ADAPTIVE LEARNING IN AGRICULTURE WITH THE HELP OF MACHINE LEARNING

Rahul Gupta[1], Dr Bikash Debata[2], Upendra Sharma.U.S[3]

JAIN (Deemed-to-be University), Bengaluru, India

Email Id-[1] rahul_g@cms.ac.in,[2] bikash@cms.ac.in, [3]Upendra.sharma@jainuniversity.ac.in

Abstract

Food is known to be a fundamental human need that can be met by farming, Agriculture plays an important role in sustaining human activities. Pre-harvesting, harvesting, and post-harvesting are the three main categories in which we can distinguish the agricultural practices. Major threats such as overpopulation and resource competition pose a threat to the planet's food security. Advancements in smart farming and precision agriculture provide valuable resources to solve agricultural productivity issues in order to address the ever-increasing dynamic problems in agricultural production systems. The secret to ensuring future food sustainability is data analytics. And on the other end, Machine Learning (ML) is the core of learning that works in a way like human brain does. ML is a current technology that is assisting farmers in reducing farming losses by making detailed crop advice and observations. The current study presents a systematic review of ML applications in supply units provided on the basis of farming. The study demonstrates how ML strategies can support these supply units and contribute to sustainability with the help of adaptive learning. The system recognizes the role of ML algorithms in delivering real time analytic comprehensions for proactive data driven decision making offers recommendations for effective management of Agro-Supply Chains(ASCs) for enhanced agricultural production and sustainability to researchers, practitioners, and policymakers and a quick snap about the conducts a comprehensive review of the most recent ML applications in agriculture to address issues in three areas: pre-harvesting, harvesting, and post-harvesting..

Key words: Agriculture, Crop, Deep Learning, Farming, Harvesting, Machine Learning (ML).

Introduction

Agriculture is the practice, craft, and technology of raising eatable plants and livestock. Agriculture is a central advancement in the growth of sedentary human civilization, as it allowed people to live in cities by creating food surpluses from domesticated species. People grow crops or keep animals for food and raw materials on farms. Agriculture has a long tradition dating back thousands of years, but no one knows exactly when it began. The Neolithic Revolution resulted from the advent of cultivation, in which people abandoned nomadic hunting and settled in what would become settlements[1].

In the 20th century, agro-industries based on large scale mono-culture came to dominate agricultural production to promote ASCs, despite the fact that around two-billion people still relied on continuation agriculture. Modern agronomy, plant propagation, agro-chemicals like pesticides/fertilizers, and technical advancements dramatically improved produces thus wreaking havoc on the environment[1]. Agriculture's long-term viability is critical to ensuring food survival and poverty extermination for the world's rapidly expanding population. By 2050, it is projected that global food demand will need to rise by 60-110 percent to feed 9-10 billion people[2]. Agriculture encompasses a wide range of products, including flowers manure or dung, nursery plants, animal hides (furs or skins), pelt, horses, mushrooms, fabrics (wool, cotton, flax, and hemp), biofuel, and medicines, to name a few (biopharmaceuticals, marijuana, opium). Many people still depend on survival agriculture and minor farms to make ends meet.

The yield is the amount of food produced on a given amount of soil, and it is often insufficient. The farmer grows just enough food to provide for his family and himself and his animals. Because survival farmers are typically less trained and have less resources to invest in machinery, this is the case. Famines are often caused by droughts and other problems. Deforestation would deliver new ground for growing more food where profits are poor. This provides additional nourishment for the farmer's family, but it could have long-term negative consequences for the country and environment.

Assistances of climate warming, aquifer exhaustion, degradation, resistance due to antibiotics, and hormonal growth in commercial-meat processing are also environmental concerns. Agriculture is also particularly vulnerable to environmental destruction, such as global warming, environment exhaustion, soil deprivation, and, desertification, both of which result in lower crop yields. While, certain genetically adapted species are debarred in some countries, they are widely used.

Modern agronomy, plant propagation, agrochemicals like fertilizers and pesticides, and technological advancements have dramatically increased yields thus creating chaos on the environment. In a similar way meat production has risen as a result of selective breeding and modern animal husbandry methods, but they have also raised concerns about animal welfare and environment harms [1]. Agronomy is the science and technology of growing and harvesting plants for fruit, wood, fiber, recreation, and environmental conservation in agriculture. It's a profession that's both charitable and analytical. Plant genetics, plant morphology, meteorology, and soil science all fall under the umbrella of agronomy. Foods, fabrics, oils, and raw materials (such as rubber) are the 4 central classifications of agricultural goods. Cereals (grains), fruits, oils, vegetables, beef, milk, eggs and mushrooms, are all food types. Agriculture employs second to the service sector, over one-third of the world's work-force, despite a global pattern of declining agricultural jobs in recent decades, predominantly in developed countries where small-holding agriculture is being displaced by industrial agriculture and mechanization.

Subsistence farming is done exclusively to encounter the needs of one's family or community, with nothing left over for transportation. In Monsoon Asia and South-East Asia, it is widely used. In 2018, approximately 2.5 billion subsistence farmers employed, farming roughly 60 percent of the world's arable land[3]. Land under temporary farm crops (multiple-cropped fields are only counted once), temporary meadows for mowing or grazing, market and kitchen gardens, and partly fallow land are all considered arable land (lesser than 5 years). This group excludes land that has been lost due to changes in agriculture. Land under temporary farm crops (multiple cropped fields are only measured once), temporary meadows for mowing or grazing, market and kitchen gardens, and land that is partially fallow are all called arable land (lesser than 5 years). Land that has been lost due to changing agriculture is not included in this group.

Intensive farming is described as crop cultivation with a little unplanted ratio and a great inputs usage in order to maximize productivity (automation, water, fertilizer, and pesticide). Agriculture, especially farming, is still a dangerous business, with farmers all over the world at risk of work connected illnesses, skin diseases, noise convinced damage of hearing, cancers, and lung disease linked to pesticide usage and excessive sun-exposure[4]. Pesticides and other agricultural substances can be injurious to workers' welfare, and workers who are out open to pesticides are more likely to become sick or have children with birth defects. Families may be at risk for accidents, sickness, and death in this industry because they often share jobs and live on the farm.

All farmers, regardless of area, will consider factors such as the crop to sow, the method of tillage, fertilization, and the price of the commodity before beginning crop production. These are fairly broad considerations, and one or more of them may already have been made; for example, one may wish to grow wheat. All fruitful farmers are prosperous since they always plan out each move in advance.

A list of some such considerations:

- When they'll be growing. This will comprise seed collection, quantity essential, seed sowing preparation, and so on.
- Before they begin this activity, they must first prepare the property – form of land, land condition, land resources, any necessary adjustments-augmentations to the potency of the land, and so on.
- Preparation of land for cultivation and their methods.
- Crop sowing in prepared land and farmer sowing methods will be needed to be adopted.
- Irrigation and artificial insemination (fertilizers) – quantity, timing, and availability.
- Maintenance at various levels of crop development – protection from diseases and viruses.

- Harvesting – again, harvesting processes, manpower, machine hours, and stocking of produce before marketing.

1.1. Crop:

When deciding which crop to grow, the farmer should think about the overall revenue model, which may include grains, millet, fruits, flowers, and so on. Which crop will yield the highest profit when harvested at the time of sowing? What is the crop's commercial potential? Is the crop suitable for the climate and terrain? Is he in possession of the required irrigation infrastructure, or would it have to be built, and if so, at what cost? What is the maximum amount of food that can be produced on his farm, and what is the average estimated yield? Is there an ability to meet the future irrigation demand? Disease tolerant seeds and disease and pest control approaches are available. What kind of land preparation is needed before this crop can be planted? Farmers will be wise to check the weather predictions and conditions. How will the crop be made, processed, and sold? There will also be a number of other factors to remember.

The above may seem overwhelming, but with time and firsthand experience, as well as consultation with government agriculture services and the ever-present internet, such information is readily accessible. The challenging part is that the farmer must choose which crop to plant. The rest of the considerations are listed below.

1.2. Preparation of Land:

Now that we've chosen our crop, it's time to prepare the land for it. The idea has always been to grow good land for our crop at a low cost and in a short period of time. As a consequence, let us first consider a brief theory on land preparation and approaches to land preparation. Land planning, also known as planting, and crop production should be seen as a single body. Strong field planning allows for good crop production. Farmers have been working on land planning since the dawn of agriculture. The fundamental principle has always been to split the earth to allow a seed to grow itself at the depth it requires. Farmers almost everywhere in the world now use powered mechanical means such as tractors for tilling operations, though manual and animal tillage are still used in some areas due to local conditions. Tractors come in a wide range of sizes and shapes.

1.3. Method of land preparation – Tillage Practices:

Ploughing is the process of hacking, cracking, and inverting the soil with a tractor or by hand. Organic manures and a full dose of phosphates are blended into the soil at this stage. The second stage of tillage is harrowing, which includes smoothing and pulverizing the soil to a shallow level. Weeds would be eliminated from the soil, and fertilizer would be applied. This change would also upsurge the present soil’s moisture. The last stage in improving lands’ valuation and arranging for soil with uniform moisture, water application, and other tasks is levelling. The question of what kind of tillage the crop necessitates arises. Is it a thick, shallow, or tillage that leaves earlier crop residue on the ground?

1.4. Digging

It is needed to be done in the same order as follows:

- Give the soil a rollover, making it easier for the seed with crops. The soil becomes less compacted, allowing for deeper rooting.
- Allows sunlight and oxygen to reach the earth, making the soil cleaner and killing certain viruses.
- Both weeds and old crop residues must be removed.
- Irrigation water has the ability to go farther.
- The property is being levelled and planned.

Tillage is expensive and tend to remain costly if performed physically. There are alternatives to the traditional digging technique which is determined by the farmer, type of seed, moisture of the soil, and resource costs. Minimum tillage and zero tillage are the two options. This method, over time, develops its own Eco-system, reducing disease and pests. This conservation tillage also allows for the seeding and fertilizer placement processes to be combined, resulting in less crop, fertilizer, time, cost, and labour. However, as previously mentioned, the farmer must evaluate the specific tilling method in light of his own circumstances. This method, over time, develops its own Eco-system, reducing disease and pests. This management digging also allows for the seeding/fertilizer placement processes to be combined, resulting in less crop, fertilizer, time, cost, and labor. However, as previously said, the farmer must evaluate the specific tilling process in light of his own circumstances.

1.5. Seeds' Planting:

- Use of decent class seeds is the key.
- Take help of the fertilizers so as to help in smooth germination.
- Land ploughed by any method must be moist; additionally, compaction of the soil around seed ensures seed receives the necessary moisture.
- Seeding should be done evenly and in accordance with crop's compactness specifications. Overseeing does not result in a profitable harvest. The nil and conventional tillage methods use the fewest seeds.
- Crop management is essential to discourage weeds from contaminating manure and seed water. Weed control chemicals must be added shortly after the crop is seeded.
- DAP (di-ammonium-phosphate) should be added just below the seed. Other fertilizers, such as urea and potassium, should be applied and watered prior to planting.
- Having a false furrow in the field before zero tilling and/or conservation tilling is another form of weed control. This aids the weed's growth. Now smear chemicals on the weeds to kill them. Some fertilizers, such as urea and potassium, should be applied and watered prior to planting.
- Making a false furrow in the field before zero tilling and/or conservation tilling is another way of weed control. Weeds will flourish as a result of this. Now it's time to use pesticides to get rid of the wildflowers. After which refurrow and plant-seeds.

1.6. Growth of the Crop and Fertilization:

To prevent water stress in the plants, the moisture content in the soil must be controlled after the seeds have sprouted. Water-stressed plants become highly unproductive. Fertilizers should be applied in accordance with the crop's needs. A basic rule of thumb is to apply urea in three equal amounts: once before seed sawing and two times after this crop has matured. Phosphates are only given out at the starting. Later on, potassium will be needed. On a crop-by-crop basis, farmers will need to review the advisory.

1.7. Harvesting, Storage and Marketing:

It is the fulfilment of the farmer's labors and the realization of the harvest's worth in compliance with the ASCs' requirements. Harvesting techniques differ depending on the farmer's resources, as well as from region to region and place to location. A government or private corporation is normally in charge of marketing.

1.8. What is ML

Machine Learning (ML) is the learning of analytically designed computer-based algorithms that learn from their errors and evolve over time. Artificial intelligence is thought to be a part of it[5]. ML algorithms create a model based on samples of data, mentioned to as "training data," in order to make predictions or decisions without being specifically programmed. Machine learning algorithms are used in a range of applications, such as email filtering and computer vision, where designing traditional algorithms to perform the necessary tasks is difficult or impossible. Although quantitative statistics, which focuses on making predictions for computers, is closely related to analytical learning, it is not all of the ML. The field of machine learning benefits from the study of mathematical optimization because it provides tools, theory, and implementation domains.[6].

Data mining is also a similar field of exploration that focuses on unsupervised learning for experimental data-processing. ML is also known as predictive analytics when it is used to solve market issues. ML in today's world has two goals: one is to identify data using proven models, and the other is to make predictions about possible outcomes using these models. To train a hypothetical algorithm for classifying data, it could use computer vision of moles combined with supervised learning to identify cancerous moles. Table 1 describes the possible usage of machine learning and from where ML algorithms acquires its data to implement into the learning aspect of the ML.

Table 1: Different Algorithms used in the Process of Learning and Adapting Process of Machine Learning

ML ALGORITHMS	DESCRIPTION
Bayesian Network	A Bayesian network (also called a Bayes network, opinion network, or decision system) is a probability based graphical model that utilizes a guided acyclic graph to describe a collection of variables and their conditional dependencies (DAG).
Decision Tree	A brief introduction Decision Trees are a form of supervised ML in which the data is continuously divided according to a parameter (you describe what the input is and what the corresponding result is in the training data). Two entities, judgement nodes and leaves, can be used to illustrate the tree.
Ensemble Learning	Ensemble approaches are meta-algorithms that incorporate many ML strategies into a single predictive model to reduce uncertainty (bagging), bias (boosting), or increase prediction accuracy (stacking)
Regression Analysis	Regression analysis is a set of ML techniques for predicting a constant outcome variable (y) dependent on the values of one or more predictor variables (x). In a nutshell, the aim of a regression model is to create a mathematical equation that describes y as a function of x variables.
Support Vector Machine (SVM)	The Support Vector Mechanism (SVM) is a linear model for solving classification and regression problems. It has a wide variety of applications and can solve both linear and nonlinear problems. SVM is a fundamental concept: By drawing a line or hyperplane through the data, the algorithm divides it into classes.
Artificial-Neural Networks (ANN)	An Artificial Neural-Network (ANN) is a component of a computational system that mimics how the human brain analyses and processes data. Artificial intelligence (AI) is built on this basis, and it solves problems that would be impractical or difficult to solve by human or statistical criteria.
Clustering	Cluster analysis, also known as clustering, is a task that requires unsupervised ML. It entails finding normal classification of data automatically. Clustering algorithms, unlike supervised learning (such as statistical modelling), only view the input data and look for natural groups or clusters in feature space.
Deep Learning	Deep learning is an AI utility function that impressionists the human brain's processing of information to identify objects, recognize expression, translate languages, and make decisions. Deep learning AI can learn without the need for human intervention, using both organized and unlabeled data.
Instance-Based-Learning	In ML, instance-based learning (known as memory based learning) refers to a group of self-learning algos that equate new problem instances to previously stored in memory instances rather than performing explicit generalization.
Genetic Algorithms	Genetic Algorithms are algorithms that are based on natural selection and biology, which are evolutionary concepts. GAs are adaptive heuristic search algorithms, which means that they adopt an iterative pattern that evolves over time.

1.9. Types of Machine Learning

The essence of the “feedback" or "signal" available to the learning system generally divides ML methods into three broad categories:

- *Supervised-learning*: A instructor gives the computer example inputs and ideal outputs in order for it to learn a general rule that maps inputs to outputs.
- *Unsupervised-learning*: No labels are given to the self-learning algorithm, and its left to its own devices to find order in input. Unsupervised-learning can be an end in itself (searching hidden patterns of data) or a means to an end (finding hidden patterns in data) (feature learning).

- *Reinforcement learning*: Reinforcement learning is a form of learning in which a computer program interacts with a complex environment in order to accomplish a goal (such as driving a vehicle or playing a game against an opponent). As it navigates its problem space, which it aims to refine, the app provides input in the form of rewards.

Other methods have been established that do not neatly fit into this three-fold categorization, and a ML system can use more than one. Topic simulation, dimensionality reduction, and meta learning are only a few examples.

Deep learning has currently been the leading method with much ongoing study in the area of ML.

- *Optimization:* Many learning-problems are conceived for the minimization of any loss-function on a training-set of instances, which links ML to optimization. The difference between the model's projections and the real problem instances is expressed by loss functions.

- *Generalization:* The objective of generalization distinguishes optimization and machine learning: while optimization algorithms can reduce loss on a training set, machine learning algorithms are concerned with reducing loss on unknown samples. Characterizing the generalization of numerous learning algorithms, especially deep learning algorithms, is a hot topic in current research.

- *Statistics:* In terms of methodology, ML and statistics are similar, but their main goals are different: statistics draws population inferences from a survey, while ML looks for generalizable statistical trends. ML ideas have a long tradition in statistics, from statistical concepts to computational techniques.

1.10. How ML and agriculture can be related

Why is it essential to apply ML to agricultural and applied economics now? For starters, data access has skyrocketed in a variety of fields, including agriculture, the atmosphere, and production. ML methods are better suited to manipulate vast quantities of data more effectively than conventional statistical methods, in addition to assisting in the processing of data from these novel sources. Why is it important to use ML in agricultural and applied economics right now? For instance, data access has increased dramatically in a number of sectors, including agriculture, the environment, and manufacturing. In addition to aiding in the retrieval of data from the origins, ML methods are ideally able to manipulate large amounts of data more accurately than traditional statistical methods. The Figure 1 below shows the different stages of agricultures divided into 3 stages and aspects about which a farmer has to keep the track of, throughout the process of crop life.

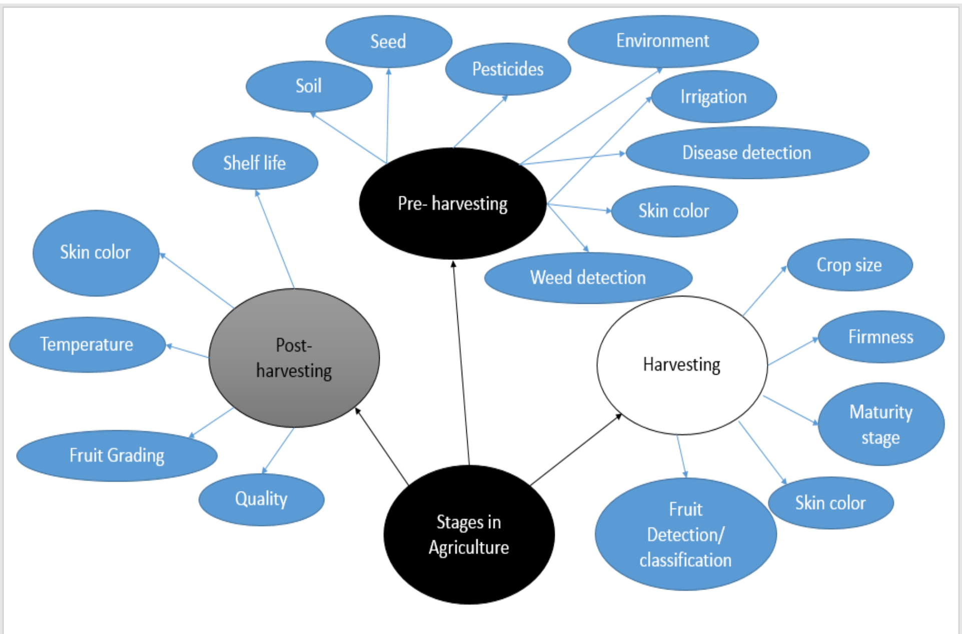

Figure 1: Stages of Application in the Areas of Machine Learning and Artificial Intelligence in Different Stages of Agricultural Harvesting

Literature Review

In a yield modelling process, Andrew Crane-Droesch showed how a semi-parametric version of a deep neural networks can account for complicated non-linear interactions, established parametric structure, and unobserved cross-sectional heterogeneity in high-dimensional datasets [4]. Using scenarios from a number of climate models, they demonstrated that climate change has a substantial negative effect on corn produce, proving that a semiparametric variant of a deep neural network technique outperforms both conventional statistical methods and fully-nonparametric neural networks in predicting yields of years withheld during model training using data on corn yield from the US Midwest.

Anna Chlingaryan et al. discovered that Over the last 15 years, there have been significant developments in ML-based methods for crop yielding predictions and nitrogen eminence approximation[7]. Quick developments in sensor machineries and Machine learning algorithms, according to the report, will be providing cost efficient and systemic answers for good yield of the and environmental situation valuation and decision building. Precision agriculture(PA) will likely see more focused use of sensor platforms and machine learning techniques in the near future, as well as the convergence of multiple sensor based modalities and specialist skills, advancement of mix system(s) incorporating various ML and signal processing techniques.

Savvas Dimitriadis, Christos Goumopoulos used ML methods to retrieve fresh data as generalized rules for decision on better natural resource management[8]. The ML application prototype proposed in the research is based on a method which is iterative and inductive of information exploration in which previously observed processes and relations are revisited to expand knowledge. The findings of the study led to the creation of a critical set of judgement rules for predicting plant condition and avoiding negative effects of water stress in plants.

Jérôme Treboux showed the impact of ML precision agro-technology is discussed over this article[9]. A data-set of highly prevised aerial-pictures of vine-yards is used to test state-of-the-art image recognition. The thesis compares an advanced ML approach to a baseline that has traditionally been used on vineyard and agricultural items. Color detection is used as the baseline, and it can distinguish interesting artefacts with an accuracy of 80%. (89.6 percent). ML, a novel technique for this kind of use case, shows that the precision of the predictions can be increased to 94.27 percent.

IGarca-Pedrero uses a novel technique to investigate the use of ML algorithm to demarcate agricultural parcels. The proposed solution combines super-pixels and supervised classification to determine if neighboring super-pixels can be combined, essentially converting the segmentation problem into a ML problem. The use of a ML algorithm for such task is encouraging, according to a visual evaluation of results obtained by the technique applied to two areas of a high-resolution satellite image of a fragmented agricultural landscape [9]

Dominique Genoud et al. found out that the results of ML algorithms on aerial image target recognition for high-precision agricultural activities are presented in his article[10]. Geotagged vineyard images make up the dataset. Advanced ML methodologies, such as Decision Tree Ensemble, outdid state of the art image recognition algorithms widely utilized in agriculture, according to the researchers.

There have been major advancements in ML-based approaches for crop yields predictions and nitrogen levels estimations over the last 15 years. According to the study, rapid advancements in sensor technology and machine learning methods that provides economical and thorough solutions for enhanced crop and environment situation assessment and conclusion making.[12]. Precision agriculture will likely see more focused use of sensor platforms and machine learning techniques in the near future, as well as the convergence of multiple sensor based modalities and specialist skills, advancement of mix systems incorporating various ML and signal processing techniques (PA).

Study by S. B. Yemeserach Mekonnen et al. provided a thorough examination of the use of various ML algorithms in censored data-analytics in agriculture-ecosystem[13]. It also goes through a case study of an IoT-powered data derived smart farm prototype as a food, electricity, and water (FEW) device. This smart farm system can provide a wide insight to the farmer in adjusting the likelihood to pick up the crop, time to crop and quantity required at the time of farming, reducing the risk factor involved in the whole process.

The complexity and volume of information produced by completely manual, high-amount data recording or phenotyping systems, such as digitally developed images, sensors and sound information, not operated networks, and data gathered from real time non-aggressive computer visional, are posing tests to precision animal agriculture's operative implementation[14]. In order to overcome the daunting challenges that global agriculture faces, ML and data mining are probable to be the important asset in this process. Though, in the animal science community, their relevance and ability in “big data” research has been underappreciated, with only occasional recognition.

Discussion

Deep learning and other ML models have attracted a lot of attention as a potential platform for biology due to their performance with big data. However, as previously said, high-complexity models are prone to overfitting unless large datasets are usable. Overfitting can quickly cause naive implementations of complex models to malfunction. As a result, the secret to using ML methods in animal science is to keep working on constructing sufficient prior information for regularization. Continue to collect datasets and combine them with various modalities to expand the number of samples available for training. It's also important to consider the computational load involved in analyzing large integrated datasets. Whenever possible, it's a good idea to think about how to make the model parallel-compatible.

Conclusion

Agriculture is going through a digital revolution as many other fields under development. The volume of data gathered from farms is growing at a rapid rate. Wireless sensor networks, the Internet of Things, robots, drones, and artificial intelligence are all becoming increasingly popular. Huge quantities of data can be mined for useful information and insights using machine learning algorithms. This paper examines the ML approaches that have been used by researchers in aggregation of non-wired sensor networks over the last two years. In the coming years, more advanced approaches, such as distributed deep learning, will be used more frequently. Artificial intelligence must be used in agriculture to increase task automation and increase yields while maximizing the use of naturally obtained resources. It showed how machine learning models can be used in a number of precision agriculture applications, such as yield estimation, weed identification, and disease detection.

The implications of ML algorithmic approaches are numerous: they discuss the current research problem of a lack of data derived integrated FEW systems, examine AI in agriculture, and advocate for the incremental introduction of machine learning technology in agriculture for future research.

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