labor costs in agriculture by addressing the issue of a declining workforce. Cutting-edge robotic systems have the ability to gather data from farms in addition to tending to and harvesting crops, therefore increasing crop yields. Often called "Agri-robots," agricultural robot's complete jobs like harvesting crops more quickly and in

greater quantities than human laborers. In in-vivo agriculture, computer vision technology is optimized for weeding, spraying, and monitoring (Dharmaraj and Vijayanand 2018; Waleed *et al*., 2020).

The use of robotics in Indian agriculture offers a number of advantages, including lower costs. Agri-bots can perform jobs like weeding and harvesting crops, which eliminates the need for fertilizer and labour. It can also draw and keep young people in the agriculture industry. AI will surely assist farmers in coming up with more effective strategies to keep weeds out of their crops. AI advancements in agriculture, particularly in India, will be adapted to local demands and a range of climatic circumstances (Awasthi Y. 2020; Maurya *et al*., 2023). Farming is about to undergo a change thanks to autonomous tractors, which can do several jobs on their own and save labour expenses and time spent. These self-driving tractors use computer programs to execute plowing, harvesting and weed control operations autonomously. Pest management is another task for AI, as pests can cause significant crop losses (Vijayakumar and Balakrishnan 2021). AI can be employed to control these infestations and use satellite images for forecasting emerging threats.

Through smartphone-based image identification, AI-based technologies, such the PEAT application called Plantix, may detect plant pests, diseases, nutrient deficits, and faults in the soil and provide prompt solutions (Grace *et al*., 2018). This promotes healthier and more fruitful harvests by assisting farmers in monitoring the health of the soil and crops. A significant amount of freshwater is needed for agriculture, and future demands are predicted to rise. Water conservation is crucial, and drip irrigation systems of today use a great deal less water than those of the past. Certain crops, like paddy rice, need different amounts of water as they develop (John *et al*., 2023). A solution is provided by an automated drip irrigation system that calculates soil wetness levels using photos taken with a smartphone and sends the information to a microcontroller via a GSM module. The microcontroller notifies the farmer's mobile device about field conditions and decides when to turn on irrigation. When applied to rice fields over a three-month period, experimental results indicate water savings of around 41.5% compared to conventional flood irrigation and 13% compared to typical drip irrigation methods (Barkunan *et al*., 2019).

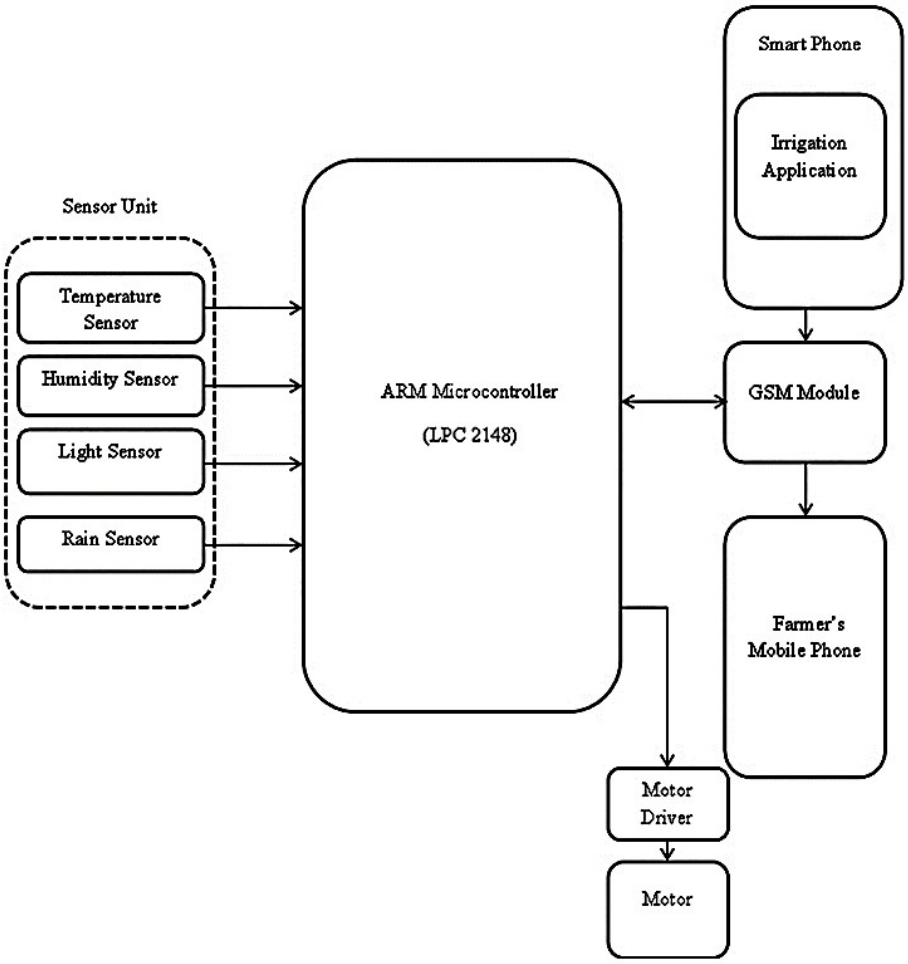

Figure 4: Block diagram of proposed Smart Sensor based irrigation system

The working of proposed irrigation system is classified into three major categories based on the moisture content of the soil and inputs from the sensor unit. The categories are as follows:

1. Soil is in wet condition - Motor needs to be in OFF state.
2. Soil is in dry condition and the possibility of rainfall - Motor needs to be in OFF state.
3. Soil is in dry condition and there is no possibility of rainfall - The motor needs to be in an ON state.

The system continuously captures the soil image and sensor inputs and manages the agricultural field by repeatedly doing the above-mentioned process at predefined time intervals. Finally, the status of the irrigation process is updated periodically on the farmer's mobile through SMS.

IV. WEATHER FORECASTING AND SOWING MANAGEMENT APP

- FASAL (Forecasting agricultural output using Space, Agro-meteorological and land-based observations)
- AI Sowing App powered by Microsoft Cortana

1. **FASAL:** Having embarked on the trip in 2018 with a mere four members of their team, Fasal is well on its way to making a significant influence on Indian agriculture! Through the delivery of actionable advising services that are tailored to the individual needs of farms, crops, and crop stages, Fasal has assisted many farmers in lowering cultivation costs while improving quality and output. This has been possible because of our AI-powered horticultural platform. Bolandnazar *et al.* (2020) assert that they significantly influence the UN's Sustainable Development Goals through their promotion of sustainable agriculture and solutions that touch on social, economic, and environmental aspects.

2. **Microsoft:** in collaboration with ICRISAT, developed an AI Sowing App powered by Microsoft Cortana Intelligence Suite including Machine Learning and Power BI. The app sends sowing advisories to participating farmers on the optimal date to sow. The best part is the farmers don't need to install any sensors in their fields or incur any capital expenditure. All they need is a feature phone capable of receiving text messages (John *et al*., 2022).

V. ROLE OF AI IN LIVESTOCK MANAGEMENT

Farming could be revolutionized by a smart collar for cows. Halter is a firm from New Zealand that is advancing farming by providing smart collars for cows. Currently available behavior monitoring, and analysis automation systems typically include of sensors mounted on an animal's leg, neck, or ear, sensor nodes for processing and transmitting observations, and an AI-enabled model for updating the animal's status. Data is a key component of livestock automation systems, yet most livestock data is unstructured. It can be classified as text, image, audio, or any other type of media. A public dashboard with remote access from any location can be created using the data. Providing summary data on a daily basis can help in planning for the upcoming days (Ullah *et al*., 2018).

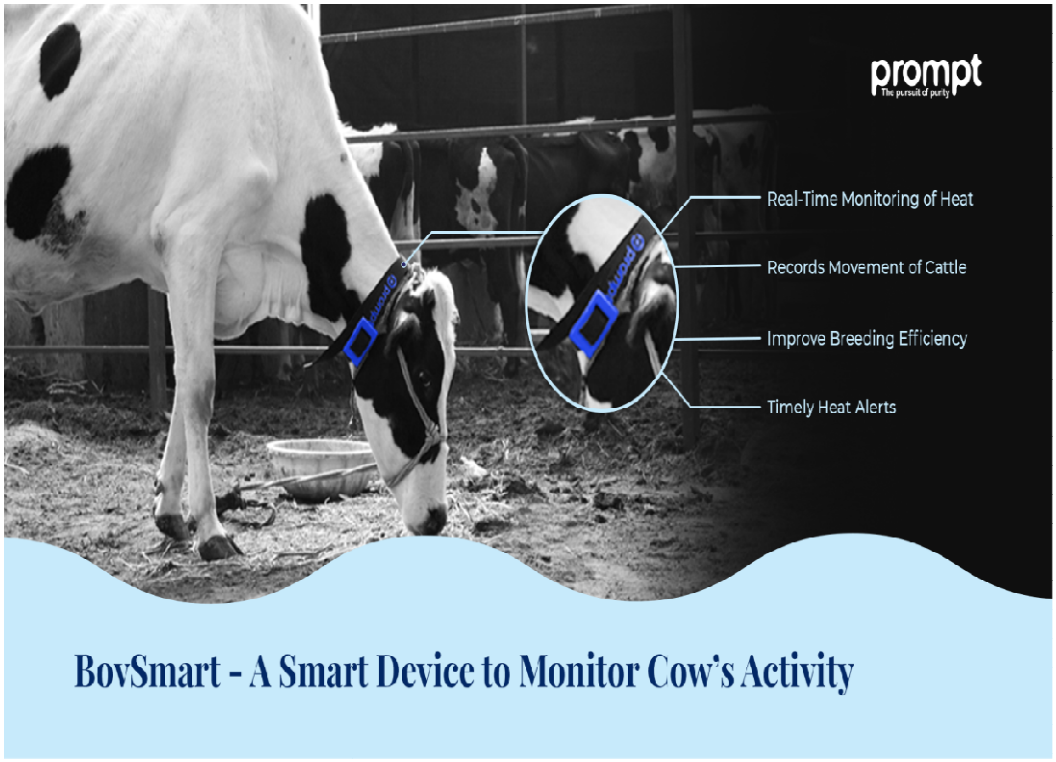

Figure 5: Smart collar system for smart dairy management

1. **AI Robots in Agriculture:** Robotics was first developed in agriculture in the early times of the year 1920. Israel-based startup with an idea to help farmers solve the labor shortage problem. Designed to work in a greenhouse environment. Driverless robots have two robotic arms to pick and harvest tomatoes on both sides of a row simultaneously. More than 30% of the crops grown in greenhouses are tomatoes. Robots can reduce the labor needs of harvesting by about 90% and cut production costs by about 50% by saving on manpower costs (John *et al*., 2023; John *et al*., 2018).

2. **Challenges in the Adoption of AI-Based Technologies in India**

   - Subdivision of land into small and fragmented holdings.
   - The high initial costs and ongoing expenses of implementation and maintenance.
   - Concerns related to privacy and security.
   - Limited access to advanced technology.
   - A shortage of technical expertise.
   - Insufficient connectivity and infrastructure deficiencies in rural areas.
   - A lack of awareness and accessibility among smallholders regarding the latest technologies and government programs and subsidies.

3. Pros and Cons of Artificial Intelligence

Pros	Cons
AI, when properly coded, exhibits a low error rate compared to humans.	AI lacks human creativity and out-of-the-box thinking.
It offers incredible precision, accuracy and speed.	Overreliance on AI can lead to human passivity and reduced productivity.
AI can predict user actions, queries and behaviors.	Building, rebuilding and repairing AI systems can be costly and time-consuming.
AI systems can serve as efficient assistants, offering recommendations and guidance.	The replacement of jobs by robots can lead to unemployment issues.
It can detect fraudulent activities in card-based systems and potentially other domains.	Concerns exist regarding the societal impact of widespread job displacement.
AI can interact with humans in various forms for entertainment or task completion.	Some AI applications, like robotic repair, may require additional resources and expenses.
It has applications in medical fields, such as health risk assessment and emotional state analysis	AI lacks human creativity and out-of-the-box thinking.

VI. FUTURE PROSPECTS AND EMERGING TRENDS

- Integration of AI with other technologies (e.g., Internet of Things, blockchain)
- Collaborative platforms and knowledge sharing for agricultural innovation.
- Advancements in machine learning and deep learning algorithms
- AI-powered decision support systems for personalized farming recommendations.

The integration of AI-powered technology is poised to bring about significant breakthroughs in agriculture, especially in India in the future. This change will result in a revolution in the farming industry, as autonomous tractors will be used to complete a range of activities, saving money and time on labour (Nawaz *et al*., 2020). Even while AI is expected to increase efficiency and decrease the need for labour, there is a contradictory fear that the large workforce in agriculture could become unemployed. Nevertheless, there are ways to deal with this concern (Bisht *et al*., 2022).

- Introduce cost-effective AI technologies accessible to farmers.
- Promote collaboration between policymakers and AI experts.
- Develop AI-based automated irrigation systems for efficient water usage.
- Conduct location-specific trials to expand the database for improved farm-level management using digital technologies.

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