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ADVANCEMENT IN AGRICULTURE WITH AI, ML AND IOT: AN OVERVIEW

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Abstract: For a very long time, it has been believed that the primary source of supplies for supplying people's basic needs has been agriculture. It is recognised as both a necessary kind of employment and a significant industrial sector in India. In order to maintain a healthy diversity, farmers should engage in traditional naked eye observation and produce healthy crops without using pesticides on their cultivation field or on the animals that eat such products. Farmers are assisted by a variety of machine learning algorithms in their agricultural processes. Systems like soil categorization, crop forecasting, disease detection, and fertilizer recommendation are created to make farming easier. To obtain a high degree of accuracy for the suggested approaches for disease prediction, crops prediction and soil classification, machine learning algorithms like SVM, kNN, and decision trees are utilised. Use of IoT in agriculture includes water sprinklers, drones, robots, livestock management, smart greenhouse, etc.

Key word: Machine Learning (ML), Artificial Intelligence (AI), Internet of Thing (IoT)

SECTION I

1.1 INTRODUCTION

Agriculture has long been regarded as the primary source of supplies for meeting people's basic requirements. It is regarded as a basic employment as well as one of India's important industrial sectors. Farmers should practise traditional naked eye observation and produce healthy crops without applying chemicals to their cultivation field or to the animals who eat those crops in order to maintain a healthy diversity. But in today's world, the weather is changing quickly in opposition to natural resources, reducing the availability of food and boosting security. Farmers are in rural areas, and if crop production revenue declines, farms at an industry level will have animpact on their way of life. Agriculture's complex process of crop prediction has led to the development and testing of numerous models. By the end of 2050, there will be 9.1 billion people on the planet, an increase of around 34% from the current number. In the future years, there will be a 70% increase in global food demand, while the amount of agricultural land will substantially decrease owing to urbanisation. India, which will be the most populous nation by 2050, is now falling behind the domestic food production. Lack of planning, unexpected weather, inappropriate harvesting and irrigation methods, and poor animal management are the main causes of decreased food production. Global warming has caused a significant change in the weather during the past few years. Because of the increase in the earth's average temperature, climatic conditions are unclear. Since many years, AI and IoT have made many developments in agricultural fields.

In order to comprehend the workings of the complete ecosystem and discover strategies for soil restoration and healthy crop production, machine learning algorithms analyse the soil by looking at its moisture content, temperature, and evaporation processes. Since artificial intelligence and machine learning are now widely accessible, using applications related to this technology has considerably aided farmers in effectively managing their cattle. Robotics, drones, and intelligent monitoring systems are just a few of the applications of AI technology that have transformed farming. In addition, tools developed to track farm animal health and identify illnesses and injuries help farmers save time and labour. In the world of agriculture, applications of artificial intelligence and machine learning are equally crucial. The farmers' primary tasks are made easier and less stressful by the machine learning tools. The support vector machines based on machine learning (ML) aid farmers in farm monitoring and are extensively employed in rice fields to increase productivity and streamline production. Additionally, there are numerous ways that machine learning can help farmers identify a specific disease and take action by applying a pesticide based on the location, time, and area of the damaged crops. It is difficult to choose the proper species since it necessitates looking for the right species, controlling the nutrients utilised, adapting to climate change, testing for disease resistance, and many other things. Here, machine learning software analyses years' worth of field data to assist farmers in selecting the appropriate genes in response to shifting weather circumstances. By integrating morphology into its systems, it also helps to categorise the species quickly and with far greater accuracy.

1.2 BACKGROUND OF SURVEY

With the development of AI and machine learning, the agricultural industries have advanced significantly. The primary goal of this study is to provide an overview of current development in AI and ML. Crop production has always involved a specific procedure of work, from planting through cultivating. Any error in crop and fertiliser selection might result in poor yield and financial loss for farmers. Farmers now have an easier time cultivating crops because of AI and ML. The farming process is now faster than it was in the past because of innovations like crop prediction systems, weather prediction systems, fertiliser suggestion systems, and weed detection systems. AI technology aids in the detection of pests, plant diseases, and undernutrition in farms. Artificial intelligence (AI) sensors can identify and target weeds before deciding which herbicide to use in the area. This will also reduce the consumption of fertilisers. Many technical firms created robots that accurately monitor weeds with spray guns by using computer vision and artificial intelligence. These robots can reduce the amount of pesticides that are typically sprayed on crops and the cost of herbicides. By substantially reducing the amount of pesticides required in the fields, these smart AI sprayers can increase the quality of agricultural output while also bringing about economic efficiency. We'll talk about a lot of machine learning methods and IoT in agriculture in later sections.

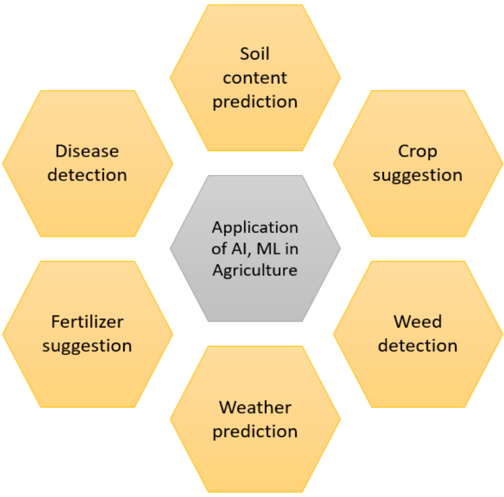

fig 1. Application of AI, ML and IOT in agriculture

SECTION II

2.1 NEED OF AI, ML IN AGRICULTURE

In order to produce healthier crops, manage pests and growing conditions, organise data for farmers, lessen workloads, and improve a variety of agricultural-related jobs along the entire food supply chain, the agriculture business is turning to artificial intelligence technologies. Below mentioned points give some examples which require Al in agriculture.

Crop yield prediction and price forecasts
It helps in identifying the output yield of the crops and forecast the prices for the next few weeks that will help the farmer to obtain the maximum profit.

Intelligent spraying
Artificial sensors help in detecting weed affected areas and can precisely spray herbicides in the right region that reduces the usage of the herbicides.

Predictive insights
Insights include the right time to sow the seeds, some impacts created by weather conditions etc for maximum productivity of the crop.
Crop and soil monitoring
Using artificial intelligence, we can monitor the crop health for diagnosing pests, defects, and nutrients deficiencies in the soil.

Disease Diagnosis
To get information and classification of plant diseases help the farmers to control the disease through proper method and strategy.
Machine learning (ML) is the current technology that has already begun to play an important role in making agriculture more efficient and effective by benefiting farmers to minimise the losses in the farming by providing rich recommendations and insights about the crops. Below mentioned points are the examples which require ML in agriculture.

Robots
Hyper effective harvesting bots can replace human workers in the agriculture sector and reduce the labour costs.

Resource Management
With the ML/AI farmers save energy, reduce pesticides, improve yield and shorten the time to market.
Species Recognition At earlier times plant classification was based on colour, shape of the leaves. Machine learning enables much more complex, accurate, and faster analysis of plants using more sophisticated techniques such as analysing leaf vein morphology.

Species Breeding

The laborious process of species selection entails looking for certain genes that will guarantee an organism's efficient responsiveness to nutrients and water. ML allows us to draw from decades of field data for detailed crop performance analysis. A probability model from this data predicts which genes will contribute a sought-after genetic advantage to a plant.

Watering

Farmers use ML/AI to monitor growing areas for crop humidity, soil composition. So, this ML use results in increased yields due to the optimization of water and fertiliser use.

2.2 WORKING OF AI, ML IN AGRICULTURAL SYSTEM

According to Vishal Meshram *et. al.*, 2021 [1] agriculture task can be broadly classified into three major steps which includes pre-harvesting, harvesting and post harvesting.

A. Pre-harvesting

Numerous factors have an impact on the quality of crops. These factors may vary based on environmental condition, type of plant or custom practices. Hence machine learning is used to figure out parameters of soil, seed quality, fertiliser treatment, pruning, genetic and environmental variables, and irrigation. The pre-harvesting issues listed below can be resolved using machine learning using the following ways:

1. Seed selections:

Farmers find it challenging to select seeds that will yield the highest and pose the fewest risks. Researchers can estimate the yields and dangers of various seeds at a particular farm using machine learning, and then choose a combination of types that reflects the best trade-off.

2. Micronutrients prediction:

Micronutrients are vital plant nutrients that are present in tissue in minute levels yet are crucial for the growth and development of plants. In order to enhance yield, machine learning algorithms can be used to estimate soil nutrients, such as N, P, Mg, and others.

3. Weed detection:

The expense of agriculture rises when weeds are present, and work is more difficult to complete. The need for irrigation rises as a result. The amount of time and money spent on manual labour can be considerably reduced by weed detection utilising machine learning.

4. Disease detection:

Farmers spend billions of dollars managing diseases, frequently without enough technical support, which has negative effects such as contamination and poor disease control. In such cases, automatic disease detection proves beneficial. The benefit of automatic plant disease detection is that it decreases the amount of labour required to monitor large crop farms and can identify disease symptoms at very early stages, for instance when they first develop on plant leaves.

B. Harvesting

A crop is harvested when it is taken out of its growing environment and moved to a safer location for processing, consumption, or storage. Few harvesting factors influencing agricultural produce are maturity age, fruit detection and classification, season, time, size and other. Following are some harvesting procedures that can be carried out more effectively using machine learning:

1. Fruit detection and classification:

Many human-related limitations are associated with manual classification, such as the requirement that an individual be knowledgeable about the diverse traits of fruits and vegetables. For manual classification to remain constant, an ongoing, reliable aspect recognition method is needed. The agriculture sector today uses automated classification techniques and frequently makes use of computer vision. The use of image processing is being pushed into practically every field by improvements in industrial automation and image processing techniques. Classifying and evaluating fruits based on their appearance is still a difficult task. It is possible to grade and sort fruits automatically using fruit classification.

2. Maturity age:

When a fruit reaches maturity, it is prepared for harvest. The fruit or vegetable's edible portion has reached its full size at this point. Few factors deciding maturity of yield are skin colour, firmness, shape, size, aroma and many others. There are multiple machine learning techniques which help in determining and predicting these factors usinSg which yield can be harvested on time, not before it is premature or not after maturity.

C. Post-harvesting

Post-harvest handling, which includes cooling, cleaning, sorting, and packing, is the phase of crop production that comes just after harvest. Whether a crop is sold for fresh consumption or utilised as an ingredient in a processed food product, post-harvest treatment significantly impacts final quality. Some of the post-harvesting factors which influence agricultural production are temperature, humidity, length of storage, shelf life, etc. The post-harvesting issues listed below can be resolved using machine learning using the following ways:

1.Temperature:

The quality of vegetables after harvest is primarily influenced by temperature. Produce's temperature influences water loss, metabolic changes, flavour, texture, and nutritional loss, as well as the growth of decay. Multiple machine learning techniques can be used in order to reduce post harvest losses from the effect of temperature

2.Shelf life:

The amount of time that a thing can be kept before it loses its suitability for use or consumption is its shelf life. Machine learning technology can evaluate fresh produce and determine how many days are left with it. Each link in the food supply chain benefits from shelf-life prediction. Additionally, AI has increased its capability and made it more accessible.

SECTION III

3.1 MACHINE LEARNING ALGORITHMS USED IN AGRICULTURE

1. Soil classification

Sk Al Zaminur Rahman *et al.*, 2018 [2] in their work has proposed a soil classification system by using various machine learning algorithms such as k Nearest Neighbor, Bagged tree and Support vector machines.

K-Nearest Neighbor: The K-Nearest Neighbor (K-NN) algorithm is a classification method for a set of data based on learning data that has already been categorised. It is one of the supervised methods in data mining. Included in supervised learning, where the outcomes of fresh query instances are categorised using the vast majority of the vicinity of the current categories in K-NN. One of the most well-liked algorithms for pattern identification is K-Nearest Neighbor (KNN). Numerous researchers have discovered that the KNN algorithm performs quite well on various data sets. KNN has a number of key benefits, including simplicity and noise resistance.

Bagged Tree: A collection of models created by bagging are individually trained using a random sample of the data. To create the final projection, the predictions from those models are combined by averaging.

Support vector machine: Support Vector Machines are supervised learning models that are non-parametric and driven by a geometric notion of what constitutes a "good" classifier. The goal of the SVM algorithm is to locate an ideal hyperplane (or decision boundary) in an N-dimensional space (where N is the number of features) that clearly classifies data points for linearly separable data points. The data points that are closest to the hyperplane are known as support vectors. The SVM algorithm treats the problem as a restricted optimization problem by attempting to maximise the margin around the separating hyperplane. SVM can be used to identify a variety of soil properties, including moisture content, nutrients, structure, quality, pH, texture, and many others.

2. Crop yield prediction

D.Jayanarayana Reddy *et. al.*, 2021 [3] has reviewed some ML models for crop yield prediction such as SVM, CNN, H-ANN, ANN and MLR and DNN.

SVM: The SVM method has implemented a cascade of two SVM classifiers for achieving the accuracy, specificity and precision metrics.

CNN, MCNN: The CNN model was developed which utilised spatial features as input and trained by backpropagation that reduced error of prediction as well.

Hybrid-ANN: The developed (H-ANN) was used to forecast agricultural data such as air temperature and crop yield estimation. IN H-ANN, the LN algorithm was used to train the ANN

ANN and Multiple Linear Regression: The developed model is a combination of backpropagation algorithm with ANN to evaluate the exact crop yield.

DNN: The DNN model was performed for the feature selection. Next, the DNN model has reduced the measurement of input space without affecting the accuracy.

3. Disease and weed detection

Paramasivam Alagumariappan et al., 2020 [4] in their work has proposed a Intelligent Plant Disease Identification System Using Machine Learning where they have used machine learning techniques like Extreme Learning Machine (ELM) and Support Vector Machine (SVM).

Extreme Learning Machine (ELM): Extreme Learning Machine (ELM) is a novel training algorithm used to train a single hidden layer feedforward neural network. The computational speed of the ELM is high when compared to other traditional learning algorithms. ELM is used in all classification and regression problems.

Support Vector Machine (SVM): Support Vector Machine Classification (SVM) is a binary classifier which falls under machine learning. It is a supervised learning model that analyses data for classification and regression analysis. As the proposed research is conducted based on the two-class binary classification problem, the most efficient hyperplane is selected by the SVM classifier, which divides all input samples into two classes. The effective hyperplane is considered as a classifier line and the sample inputs which are nearest to the classification line are called support vectors.

3.2 ADVANCEMENT IN IOT FOR AGRICULTURE

IoT solutions are geared toward assisting farmers in bridging the supply-demand gap by guaranteeing good harvests, financial success, and environmental protection. Precision agriculture is the process of utilising IoT technology to guarantee the best allocation of resources in order to produce high crop yields and lower operating expenses. Specialised equipment, wireless connectivity, software, and IT services make up IoT in agriculture technologies.

The Use of IoT in Agriculture:

Sensors: In this method of farm management, sensors, control systems, robotics, autonomous vehicles, automated hardware, variable rate technology, motion detectors, button cameras, and wearable devices all play a significant role in the data acquired by smart agriculture sensors. The business's overall health, employee productivity, and equipment effectiveness may all be monitored using this data. A better product distribution strategy may be planned when it is possible to predict the output of a factory.

Agricultural Drones: Drones for agriculture are being utilised both on the ground and in the air to improve a variety of agricultural activities, including irrigation, crop monitoring, crop spraying, planting, and soil and field analyses. Drones can monitor crops in a variety of geographic locations and can assist farmers in choosing the right seeds, fertiliser, and watering schedule. Most significantly, crop scouting enables them to promptly respond to threats from locusts, fungus, pests, weeds, and more.

Livestock tracking and geofencing: Farm owners can use wireless IoT applications to gather information about the whereabouts, condition, and health of their cattle. This knowledge lowers labour expenses and aids in the prevention of sickness. In order to monitor an animal's health, position, and output, IoT agriculture sensors can be linked to it just like they can to crops. This makes it easier for farmers to maintain their cattle so they can produce large quantities of milk, meat, and other products.

Smart Greenhouses: An IoT-powered smart greenhouse can intelligently monitor and regulate the climate without the need for human involvement. IoT has made it possible for weather stations to automatically change the environment conditions in accordance with a specific set of instructions, making our greenhouses smarter. The usage of IoT in greenhouses has eliminated the need for human interaction, which reduces costs and boosts accuracy throughout the process. For instance, creating modern, affordable greenhouses utilising IoT sensors driven by solar energy. These sensors gather and send real-time data that is used to precisely track the state of the greenhouse in real-time. The sensors allow for the monitoring of greenhouse conditions and water use via emails or SMS warnings. IoT is utilised for automatic and intelligent irrigation. Information on the pressure, humidity, temperature, and light levels is provided in part by these sensors.

Soil: Since crops are only as good as the soil in which they are grown, soil quality is crucial to agriculture and farming. IoT-based sensors are buried in the earth to monitor soil quality and test for nutrients (nitrogen, phosphorus, and potassium), pH levels, moisture, and much more. All of this information may provide farmers with the tools they need to increase yields, farm productivity, and efficiency because it is the best and most accurate information currently accessible.

Predictive analytics: By assisting the farmer in making decisions about crop production, storage, marketing tactics, and risk management, crop prediction is crucial. Artificial networks use data from agricultural sensors to predict how much a crop will produce. Variables including soil, temperature, pressure, rainfall, and humidity are included in this data. The farmers can get trustworthy soil data from either the dashboard or a mobile app that has been specially created. Using the sensor network that eventually creates an information matrix, farmers may predict crop output. Farmers must be able to project the future in order to predict hazards and plan for storage, marketing, and other parts of their business. Farmers may access trustworthy data on each of these components on a programmable dashboard owing to Data on elements including wind pressure, soil moisture, temperature, and humidity are gathered through sensors that help.

Robotics: Since the industrial revolution of the 1800s, automation has advanced to manage complicated tasks and increase productivity. Farmers are starting to pay attention to agribots, sometimes referred to as agriculture robots, as a result of the worldwide labour shortage and increased demand. Thanks to recent advancements in sensor and AI technologies that enable machines to learn from their surroundings, ag robots are now more widely known.

SECTION IV

4.1 RELATED WORK

1. *Soil Classification*

Sk Al Zaminur Rahman *et al.*,2018 [2] has proposed a system where the task is to study the features and characteristics of various soil types that can determine which crops are best suited for particular soil types. The soil types are determined using machine learning techniques. Therefore, three distinct approaches are used that are weighted K-NN (K-Nearest Neighbors), Gaussian Kernel based SVM (support vector machines), and Bagged Tree. A model is suggested for identifying soil types and suggesting appropriate crop yields for that particular soil. Although SVM has provided the highest accuracy in soil classification, bagged tree and K-NN also exhibit good accuracy.

Prof. A. V. Deorankar *et al.*, 2018 [5] has suggested examining recent research, the issues it addressed, and its future directions. The analytical examination of numerous cutting-edge and effective classification mechanisms and procedures is the main focus. In order to increase the classification's accuracy, it has been attempted to analyse the elements that these approaches have addressed. The two most crucial factors for enhancing classification accuracy are the proper use of the numerous features included in remotely sensed data and the selection of the most appropriate classifier.

2. *Crop yield prediction*

D.Jayanarayana Reddy *et al.*, 2021 [3] examines machine learning (ML) methods which are applied to crop yield estimation and provides a thorough review of the methods' accuracy. Crop yield analysis is a procedure used in agriculture. Data is used to predict agricultural yield, and then it goes through pre-processing to remove noisy data. In order to do the classification using ML algorithms, the pre-processed data is put through a feature extraction process that includes elements like soil information, nutrients, field management, etc. ML algorithms are used like SVM, CNN, H-ANN, ANN, MLR. Then calculate the yield of the crop based on then temperature, rainfall.

Mayank Champaneri *et al.*, 2020 [6] published a system Crop yield prediction using Machine learning which helps farmers before cultivating on the agricultural field, will assist the farmers in learning the yield of their crop, enabling them to make the best choices. The farmer will have access to the prediction's outcomes. Therefore, there are various ways or algorithms for this type of data analytics in crop prediction, and we can anticipate crop production with the aid of those algorithms. It employs the random forest algorithm. by examining all of these concerns and issues, such as the weather, temperature, humidity, rain, and moisture. The current study demonstrated the possible use of data mining approaches in agricultural production prediction based on the meteorological input factors. More than 75% of predictions are accurate. By offering climatic information

3. *Plant disease prediction*

Paramasivam Alagumariappan *et al.*, 2020 [4] proposed an Intelligent Plant Disease Identification System Using Machine Learning which creates a small decision support system using the Raspberry PI (System onboard hardware) to categorise various plants, including plants with and without diseases. To train the classifier model, plant data for several plants with and without illnesses were used. During the training phase, plant photos from the database are used as input, and informative features are retrieved from the image using Hu moments and Haralick texture features. Additionally, two distinct classification methods, such as the Support Vector Machine (SVM) with a Linear and Polynomial kernel, get the retrieved features. The knowledge model is also developed at the conclusion of the training process. Using the Raspberry PI camera, a real-time plant image is captured throughout the testing phase and submitted to feature extraction techniques. It is observed that the accuracy of Extreme Learning Machine is higher when compared to SVM with Linear kernel (LSVM) and SVM with Polynomial kernel (PSVM).

Aiming to examine the efficacy of ML ((SVM), Random Forest (RF), Stochastic Gradient Descent (SGD), and DL (Inception-v3, VGG-16, and VGG-19) in terms of citrus plant disease diagnosis, R, Sujatha *et al.*, 2021 [7] were prompted by previous research. The area under the curve, F1 score, precision, and other metrics are taken into account. The illness classification accuracy (CA) obtained through experimentation is quite high, demonstrating that DL methods beat ML methods in terms of disease identification, as seen in the following: CA of RF as 76.8% > SGD as 86.5% > SVM as 87% > VGG-19 as 87.4% > Inception-v3 as 89% > VGG-16 as 89.5%. The conclusion drawn from the results is that VGG-16 provides the best CA, whilst RF provides the least.

SECTION V

5.1 CURRENT TRENDS

To boost productivity, a variety of sensors are employed in farms, including those that monitor crop health, light, moisture, grassland temperature, rainfall, ph, and leaf wetness. These sensors carry out a variety of tasks, including tracking plants and animals as well as measuring the temperature and humidity of the soil.

Agriculture-related IoT trends include:

1. Drones used in the air and on the ground for irrigation, crop health evaluation, spraying, monitoring, and field analysis
2. IoT app development is an interesting process for many companies.
3. Modern Greenhouse monitors don't need assistance from a human.
4. Weather, humidity, rainfall, soil, temperature and other variables are all predicted by analytics.

Due to their extensive experience with data analysis and prediction, AI and ML can make a devastating contribution. Data science is used to process and organise every important piece of agricultural data gathered by IoT devices and ML algorithms. AI and ML estimating yield and quality. Harvest Automation HV-100, Agrod E-Series, Robotic Vacuum Apple Picker, Sweeper, Dogtooth are some examples of robots which are used as harvesting robots. Reputed companies invented autonomous tractors that can be controlled remotely using a tablet and has the ability to take tools off the ground, recognise the limits of a farm, and steer automatically.

Agriculture-related AI/ML trends include:

1. Symptoms and virus identification in fields
2. Weather is predicted by using AI
3. Eliminating weeds with machine learning by identifying plant/crop species
4. Robots that can herd cattle on their own

5.2 CONCLUSION

This survey included a wide range of agricultural topics where AI, ML, and IoT are assisting farmers in their farming operations. In this paper, machine learning algorithms utilised for diverse tasks are mentioned. Due to a lack of time and an increase in agricultural demand, AI and ML help farmers grow their crops more effectively and quickly. The crop that will be cultivated on that soil will greatly benefit from the features such as soil content. Advancement in IoT has contributed in various ways from seed sowing to crop plucking. AI, ML will always be a developing field where new algorithms and experiments happen. In agriculture its contribution is huge.

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