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A REVIEW ON THE ROLE OF MACHINE LEARNING IN AGRICULTURE

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Abstract. Machine learning is a promising domain which is widely used now a days in the field of agriculture. The availability of manpower for agriculture is not enough and skill full farmers are less. Understanding the situation of the crop is not that much easy to detect and prevent the diseases in the crop. It is also widely employed in various agricultural fields such as topsoil management, yield management, water management, disease management and climate conditions. The machine learning models facilitate very fast and optimal decisions. The model of machine learning involves with training and testing to predict the accuracy of the result. The use of machine learning in agriculture helps to increase the productivity and better management on soil classification, disease detection, species management, water management, yield prediction, crop quality and weed detection. This article aims at providing detailed information on various machine learning approaches proposed in the past five years by emphasizing the advantage and disadvantages. It also compares different machine learning algorithms used in the modern agricultural field.

Key words: Machine Learning, Agriculture, Data Analysis, Training Methods and Sensors.

AMS subject classifications. 68T05

1. Introduction.

Now a days, agriculture is the major source in all over the world, it plays a vital role in the global economy. Many of the research projects and funding projects are continuously implement with the latest technologies. Increasing the yield of the crop, automating the work done for the crop, minimizing the manpower, reducing the disease ratio by detecting on initial stages with existing matched patterns and finally harvesting with machinery in minimum time [1]. Machine learning in agriculture implemented with different crops from sowing to harvesting using many techniques from different technologies like big data, artificial intelligence, drones and data mining. Using these technologies, for mapping with existing data to identify and fix the solution of frequent problems. And defining the machine with related scenario based on the weather conditions and the moisture position using sensors detectors.

Agriculture in normal processing with manpower may have many problems with less expertise for knowing the crop complete processing, disease identification, appropriate pesticides usage on initial stages instead of spreading on whole crop, huge manpower utilization from sowing to harvesting of the crop. There may be many consequences to know everything about the crop and all types of crop manually, without having any experience. So, the new people working on the crop have difficulties in knowing everything. Mainly the cost of the crop is very high because of utilizing everything on manpower. Even now a days many machineries are using in cultivating crops in agriculture and also manpower is needed to form sowing to harvesting, but many crop automation is not possible because of the crops depends on environment conditions and soil management [1].

The Machine learning algorithms are processed on deep learning and artificial intelligence algorithms based implementations. Train the system with deep learning and automated with artificial intelligence combination mechanism. Using machine learning in agriculture trained the system with deep learning mechanism inbuilt with sensors intermediate for collecting and processing the data. Once the current status data is processed by the sensor then the machine understands the process of deep learning and also mapping with artificial intelligence. Machine learning in agriculture mainly depends on the existing dataset mapping with new data set processed by the sensor. Deep learning in agriculture also is a trend nowadays. Using the latest technologies on image processing with data analysis of existing models which matches with the results and its excellent outcome.

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These days we can overcome many problems and challenges on different agriculture fields and food production using deep learning mechanism. Deep learning used on different crop fields with natural language processing, speech recognition with learning, sensors to detect temperature on soil based on the crop and weather condition from sowing to harvesting of the crop [2].

The usage of machine learning helps farmers to collect the information and data by using it in agriculture with the aid of information technology to make the best decisions on high output from the farms [3]. Machine learning algorithms can be used for many applications in agriculture; like crop suggestions based on the pest detection in plants, soil fertility, weed detection, yield cultivation of crops and plant disease detection based on the disease identification on early stages will recovery the plant so that automatically increase the crop. It is very important to minimize the utilization of pesticides as considering food quality and health measures of the people. Apart from monitoring environmental conditions on a farm, intelligent agriculture must analyse understand how weather circumstances cause environmental changes at the farm and how long-term crop cultivation brings about soil erosion or changes in the soil structure. Through minimizing water management we can save the water instead of wastage and use the same water for another crop. Monitoring a farm using machine learning can prevent low productivity of crops [4]. Using crop management improves the yield of the crop can take care from sowing to harvesting.

2. Literature survey. In agriculture, using machine learning indicates using many crops. A previous study [5] explains the harvesting in date fruit orchard using robotics and Deep Learning mechanism. There are two pre-learning CNN mechanisms; namely, AlexNet and VGG-16. To construct a study machine imaginative and prescient system, also based on the high-quality image dataset of 5 data types for all maturity stages. The suggested method accomplish extremely good classification based on the difficult dataset with matching ration. The high-quality pixel images data sets are used in future to improve mapping of different date fruit orchards.

In another study [6] conducted on the graphical representation of modelling, primarily with the references of sparse linear additive and proposed processes to discover a sparse in part linear additive shape on development of directed open-chain graphical representation. The study updates the outcomes as a case study the use of variable dataset accumulated on the runtime of the plant manufacturing and also proposed view is tremendous for discovering strengthened variable or fixed based on temporary with proper output graph. They proposed a method regarding the energy-efficient improvement management. Anyhow, the new approach that the team invented predicted to be applicable for various surveys which are primarily based on the statistical methods. Here, they mainly focused on the classification of normal additive samples, but their scheme can be without difficulty, moved further with elaboration and naturally through involving arbitrary link models. Here they assumed the hill mountaineering approach for getting associated best results inside the fixed period.

Machine learning is famous with its ability to achieve maximum on many domain-based technologies. Machine learning can be regarded the top-rated analytic tool for fog computing applications. Instead of modern day's achievements, machine learning purposes and literature also plays a major role. The latest research gap defines fog computing. The research achievement of machine learning in three elements are resource management, accuracy and security. Machine learning is implementing mainly on resource management instead of accuracy and security in fog computing. Machine learning include cloud computing in one of the layers. Even many problems and challenges have been open-ended with these combinations. Even most of the challenging problems regarding safety measures used in cloud computing. Supervised learning in fog computing is one of the famous machine learning assignment. In the healthcare domain most of the applications have utilized machine learning and also many open challenges and issues are there in fog computing in machine learning [7].

A prior study [8] has planned a correct and strong algorithm for a new mechanism to critically find the growth of cucumber using robotic harvesting automated process in agriculture. This algorithm is a different sort of implementations and mining methodologies of existing data to gain of cucumber field with extraordinary components. This mechanism combines vector elements with image pixels match to get the starting stage itself on next level onwards. Many outcomes of the yield were taken as the feedback as input for modelling and testing the final algorithm. This algorithm outcome of the application is more efficient for harvesting the cucumber.

Deep Learning resolves many diseases from detecting with proper data set and using pesticides with minimal quantity for curing the plants of the crop [9]. Another study [10] explains crop prediction, implementing many techniques including artificial neural networks. Based on the artificial intelligence finding the soil state

depending on the weather condition with maximizing the yield of the crop. Later, a study [11] referred around 40 research papers defined as a survey on all the aspects of machine learning in agriculture. The reference papers appeared in standard journals with high cited papers and many are the reputed papers with implemented on all over the world on machine learning in agriculture. Machine learning in agriculture using sensor data on the agricultural field using artificial intelligence with high suggestions from sowing to harvesting.

3. Machine Learning In Agriculture. The latest trend in agriculture using machine learning are implementing smart farming with latest techniques. Many recent mechanisms are using for farming to find soil moisture based on the type of crop with water management, disease detection and selection of pesticide with existing patterns, crop management. Machine learning consists of five major components as shown in Figure 3.1. These five major components are 1). Collecting data from the farm 2). Stored data 3). Data pre-processing 4). Train the model and 5). Performance metrics.

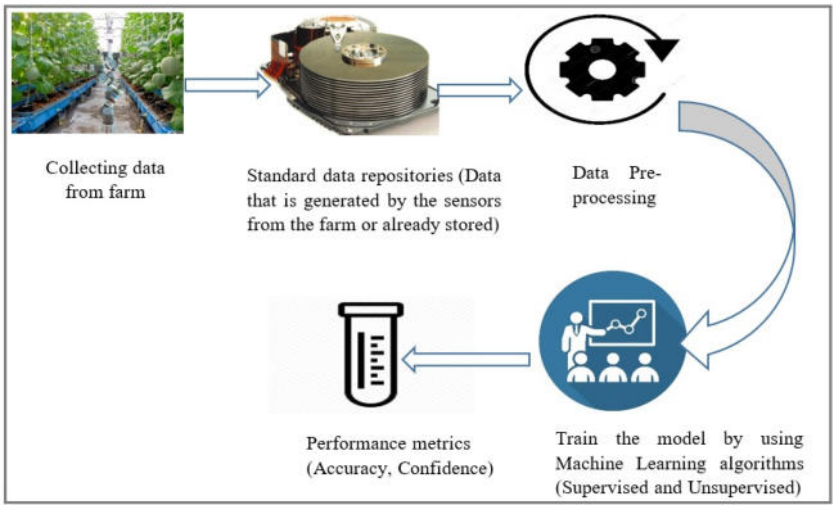

FIG. 3.1. *General process of machine learning*

3.1. Collecting data from the farm. Most of the researchers used different sensors such as temperature sensor, passive Infrared sensor, ultraviolet sensor, pH sensor, soil moisture sensor, humidity sensor, gas sensor, barometric Pressure, hyperspectral camera, multispectral camera, DSLR camera, NPK sensor, obstacle sensor, acoustic sensor, water level sensor, water quality Sensor, GPS sensor and MooMonitor sensor to collect the data about the soil fertility, yield of crops, climate condition, pest detection in plants, weed detection, identifying diseases, etc. This data gives more accurate results, but it is cost-oriented, time-consuming and also more difficult to collect. A study [12] developed a robot with different sensors and it is collected various environmental factors that effects on soil such as soil temperature, pH value in soil, the intensity of sunlight, soil moisture, humidity etc. to grow a plant. Later, another study [13] proposed and designed an optical transducer to measure soil nutrients such as Nitrogen, Phosphorus and Potassium, and these nutrients are called primary nutrients. Soil nutrient not only depends on primary nutrients and also having macronutrients and micronutrients [14]. Generally, the soil fertility and environmental factors both are interrelated.

Another study [15] developed a smart irrigation system for agriculture by using temperature, humidity and UV sensors. Soil fertility, types of crop and climate condition are the essential parameters for designing a smart irrigation system. So, while collecting soil nutrients, also collect environmental factors and type of crop, it will generate more accurate results for decisions from the data analysis. Hyperspectral Image of different crops by using hyperspectral cameras for crop classification have used in another study [16]. Later a study [17] has used the acoustic sensor for detecting insect's pests in the underground. This sensor is mostly useful for detecting insects in underground crops like carrot, potato, groundnuts, onion, taro, turmeric, garlic, etc. A research collected [18] 83,260 and 16,652 colour images format as JPEG from wheat planting of Shandong

Province, China, to train and test a model respectively for winter wheat leaf diseases by using Canon EOS 80D camera.

3.2. Standard data repositories. The main benefit of the existing data is the researcher doesn't want to spend money on collecting data. This data takes less time and also easy to collect, but it gives the less accurate results [19]. This data is especially available in various websites. The researchers can download from the websites and performs the data analysis. The forms of data include images, tables, text, graphics, audios and videos. The following industries are mainly providing datasets for analysing the data by using machine learning algorithms in agriculture. UCI, MIT, Kaggle, University of Arkansas, Live tree, China Agro. and Econ. Data, Open Government Data, OpenAg, GitHub, Data. world, Knoema, USDA-ARS, V2 Plant Seedlings Dataset, Food and agriculture data, Pesticide Use in Agriculture and Soil Resources Development Institute are providing data to the data analysis.

A study [20] used soil related data of upazila of Khulna district in Bangladesh for soil classification and crop suggestion, collected data from soil resources development institute, bangladesh. Another study [21] are collected from 3010 images of rice plants with diseases from the high-standard rice experimental field of the hunan rice research institute in China to detect the rice plant diseases. Another study [18] collected eight categories of 16652 images from Shandong Province, China to identify 8 different diseases from the wheat winter crops. And another study [22] collected 1070 real-time mango tree leaves images from shri mata vaishno devi university in the district of Katra located in Jammu and kashmir, India to identify the fungal disease named as anthracnose. This method is less expensive, easier to collect and cost-effective but the error rate is high and not suitable for all areas.

3.3. Data pre-processing. The major issues in real-time data are inconsistent, duplication, noise and missing values. This type of dataset is very critical for analysing the process and increases the error rate. Data pre-processing performs on the raw data for further processing to enhance the quality of the data. Data pre-processing is major crucial step in machine learning to improve efficiency while data processing. Pre-processing can removing the noise, inserts the missing values, the appropriate data range, and extracting the functionality etc. A study [21] used Two-Dimensional Filter Mask Combined with Weighted Multistage Median Filter (2DFM-AMMF) to remove the noise from the rice plant images. Majority of image related works are used segmentation and feature enhancement to improve the quality in data. Another study [23] removed salt and pepper noise by using Gaussian Median and Gaussian filter respectively to enhance the image quality to the 4-different crops and 2-weeds namely Paragrass and Nutsedge are chosen for classification. And another study [24] used Principle Component Analysis to remove the dimensionality and multicollinearity problems for water supply forecasting in the US West.

3.4. Train the model by using machine learning algorithms. Machine Learning algorithms are classified into two types; Supervised Learning and Unsupervised learning. The use of machine learning in agriculture helps to a). Soil classification b). Disease Detection c). Species management d). Water Management e). Yield Prediction f). Crop Quality g). Weed Detection.

3.4.1. Soil classification. Soil is classified based on its strength and property, it can be helps to grow the crop. Former uses the soil classification system for predicting the soil behaviour. Based on the chemical and physical properties of the layers of soil, soil can be classified and named. Soil classification can be used to identify the best crops and type of fertilizer based on the type of soil. Climate changes also plays a major role in soil management with water management. Using machine learning techniques, suggests associated procedures, moisture techniques concerning the temperature. A study[20] used Machine learning algorithms such as Gaussian kernel-based Support Vector Machines (SVM), k-Nearest Neighbour (k-NN), and Bagged Trees are used for soil classification, but proposed Gaussian kernel-based Support Vector Machines (SVM) based method performs better than the k-Nearest Neighbour (k-NN), and Bagged Trees.

3.4.2. Disease Detection. Disease mainly depends on the weather and climatic conditions, soil characteristics and plant strength. Detection of disease based on climatic conditions and viral diseases are broadly pest and managing of disease utilization simultaneously. Disease detection also compares with a dataset as per the weather conditions and age of the plant. A study [21] compared two machine learning algorithms

such as combination of Fuzzy C-means and K-mean clustering(FCM-KM) + faster Region Convolutional Neural Network(R-CNN) and faster Region Convolutional Neural Network(R-CNN) for detecting the rice plant disease such as rice blast, bacterial blight and sheath blight, but proposed combined of Fuzzy C-means and K-mean clustering(FCM-KM) + faster Region Convolutional Neural Network(R-CNN) performs better than the faster Region Convolutional Neural Network(R-CNN). This method is not suitable for large scale rice plant disease detection. A another study [3] compared 5-different machine learning algorithms such as Support Vector Machines (SVM), Artificial Neural Networks (ANN), K-Nearest Neighbour (KNN), Fuzzy and Conventional Neural Networks (CNN) for identification of different diseases in different crops. Among these 5-machine learning algorithms, Conventional Neural Network classification is given more accurate results and also suitable for more crops. And another study [18] used Machine Learning algorithm such as Matrix-based Convolutional Neural Network (M-bCNN) for winter wheat leaf diseases by classifying 8 different leaf diseases such as normal leaf, mechanical damage leaf, powdery mildew, cochliobolus heterostrophus, bacterial leaf streak, bacterial leaf blight, leaf rust and stripe rust.

3.4.3. Species management. Species Breeding: The selection of species is an important mechanism, based on the soil along with region weather conditions and water associated vitamins with good taste. Using deep learning procedures existing patterns, data sets are mapped for solving the many challenges instead of assumptions. A study [25] used Cascaded Support Vector Machine algorithm for classifying 9-different sunflower seeds.

Species Recognition: Manual selection of plants can be based on the leaves colour, age and shape of the plant. The selection of plant will be the first step of the crop and the roots of the plant concerning the age and veins colour on the leaves. A study [26] used 3- different classifiers like Color-Shape-Texture, Pixel and SIFT based to classify 5 categories of species like Flowers, Fruit, Leaf, LeafScan and Stem. A another study [16] used combination of Feature Band Set (FBS) and Object Oriented Classification (OOC) to classify different crops using Hyperspectral Images.

3.4.4. Water Management. Water management plays a major role in every crop. Using a machine learning mechanism we can efficiently use the water so that excess water will be used for another crop. Based on the crop and soil type we can provide the water daily, weekly and monthly. A study [27] used soil temperature, moisture and pH sensors to find the soil water content level in automatic water dripping system for agriculture. The main benefit of an automatic irrigation system is to correct water usage, power and time saving but it consumes more money from farmers.

3.4.5. Yield Prediction. Every crop we suppose to concentrate as per yield prediction. Yield prediction defines mainly mapping of yield, demand based on the crop outcome and evaluation. The yield prediction can be defined from the earlier dataset and what type of latest technologies available and applicable on all the ways based on the current crop, climatic and financial situations for improving the yield. A study [28] used Tensor Flow with Convolutional Neural Networks and Linear Regression for estimating the yield from Sorghum field.

3.4.6. Crop Quality. Crop quality is the way to finalize the crop outcome in the form of financial. Based on the final quantity of yield, minimal wastage and the quality of the crop after harvesting can be detected. As per these parameters, we can define the crop quality and also compare with the dataset. A study [29] connected different sensors to the drone to monitor the crop quality. This drone can monitor the crop, gives alert to the farmer when any issues identify on the crop.

3.4.7. Weed Detection. Weed detection is the main problem on every crop, based on this the final yield defines. It is a very important threat on the crop that effects on the yield. Concerning the age of the plant and the weed, the stage needs to detect. Once we minimize the weed then only the yield will be good otherwise the fertilizers and the pesticides also not working on the crop. The work of the weed is to eat the whole energy of the soil. So the crop quantity will be by default minimum. Machine learning has many mechanisms to detect the type of weed on every crop and intimate. A study [30] used to Support Vector Machine and Conventional Neural Network for detecting Broad-leaf weed detection in the pasture from the images. Another study [23] used SVM, ANN and CNN for classifying the 4- different crops and 2- different weeds, but CNN gives better results compared with the remaining methods.

3.5. Performance metrics. The best method is decided by using the accuracy. The method which has the highest accuracy is the best. The more accurate models can give the better decisions as an outcome. The following Table 3.1 shows different machine learning algorithms used in agriculture and with its accuracy.

TABLE 3.1
Comparison of different machine learning algorithms are used in agriculture.

S.No	Subdomain	Ref.No	Crop	Algorithm	Accuracy
1.	Soil Classification	[20]	—	J48	92.30
				Support Vector Machines	94.95
2.	Disease Detection	[21]	Paddy Diseases	Faster R-CNN	91.28
				FCM-KM+ Faster R-CNN	97.50
3.	Disease Detection	[18]	Wheat Diseases	Matrix-based CNN	96.50
4.	Species Breeding	[25]	Sunflower Seeds	Support Vector Machines	98.82
5.	Yield Prediction	[28]	Sorghum field	CNN and Linear Regression	74.50
6.	Weed Detection	[30]	Pasture	Support Vector Machine	89.40
				CNN	96.88
7.	Species Recognition	[26]	5-Species	SIFT based	98.00
8.	Weed Detection	[23]	4-crops,2-weeds	SVM, ANN and CNN	CNN best
9.	Disease Detection	[3]	6-crops	SVM	92.31
			2-crops	ANN	93.70
			2-crops	KNN	88.75
			1-crop	FNN	88.00
			4-crops	CNN	98.62

4. Conclusion. Machine learning is widely used in modern agriculture. In addition to the Machine learning, deep learning, artificial intelligence and robotics using much more for minimizing the manpower and manual mistakes and almost everything needs to do automation form sowing to harvesting the crops. Using the latest technologies and mechanisms for minimizing the manual mistakes for detecting the type of crop to pesticides selection concerning the dataset mapped. The use of machine learning in agriculture helps in the different sub areas like soil classification, disease detection, species management, water management, yield prediction, crop quality and weed detection processing also implanting with machine learning. In this paper our focus is to provide detailed survey about how various machine learning algorithms were used in different fields of modern agriculture. This paper provides a detailed comprehensive comparative analysis of various machine learning algorithms.

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