ARTIFICIAL INTELLIGENCE FOR SMART CITIES AND VILLAGES: ADVANCED TECHNOLOGIES, DEVELOPMENT, AND CHALLENGES

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CHAPTER 14

Artificial Intelligence: A New Hope in Agriculture

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Abstract: Conventional agriculture strategies do not suffice to serve the food demand for the growing population nowadays. Scientists carried out many investigations for effective agricultural outputs over the last few decades. The newly emerging technologies such as Artificial Intelligence (AI), deep learning, machine learning, Internet of Things (IoT), cloud computing, cognitive computing and so on are motivating the agriculture scientists to invent novel methods in farming. Researchers performed Crop wise specific studies for the benefit of the farmers, which use different technological devices like sensors, cameras, drones, *etc*. Automation of agricultural equipment has become crucial to provide instant results to help the farmers in decision-making wherever required. The article thoroughly explains the impact of automation and AI in the field of agriculture today. It also highlights the usage of prominent AI techniques nowadays and possible research directions to make use of AI to assist the farmers.

Keywords: Automation, Agriculture, Deep learning, Farming, Machine learning, Sensors.

INTRODUCTION

As stated by the UN Food and Agriculture Organization, the population will rise by 2 billion in 2050. Conversely, mere 4% excess land can come under farming at that time [1, 2]. Hence, the practice of up-to-date technical solutions to make farming further competent becomes an extreme requirement. The rise of modern technologies like AI, Satellite Imagery, Cloud Machine Learning, Cognitive computing and advanced analytics are generating an environment for smart agriculture. The combination of these techniques is empowering farmers to real-

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ize greater mediocre harvest and healthier regulation of crop prices. Although AI realizes a lot of straight use through segments, it can lead to a paradigm shift, which results in new ways of present agriculture.

Primarily AI is the perception of an expertise to imitate human intellect. Later, AI has progressed in methods, which had extremely surpassed its former notion. In recent times, there is a radical improvement in the techniques of data gathering, handling and computation. The development of intelligent systems to conquer diverse jobs can boost throughput. Strong applications are much necessary for the wide-ranging implementation of AI in farming. Management of dynamic exterior circumstances, assistance in instant decision-making and implementation of suitable policy for proficient data gathering are possible by such AI applications. AI built elucidations infuse human life and commercial methods. Hence, focus on virtuous ways and standard methods of resource usage are essential.

Unreasonable charges incurred due to the employment of diverse cognitive resolutions in agriculture are another essential characteristic to address. We must reduce the expenditure and the new AI techniques should be accessible to the ordinary and poor people. Stringent AI related government policies should be developed and instigated to get the objectives.

AI facilitates agriculturalists to do bigger through a smaller amount by increasing value and confirming quicker go-to-market for harvests. We made a thorough study of various automated agriculture inventions as part of the literature review. In the remaining sections, we discussed new trends in AI from the perspective of agriculture and possible research directions in this domain.

BACKGROUND

Nabavi-Pelesaraei [3] conducted energy output as well as ecological influence forecast of paddy production in Guilan province, Iran built on Adaptive Neuro Fuzzy Inference System (ANFIS) in addition to Artificial Neural Networks (ANNs). The staggered ANFIS is a helpful instrument to supervisors for huge scope arranging in anticipating vitality yield and ecological files of rural creation frameworks attributable to its higher speed of calculation forms contrasted with ANN model, regardless of ANN's higher precision.

Dahikar and Rode [4] have specified that ANNs emerged as potential instruments to model and predict. It upsurges the worth of crop production and influences mineral proportion assessment. They employed the Harvest expectation technique to expect the appropriate yield by identifying the boundary of soil and still boundary known through the weather.

Patricio and Rieder [5] highlighted vision based computer results in conjunction with AI procedures that attained vital outcomes in finding image patterns. They conducted an efficient survey that intends to recognize the pertinence of PC visualization in exactness farming to create five maximum delivered ounces on the planet. From the consequences of the efficient audit, it is conceivable to distinguish incredible chances.

Eli-Chukwu [6] has stated that the utilization of AI has been obvious in the horticultural part as of late. The segment faces various difficulties to expand its yield including inappropriate soil treatment, illness and irritation pervasion, large information necessities, low yield, and information hole between ranchers what's more, innovation. The primary idea of AI in farming is its adaptability, elite, precision, and cost-adequacy. This paper presents a survey of the uses of AI in soil the board, crop the board, weed the board and sickness the executives. It lays an extraordinary spotlight on the quality and restrictions of the application and the path in using master frameworks for higher profitability.

Badjonski and Ivanovic [7] from their experimental knowledge showed that human specialists decide on reasonable half-breeds to develop in four steps. Based on a similar guideline, utilizing an operator-arranged approach, they constructed an overall master framework model. The information base comprises a few operators. Operators utilize their own language and update their inside convictions until an answer is reached. They utilized a general model for the making of a specialist framework model for the assurance of ideal maize mixtures to develop.

Harfouche *et al*. [8] have found that rearing harvests for high return and better flexibility than new and variable atmospheres are basic to guarantee proceeded with food security, biomass creation, and biological system administrations. Basic to progress is the need to acclimatize a lot of information into naturally important translations. Investigate developing methodologies and difficulties for multi omics enormous information joining is investigated by methods for people to achieve (Next-Gen) man-made brainpower (Manufactured intelligence), and propose a useful way to progress.

Jha *et al*. [9] have stated that horticulture using robots is the primary concern and rising subject for each nation. The total populace is expanding at an exceptionally quick rate and with increment in the populace the requirement for food increments energetically. Conventional strategies utilized by ranchers are not adequate to serve the expanding request thus; they need to hamper the dirt by utilizing destructive pesticides efficiently. This influences the agrarian practice a great deal and in the end, the land stays infertile with no ripeness. For this purpose, the

diverse uses of robots are discussed. Some of the issues faced in farming field are harvest ailments, absence of capacity, pesticide control, weed and absence of water system, which can be illuminated by previously mentioned various procedures.

In recent times, it is necessary to decode the topics like utilization of harmful pesticides, well-ordered water system, and regulation of contamination and impacts of conditions in horticultural preparation. Mechanization of cultivating rehearses has demonstrated to build the addition from the dirt and furthermore has reinforced the dirt fruitfulness. The article reviews the efforts of numerous scientists to acquire a concise diagram which shows the current execution of mechanization in horticulture. It likewise talks about the execution of a recommended framework in plant ranch for blossom and leaf recognizable proof as well as watering utilizing IoT.

Kaab *et al*. [10] have carried upon a research which intends to utilize two man-made reasoning (AI) techniques, to be specific, counterfeit neural systems (ANNs) and versatile ANFIS model, for anticipating life cycle ecological effects and yield vitality of sugarcane creation in planted or ratoon ranches. The authors investigated the Khuzestan region of Iran. In view of the support for grave methodology, they utilized Life Cycle Appraisal (LCA) to assess ecological effects and study natural effect classes of sugarcane creation. Results from ANN models showed that the coefficient of assurance (R2) fluctuates from 0.923 to 0.986 in planted homesteads and 0.942 to 0.982 in ratoon ranches in the preparing stage for natural effects and output vitality. The creation of results from ANFIS model, in light of a crossover learning calculation, indicated that, for forecast of natural effects, R2 changes from 0.912 to 0.978 and 0.986 to 0.999 in plant and ratoon ranches, separately, and for the expectation of yield.

Weersink *et al*. [11] clarified definitions of the threshold expressions used in the works of agriculture and examined transformations among different action schemes recommended by several definitions.

Onstad [12] presented for the first time, the universal methods to reckon economic-injury levels and economic thresholds. Sharma *et al*. [13] discussed recent trends in IoT from the perspective of smart cities. Verma *et al*. [14] explained modern tools in data mining and machine learning. Mangla *et al*. [15] discussed various day-to-day applications of IoT and its practical issues. Ayed and Hanana [16] described the essentiality and boundaries of AI and machine learning in the food and agriculture sector.

NEW TECHNOLOGY TRENDS

Use of Robotics

Robots can manage important agricultural works such as weeding, precise placement of fertilizers, localized spraying of pesticides and fungicides, crop harvesting, crop yield estimation, picking & packing of crops and so on. It reduces the labour cost and makes the work easy. With the help of robots, within a short time, we can get the work done. We can automate many works in agriculture without human intervention [17].

Implementation of Computer Vision and Deep Learning Algorithms

Computer vision mixes intense image capturing with fast computing capabilities. With the use of particular crop images of the target region, we can get good outputs with the help of image processing techniques. With the combination of computer vision and deep learning strategies, we can obtain maximum accuracy in the results, which in turn help farmers in decision-making [18].

Predictive Analytics

A farmer can take the help of agricultural data collections from various data sources. By using data processing and analysis, we can predict various features like weather conditions, crop economics, pest dynamics and so on. It is already in the implementation by government organizations in developed countries. Other nations are also adopting this technology slowly [19].

Precision Agriculture

Effective use of sensors, cameras and other devices in the implementation of AI assists the farmer to make worthy decisions on crop quality, crop-pest relationship dynamics, crop health, nutrition values, pesticide selection, and adoption of proper pest management scheme and so on [20].

Effective Usage of Drones

We are using drone technology very frequently nowadays in various fields. Agriculture sector is no exception. Unmanned drones with AI enabled cameras can capture the total picture of a large area. The image collection can be processed and subjected to analysis to pinpoint the problems and suggest real-time solutions [21].

Self-driving Tractors

Scheduling driverless tractors are common nowadays to spot their location, pick the swiftness and escape hindrances like faunas, humans or materials in the target region. They function using a controller checking the movement at a control station or with remote control from a distance. With these, we can manage many basic tasks related to agriculture fields reducing manual labour [22].

USE OF ARTIFICIAL NEURAL NETWORKS

Though the introduction of ANN was nearly 45 years ago, it has a high impact in today's life due to its accuracy in the determination of crop dynamics or behavioural patterns. The main limitation is the requirement of large train data. We can overcome this with alternate techniques such as data augmentation. More intense data analysis is possible with convolution neural networks [23].

Seasonal Forecasting

We can use AI effectively to develop seasonal forecasting models. However, these models suit well for small farmers, in largely populated countries like India, a normal peasant gets to benefit from them by the proper crop selection process [24].

We mentioned some applications of AI in Fig. (**1**) and Table **1**.

CASE STUDIES

We mentioned below some case studies pertaining to the use of AI in agriculture.

- Blue River Technology constructed a robot named See & Spray. It influences computer vision to screen and exactly spray hoes on cotton plants. Precision spraying assists in the omission of herbicide resistance. As stated on its website, the company asserts that its precision technology abolishes 80 percent of the volume of chemicals usually sprayed on harvests and can lessen herbicide costs by 90 percent [25].
- PEAT [26] generated a deep learning instrument termed Plantix, which detects potential defects and nutrient deficiencies in the soil. Software algorithms led the analysis, which associate precise greenery patterns with certain soil deficiencies, plant pests and diseases. The image recognition app finds likely flaws through images taken by the user's smart phone camera. Users receive required soil restoration techniques, tips and other promising solutions.
- aWhere [27] deploys machine learning and satellite technology for forecasting climate, harvest analysis as well as harvest assessment. For instance, we can

anticipate day-to-day meteorological conditions and tailor those based on the requirements of individual customers.

- FarmShots is an integrated scouting and variable rate prescription platform for farmers, agronomists and retailers. It concentrates on farming data exploration to identify vulnerabilities to harvest. Alreshidi [28] mentioned Farmshots and aWhere as recent examples, which use AI in agriculture. It uses satellite technology and drone technology. It promotes the software to use through mobile devices.

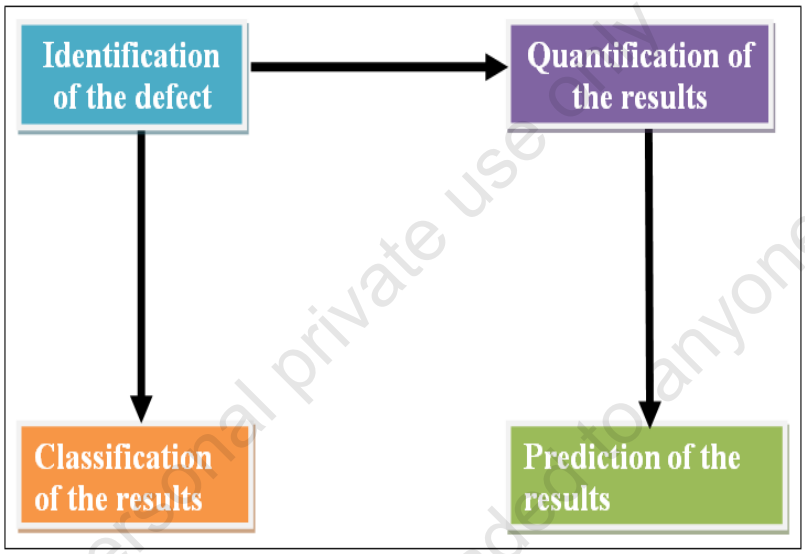

Fig. (1). Application of machine learning in the identification of plant stress.

RESEARCH SCOPE

The following are possible research directions for the usage of AI in agriculture [1, 11, 12, 23, 29 - 31]. The researchers can,

- Provide cognitive solutions mixed with IoT to help the farmer on various occasions.
- Use AI in crop specific disease detection, which helps in the identification of pests and deficiency in nutrients.
- Identify crop readiness by AI.
- Categorize crop/grain/fruit and segregate them in separate stacks prior to sales using machine learning or deep learning.
- Monitor Soil fertility using AI.
- Automate finding optimal crop mixture for a particular region.

Table 1. Some applications of AI in agriculture.

Function	Application of AI
Weeding	Precision management of weeds
	Weeding with the help of robots
	Detection of weeds
	Automatic weed prevention
Use of drones	Pesticide spraying
	Crop monitoring
	Remote sensing
	Precision agriculture monitoring
	Spraying fertilizers
Use of sensors	Measurement of soil, temperature, wind speed, *etc.*
	Drip irrigation
	Management of drought situations

- Find low cost sensors or devices to implement in AI solutions.
- Provide crop specific decision support systems using AI.
- Automate report generation of crop health to detect incongruities.
- Automate water management in the field for the effective usage of water.
- Automate provision of periodic guidelines regarding crop rotation, most favourable planting, attacks of pests, pesticide dose and so on.
- Automate estimation of crop economic attributes, which help the farmer in getting profit.
- Automate the identification of stress level in a plant.
- Automate using fuzzy logic wherever needed.
- Automate using neuron fuzzy logic wherever needed.
- Automate using expert systems wherever needed.
- Automate using Artificial, Convolution, or Recurrent Neural Networks depending on the application and crop.

CONCLUDING REMARKS

Traditional techniques are not sufficient to deal with the issue of growing food demand incurred due to the emerging population scenario. We should implement modern techniques and methods in order to meet the requirements today. AI is a field of growing opportunities to solve the majority of farming problems. The government should allocate appropriate research funds in this domain in order to serve the needs of farmers who are facing many problems including financial

issues, weather uncertainties, marketing hazards and so on. As agriculture is the main sector contributing to development, the coordination of agriculture scientists with technology experts in finding solutions to common agriculture problems can help the agro-based nations in several ways. In this paper, we suggested probable research directions and modern technologies to motivate AI researchers in the agriculture sector. We can anticipate a big number of agriculture automation solutions in the near future.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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