FUTURE AGRICULTURE WITH AI & IoT TECHNOLOGY

Rapidly increasing population, shrinking agriculture land, dwindling natural resources, climate change and shifting market demands are pushing the pressure on agricultural production systems throughout the world. Over 58% of rural households rely primarily on agriculture which faces several challenges in field operations, managing inputs from sowing to harvest. Agriculture needs to be greatly modernized to meet these issues. We require climate resilient and sustainable efficient production system in output for future generations. Artificial Intelligence (AI) holds promise in addressing these challenges.

Artificial intelligence (AI), branch of computer science, enables machines to learn, make decisions and perform tasks without human intervention. AI-powered farming solutions can help farmers in enhancing the quality of their produce and get quick go-to-market strategies (GTM) for crops, which portrays a detailed vision of smart farming. It could serve as a link to enhance quality products with less effort in traditional methods of farming. Farmers can benefit from this service and keep up with technological improvements by receiving timely and accurate door-to-door solutions to their problems via chatbots or other conversational platforms.

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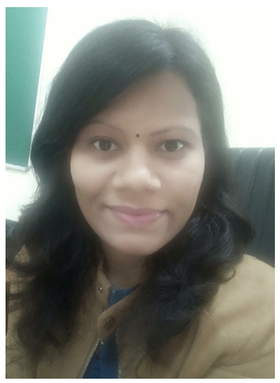
ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI), a replica of human intelligent behaviour, thinks and acts impartially and delivers human-like performance using purely logical thinking. AI is represented by non-biological components and ability to accomplish complex goals through the use of gadgets like smartphones, smart homes, intelligent transportation systems, AI-enabled cameras, smartwatches, smart healthcare equipment, etc. AI is utilized everywhere viz., in banking, healthcare, space research, education etc. It is an analytical process associated with human thinking, including speech recognition, natural language understanding, translation, knowledge management, image analysis, decision-making, learning, etc. to make the system more powerful and useful. AI can help farmers to analyze different factors viz., weather conditions, temperature, water usage or soil conditions of their farm to make better decisions in real-time.

AI powered techniques application in multiple areas of agricultural operations :

1. IoT (Internet of Thing) driven Growth:

Huge data, on weather pattern, soil parameters, rainfall, pest infestation, images and researches, is generated. Data can be sensed and strong insights be provided to improve yield with the help of cognitive IoT solutions. Proximity and remote sensing are primarily used for intelligent data fusion. Soil Testing can be done effectively by proximity sensing with sensors in contact with soil or at a very close range. Whereas remote sensing requires airborne sensors or satellite systems. Conventionally crop health monitoring is labor-intensive and time-consuming. AI is an efficient way to monitor and identify crop health or nutrient deficiencies in soil. AI-enabled applications to analyze plant health patterns in agriculture are better instruments in better understanding of soil health, plant pests and plant diseases.



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2. Predictive Agriculture System based on Images:

Field images are used for crop health identification, its problem and further solution. The images are useful in crop monitoring, field scanning and analysis. Drone data are combined with visual recognition technology and IoT to ensure rapid actions by farmers. To achieve accurate results and enhance precision farming by applying inputs at right time, place, and in right quantity, several images are fed and trained in machine learning model. Here are some specific instances of how image analysis can be applied in agriculture:

Overview of entire process of Image based Predictive system

a. Crop readiness identification

The ripening stage of crops/fruits is determined by taking various crop images. For better-quality output, different levels of harvest readiness for harvesting can be classified on the basis of the type of crop or fruit. Water stress can easily be detected by low-cost computer vision system and machine learning algorithms.

b. Disease Detection

Plant diseases are a major threat to production, economy, environment and food security. Detection of crop disease initially, is very essential for controlling diseases. Computer-assisted systems can be used to diagnose diseases with a high degree of accuracy using smartphones and recommend control measures. Based on leaf wetness duration, several disease incidence forecasting models using fuzzy logic (ANN, ANFIS, and SVM) are available. These tools can give early-warning of pest and disease outbreaks and suggest the suitable management practices.

c. Field Management:

High-definition images from airborne systems (drones or copters) can be used to create a field map and identify the crop's requirement for water, fertilizers, or pesticides during crop cultivation, for real-time estimates. Sky Squirrel technology has smoothened the drone-based Ariel imaging solutions for crop health monitoring. Images captured from fields are analyzed by experts.

d. Optimizing agronomic inputs

Using factors like soil quality, weather forecasts, seed types and local pest infestations, cognitive solutions recommend farmers to grow suitable crops. A customized suggestion can be made by considering the farm's requirements, local conditions and its previous cropping history. Remote sensing can be used to forecast the expected crop production and yield over a given area under specific conditions. Advanced data analyses can help farmers in saving natural resources and reduce the amount of inputs needed for successful harvests.

3. Automated Irrigation System

In agriculture, managing the soil and irrigation is critically important. Wastage of water is one of the main issues with conventional irrigation systems. IoT-based smart irrigation system machines automate irrigation and enhance the overall yield. These systems are trained on weather patterns, soil condition, and the types of crops to be cultivated. AI enabled smart water meters and sensors, support the saving in water consumption and budgeting without interacting with the farmer, moisture and temperature sensors directly interact with field components and distribute the required water among the crops. Smart sensors in sprinklers and drips irrigation may enable water supply as per plant need. Additionally, the technology helps automate greenhouses.

4. Decrease pesticide usage

Robotics, machine learning, and computer vision can be used to manage weeds effectively. Data collection and analysis by AI assist farmers in spraying herbicides to weed-infested fields and in monitoring weed infestation. Spraying the right amount of herbicides over an infested area minimizes the overuse of pesticides, which lowers pesticide costs and conserves the environment. Farmers can use agriculture bots to help them develop effective weed control strategies for their crops. Additionally, this will aid farmers in overcoming the labor shortage.

5. Agriculture Robot (Agbots)

Organizations are working to create multi-tasking robots that can operate in real-time. Robotics in weed-control and crop harvesting in fields are now available. Agbots with computer vision algorithms, identify weeds and spray herbicides precisely. The Smart See and Spray Model assists in distinguishing economic plants from weeds. Additionally, robots for picking and packing robots are being developed by researchers. The other robots available for weed control are BoniRob, Roboter and Hortibot. Energid Citrus Picking System, designed exclusively for picking citrus fruits in every two to three seconds, is way affordable than hiring human labor.

6. Unmanned aerial vehicles (UAVs)

UAVs, remote-sensing autonomous vehicles, capture images and collect data about a particular scene to provide new opportunities for enhancing crop yields through in-depth crop analysis. Drone-based solutions benefits agricultural sector in dealing with adverse climatic conditions, enhancing productivity, precision farming and crop yield management. Animal tracking, aerial seeding, spraying of pesticides, and plant nutrients can be done with drones. IoT-enabled drones track animals' accurate locations in addition to monitoring their body temperatures and getting notified about the

initiation of their ovulating periods besides can manage large livestock herd with quick-acting thermal sensors, including high-resolution infrared cameras, detect diseased animal using their heat signs and can effectively be used in precision dairy farming. Animal sensors come in a variety of shapes and sizes. In the market, there are specialized collars, ear tags, implants, and microchips with micro cameras and remote signaling functions. Crop failure can be easily be detected with the help of drones and can be effectively implemented for crop insurance schemes in settlements of claims dependent on the degree of damage.

7. Supply Chain Management

AI has yet to have a significant impact on agricultural supply chain management. Its use in supply chain planning, resource optimization, including forecasting demand, and logistics will result in cost savings for farmers and solutions to the information asymmetry problem for stakeholders. Platforms such as Jivabhumi's 'Food print' provide a digital marketplace for the aggregation of farm produce. Farmers and institutional purchasers are connected through blockchain technology which provides direct communication between two parties initiate transactions. Blockchain technology quickly track and process information related to food items right from their source to the end consumer.

8. Food Quality

AI is playing a key role in food safety and quality assurance. It performs most of the human tasks with precision and efficiency through machine learning from experience, analyze data analyses from inputs and outputs.

9. Precision Farming

Precision farming offers precision through geological mapping, optimum planting and harvesting time estimators, and efficient management of water resources, plant and fertilizer management, rodent and pest attacks. AI models readily identify the optimal sowing season in different seasons. Timely identification of pest attack potential minimizes the possibility of pest infestation. OneSoil app help farmers to make better choices as it monitors the crops remotely, identifies problems in the fields, check the weather forecast, and calculate fertilizer rate etc.

10. Smartphone Apps

Farmers can use specially designed smartphone apps to analyze collected data, record information, predict weather changes, and so on. Apps with computer vision algorithms analyze images and reveal information about damaged leaves, soil color, and leaves shape. They assist farmers by detecting disorders and then recommending preferable measures to protect the whole crop. Plantix app detects current crop condition and prepares a report on any problems arising. Trace Genomics app help farmers for soil and crop health monitoring and thus, producing healthy crops. AGRENIO app advises farmers how much and when to irrigate their crops using data from sensors installed in their fields.

11. Robotics in agriculture

a) Chat bots

The newest idea is to create a chatbot, especially for farmers. The Farmer chatbot can be modified to meet sector-specific requirements. Chatbots include automated interactions with conversational virtual assistants. This emerging technology can provide solutions to farmers' queries and advice on specific farm challenges. Additionally, timely and interactive crop monitoring can be done remotely by this innovative method.

b) Driverless Tractors

All farm operations are performed autonomously and precisely by remote-controlled driverless tractors. Sensors mounted on tractors regulate and perform all required practices, monitor obstructions, and apply required farm inputs. GPS-enabled agriculture machinery is now equipped with radars and sensors to encourage new possibilities of enterprising farming.

12. Agricultural product monitoring and storage control

Post-harvest storage, drying, and grading of agricultural produce are crucial aspects of agriculture production. With the concept of artificial intelligence, monitoring and controlling the quality control mechanism of agricultural products can be done efficiently.

13. Weather forecasting

Forecasting future weather patterns is a complex task and it requires the use of various sensors, satellites, and computer models. Through reinforcement learning, artificial intelligence algorithms analyze previous weather forecasts and actual outcomes. Deep learning techniques have proven successful in fields such as image and speech recognition, and natural language processing (NLP). It can be easily implemented in the weather and climate fields as well to predict climate efficiently to minimize chances of crop losses and improve productivity.

14. Decision support system

A web or app-based system enables stakeholders to meet specified goals. The utility of DSS has been demonstrated in a variety of agricultural sectors. The DSS idea is now being extended to spatial decision support systems through the integration of GIS and DSS in policy decision analysis, watershed, and crop production management. Some examples are SWAT, AQUACROP, INFOCROP, CROPWAT, DSSAT, HYDRUS, MIKESHE, etc.

AI start-ups: Race for AI

- **Blue River Technology:** Farmers are facing challenges of herbicide resistance in weed control. Herbicide resistance is observed in over 250 weed species. A robot named, See & Spray was developed by a California-based company Start-up that uses computer vision to monitor and spray herbicide precisely on weeds in cotton plants.
- **Harvest CROO robotics:** Automation is a time-saving and drudgery-reducing strategy that resolves labour-force challenges. Harvest CROO Robotics has created a robot for strawberry harvesting that can harvest 8 acres and replace 30 human laborers in a single day.
- **PEAT (machine vision for pests/ soil defects diagnosis):** To identify soil potential defects and nutritional deficiencies, Plantix, has been developed by agricultural tech startup PEAT. Software algorithms correlate specific foliage patterns with soil defects, plant pests, and diseases.
- **Agribolo:** It empowers farmers with latest mandi/weather updates, best farm practices and expert advice. It also provide "Agri Mart" & "Agro Services" a marketplace to buy/rent/sell agri-based products & services along with e-mandi services.

Challenges in AI Adoption in Agriculture

Despite the fact that AI has applications in agriculture, there is still a shortage of high-tech machine learning solutions. Machine learning requires a large amount of data to forecast precise solutions. This is the reason why, AI is mostly used in agronomic products such as seeds, fertilizer, and pesticides rather than in-field specific solutions.

CONCLUSION

Adoption of AI can result in increased production capacity, lower production costs, and less drudgery in agriculture. To perform real-time management, more precise automation in agriculture is needed. AI will assist in the transition from traditional to precision agriculture. With advanced strategies, AI-based innovations enhance efficiency and crop production rate. Agriculture cannot be entirely dependent on AI. Indian farmers lack technical knowledge and awareness about these technologies.