PRECISION AGRICULTURE: AN EXTENSIVE ANALYSIS FOR APPLICATIONS OF MACHINE LEARNING TECHNIQUES

Rachana Singh Sisodia, Ankita Rani
Department of Computer Science & Engineering , Ajay Kumar Garg Engineering College Ghaziabad
sisodiarachana@akgec.ac.in, raniankita@akgec.ac.in

***Abstract*—Precision Agriculture enables and enhances smart agricultural techniques.The world's population will reach to 9.67 billion approximately by the end of 2050.Agriculture is considered as an essential food source from many past decades. ML and IoT embedded models participate as an important factor in the revolution of agriculture. The production of the crops depends on soil composition, various weather conditions, variegated plant diseases, unbridled use of chemical fertilizers etc. The regions focused are prediction of parameters of soil such as moisture content and organic carbon, crop yield prediction, detection of disease and weed in crops and also species detection. As per the official records, 45% of the world's population rely on Agricultural activities but unfortunately, the production gets affected due to lack of information of the adverse and fluctuating weather conditions, unbalanced soil composition and late prediction of plant diseases. This paper presents a combined and systematic study of ML application for sustainable agriculture supply chain (ASC) performance.**

***Index Terms*— ML, Precision Agriculture (PA)**

I. INTRODUCTION

Advances in Artificial Intelligence (AI) are one of the key enablers in the reference of Precision Agriculture[1][2]. Weather predictions, disease and weed predictions, soil nutrients are considered as the primary factor to refine the performance and crop production. The properties of soil depend on various geographical and climatic factors of the land we use.A remarkable list of details for a farmer is the prediction of precise crop yield and further guidance for the improvement of the crop yield can be achieved. The value- pH, variations in soil and quality, weather scale: temperature, humidity, sunshine cycle, rainfall, fertilizers, and harvesting timetable are few of the major variables that play momentous role in crop yield prediction. Disease related to microorganisms and bacteria receives their energy from the plants they survive on, which in return affects the crop production. The farmers can have economic loss, if the diseases are not detected at the right time. Immoderate assumption of pesticides accelerates to atmospheric harm and also unbalance the water and soil cycle of the agricultural areas.

Fig 1. Precision Agriculture[1]

The focus of PA is to diminish the production cost and fluctuating environmental effects to upgrade land profits. In 1990, John Deere coined the technology of spraying the fertilizers and sowing of seeds tractors embedded with Global positioning system (GPS) as shown in Fig 1. For accumulating data related to nutrients of soil, water requirements, fertilizers need, sensors (IoT based) can be implemented in agricultural farm. Using computer vision techniques, weed and diseases in plant are getting identified by autonomous or semi-autonomous devices such as unnamed aerial vehicle (UAV) and robots. The data received from the sensors are further analyzed using algorithms that results in controlled farming. In past years, many farmers have lost their lives due to unsatisfactory crop yield. Using ML algorithms that correctly predicts uncertain weather conditions and rainfall at right time ensured the productivity and saved many lives also. This paper bestowed a review of the ML application in reference to PA. This paper will showcase a deep insight into the research section regarding the assuming digital enactment in the area of agricultural management.

A. Effect of AI and IoT in Agriculture

Nowadays, the agricultural area is incorporating smart methods like AI and IoT to cultivate organic products efficiently in limited land regions as well as to overthrow the old traditional challenges of farming. To monitor moisture and composition of soil, IoT based smart farming system using sensors is introduced. To determine the appropriate amount of fertilizers needed for soils before the sowing of crops, ML algorithms are explored. The drones embedded with cameras are designed and implemented for various applications like drip irrigation, monitoring of crop and spraying pesticides when needed is considered as a revolutionary step in the field of PA. AI -enabled models can be used to harvest crops at comparatively higher speed covering more field areas.

B. Machine Learning applications in PA

Due to global warming, varying rainfall patterns and traditional practices the production of the crop is degraded. Sometimes use of excessive fertilizers destroy the growth of plant. The AI systems are applicable depicting extreme weather events like hail, heat and cold waves, floods, drought etc. In this paper, the author has considered few applications like manipulating soil nutrients and weather factors, disease and weed detection using ML models in variety of crops and also presented a comparison.

II. RELATED WORK

a. Properties of Soil and Conditions of Weather

In PA, soil nutrients, prediction of weather and disease and weed detection are counted as the comparatively high factor for the betterment of agricultural domain. The soil attributes are relevant point to take into reflection because they are straightly connected to the geographical and weather circumstances of the land . The picking of crop, preparation of land, choice of seed, crop production, and picking of fertilizers is very much important. Somewhere it depends on the geographical and climate conditions. The nutrients in the soil, humidity are generally tracked by sensors based on electromagnetic. The agriculturalist get the idea of the composition of soil and it helps them to take appropriate decision to choose the right crop.

Table1. Properties of Soil and Conditions of Weather

SI	Reference	ML Algorithm	Accuracy Measure
Various ML Algorithms for the Prediction of frequent Weather variations and Properties of Soil			
1	Reda et al.[2]	EL Algorithm	For SOC
			R2 with 0.95, RMSE having 1.91, performance to deviation (RPD) of 4.88.
			TN
			R-2 of 0.93 and RMSE of 0.58, RPD with 4.90
2	Andrade *et al.[3]*	CR, XGB and RF, OLS	RFpredicts best at R^2 of 0.50, CEC of 0.76 and SOM of 0.55
3	Mahmoudzadeh *et al.* [4]	kNN, XGBoost, Cubist method, and SVM	R2 of 0.61
4	Benke *et al.[9]*	GLMM-estimated by REML	Calculation for error in prediction for EC, MSPE with 0.685 and MAPE is 0.634
5	Shin et al.	Regularized Extreme Learning Model	RMSE starts of the range of 1.02 to 3.35 was recorded
6	Acheing[5]	SVR, ANN, DNN	Prediction of SWRC(soil water retention curve) under dry/wet conditions is achieved.
7	Alizamiret al.[14]	ANN, ELM, CART(Regression trees and Classification) and GMDH	Including temperature of air data with data input ELM outstandingly finds with RMSE of 1.915,1.428,1.455 and NSE of 0.966, 0.976,0.965 and R^2 with 0.976, 0.982,0.983 for depths of 5,15 and 50.5 cm
8	Sierra and Jesus[6]	k-Nearest Neighbour, RF, k-means clustering, SVM, Neural Network	NN performs excellent for the frequency of rainfall with average F score to 0.5 and R with 0.1-0.8 subjected on the particular duration of year and guage analysed

Table 2. Crop Yield Prediction

SI	Reference	ML Algorithm	Accuracy Measure
Crop Yield Prediction- Various ML Algorithms			
1	Kamir et al.[12]	Ensemble based Learners using 9 ML algorithms	Super Vector Regression with radial basis functions displayed lowest RMSE of 0.59 an R^2 score of 0.73
2	Chu and Yu[11]	BBI-model combination of two BPNN with RNN (Ind RNN)	rice prediction with MAE of 0.0044 and RMSE of 0.0057
3	Feng et al.[10]	A hybrid NDVI, SPEI, APSIM, with MLR & RF	APSIM and RF hybrid model that predicts best one month before reaping RMSE of 0.71 t /ha , MAPE of 17.59%, and ROC score of 0.90)
4	Gumuscu *et al.[15]*	kNN, SVM and Decisions Trees	accuracy rates of 37%
			92% is achieved for first 300 days.
5	Gyamerah *et al.[16]*	Quantile-RF and Epanechnikov kernel function (QRF-E) is proposed	QRF-mean best predicts for the crop 9Groundnut) with MAPE of 24.0025%, R^2 of 0.9730 and RMSE of 0.3787 t/ha,
6	Peng *et al.[17]*	EVI, NDVI or LST, and using NIRv	It is measured that satellite based high-resolution SIF products is useful in crop yield prediction with good-quality SIF products.

Table3. Weed & Disease-Identification

SI	Reference	ML Algorithm	Accuracy Metrics
Various ML Algorithm for the Identification of Weed and Disease in Crops			
1	Samba-sivan and Opiyo [18]	DL model-CNN based	Top accuracy of 99.30% is achieved.
	Waheed *et al.[19]*	Dense CNN model	Accuracy of 98.06% is recorded in recognising corn disease
3	Jiang *et al.*	GCN- CNN based	Recognition performance of 97.80%, 99.37%, 98.93% and 96.51% is received for four disease
4	Kerkech *et al.*	CNN	Performance improved with accuracy of 93% at grapevine and at leaf level, 87% is recorded.
5	Oslen *et al.*	DL algorithm Inc-v3 together with ResNet version 50	Performance in terms of accuracy of 95.2% & 94.9% is observed
6	Sudars *et al.*	Camera with High resolution like Intel RealSense-D435, Canon-EOS (800D) , and Sony-W800.	Inclusion of dataset of 1120 leaf images under which 7 food crops and 9 weed species are identified, 7853 altogether parameters were constructed.

III. METHODOLOGY

The study begins with a foundational understanding of ML, exploring its historical evolution and various applications in agriculture. This sets the stage for understanding how ML can enhance farming practice. The paper delves into specific ML algorithms, such as decision trees, SVM, and RF. These algorithms are crucial for tasks like crop monitoring, disease diagnosis, and yield forecasting, showcasing their practical applications in agriculture.

Various ML models have been continuous used to enhance the performance of PA. The dataset collected from various regions ensures the correct prediction of soil, weed and crop yield. The data set is checked and examined that derives satisfactory performance. The study focuses the role of knowledge visualization tools in bridging the gap between data-driven insights and practical applications, ensuring that farmers can make well-informed decisions based on the data. This comprehensive methodology illustrates how ML can revolutionize precision agriculture, leading to more sustainable farming practices and optimized resource utilization.For regression algorithms ELM,SVR and RF , non-linear datasets are utilized for accurate prediction. Large datasets acquired from satellite that is easily managed by regression algorithms with low union and better accuracy.

IV. RESULT AND DISCUSSION

The ML and DL applications tremendously depends on the agricultural changes and available datasets.For better prediction and accurate selection of ML algorithms, basically 4-5 algorithms can be used by the researchers that has comparatively better prediction and robust to parameters like outliers, non-linearity and noise. The basic engaged algorithms are cubist, ELM, Random Forest and SVR algorithm. As per discussion, patterns of weather frequently encounter outlier events which might influence the predicting of accuracy, but algorithms such as ELM, NN are healthy to outliers and delivers imposed predictions.The prediction of considered parameters using ML reveal low error keys such as RMSE, and R^2 which are important measures in terms of accuracy.

V. CONCLUSION AND FUTUREWORK

Precision agriculture is transforming the farming landscape by leveraging technology to optimize outputs with concise inputs. The integration of IoT-based and enabled smart sensors, actuators, satellite imaging, robots, and drones has revolutionized the industry. These cutting-edge components collect real-time data, enabling data-driven decision-making without human intervention.

These techniques leverage drones and robots equipped with digital cameras to monitor and manage crops. Livestock management is another critical aspect of farming worldwide. A knowledge-dependent agricultural system, powered by IoT devices and AI tools, proficiently streamlines livestock system. It includes monitoring animal health and behavior, automating feeding and breeding schedules, optimizing living conditions and habitat management and detecting early warning signs of disease or stress.

As a extent in future, chatbots which is based on NLP can be designed for peasants DL, ML and hybrid algorithms may be more explored in the agriculture business.

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ABOUT THE AUTHORS

Rachana Singh Sisodia is currently working as an Assistant Professor in Ajay Kumar Garg Engineering College, Ghaziabad with 4.7 years of Professional experience. She has completed her M.Tech from Madan Mohan Malviya Engineering College, Gorakhpur and currently she is pursuing PhD from Sharda University. She is having confidence in incorporating new emerging technologies in her learning like NLP, Image Processing, ML and DL.

Ankita Rani is currently working as an Assistant Professor in Ajay Kumar Garg Engineering College, Ghaziabad with 9.5 years of Academic Experience. She has finished her M.Tech from Teerthanker Mahaveer University, Moradabad. She has worked with many renowned Institutes and now she is doing her PhD from IFTM University, Moradabad. She is indulged in learning new technologies and her area of interest is ML, DL and cloud computing.