Machine Learning In Agriculture: A Review

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Abstract: Agriculture 4.0 (A4.0) major area of study to focus on for efficient agricultural production. Agriculture crop product has emerged with several new computational methods. However, few important factors were not possible to maintain and monitor promptly as today is possible. Computational intelligence and machine learning techniques evolved to analyze, quantify, monitor, and predict agricultural crops. The robustness in machine learning methods and computational techniques provided easy, accurate, up to date future predictions. Machine learning is one of the dominant fields in theses that are used for computational analysis of the obtained data. The historical data can be analyzed and processed for future prediction. In agricultural science crop yield prediction is a major area of study to make aware of future repercussions relating to the agricultural crop. This study highlights the Evaluation, applications, and challenges of machine learning for crop yield prediction.

Index Terms: Machine learning, IIoT, Agri 4.0, Precision, Crop yield prediction.

1. INTRODUCTION

The regional and global impact of agricultural crop yield is growing due to economic and social impact. Computer methods are widely adopted to improve crop yield in agricultural field. In smart decision making and future prediction computational methods improved estimation effects. Number of machine learning algorithms have been proposed to test, quantify and evaluate different data for intelligence guess work. Machin learning is widely considered for future prediction in agricultural, health, education, scientific computations and experimentation, real time monitoring (IoT) and prediction real time data (Oguntunde et al., 2018).

Machin learning augments the areas for research such prediction, classification, clustering and ensemble learning. Prediction accuracy is essential for data analysis by implementing supervised, unsupervised and semi-supervised algorithms. Prediction is one of complex areas ofmachine learning algorithm which focus factors for predicting accuracy rate (Nguyen et al., 2019). Prediction accuracy criteria includes accuracy, speed, robustness, scalability and interoperability. Prediction is important to guess andestimate the important variations in data. Machine learning algorithms often applied on primary and secondary data for data analysis and prediction. Machine learning algorithms (i-e SVM, DT, ANN etc) accuracy rate may vary according to accuracy parameters such as root mean square, mean absolute error, confusion matrix etc. Machine learning Prediction accuracy can be improved applying different techniques such as treating missing values,feature Engineering, feature selection, multiple algorithms, Algorithm tuning and Ensemble methods (Balakrishnan & Muthukumarasamy, 2016). Keeping these factors in view this study intended to improve prediction accuracy in machine learning.

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2 MOTIVATION OF RESEARCH

Human guess is old traditional methods which often based on assumptions however without having any avoidance to cope with issue. Specifically, plant nutrition, health, disease identification and growth level may need sensitive treatments and remedies forplant health assessment. The implementation of machine learning methods in agricultural science improved the computerized guessed work for future prediction. The important factor of agriculture field assessment such as soil status prediction, soil salinity, soil pH level, Soil nitrogen level prediction, temperature update, humidity prediction and crop yield prediction and many more application in todayworld. ML can perform automated decision accuracy without being explicitly programmed in different scenario. Data – driven approaches provided to support obtained data analysis and probabilisticdecision making in real life applications.

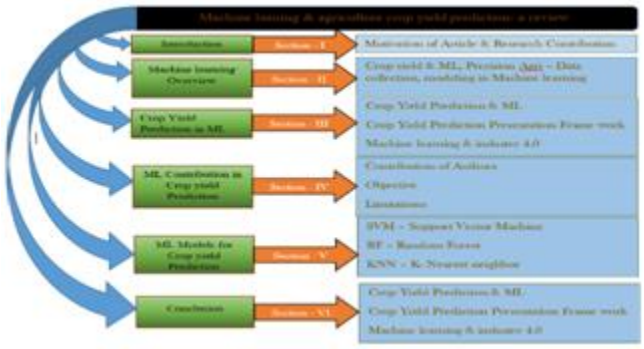

Figure 1 Organization of paper

2.1Contributionof Research

This research paper based on the following research contribution.

- The research reviews concept of machine learning and its statistical modeling in agricultural crop yield
- Various machine leaning applications are discussed with their limitation entails for future aspect of study
- The functional concepts with machine leaning modeling widely used for crop yield prediction.

3 MACHINE LEARNING OVERVIEW

Machine learning techniques are adopted to learn from experiences (i-e training data) for accurate future prediction

and its variable effects on real time scenario. Data sets actually obtained from different applications having different features named as variables and accuracy is performed by different matching learning models (Wuest et al., 2016). Machine learning models are further evaluates to apply different accuracy parameter to check perdition accuracy. Computational intelligence and machine learning technique evolved to analyses, quantify, monitor and predict agricultural crops. The robustness in machine learning methods and computational techniques provided easy, accurate, up to date future prediction (Reisi-gahrouei et al., 2019). Machine learning learns from the data which is based on the historical facts and acts accordingly without explicit programming. Machine learningwith IoT brought new applications of in real life for monitoring real time scenario and make prediction on the basis of the obtained statistic. Machine learning with emerging fields provides many new applications and challenges for future prediction. The field of data science and probabilistic models in big data, IoT, image processing and high-performance computing power has led to overcome several complexities. Machine learning and computer vision in agricultural field introduced new trend of monitoring and predictions. Computer vision employs learning with “see”. Computational learning theories are evolved in the field of machine learning for the better learning experience and future perdition analysis. Computer vision has reduced the cost of equipment, increases the computational power and save the time for the agricultural production (Patrício&Rieder, 2018). The most of the agricultural crop monitoring using drones, livestock management, yield prediction, forestry management, spraying pesticides, grading and sorting crops are important applications of computer vision in agriculture (Chouhan et al., 2020).

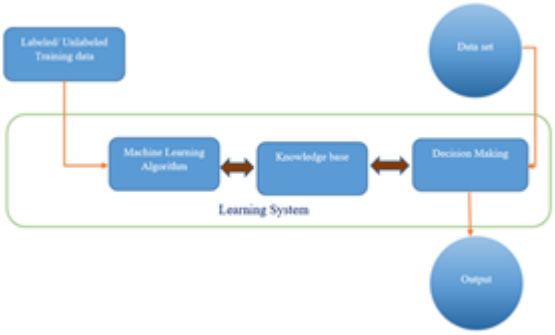

Figure 2**FIGURE 2 ML SYSTEM (ADOPTED FROM DU & SUN 2006)**

Machine learning in real life applications provide effective way of managing data records for better data analysis and future prediction. The data analysis can be considered important factor in machine learning and it covers most of the fields of statistical data records. The data comes on the form of different datasets which contains different attributes and instances. Learning from experiences (i-e from data sets values) via the computer programs can help automatically decision making. These data sets are evaluated and experimented by using different machine learning models (Cui et al., 2018). Machine learning models are used for the predictionon thebasis of classification, regression and clustering etc. ML techniques can be categories named supervised machine learning and unsupervised machine learning however the hybridization of these two techniquesnamed semi-supervised technique. These techniquesare implemented by optioneddata related to crucial attributes.

recorded parameters and data from remote sensing can further quantify, explore and predict agricultural crop yield by applying machine learning methods (Li et al., 2019). Machine learning Models can automatically learn and solve large non-linear problems from the different nature of datasets which often obtained by real time multiple sources.Machine learning is multi-area field in which multiple techniques can be applied on real time data. Multiple data regression, classification and cluster analysis are major methods for data analysis in machine learning which improves data quantification and probabilistic fusion of information. Discussed below:Classification is properties of the supervised model characteristics. Classification is nature of predictive model approach in which class labeled is predicted for input data in the form of two output classes i-e Yes or No. In classification the input values are divided when output attribute consist finite and discrete value(Liakos et al., 2018). In supervised learning the relationships and model dependencies between the target prediction output and input features. Objective is to construct general rule for mapping out input and output. The train model is used to predict missing labels for testing of datasets. SVM, Random forest and decision trees are examples of supervised machine learning model.

3.2 Regression

Regression is machine learning method which is used for the continuous outcome variable (Y) which based on one or multiple predictor variables (X). The main objective is to build a mathematical model that elaborate the Y function of the x variables. Machine learning provide several learning models one of them is known regression which provides prediction accuracy from input variables(Xie et al., 2018). However input variable possess fix values i-e discrete values. There are many tyeps of regression in machine learning which are linear regression, ridge regression, Lasso regression, polynomial regression,Bayesian linear regression and logistic regression. The most complex linear regression algorithm include ordinary least square regression, Multivariate adaptive regression splines, multiple linear regression and locally estimated scatterplot smoothing.

3.3 Cluster

Cluster is data mining technique in machine learning which is used for the grouping of data values. In cluster the data points having same value or properties. However data points are arranged in one cluster having same values and data values having different points are arranged clusters having dissimilar properties. Clustering is unsupervised technique in machine learning which is used to automatically group data discovering. Clustering interprets only input data and finds clusters in data points. It used where there is no need of classification and having no class prediction but used contrary for discovering data groups. Some important algorithms K-Means, affinity propagation,

Agglomerative clustering, mean shift etc. used widely in machine learning for specific area of study (Patibandla & Veeranjaneyulu, 2018).

3.4 Association rule

Association rule is data mining and machine learning technique that used to find the relation among variables in data set. It is used to find the hidden correlations in data sets. The frequency of associations are used to count across large data sets. It is fast and efficient rule based non numeric data mining categorization technique. The rule based learning enhances the capability of the learning and generates the new rule for the decision making. Basket data analysis, web usage mining and intrusion detection, bioinformatics are the practical examples of association rule based learning. In machine learning there are many algorithms which practical applied for the data analyzation and prediction.

4 Agriculture data collection and prediction

The broad – scale crop yield is possible by using machine learning methods. Machine learning is sub - field of artificial intelligence. The broad scale adaptation can be applied in three groups field surveys, remote sensing (RS), crop modeling. Firstly survey based approach uses random sampling for prediction in most of the countries in the world. However, this method is time consuming, costly and having weak prediction accuracy. The survey field has also drawback that real data has not been used and devouring imperative impact on prediction accuracy. The second method of data collection is remote sensing which has been very imperative and popular since last few decade named remote sensing. Remote sensing provides the way to sense, store and forward accurate data related to different factors which impacts on agricultural crop yield. These factors are crucial during growth period of crop and monitoring plays critical role for identifying strengths and weakness of plant growth. The process base modeling and statistical modeling are two key approaches which are widely used for the climate variability. Predicting crop yield by applying process based modeling at the field of scale due to physiological process of crop growth. The statistical modeling approach is used to apply for learning from historical data and following the precision for better prediction.

5 Machine learning Applications in agriculture

Crop yield prediction is novel approach to improve crop production, reduce cost, efficiency to reduce environmental pollution, minimal resources consumption, less labor expenses, real time monitoring are key factor in precision agriculture (PA) (Goap et al., 2018). However potential growth of crop depends upon many crucial factors such as soil properties, weather conditions, irrigation system, topography, fertilizer management and crop seeds. Modern technology based on remote monitoring and sensing different crucial parameters to adopt rapid input. Remote sensing such as drone video, picture, satellite and air-born multispectral scanning enable efficient weed management (Khaki et al., 2020). A detailed diagram of agricultural machine learning presentation is depicted below:

6 Crop Yield prediction

It is easy to predict crop yield by crucial parameters including soil, water and air respectively (Khaki et al., 2020). Computational image processing and machine learning techniques imperative process and evaluate captured pictures by different techniques. Implementing automated cameras and drone technology can easily extract the features of plant leafs characteristics. Image data acquisition can easily detect and estimate different parameters and easily identify effects on crop yield. Machine learning important factors which are needed to be focus in agricultural machine learning has arisen many new challenges for the accurate crop monitoring, irrigation monitoring, predictive analysis, and diagnostics of the soil defects, weed detection, water treatment and right seed right area. The self-leaning methods from the previous data record and experiences. The human involvement is not considered for this automated learning which is actually base on computer based methods. Machine learning is emerging trend in computer research (Aaron E, 2018). Machine learning the field of computer science. However it comes in the category of artificial intelligence i.e. subfield of artificial intelligence. The expressive power, translucency, portability, algorithmic complexity are major properties of machine learning. Machine learning is widely used data analytics, predictive analysis, service personalization, sentiment analysis, computer vision and natural language processing.

7 Machine learning and Industry 4.0

The availability of resources anytime and anywhere change the way of the business and investment methods with integration of smart digital technology known as industry 4.0 (Aceto et al., 2020). IoT provides ease of monitor real time parameters for the further evaluation of the raw data by applying different machine learning algorithms. The industrial internet of things (IIoT), Cyber physical systems, smart manufacturing, and smart factories are trending applications of the industry 4.0 (Wan et al., 2016). Embedded devices enlarges the capacity and capability of the working industry for product manufacturing. This provides efficient communication mechanism based on controlled and distributed process of manufacturing (Trivelli et al., 2019). Image processing is computer based technique which is sub part of the machine learning. In computer science, Image processing is the study of digital image which investigate, modify, adjust the properties of image by applying computer based methods. Image processing in agriculture science has many new applications and challenges which are widely studied in world. Industry 4.0 and Agricultural 4.0 (A4.0) has greater global impact on yield production. The smart world with integration of IoT devices changed the way for agriculture industry to produce more product within small area (Sott et al., 2020). The concept of industry 4.0 has emerged with agriculture to produce new terms for the agricultural science such as agriculture 4.0 (A4.0), smart agriculture, smart forming and agro –food. The transformation from traditional methods to the smart digital industry brought automation, reliability, cost saving activities, time saving, and scalability and increases the quality product. The environmental effect can easily be identified by implementing smart IoT device and can entail the changes which can effect on plant.

8 IoT (Internet of Things)

IoT promotes global connectivity which provide ease of sense, share and communicate over worldwide. This important to know how this impacts on Pakistan. Pakistan underdeveloped country and having very dense areas where IoT cannot work more efficiently due to harsh and remote regions i-e Hilly, desert or mountainous regions where connectivity with internet is very difficult. However most of regions are very important to implement IoT enabling technologies. Most of fields of life are needed to implement IoT for good and efficient improvement in Social, economic status of daily life (Dortmund & Stolpe, n.d.). Pakistan is agriculture country IoT can implement for the improvement of agro-industry. IoT sensing devices can sense temperature, steam in mining area where most of the critical condition is faced on regular basis. Agriculture industry now have been smarter than ever before due to advance development of technology. This technology have greater impacts in crop production with several new tools and techniques. In agricultural technology many new advanced technology concept are introduced. The water control and saving water drip irrigation is introduced for irrigation management. Another concept of smart farming with several implementation of latest equipment in the region is also arise deep interest in agriculture industry.The major part of technology includes IoT enabling devise, WSN, RFID which brought advanced sensing devices for senses data even minor variations in respective applications. Sensing devices itself are just for sensing where further it needed to be process and analyses for experimentation. Crop management is broad area which is used to produce crop yield with effective monitoring. The cost of monitoring and reduction of operational costs can efficiently managed by IoT enabled devices. Precision agriculture depends on different factors such as soil properties, irrigation management, environmental changes and nitrogenous fertilizers management. Sensing technology gives effectively acquisition of spectral data can improve data accuracy (Patrício & Rieder, 2018). Remote sensing and spatial variations in water, soil and environmental condition can be improved via applying air born It is due to accurate and timely input data is needed to measure over remote regions from different regions of crop. Automation industry in agriculture is now dependent of IoT and its enabling technologies. Machine learning models applied for obtained sensory device agricultural data such as weather, soil data, irrigation data, livestock data and yield data (Espejo-Garcia et al., n.d.). These data groups has different nature for data analysis for which machine learning has different types of learning methods i-e supervised, un - supervised and reinforcement methods. These methods are used according to the nature of data i-e linear, non-linear and mixed type of data.

9 Summary of Related Work and Limitations

Bu, F., & Wang, X. (2019) The study suggest some advance technology which actually used to save water, time and resources. Artificial intelligence and cloud computing is used to implement in agriculture production. The objective was to measure, control and determine water requirements by applying artificial intelligence advanced model deep reinforcement learning. The limitation of this study is However study suggest more suitable intelligence of water management, but this study could process further like implementation of supervised machine learning models for further improvements of water requirements. Rehman, T. U.(2019) contributed The study is to review the statistical machine learning techniques including supervised and unsupervised learning for the agricultural environment. The study is to apply machine vision approach in agricultural data and suggest some future implementation of the machine vision approaches. The main objective of the study was Computer vision approach and Machine learning statistical techniques are reviewed. The limitation of their work is However this review focus primary level techniques. However, study can be extended by applying Big data and Data mining approaches which can improve effective review with several methods.Goldstein, A., Fink, L. (2018) focused on Crop yield prediction from the collected data form soil and environmental variables which applied on eight plots However machine learning algorithms applied different for the classification and regression of the efficient crop yield. The Objective of their study was to predict the crop yield from environmental data which recorded by applying sensors. The limitation of the study are Author's primary focus was on prediction of crop yield. However their study lacks irrigation management in crop filed which can be predicted by soil data. Vineela, M. T (2018)
Automated irrigation control with the same approach

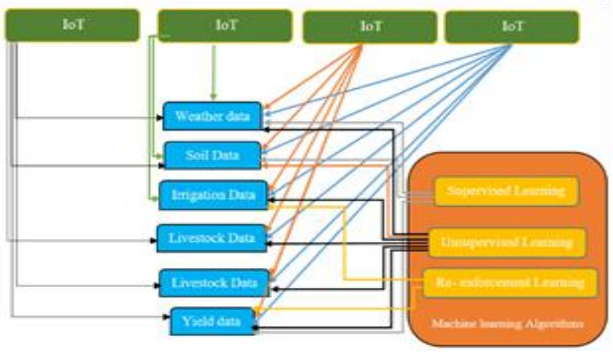

Figure 3 IoT in Agriculture

is also discussed in (Vineela et al., 2018). Focused on the implementation of the IoT and WSN technology for the monitoring of the water stress in the pipe, water need in the agricultural field with the water arrival of the each and every part of the crops.Water monitoring with effect of pipe stress and need of water in agriculture field. Automated irrigation control with implementation of IoT and WSN technology is applied. The addition of Machine learning and computer vision approaches can improve accurate analysis and prediction of water, soil and other agricultural parameters. This study lacks to implement Machine learning statistical models such supervised, unsupervised and semi-supervised models. Ana Laura Diedrichs (2018) Presented a model of machine learning algorithms which predicts the agricultural frost prediction system on the basis of different condition of the crop. Main objective was to predict the frost on the basis of different condition of cropMain focus was on the frost prediction whereas in agriculture snow and weather parameters are also important to focus which is not part of this study. Tato, J. H (2018) Good effective

contribution in field of solar energy forecasting for short period of time. Obtaining efficient results by applying machine learning approach.Kamilaris, A (2018) In agriculture the concept of Deep learning and its applications are focused in this study. To Specify agricultural problems in respective area of deep learning approach with other approaches. To employ, compare and seek opportunities in deep learning approach comparison for agriculture with other popular techniques on data samples. The effective approach for comparison of Deep learning is done but it lacks few latest trends of machine learning methods. However obtained data is also not real time measurement. Balducci, (2018) Controlling the activities of agriculture area where it
is good to cover these areas by applying various machine learning techniques on different data samples and suggests the models for best investment in agriculture.To compare different machine learning models for data construction, design and deployment of real practical task. Few limitations are identified in this work are lack of agricultural main areas such as soil level, environmental parameters and air pollution. Saha A.K (2018) This paper considers the drone technology with covered cameras, sensors and integrating module for improving agriculture vehicles activities in crops. To monitor agriculture area by the integration of drone and raspberry Pi modules. Machine learning and IoT concept and importance is highlighted. Limited area of study is considered however this work lack the some water, temperature and other important parameters for the agriculture crop. Somov, A (2018) Monitoring and controlling of tomato crop is used to focus in Machine learning and IoT. Their approach is used to vary for further crops also such as cotton wheat and sugar. Machine learning approach is also limited in this study which can be further analyze comparatively.Keith H. Coble (2018)An efficient analytical technique related to the agricultural and applied economics contribution. Big data concepts are discussed in detailed which is part of research and developmentof agricultural data analytics.Objective was to apply analytical techniques of applied economics with additional contribution of Big Data on agricultural data.Big Data concept is very attractive in agriculture where new techniques of big data such as comparative models can be implemented to measure data. Choudhary, (2018) The application of Nano – technology in agriculture are discussed in detail with several new trends and application of Nano-technology. Objective of study to measure environmental data by applying IoT with the implementation. This study lacks machine learning approaches which can improve prediction accuracy and estimation crop yield. Anat Goldstein1 , Lior Fink1, Amit Meitin1(2017)The study is about Predicting irrigation recommendationsDifferent regression and classification algorithms were applied on this dataset to develop models that were able to predict the weekly irrigation plan as recommended by the agronomist. The main objective of study was to predict irrigation control requirements in agriculture fields by applying classification and regression algorithms by predicting weekly irrigation plan.The study lacks few important parameters of waters which are not focused such as turbidity of water, water pollution, water evaporation rate which directly effects on irrigation control in agriculture field. Mirani, A. A (2017)Studied on challenges and opportunities in ubiquitous computingObjective is to highlight ubiquity in real life applications. Real time implementation is not focused. Sami Khanal et. al (2017)Thermal RS in agriculture discussed here which includes irrigation scheduling, drought monitoring, crop disease, detection, and mapping of soil properties, residues and tillage, field tiles, and crop maturity and yield.Author's main objective was to thermal remote sensing which were used to predict crop yield.Thermal remote sensing parameters are used in their study. Tiantian Yang et.al (2016)A robust reservoir outflow simulation model is presented, which incorporates one of the well-developed data-mining models (Classification and Regression Tree) to predict the complicated human-controlled reservoir outflows and extract the reservoir operation patterns.In their study author focused to develop a simulation model which can extracts the reservoir operations & human controlled outflows. Implemented classification & regression tree. The study is about Water reservoirs. Park, S (2016) Six drought factors were selected based on the relative importance by their category to develop drought indicators that represent meteorological and agricultural drought by using the relative importance as weights. Drought Monitor (USDM) maps, which showed a strong visual agreement. Agricultural drought conditions on region based approach. The focused region areas were arid and humid. Drought maps distribution were produced automatically. Lacks the other important agricultural parameters such as soil, wind and environmental factors.Grinblat, G. (2016) The main contribution of this research is to identify plant identification from leaf vein pattern. The objective of this study was to introduce the method of CNN in agriculture industry to identification of plant leaf. Plant diseases & plant identification are focused to study. Vázquez-Arellano, (2016) Main contribution of author's study is apply machine learning methods for the agriculture crop protection with agent detection methods. The objective of their work is to investigate and apply supervised and unsupervised machine learning methods in agriculture filed protection.Their work was interesting in terms of security and protection with object detection in agriculture field area.

CONCLUSION

This study presented to highlight machine learning applications and its important in agriculture crop yield prediction. Machine learning is one of dominant field in theses which are used for computational analysis of the obtained data. The historical data can be analyses and processed for future prediction. In agricultural science crop yield prediction is major area of study make aware from future repercussions relating to agricultural crop. This study highlights the Evaluation, applications and challenges of machine learning for crop yield prediction.

FUTURE RECOMMENDATION

This study lacks challenges which machine learning needed to be reviewed for future research.

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