IoT & AI IN AGRICULTURE : THEIR APPLICATIONS AND BENEFITS

Ms.Ashika K A [1] Dr.S.Sheeja [2]

ABSTRACT

The Internet of Things is the hot point in the Internet field. Various interconnected physical articles outfitted with sensors, programming and other technologies exchange data with other systems or smart objects over the internet is termed as "Internet of Things". These keen physical items gather information from their environment. Artificial intelligence processes information in different ways to start appropriate activities. Hence, Internet of Things and AI will bring unfathomable advantages and help people in living a brilliant and extravagant life. In this paper, the basic architecture of IoT-enabled smart farming, Role of AI in smart farming, various applications of IoT in agriculture as well as their benefits have been studied and explained. This paper also brings out various machine learning approaches adopted by various authors.

Keywords : Internet of Things, IoT, Precision Agriculture, Smart Farming, Greenhouse, AI, Artificial Intelligence, Machine Learning.

I INTRODUCTION

We know that agriculture is the backbone of our economic system. Improvements in agriculture help us improve our economic system also. Internet of Things (IoT) makes everything intelligent, impacts everyone's life, and one can say, is the future of every field. Modernized concepts have been brought in the traditional farming system. Researchers working under this domain bring new theories and practices which help the farmers or agricultural systems to work more efficiently. By incorporating IoT in agriculture, they evaluate various parameters using smart sensing devices placed at the farmland. According to the result of the analysis of observations, various agricultural activities are performed to improve farming [1].

Precision Agriculture

Precision Agriculture is an approach to farm management. It uses Information Technology (IT) to ensure optimum productivity as well as the health of the crops. Crops receive only the required amount of water and other elements. Through the precise measures and operations, Precision Agriculture ensures profitability, sustainability, and protection of the environment. Various methodologies and techniques are used to perform various agricultural activities.

Traditional Vs AI-driven Precision Agriculture

Before the introduction of AI-based technology in precision agriculture, most agricultural products and processes relied heavily on the use of vast areas of land for the production of food and other farm outputs. This traditional method of farming needed a lot of farm inputs like fertilizers and pesticides, a large workforce for the inspection of the crops and other activities on the farmland, which involved heavy machinery, and a host of other factors. Although these processes were effective, they increased the rate of pollution in the environment, were expensive, and above all, unable to cater to the increased need of a growing population since the available areas of land would soon be occupied, leaving little to nothing for agricultural processes. The traditional methods of farming were strictly based on trial and error, where farmers only planted their crops and waited for the worst to happen. AI-driven precision agriculture brings effectiveness,

[1]Research Scholar, Department of Computer Science
Karpagam Academy of Higher Education

[2]Professor , Department of CS, CA & IT
Karpagam Academy of Higher Education

safety and accuracy to the table. It utilizes farm data to calculate the exact amounts of farm inputs needed for the best production, predicts the possible weather conditions to influence the choice of crops and farming decision and above all, reduces the need for a large workforce while promoting the growth of organic and pesticide-free foods around the world.

II THE ARCHITECTURE OF SMART FARMING SYSTEM

An accurate cultivating-framework comprises detection of soil, crop and other required parameters, the direction of information from the field to control station for dynamic decision making, and representation of results to the producer through an application. As per these techniques, four essential layers are characterized in the Fig.1.

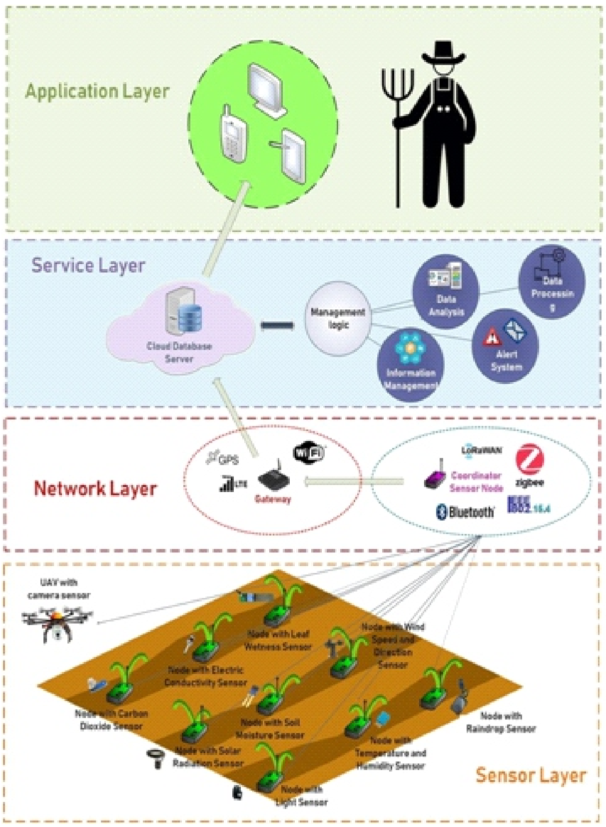

Fig.1. Precision farming system architecture

There are four basic agrarian layers [2] :

A. The Sensor layer

B. The Network layer

C. The Service layer

D. The Application layer

The layers are briefly explained below :

A. *The Sensor Layer*

The Sensor Layer includes a wide range of sensors for assorted information and checking. Sensors can be set in the soil, on the yields or on UAVs [3]. UAVs utilizes various sorts of sensors, for example, Visible light sensors (RGB), Multispectral sensors, Hyperspectral sensors, Thermal sensors and so on to gather different sorts of information [2].

B. *The Network layer*

The Network Layer comprises various technologies of communication. Wireless Sensor Networks (WSNs) used by the IoT for crop/field management is efficient [2].

C. *The Service layer*

The Service Layer includes handling and investigation of the gathered information. A critical number of studies concentrating on PA talk about the most proficient management and mining of data. These studies help to stay away from a low degree of efficiency in the fields by employing precise forecasts [2].

D. *The Application Layer*

The information analyzed from the sensor network is then used to provide meaningful insights about the farmland/crop. Visualized information of the analyzed data is provided in the application layer. The farmer can take appropriate actions based on the results he obtains after the analysis[3].

III APPLICATIONS OF IOT IN AGRICULTURE

Some of the categories and its examples with the application of IoT techniques are given below:

A. *Controlled Environment Planning*

1) *Greenhouse Environment Monitoring*

Various environmental factors such as atmospheric temperature, humidity, light etc. are collected over the wireless sensor network and transmitted to the cloud. Data mining procedures are utilized to recognize behavioural patterns [4].

2) Greenhouse automatic control

The temperature inside the greenhouse improves and alters itself consequently. The lightning and water system frameworks inside the greenhouse can be made do with no human supervision too. Greenhouse cultivation seems to be easy when contrasted with open fields [5].

3) **Greenhouse plant growth monitoring**

At Greenhouse, a shut structure, the plants get security from extreme climate conditions and different bug assaults. Plants get an ideal measure of water through a drip irrigation system framework which works as indicated by the soil dampness levels. Dribble fertigation procedures help to apply the best possible sum and selection of minerals based on soil health. In the wake of achieving the necessary growth of the crop, the data are given to the farmer [13].

4) **Greenhouse pest management**

The framework planned can ceaselessly screen the number of pests stuck on yellow clingy papers conveyed in various areas and can quantify the natural parameters at the same time. The pests are checked through image processing and AI calculations [15].

B. Open Field Planting

1) Field Environment Monitoring

Checking environmental variables is the central point to improve the yield of effective harvests. The [14] temperature and moistness of the rural field are observed through sensors [14].

2) Crop growth Monitoring

Crop management devices are an essential part of utilizing PA innovation productively. These devices are regularly put on the field. They will screen water levels, crop wellbeing, and other pertinent biochemical and physical properties. Utilizing crop observing devices, a farmer can proactively oversee peculiarities, manufacture forecast-based models and methodologies, and forestall possibly unsafe infections.

3) Crop disease detection

The IoT-based observing system for disease forecast offers support to store the ecological and soil data gathered from a remote sensor arrangement introduced in the planted region in a database. Besides, it permits clients to screen the natural data about the planted crops progressively through any Internet-empowered gadgets. Artificial intelligence and prediction algorithms permit the framework to imitate the dynamic capacity of a human master with regard to the illnesses, and issue cautioning messages to the clients before the flare-up of disease and advances farming items with no (or negligible) synthetic compound deposits on top-notch crops [6].

There are frameworks which can produce messages at various stages to inform farmers. It will help farmers by getting live information (Temperature, mugginess, soil dampness, UV index, IR) from the farmland to find a way to empower them to do shrewd cultivation by improving yields and sparing assets (water, fertilizers) [7].

4) Precision irrigation

The shortage of clean water around the world has necessitated it ideal usage. There are frameworks to foresee the water system prerequisites of a field utilizing detection of ground parameters like soil dampness, soil temperature, and natural conditions alongside the climate conjecture information from the Internet. The nodes, associated with the ground and ecological detection, consider soil dampness, soil temperature, air temperature, Ultraviolet (UV) light radiation, and relative mugginess of the yield field [9]. Shadi Alzu'bi [8] proposes an improved watering framework in which image processing is applied, considering soil split rate, plant leave shading and so forth. The sensor hub information is remotely gathered over the cloud utilizing web-administrations, and a decision support system gives constant data bits of knowledge depending on the examination of sensors' information and climate conjecture information [9].

Farm machinery positioning and navigation

[12] provide an architecture for the agricultural machinery's intelligent scheduling in cross-local work. They set the private cloud of agricultural apparatus with the guide of cloud computing innovation, and the agrarian hardware will interface together through the Internet of Things innovation.

C. Livestock breeding

1) Livestock farm and pasture environment monitoring

For tracking as well as identifying animals, RFID is widely utilized in farm monitoring. It assists with observing, perceiving, recognizability of animals, and their administration [10].

Live stock healthcare monitoring.

2) Livestock positioning and behaviour recognition

3) Livestock identification

D. Aquaculture and aquaponics

1) Water quality monitoring and control

2) Fish detection

3) Precision feeding

4) Aquaponics related applications [11]

IV AI IN AGRICULTURE

AI is the use of man-made brainpower (AI) that gives frameworks the capacity to take in and improve as a matter of fact without being expressly customized or programmed.

The way toward learning starts with perceptions or information, for example, models, direct understanding, or guidance, so as to search for patterns in the data and settle on better choices later on depending on the models that we give. The essential point is to permit computers to learn naturally without human intercession or help and modify activities appropriately.

Uses of Machine Learning in Yield Prediction

Yield expectation is significant for yield mapping, yield estimation, coordinating of harvest supply as per request [21].

A portion of the instances of ML applications are given underneath:

In [19] the spectral-spatial arrangement of high spatial resolution RGB pictures acquired from UAVs has been utilized for identification of tomatoes in the picture. Bayesian Information Criterion (BIC) was utilized to decide the ideal number of groups for the picture. Spectral clustering was completed utilizing K-means, Expectation Maximisation (EM) and Self-Organizing Map (SOM) calculations to order the pixels into two gatherings for example tomatoes and non-tomatoes.

In [16] Ramos proposed a non-ruinous strategy to take count of the number of natural products on a coffee branch. The framework gathered data from computerized pictures of a side of the branch and its developing fruits.

The number of fruits on the branch, their level of development and weight were assessed by Machine Vision System (MVS). This examination assisted coffee cultivators with the right organization and utilization of the assets.

Su YX [20] utilized rice as the exploration crop and built up a support vector machine-based open crop model (SBOCM). He incorporated the formative stage and yield forecast models in SBOCM. Essential land data had been utilized for the forecast. In view of the rule of scale similarity of modelling data, an open reading frame was intended for the dynamic everyday contribution of meteorological information and yield of rice advancement and yield records.

W.S Lee [17] proposed a novel algorithmic system to distinguish nonmature green citrus organic product in tree canopy under common open-air conditions. Shape examination was a piece of the calculation. It was directed to identify however as many organic products as could be expected under the circumstances. Texture classification was another piece of the calculation. Support Vector machine (SVM) and Canny edge recognition joined with a graph-based connection component calculation and Hough line discovery were utilized to evacuate bogus positives.

In [18], fundamental contributions for yield potential forecast were remote detecting vegetation indices and assessed soil parameters. That is, on-line multi-layer soil information, and satellite imager crop development attributes were utilized to foresee the wheat yield.

Table 1 outlines the above papers for the instance of Crop yield expectation [21].

V THE ROLE OF AI-DRIVEN TECHNOLOGY IN PRECISION FARMING

Some of the benefits associated with AI-driven technologies and precision agriculture include, but are not limited to, the following;

A. *Analysis of Farm Data*

With the help of AI, farm data like temperature, weather conditions, soil conditions, and soil usage can be effectively collected and analysed to influence decision making on the farm. This can make planning more productive and boost yield. With this technology, farmers can confidently select the best-performing crops based on the farm data and save time and resources. The amount of use of fertilizers can affect production. The past data collected can be used for knowing or predicting what works and what does not. The best possible crop suggestion is possible before the season keeping the past data and other sensor, environment data in the view.

B. *Improvement of harvest quality and accuracy*

Precision agriculture utilizes AI-based processes for the detection of nutrients on farmland, predicting the possible outbreak of diseases in both plants and animals. Precision agriculture can also play a significant role in weed detection, and deciding on the best herbicide to apply. This can limit the over-application of herbicides and other pesticides on the farm; thus, controlling pollution while increasing food safety.

C. *Increased agricultural accuracy and productivity*

Gone are the days when farm work is carried out via a trial and error process. Farmers can now create a seasonal forecasting model to boost their accuracy and productivity. With these models, they can accurately predict upcoming weather conditions several months ahead of time and decide

Table 1 : Crop Yield Prediction

Article	Crop	functionality	Models/Algorithms
[19]	tomato	Detection of tomatoes by means of discovery of RGB picture caught by UAV	Clustering/ Expectation Maximisation
[16]	coffee	Number of coffee fruits on a branch is counted automatically	Support Vector Machine
[20]	rice	Prediction of yield and developing stage of rice	Support Vector Machine
[17]	Citrus fruit	Identification of the quantity of nonmature green citrus under regular open-air conditions.	Support Vector Machine
[18]	wheat	Wheat yield forecast inside field variation	SNKs or ANN

on what to do. AI-based processes like deep learning algorithms and computer vision can capture farm data from UAV drones for farm inspections.

D. *Automated farm processes*

AI promotes the production, process, and packaging of highly organic food in a hygienic way. Automated machines can perform farm tasks with little or no human intervention, hence reducing the possibilities of cross-contamination and food-borne diseases. These systems can run scheduled checks on farms and analyse farm data for better yield. Agriculture robots can be used for doing multiple tasks intelligently by learning the output of the tasks they do and improve themselves as humans do. However, present-day machines (mechanical ones) cannot replace humans in some critical tasks on the farm.

VI BENEFITS OF IOT IN AGRICULTURE

There are different advantages and focal points to utilizing IoT in agriculture. Some of the advantages are given below:

Effectiveness of information: It will improve the productivity of contributions of agribusiness by giving efficient inputs related to Soil, Water, Fertilizers, Pesticides, and so forth.

Cost reduction: It will diminish the cost of production.

Profitability: It will expand productivity and so the profitability of farmers.

Maintainability: Improves manageability.

***Food Safety*:** It will assist in achieving the Food Safety Mission.

Environment protection: It plays an important role in environmental protection by employing minimal requirement approaches. [11]

Better authority over the internal procedures and, accordingly, lower chances of risk: The capacity to anticipate the yield of crops permits the farmer to get ready for better item dissemination. It will ensure a good market because the farmer can pre-plan what to cultivate during a particular season.

Heaps of information: information can be utilized to follow the condition of your business as a rule just as staff execution, hardware productivity, and so on.

Cost management and waste reduction: Being ready to perceive any inconsistencies in the harvest development or livestock wellbeing, you will be free from the dangers of losing your yield.

Expanded business effectiveness through procedure mechanization: By utilizing modern gadgets, you can computerize various procedures over your creation cycle, for example, water system, bug control or fertilization.

Improved quality and yield: Achieve better authority over the production procedure and keep up better standards of harvest quality and development through mechanization.

VII CONCLUSION

This paper studies utilization of IoT and AI in different regions of farming. The full utilization of IoT in farming will really accomplish precision farming and cater to the needs of an expanding population. Technological advances giving low-cost sensors and more secure network systems will help in further application.

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