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Application of Artificial Intelligence in Indian Agriculture

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Agriculture is the backbone of India's economy. It is the principal livelihood for over 58% of the rural households. But it faces difficult challenges from sowing to harvest. Hence modernisation of agriculture is most needed to address these challenges. In agriculture there is a quick adaptation to AI in its various farming techniques where Artificial Intelligence (AI) is one of the key areas of research in computer science with its rapid technological advancement and vast area of application, AI is becoming relevant very rapidly because of its robust applicability in the problems particularly that cannot be solved well by humans. Such an area of extreme importance is agriculture where about 80% of the population is directly engaged on 159.7 million hectares of agricultural land. Such a venture cannot run smoothly. Hence farming solutions which are AI powered enable a farmer to do more with less, enhancing the quality, also providing a quick GTM (go-to-market strategy) strategy for crops. A direct application of AI (Artificial Intelligence) or machine intelligence across the farming sector could act to be an apotheosis of shifting of traditional farming practice today. AI powered agriculture, analysing its service in interpreting, acquiring and reacting to different situation to enhance efficiency.

Artificial intelligence technology is supporting different sectors in agriculture to boost productivity and efficiency. AI solutions are assisting to overcome the traditional challenges in every field. Intervening of AI in agriculture is helping farmers to improve their farming efficiency and reduce environmental hostile impacts. The agriculture industry strongly and openly grasped AI into their practice to change the overall outcome. AI is shifting the way of food production where the agricultural sector's emissions have decreased by 20%. Inculcating AI technology in agriculture is helping to control and manage any uninvited natural condition.

What's Artificial About Intelligence in AI?

AI is the study of computer system that attempt to model and apply the intelligence of human mind. It simulates the intelligent behaviour of human

beings think and act (and in times to come, better than them), achieving human-like performance in all cognitive tasks using purely logical reasoning. The 'artificial' in AI represents 'non-biological', the 'intelligence' represents as 'ability to accomplish complex goals or tasks'. AI is the analytic process one can associate with human thinking like speech recognition, natural language understanding and translation, knowledge management, image analysis, decision making, learning etc. which will make systems powerful and useful.

AI technology is rapidly remedying the problems while recommending specific action that is required to overcome the problem. AI is a smart monitor system to find solutions quickly. Let's see how AI is being used in agriculture to improve results with a minimal environmental cost and maximise the capacity. AI promises to drive an agricultural revolution at a time when the world must produce more food using fewer resources. This article briefly discusses key applications of AI in agriculture along different stages of the cropping cycle that have the potential to pay dividends to farmers in efficiency gains and higher incomes.

Smart Irrigation

Soil and irrigation management issues are pertaining very crucial in agriculture. Improper irrigation and soil management lead to crop loss and degraded quality. Hence a smart management system is needed to improve the productivity. The smart Irrigation system is an Internet of things (IoT) based device which is can automate the irrigation process by analysing the moisture of soil and the climate condition. Irrigation is one of the most labour intensive processes in farming which can be avoided by artificial intelligence because it is aware of historical weather pattern, soil quality and kind of crops to be grown. Automated irrigation systems are designed to utilize real time machine which can constantly maintain desired soil conditions in order to increase average yields. Not only reduces the drudgery of farmers significantly but also provide the potential to drive down productions costs. Given that agriculture utilizes about 70% of the country's freshwater, hence the consciousness of AI would be a big impact on saving water loss for agriculture.

Monitoring Crop and Soil Health

Conducting or monitoring identifies possible defects and nutrient deficiencies in the soil can be efficiently done by utilizing AI. With the image

recognition approach, AI identifies defects through images captured by the camera accurately. Such AI-enabled applications are very supportive in understanding soil defects, plant pests, plant stress and diseases. Remote sensing (RS) techniques along with hyper spectral imaging and 3D laser scanning are effective to construct crop matrix over thousands of acres of cultivable land. There is a revolutionary shift by inculcating AI in monitoring farm land by farmers from the perspectives of both time and effort.

Decrease Pesticide Usage

Weed management can be effectively done by implementing computer vision, robotics, and machine learning. With the help of the AI, data are collected to check the weed infestation area which helps the farmers to spray chemicals only where the weeds are. By this there is a reduction in over pesticide losses as well as herbicide losses. It has been reported that average losses of up to 90% of the total crop production happened due to the infestation of weed (Meena, 2015). Similarly average losses of up to 19% have been reported due to pests (Dhaliwal *et al.*, 2015). This leads to a over use of pesticides and there may be chances of further contamination of the soil and groundwater. To address these issues AI-enabled agriculture bots help farmers to find more efficient ways to protect their crops from weeds. This also helps farmers to overcome the labour challenge.

Case Study: An objective oriented approach to frame a rule base was taken by Ghosh and Samanta (2003) in developing TEAPEST, an expert system for pest management in tea (Fig. 1).

Figure 1. Components of TEAPEST expert system

Image-based Insight Generation

Precision farming is one of the most efficient areas in farming today. In-depth field analysis, crop monitoring, scanning of fields and so on can be

easily done by drone-based images. Computer vision technology, IOT and drone data can be associated to ensure rapid actions by farmers. These are some specific areas where image analysis can be specifically done in agriculture:

Crop Readiness Identification

Images of different crops under white/UV-A light are captured to know the ripening stage of crop/fruits. Farmers can classify different levels of readiness based on the crop/fruit category.

Disease Detection

Crop diseases are having grave concern to a farmers. Proper expertise and experience are required in order to detect an ailing plant and to take necessary steps for recovery. Diagnosis of the diseases and control measures can be effectively done by computer aided system. Fuzzy logic based model has been developed to forecast diseases based on leaf wetness duration. Pre-processing of image segment of the leaf image into areas like background, non-diseased part and diseased part. Then cropped diseased part send to remote labs for further diagnosis. Pest identification, nutrient deficiency recognition can also be done by image processing (Fig. 2).

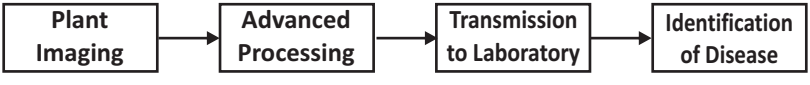

Figure 2. Steps in disease detection and diagnosis

Case study: Fasal implemented in Chhattisgarh and Andhra Pradesh, saved 50% water, downy and powdery mildew disease prediction by preventive sprays in Vineyards.

Field Management

By creating a field map and identifying areas where crops require water, fertilizer or pesticides using high-definition images from airborne systems (drone or copters), real-time estimation can be done during cultivation period. This helps in resource optimization to a large extent.

Significance of drone and Unmanned aerial vehicles UAV

Unmanned aerial vehicles (UAV) are remote sensing autonomous vehicles which help in capturing images and collecting data about a particular scene. The use of UAV leads to low cost of operation in wide

environmental monitoring. Technologies in drones is quickly gaining trust among farmers by providing new ways of increasing crop yields through in-depth analysis, long-distance crop spraying and high-efficiency crop analysis. Practical applications for drone technology are becoming more prevalent, therefore it is likely that drone-powered solutions will be on the notch over the next few years. Drone based solutions in agriculture sector have a lot of implication like dealing with adverse climatic conditions, productivity gains, precision farming and crop yield management.

- Drone can be used to produce a 3-D field map of detailed terrain, drainage, soil viability and irrigation before crop cycle. Necessary supplements for plants can be provided by aerial spraying of pods with seeds and plant nutrients into the soil. Apart from that, inculcating programme in drones which can spray liquids by modulating distance from the ground depending on the terrain.
- High-resolution cameras in drones collect precision field images which can be passed through convolution neural network to identify areas with weeds, which crop water needs, plant stress level in mid- growth stage. Infected plants can be detected by scanning crops in both RGB and near-infra red light.
- Effective management of soil N_2 levels can be achieved by drone. Drones can be programmed to atomize liquids by regulating the distance from the ground surface depending on the terrain.

Supply Chain Management

In agricultural supply chain management the AI is yet to make major inroads. Its efficient application in supply chain planning and optimisation, including demand forecasting and logistics, can lead to huge cost savings for farmers, and solve the information asymmetry problem for stakeholders.

Case Study: Platforms like Jivabhumi's 'Food print' aggregates and traces farm produce, and offers a digital marketplace. It uses blockchain technology to connect farmers and institutional buyers via an efficient and traceable supply chain (Baruah, 2019).

Soil Analysis and Monitoring

AI can be used to monitor soil health with the help of sensors, cameras, and infrared rays that scan the soil for its nutritional properties (Sennaar, 2019; Baruah, 2018). This also helps in understanding the reaction of

specific seeds to different soils, the impact of weather changes on the soil, and the probability of the spread of diseases and pests. It is very efficient way to improve crop inputs, leading to cost savings and productivity gains for farmers.

Precision Farming

Precision farming is a technique of farming which has high accuracy and control capacity (Fig. 3). It substitutes the repetitive and labour intensive part of farming, besides providing guidance regarding crop rotation. The advanced technologies that enable precision farming are high precision positioning system, geological mapping, remote sensing, integrated electronic communication, variable rate technology, optimum planting and harvesting time estimator, water resource management, plant and soil nutrient management, attacks by pest and rodents. It includes right time, right place and right amounts of application of farm inputs.

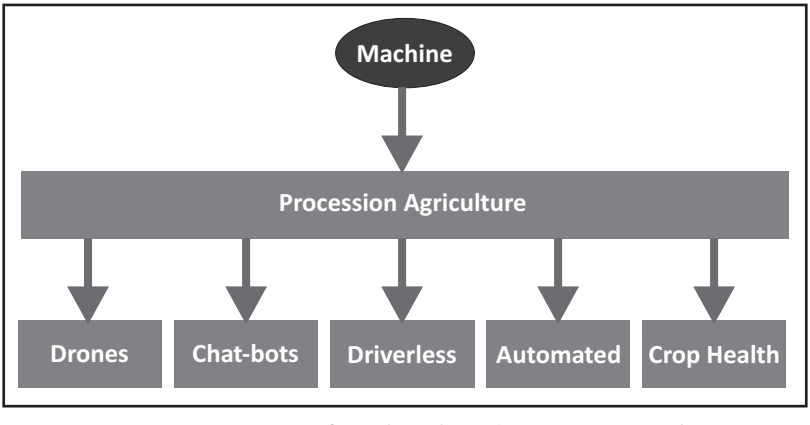

Figure 3. Comonents of machine based precision agriculture

High resolution images and multiple sensor data can detect the different stress level of plant by AI. This entire set of data generated from multiple sources needs to be utilized as an input data for AI machine learning. Optimal sowing period can be recognized by AI models in various seasons. Statistical climatic data, real time Moisture Adequacy Data (MAI) from daily rainfall statistics and soil moisture are required to construct forecast charts to determine the best sowing time to farmers. AI has strategic advantage for forecasting potential pest attacks which reduces the potential chances of pest attack.

Chat Bots for Farmers

Chat bots includes automates interactions with end users like conversational virtual assistant. In agriculture these are used for communication between farmers, government stakeholders, manufacturers and markets. Agriculture could also grasp this emerging technology by assisting farmers with answers to their questions, giving advice and recommendations on specific farm problems. Timely and interactive monitoring of the crops remotely will be provided by this innovative mode.

Driverless Tractors

Robotic agriculture is an anticipated future which is going to be implemented in the next 10-15 years. Driverless tractors are independent tractors that perform all the farm practices autonomously and precisely. They are fixed with sensors that are able to perform the required practices, monitoring obstacles and determining where to apply the farm inputs. Driverless vehicle technology becomes prevalent across a wide array of technological firms. Agriculture is now combining off- shelf technologies such as GPS systems, radars and sensors which promote new avenues of enterprising farming.

Automation of Green House

There are many factors that influence plant growth and the ripening of produce in green house. It is impossible for humans to analyse all these factors and know *exactly* how plants will grow. AI makes analysis of all these growth factors possible and provides highly accurate assessments of plant growth.

Support Vector Machines

Support vector machines (SVMs) were first introduced in statistical learning theory foundation work. SVM is intrinsically a binary classifier that constructs a linear separating hyper plane to classify data instances. Classification, regression, and clustering of image based agricultural data can be done by SVM. Based on global optimization, SVMs deal with over fitting problems which makes it appealing in various applications. Most used SVM algorithms include the support vector regression, least squares support vector machine, and successive projection algorithm-support vector machine.

Agricultural Product Monitoring and Storage Control

In agriculture storage, drying, grading of harvested crops are also very important aspects. Monitoring and quality control mechanisms of agricultural products are employed by the concept of artificial intelligence.

Weather Forecasting

A variety of sensors, satellites and computer models are utilized by meteorologists to predict future weather patterns. Reinforcement learning is applied by artificial intelligence (AI) techniques considering past predictions and actual outcomes. Deep learning techniques have already been shown to be successful in areas like image and speech recognition and natural language processing (NLP), and it can be applied to the weather and climate fields as well. Therefore AI is efficiently working prediction to minimize the potential chances of crop losses and improve the productivity.

Challenges in AI Adoption in Agriculture

Through vast opportunities for applications in agriculture are offered by Artificial intelligence still there exists a lack of familiarity with robust high tech technology solutions in farms across most parts of the country. Farming exposures to external factors like weather conditions, and presence of pests is quite a lot which are uncertain. So planning during the start of harvesting may not be an optimal one because of changes in external parameters. A lot of data is needed in AI system to train machines and to make precise predictions. In case of vast agricultural land, though spatial data can be gathered easily, temporal data is hard to get due to some defined constraints. Also in India adopting the AI in agriculture becomes more cost expensive and simultaneously it promotes unemployment.

Conclusion

The AI can help the farmers to increase the capacity of production and reduce the cost of production and drudgery. No need to say that diffusion of AI in all application domains will also bring an ideal shift in the way we do research and development in agriculture now. AI moves towards more automation with more accuracy to perform on real time management, which is helping in standard shifting of traditional agriculture to precision agriculture with low cost. The AI solution must be viable and accessible to the farming community. For faster adoption and greater insight among the

farmers AI solutions should offer an open source platform by making its solutions more affordable.

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