

Artificial Intelligence

Emergence in Agriculture

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Agriculture, one of the prime sector and foundation of economy is under immense pressure. Increasing the total production by 70% in order to meet the world's demand in the next 30 years is an objective imperiled by reducing resources, climatic changes and other man-made and natural threats. According to UN Food and Agriculture Organization, the population will increase by 2 billion by 2050. However, only 4% additional land will come under cultivation by then.

Key words: Agriculture, Artificial Intelligence, Crop yield, Robotics

DESPITE its relatively short life, Artificial Intelligence is seen and remains one of the greatest imperatives. The idea that these problems will be surpassed using the technology goes forward, some opinions advocating that humanity will merge with AI. In the new phase of technical evolution, millions of people still struggling to get access to basic resources, like food, water and shelter. This study outlines the trends of adoption and the development of artificial intelligence in agriculture, focusing on expert systems, sensors for collecting and transmitting data and robots developed for agriculture, in an attempt to reveal their potential impact in this field.

AI IN AGRICULTURE

In recent years, modern and intelligent techniques like aeroponics, wireless sensors, expert systems etc. have achieved significant attention in agriculture. It is applied in agriculture sector to plan the several activities and missions properly by utilising limited resources with minimum human interference. Rapid adoption of Artificial Intelligence (AI) in agriculture both in terms of agricultural products and in-field

farming techniques. Cognitive computing in particular, is all set to become the most disruptive technology in agriculture services as it can understand, learn, and respond to different situations (based on learning) to increase efficiency.

Providing some of these solutions as a service like expert system chat bot or other conversational platform to farmers will help them keep pace with technological evolution as well as apply the same in their daily farming, and reduce the complicated manually monitoring and controlling process. Microsoft is working with 175 farmers in Andhra Pradesh, India to provide advisory services for sowing, land, and fertilizer and so on. This initiative has already resulted in 30% higher yield/ha on an average compared to 2018. Given below are top areas where the use of cognitive solutions can benefit agriculture.

Knowing the field before you start- Image-based insight generation

Precision farming is one of the most discussed areas in farming today. Drone-based images can help in in-depth field analysis, crop monitoring, scanning of fields and so on. Computer vision technology,

Internet of Things (IoT) and drone data can be combined to ensure rapid actions by farmers. Feeds from drone image data can generate alerts in real time to accelerate precision farming. Huge volumes of data get generated everyday in both structured and unstructured format. These relate to data on historical weather pattern, soil reports, new research, rainfall, pest infestation, images from drones and cameras etc. Cognitive IoT solutions can sense all this data and provide strong insights to improve yield.

Proximity Sensing and Remote Sensing are technologies that can primarily be used for intelligent data fusion. One use case of this high-resolution data is Soil Testing. While remote sensing requires sensors to be built in to air borne or satellite systems, proximity sensing requires sensors in contact with soil or at a very close range. This helps in soil characterization based on the soil below the surface in a particular place.

Platform and the Visual Recognition platforms in commercial drones for image analysis in real time. Example, images of different crop under white/UV-Align are captured

to determine how ripe the green fruits are. Farmers can create different levels of readiness based on the crop/fruit category and add the minto separate stacks before sending them to the market.

Identification of optimal mix for agronomic products

Based on multiple parameters like soil condition, weather forecast, type of seeds, infestation in a certain area and so on, cognitive solutions make recommendations to farmers on the best choice of crops and hybrid seeds. The recommendation can be further personalized based on the farm's requirement, local conditions, and data about successful farming in the past etc. External factors like marketplace trends, prices or consumer needs can be a factor to enable farmers take a well-informed decision.

Hardware solutions like Rowbot (pertaining to corns) are already pairing data-collecting software with robotics to prepare the best fertilizer for growing corns in addition to other activities to maximize output.

Automation techniques in irrigation to enable farming

In terms of human intensive processes in farming, irrigation is one such process. Machines trained on historical weather pattern, soil quality and kind of crops to be grown, can automate irrigation and increase overall yield.

Health monitoring of crops

Remote sensing techniques alongwith hyper spectral imaging and 3d laser scanning are essential to build crop metrics across thousands of acres. It has the potential to bring in a revolutionary change in terms of how farmlands are monitored by farmers both from time and effort perspective. This technology will also be used to monitor crops along their entire lifecycle including report generation in case of an omalies.

Preprocessing of image ensure the leaf images are segmented into areas like background, non-diseased part and diseased part. The diseased part is then cropped and send to remote labs for further diagnosis. It also

helps in pest identiûcation, nutrient deûiciency recognition and more.

Field management

Using high-definition images from airborne systems (drone or copters), real-time estimates can be made during cultivation period by creating affeld map and identifying are as where crops require water, fertilizer or pesticides. This helps in resource optimization to a huge extent.

Supply chain management

In farming and agriculture today, outside the traditional scenarios, a farmer is often beholden to a particular supplier or partner. They may, for example, be sending a certain amount of their most recent harvest to a local grocer or department chain. Regardless of who is partnered up in agriculture, it is not always possible to know precisely how much and when a particular crop is going to be ready. This coupled with changing demand on the consumer side can lead to severe supply issues. Data driven AI solutions can alleviate some of the problems that arise in the supply chain, merely because it affords more over sight regarding the crops and harvest each season. This is true of not just the farmers working with the plants, but everyone else along the supply chain, information including distributors, packagers, retailers, and more. When passed on, the data can genuinely help everyone in the progress.

Technology has helped grow agricultural market places from merely physical places to physical and digital markets. Almost 900 startups are involved in digital marketplaces of some kind, and have received cumulative funding of 682 million USD. Studies have noted that improved market transparency reduce price dispersion and waste.

AI AND ROBOTICS IN FARMING

As per a recent study, the total addressable market for robotic-based solutions (including drone etc.) across the globe is 127.3 billion USD and for agriculture it is at 32.4 billion USD.

Drone based solutions in agriculture have a lot of signiûcance in terms of managing adverse weather conditions, productivity gains, precision farming and yield management in the following:

- Before the crop cycle, drone robos can be used to produce a 3-D ûeld map of detailed terrain, drainage, soil viability and irrigation. Nitrogen-level management can also be done by drone solutions.
- Aerial spraying of pods with seeds and plant nutrients in to the soil provides necessary supplements for plants. Apart from that, Drones can be programmed to spray liquids by modulating distance from the ground depending on the terrain.
- Crop Monitoring and Health assessment remains one of the most significant are a sin agriculture to provide drone-based solutions in collaboration with Artificial Intelligence and computer vision technology. High-resolution came rasin drones collect precision field images which can be passed through convolution neural network to identify areas with weeds, which crops need water, plant stress level in mid- growth stage. In terms of infected plants, by scanning crops in both RGB and near-infra red light, it is possible to generate multispectral images using drone devices. With this, it is possible to specify which plants have been infected including their location in a vast ûeld to apply remedies, instantly. The multi spectral images combine hyper spectral images with 3D scanning techniques to deûine the spatial information system that is used for acres of land. The temporal component provides the guidance for the entire lifecycle of theplant.

Role of robotics in agriculture

Precision farming

Objectives of precision farming:

Profitability: Identifying crops and market strategically as well as predicting ROI based on cost and margin.

Efficiency: By investing in precision algorithm, better, faster and cheaper farming opportunities can be utilized.

This enables overall accuracy and efficient use of resource

Sustainability: Improved social, environmental and economic performance ensures incremental improvements each season for all the performance indicators.

This is a more accurate and controlled technique that replaces the repetitive and labor-intensive part of farming. It also provides guidance about crop rotation, optimum planting and harvesting time, water management, nutrient management, pest attacks and so on. For Example,

- Identification of stress level in a plant is obtained from high-resolution images and multiple sensor data on plants. This largeset of data from multiple sources needs to be used as an input for Machine Learning to enable data fusion and feature identification for stress recognition.
- Machine learning models trained on plant images can be used to recognize stress levels in plants. The entire approach can be classified into four stages of identification, classification, quantification and prediction to make better decisions.

Few of the technologies that enable precision farming are given below:

- High precision positioning system
- Automated steering system
- Geomapping
- Sensor and remotesensing
- Integrated electronic communication
- Variable rate technology

Crop yield management

The emergence of new age technologies like Robotics, Cloud Machine Learning, Satellite Imagery and advanced analytics are creating a complete ecosystem for smart farming. Mix of all these technology enable farmers to achieve higher average yield and better price control.

Microsoft is currently working with farmers from Andhra Pradesh to provide advisory services using Cortana Intelligence Suite including Machine Learning and Power BI.

The pilot project use an AI sowing app to recommend sowing date, land preparation, soil test-based fertilization, farm yard manure application, seed treatment, optimum sowing depth and more to farmers which has resulted in 30% increase in average crop yield per hectare.

Technology can also be used to identify optimal sowing period, historic climate data, real time Moisture Adequacy Data (MAI) from daily rainfall and soil moisture to build predictability and provide inputs to farmers on ideal sowing time.

To identify potential pest attacks, Microsoft in collaboration with United Phosphorus Limited is building a Pest Risk Prediction API that leverages AI and machine learning to indicate in advance, the risk of pest attack. Based on the weather condition and crop growth stage, pest attacks are predicted as High, Medium or Low.

Start Ups in artificial intelligence

Blue River technology-weed control: The ability to control weeds is a top priority for farmers and an ongoing challenge as herbicide resistance becomes more common place. Today, an estimated 250 species of weeds have become resistance to herbicides. In a research study conducted by the Weed Science Society of America on the impact of uncontrolled weeds on corn and soybean crops, annual losses to farmers are estimated at 43 billion USD. This California-based startup company developed a robot called See & Spray which reportedly leverages computer vision to monitor and precisely spray weeds on cotton plants. Precision spraying can help prevent herbicide resistance.

Harvest CROO robotics – crop harvesting: Automation is also emerging in an effort to help address challenges in the labour force. Agriculture sector is projected to experience a 6% decline in agricultural workers from 2014 to 2024.

Harvest CROO Robotics has developed a robot to help strawberry farmers pick and pack their crops.

Lack of laborers has reportedly led to millions of dollars of revenue losses in key farming regions such as California and Arizona. In the Hillsborough County, Florida region which has been described as the “nation’s winter strawberry capital,” between 10,000 and 11,000 acres of strawberries are typically harvested in a season. Harvest CROO Robotics claims that its robot can harvest 8 acres in a single day and replace 30 humanlabourers.

PEAT – machine vision for diagnosing pests / soil defects:

Deforestation and degradation of soil quality remain significant threats to food security and have a negative impact on the the economy. Domestically, the USDA has estimated that the annual cost of soil erosion is approximately 44 billion USD.

Berlin-based agricultural tech startup PEAT, has developed a deep learning application called Plantix that reportedly identifies potential defects and nutrient deficiencies in soil. Analysis is conducted by software algorithms which correlate particular foliage patterns with certain soil defects, plant pests and diseases. The image recognition app identifies possible defects through images captured by the user’s smartphone camera.

Trace Genomics – machine learning for diagnosing soil defects:

California-based Trace Genomics, provides soil analysis services to farmers. Lead investor Illumina helped develop the system which uses machine learning to provide clients with a sense of their soil’s strengths and weaknesses. The emphasis is on preventing defective crops and optimizing the potential for healthy crop production.

According to the company’s website, after submitting a sample of their soil to Trace Genomics, users reportedly receive an in-depth summary of their soils contents. Services are provided in packages which include a pathogen screening focused on bacteria and fungi as well as a comprehensive microbial evaluation.

Sky Squirrel technologies Inc. – drones and computer vision for crop analysis: The company aims to help users improve their crop yield and to reduce costs. Users pre-program the drone's route and once deployed the device will leverage computer vision to record images which will be used for analysis.

Once the drone completes its route, users can transfer a USB drive from the drone to a computer and upload the captured data to a cloud drive. Sky Squirrel uses algorithms to integrate and analyze the captured images and data to provide a detailed report on the health of the vineyard, specifically the condition of grapevine leaves. Since grapevine leaves are often telltales for grapevine diseases (such as molds and bacteria), reading the “health” of the leaves is often a good proxy for understanding the health of the plants and their fruit as a whole.

aWhere – satellites for weather prediction and crop sustainability: A Colorado based company uses machine learning algorithms in connection with satellites to predict weather, analyze crop sustainability and evaluate farms for the presence of diseases and pests.

For example, daily weather predictions, are customized based on the needs of each client and range from hyperlocal to global. Types of clients mentioned on the company's website include farmers, crop consultants and researchers. We've covered AI for weather

prediction earlier this year, but the video below gives a good idea of some of the fundamental technologies at play.

CHALLENGES IN ADOPTING ARTIFICIAL INTELLIGENCE

The farmers owning lands in developing nations is small so affording the AI solutions in terms of cost is a challenge, and therefore state supported mechanisms can make it possible.

Though AI offers vast opportunities for application in agriculture, there still exists a lack of familiarity with high tech machine learning solutions in farms across most parts of the world. Exposure of farming to external factors like weather conditions, soil conditions and presence of pests is quite a lot. What might look like a good solution while planning during the start of harvesting, may not be an optimal one because of changes in external parameters. AI systems also need a lot of data 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. For example, most of the crop-specific data can be obtained only once in a year when the crops are growing. Since the data infrastructure takes time to mature, it requires a significant amount of time to build a robust machine learning model. This is one reason why AI sees a lot of use in agronomic products such as seeds, fertilizer, pesticides and so on rather than in-

field precision solutions.

CONCLUSION

AI-driven technologies are emerging to improve efficiency and to address challenges including, crop yield, soil health and herbicide-resistance. Agricultural robots become a highly valued application of AI in this sector, adoption is apparent in the dairy farming where thousands of milking robots are already operating. It is anticipated that agricultural robots will be developed to complete an increasing diverse array of tasks in the next three to five years.

Crop and soil monitoring technologies will also be important applications as climate change continues to be researched and evaluated. One research study reported that climate change evaluated from 1980 to 2008 resulted in a 3.8% global reduction of maize and a 5.5% reduction of wheat. The amount of data that can potentially be captured by technologies will give agricultural sector a new ability to identify changes and predict opportunities. Additionally, extensive testing and validation of emerging AI applications in this sector will be critical as agriculture is impacted by environmental factors that cannot be controlled unlike other sectors where risk is easier to model and predict. It is anticipated that the agricultural industry will continue to see steady adoption of AI.

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