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A Hybrid Approach for Prediction and Classification in Rice Plant Disease Using Machine Learning Algorithm

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Abstract— Agriculture has a crucial part in the entire life of a given economy and also provides employment opportunities in the world. In agriculture, Rice is a staple food for much more than half of the total population and one of the most significant food crops in the world. But the quality and quantity of rice cultivation decreases due to plant diseases. Organisms like bacteria, virus, and fungi are the major causes of plant diseases. Manually observing the field on daily basis is not likely at all the times by the farmers to protect them from infection as well as for proper irrigation. In order to decrease the damage to crops because of diseases and escalate productivity Machine Learning (ML) techniques have been industrialized, which automates the recognition of crop disease. The aim of this paper is to review various ML algorithms such as Decision Tree, KNN, Random forest, ANN, Support vector machine which focuses on the prediction of plant diseases, to maximize crop yield. After comparing various techniques it is proposed that the combination of Decision tree and Convolutional Neural Network (CNN) algorithm improves the accuracy and prediction of the disease at an early stage.

Keywords—Agriculture, Machine learning, Machine learning algorithms, Ensemble method, Decision tree, Convolutional Neural Network.

Introduction

India being one of the developing countries has good production in agriculture. Due to a drastic growth in population there is a need to focus on production of food crops such as rice, wheat, maize etc., and thus a high demand for the organic food [1]. Rice (Oryza Sativa) is the cereal or grain which is commonly taken by most of the world's population, primarily in Asia. The production of rice crops is becoming difficult task due to variety of diseases that affect these crops. Therefore prevention of disease while cultivating rice is essential to maximize the production and hence economic growth of a country [2]. For early detection of plant disease, observing the crops for diseases initiation and their frequency of occurrence are very essential. Fungi, bacteria, viruses are the disease causing agents in crops and the spread of these infections is caused by the agents like water, air, insects, soil and infected seeds [3]. The failure in prediction of bacteria or virus in plants will lead to maximum usage of fungicide or pesticide. Many researchers are making their efforts to obtain high yield without harming the environment. Therefore the use of latest and smart technology in prediction of plant disease can reduce these problems [4]. The farmers can detect these diseases instantly by adopting AI (Artificial Intelligence) technology. Machine learning (ML) is the subcategory of AI, which can predict plant diseases. Several ML algorithms are being developed to analyze the rice plant disease and these algorithms can be used for more spontaneous, fast, and accurate prediction of plant disease [5]. This paper provides comparison of various machine algorithms for detection of plant disease and proposes a suitable algorithm for using on large amount of real-time dataset for accurate prediction of plant disease. Thus, the farmers can comprehend the presence of disease and avoid the spreading of disease.

This paper is divided into 7 sections. The second section contains the literature review of various authors related to detection of plant disease and ML and the third section provides information on the factors causing the plant disease. The fourth section provides the detailed discussion of types of rice plant disease. The fifth section describes the various machine learning algorithms. The sixth section gives the comparison table and finally, the seventh section concludes the study.

literature survey

Shima Ramesh et al. [6], presented a model to predict plant disease using ML algorithm named Random Forest (RF). The model used Histogram of an Oriented Gradient (HOG) for extracting image features. The dataset contained a total of 160 images of papaya leaves. The proposed model used Random Forest algorithm and it is then compared with Logistic Regression (LR), SVM, KNN, CART and Naïve Bayes (NB). Finally the results concluded that the proposed model achieved highest accuracy of 70.14%, while LR, SVM, KNN, CART and NB achieved 65.33%, 40.33%, 66.76%, 64.66% and 57.61% accuracy respectively.

S.Ramesh et al. [7], presented an automated model to detect rice blast disease using Artificial Neural Network (ANN). The model used K means for the image segmentation. The dataset contained a total of 300 images which were taken using camera of Redmi Note 5 smartphone. The proposed model used a Neural Network based algorithm named ANN which acquired an accuracy of 99% during training phase and 90% during testing phase.

Md. Jahid Hasan et al. [8], presented a hybrid model for identification and classification of rice diseases using the combination of Support Vector Machine with Deep Convolutional Neural Network (DCNN). The dataset contained a total of 1080 images with nine rice diseases types. The proposed model is then compared with 4 dissimilar batch sizes and the results showed that the combination of SVM with DCNN performed best with an accuracy of 97.5% when the batch size is 30 and the epoch is 15.

Nilay Ganatra et al. [9], presented a model for identification of plant leaf disease using Random Forest algorithm. The model was developed using MATLAB. The dataset contained a total of 14,956 images which were acquired from kaggle website. The developed model is compared with ANN, SVM and KNN and the results revealed that the Random Forest algorithm executed better than other algorithms with an accuracy of 73.38% while SVM, ANN and KNN achieved 67.27%, 65.68% and 63.20% respectively.

Monalisa Saha et al. [10], presented a model for prediction of plant leaf diseases using SVM algorithm combined with Convolutional Neural Network (CNN). The experiment is done using python and Jupyter notebook. The dataset contained a total of 3500 images, mainly leaves of tomato. The developed model is compared with individual algorithms such as SVM and K means and the results concluded that the combination of CNN and SVM outperformed other algorithms with an accuracy of 99% while SVM and K means acquired accuracy of 91% and 88.6% respectively.

Chaturbhujj Bhatt et al. [11], presented a model for prediction of paddy productivity in Nepal using Decision Tree (DT). The model was developed using WEKA tool. The data was collected through surveys conducted by the author with 101 farmer in Nepal. The model proposed by the author used Decision Tree algorithm and it is then compared with SVM, Multi-layer perceptron neural network and Naïve Bayes (NB). The results concluded that the Decision Tree algorithm executed better than other algorithms with an accuracy of 80.19% while SVM, NB and multi-layer perceptron neural network got accuracy of 51.48%, 62.37% and 67.67% respectively.

SALA KRISHNA RAO et al. [12], presented an ailment detection system in paddy crop using Support Vector Machine (SVM). The model was developed using Raspberry Pi for collecting the data and used in android platform. The dataset contained a total of 120 images which were collected using Raspberry Pi microprocessor. The proposed model is then compared with KNN algorithm and the outcomes revealed that the SVM algorithm bested the KNN algorithm with an accuracy of 91.23% whereas KNN achieved 85.23% of accuracy.

Nilam Sachin Patil et al. [13], presented an automatic system for prediction of paddy leaf disease using Genetic Algorithm (GA). The model was developed using MATLAB and can be used in android, apple and windows

platforms. The dataset contained a total of 423 images. The developed algorithm is compared with AdaBoost algorithm and Bagging classifier and the results showed that the proposed algorithm performed well than other algorithms with an accuracy of 91%. Meanwhile, AdaBoost algorithm and bagging classifier achieved accuracy of 84% and 81% respectively.

Factors Causing Plant Disease

A small difference in temperature or soil properties can cause the growth of pathogens which affects the quality of grains. Pathogens are the organisms which cause the disease and the 'hosts' are the plants which are affected by these pathogens. Fungi, bacteria, and viruses are the responsible for several infectious diseases. Fungus damages the plant by killing their cells and the pathogens responsible for this fungal disease in plant are Ascomycetes and Basidiomycetes. Rust is one of the fungal diseases which occurs in the crops like wheat and rice and the symptom of this disease is premature shredding of leaves. Bacterial infection is caused by the microscopic living organism which infects the plant. Burkholderia and Proteobacteria are the pathogens responsible for bacterial disease and these bacteria affects the plant on the inside with no symptoms until a particular phase. The symptoms caused by the bacteria are cankers, leaf spots, scabs etc. Viral diseases are the most difficult ones to predict and these diseases are mostly hidden in nature. The Symptoms of this disease are yellow streaking, yellow spots and stunted growth and the prevention of this disease is to dispose the affected region [14, 15].

Types Of Rice Plant Disease

A. Bacterial Blight

Bacterial Blight is a bacterial disease caused by a microbe known as "*Xanthomonas Campestris pv. Malvacearum*". On juvenile lesions early in the morning, bacterial blight causes a dark green, water-soaked angular area with a wavy edge and the emergence of bacterial slime that appears like a creamy or opaque dewdrop. As the condition progresses, the lesions turn yellow to white. When the cut end of a leaf is maintained in water, the water turns muddy due to bacterial slime. [16].

B. Brown Spot

Brown spot is a fungal disease which is caused by fungal called *Cochliobolus miyabeanus Bipolaris oryzae*. Brown spot appears like black spots on the leaf of the rice plant. The leaves should be wet for more than 8 hours for emerging brown spot. The symptoms of this disease are death of sprouts, demise of huge portion of the leaf, black spots or brown spots. It mainly occurs in nursery as well as main field. Infection can also affect the panicle neck, resulting in a brown look and a 50% drop in yield in major cases. [17].

C. False smut

False smut is a fungal disease which is caused by fungal called *Ustilaginoidea virens*. False smut reduces the grain weight and germination of seeds. It is infected during the flowering stage. This disease occurs in region with high humidity and temperature of 25-35 degree. In most panicles, only a few grains are contaminated, while the others are healthy. Individual rice grains become a clump of golden fruiting bodies. [12].

D. Leaf blast

Leaf blast is a fungal disease which is caused by fungus called *Magnaporthe grisea*. Dark patch to oval spot with reddish-brown edges and white or grey in the middle are indications of leaf blast disease. Leaf spots are elliptical in shape, with gray-white centres and brown to reddish-brown edges. Leaf lesions are about 0.4 to 0.7 inch long and 0.1 to 0.2 inch diameter when fully formed. It can affect everything above ground level, including the leaf, collar, node, neck, panicle components, and sometimes the leaf sheath.

E. Leaf Smut

Leaf smut is caused by the fungus namely *Entyloma oryzae*, which is a fungal disease. Leaf smut is distinguished by the emergence of little black specks on the leaf. Black linear lesions on leaf blades, grey, dry leaf tips, and grain darkening are all indications of this disease. [18].

F. Rice blast disease

Rice blast disease, which is caused by *Magnaporthe Oryzae*, only needs a little hours to contaminate the rice. During the suitable conditions, the growth of the fungus rice blast disease spreads in large scale in only 2 or 3 days. The crops will be damaged and the area of photosynthesis will be reduced. The symptoms of Rice blast disease are diamond-shaped lesions on the leaves. The rice blast pathogen occurs in the necks, seeds, leaves, nodes collars and root during its growth period [19].

G. Rice tungro

Rice plants with rice tungro disease have stunted growth and limited tillering, and their leaves turn yellow or orange-yellow, with rust-colored patches. The discoloration starts at the leaf tip and progresses to the blade or lower leaf section. Delay in flowering causes panicles to be tiny and not fully exerted, and the panicles to become infertile or partially loaded grains.

H. Sheath Blight

The causing agent for sheath blight is *Rhizoctoniasolani*. The occurrence of this disease is extreme at ploughing stage which damages the above region of the rice plant. The main cause for the sheath blight is heavy usage of nitrogenous fertilizers.

I. Stem Rot

Stem rot is one of the fungal diseases which is caused by fungal called *Sclerotium oryzae*. The causing agent for stem rot is *Sclerotiumoryzae*. The symptoms for this disease are black angular lesions on the leaf sheath, mycelium inside the infected culms and black sclerotia and visible numerous tiny white. It occurs only at the rice stems [20].

Machine Learning

Machine Learning is a subdivision of Artificial Intelligence (AI) that can learn from past experiences without being explicitly programmed. Depending on the situation, machine learning can be applied in three different ways: a) Identification/Detection b) Classification c) Prediction. Machine Learning can be used in different fields like game playing, medical diagnosis, precision agriculture etc. Machine Learning is based on statistical approach and is classified into [21],

- Supervised Learning Method.
- Unsupervised Learning Method.
- Reinforcement Learning Method.

Supervised learning is a technique that teaches itself from the labeled training data which helps to predict the future events from the previous experience. Unsupervised learning is a method which learns from patterns through unlabeled training data set. Reinforcement learning is a method which learns through reward basis i.e. trial and error method.

Some of the supervised classification algorithms are: Support Vector Machine, Decision tree, Artificial Neutral Network, K-Nearest Neighbor, and Random Forest. Few of the unsupervised classification algorithms are: Principal Component Analysis, Fuzzy C-Means, Linear discriminant Analysis and K-Means Clustering.

Machine learning consists of five major phases namely [22],

1) Collection of data.

2) Storing of data.

3) Data pre-processing.

4) Training the model.

5) Performance metrics.

Several researchers are using various machine learning algorithms for predicting the rice plant disease. This paper presents various machine learning algorithms, for instance, KNN, RF, DT, SVM, and ANN. The employing of machine learning includes data collection, preparation of dataset, extraction, preprocessing, selection and applying machine learning algorithm and evaluation of the performance [21].

Machine Learning Algorithms

J. SUPPORT VECTOR MACHINE (SVM)

The Support Vector Machine (SVM) is one of the supervised learning techniques that is commonly used for classification. SVM is a binary classifier that classifies between two classes using a decision boundary (hyperplane). It uses various kernel functions like polynomial kernel or radial base function when the training dataset is minimum to classify accurately and hence this algorithm must have appropriate kernel function for correct evaluation of the hyperplanes and to reduce errors in classification. Support Vector Machine classification is done by creating a hyperplane which splits cases of diverse labels of class. Support Vectors are the training point which are near to the separating function. To find the Z axis to determine the best hyperplane in a 3-dimensional non-linear data, we use,

$$Z = x^2 + y^2 \qquad (1)$$

where x and y are other two axes. SVM can obtain the best classification results from limited amount of samples in the training set. Problems which requires a pattern recognition make use of SVM. Support Vector Machine maximizes the marginal distance between different classes to reduce errors like local minima, over fitting etc. Some of the examples of SVM are time series prediction, genes detection, font recognition, image recognition etc [23].

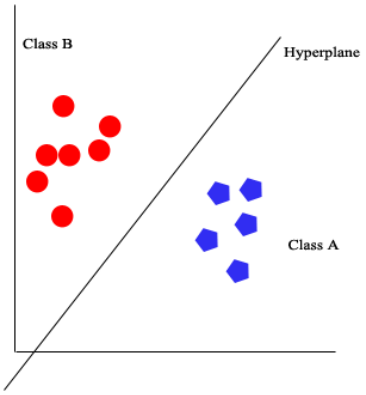

Fig 1. Support Vector machine

K. DECISION TREE ALGORITHM

The data is continuously segregated based on a parameter in a Decision Tree, which is one of the Supervised Learning techniques. The tree can be explained using two entities: decision nodes and leaves. The leaves reflect the decisions or ultimate results, and the data is split at the decision nodes. Decision Tree is a method of data mining to classify based on multiple covariates or to produce predictive algorithm for variability target. In this method the population is divided into branch like components which forms a modified tree with an internal nodes, root node and leaf nodes. To determine the appropriate root node and an approach called information gain is used. While calculating this information gain a property called 'entropy' is followed. Large and complex data basis can be handled without setting of a complex parametric structure. To find the entropy, E(S), of an attribute, we use,

$$E(S) = -p_{(+)}logp_{(+)} - p_{(-)}logp_{(-)}. \qquad (2)$$

Decision tree is similar to the structure of a tree with different nodes. This technique is used to classify a large amount of data and to identify the similar pattern in the dataset. Each node represents a decision which leads to our result. To determine the best attribute in splitting a portion of tree of the training data for this dividing criterion is used. The core of the algorithm for decision tree is iterative dichotomiser 3 (ID3), in which greedy approach is

used. Pruning a tree might help it to function even better. It requires removing branches that make use of insignificant features. We lower the tree's complexity in this way, boosting its predictive effectiveness by reducing overfitting. Pruning can be done from the base or from the leaves. CART, C4.5 and ID3 are commonly used Decision Tree in machine learning [3].

L. RANDOM FOREST ALGORITHM

Random Forest is a popular supervised learning machine learning technique. Both classification and regression problems can be solved with machine learning. Random Forest is an ensemble learning method and is more suitable for classification of huge amount of dataset as it contains a group of restructure classifiers. The term "Random Forest" refers to a collection of decision trees where each tree is on the basis of sampled random vector values individually with equal sharing of all the trees in the forest. The usual mistake of a tree divider is based on the strength of each tree in the forest and the intercommunication between them.

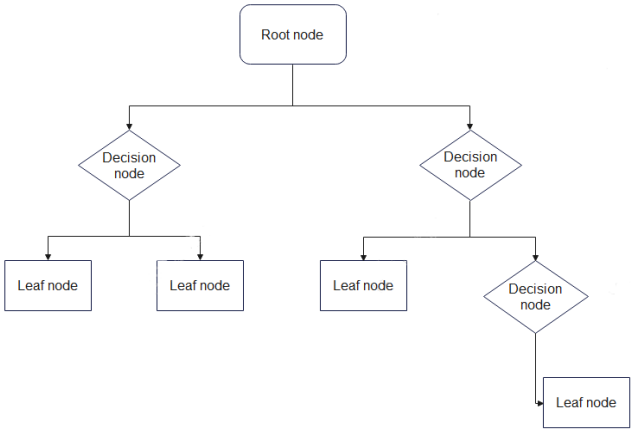

Fig 3. Decision Tree

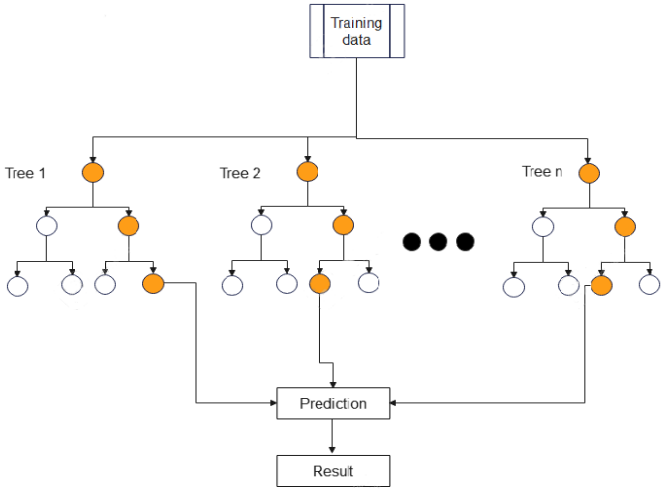

Fig 4. Random Forest

In Random Forest method, the training data set is sub divided to form different decision tree and the combination of these decision trees forms the Random forest. The Random Forest method uses various dataset for constructing a tree by a method called bootstrap aggregating. This Bootstrap aggregating is used to reduce overfitting to a certain limit but overfitting issues will not be eliminated completely. The splitting of trees (nodes) in Random Forest is based on two methods, a) Gini index b) Entropy in which Gini index is a measure of purity of the node whereas entropy is the measure of impurity of the node. Some of the examples of Random Forest are prediction of objects, recognition of images etc [24].

M. K- NEAREST NEIGHBOR(KNN) ALGORITHM

One of the most elementary Machine Learning algorithms is the K-Nearest Neighbour method, which is based on the Supervised Learning technique. Although the K-NN method can be used for both regression and classification, it is more typically employed for classification. The K-NN approach saves all available data and identifies new data points based on how similar they are to previous data. This means that as new data comes, it may be quickly sorted into a suitable category using the K-NN method. The KNN method merely saves the information during the training phase, and when fresh data is received, it classifies it into a class that is very near to actual data. KNN classifier classifies unknown occurrences by relating unknown variables to the known variables by using similarity function. Its slow learning denotes that this classifier both test and preparation is done at the same time. It is a very simple algorithm as it is based on majority vote and its k-neighbour. In KNN algorithm category each question is given a category which represents the label of its closest neighbours. To find the distance between two neighbors, we use

$$D = \sqrt{(x^1 - y^1)^2 + (x^2 - y^2)^2} \qquad (3)$$

Where D is the distance between two neighbors and x and y represent the two points. In KNN, the distance of the specified points from the each classes is calculated and knn's are determined by calculating the k minimum distances. KNN algorithm uses the Euclidean distance between the samples. The simpler way for KNN is neighborhood neighborhood (NN) rule in which k=1. KNN algorithm classifies the training data by using labels to find k nearest matches for prediction. The three important features of KNN classifiers are easy understanding of results, shorter computational time and high prediction rate [25].

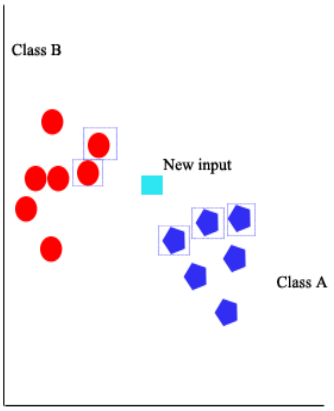

Fig 5. K Nearest Neighbor

N. ANN ALGORITHM

Artificial Neural Network (ANN), which is one of the supervised learning algorithms, is a structural and functional based biological neural network. ANN is the combination of 3 layers, 1) Input layer, 2) Hidden layer and 3) Output layer. It requires a huge amount of processors which are operated in parallel with being arranged in tiers. ANN's are adaptive in nature i.e. they are capable of modifying themselves from the training stage to the subsequent uses. In ANN, the decision of each node uses various principles like fuzzy logic, Bayesian methods etc. Some of the examples for ANN are stock market prediction, drug development, Natural Language Processing etc [7].

II. COMPARISON OF RICE PLANT DISEASE USING MACHINE LEARNING ALGORITHM

Table I. Comparison of Algorithms

S. NO	REF NO	NAME OF THE CLASSIFIER	DISEASE	ACCURACY	RESULT	LIMITATIONS

1	[9]	Random Forest	Rice plant disease	73.38%	Classified the plant disease using random forest method.	Was demonstrated on small dataset and only features from Histogram of an Oriented Gradient (HOG) was used.
2	[26]	KNN	Blast and brown spot	76.59%	Classified the plant disease using KNN classifier.	Classified only fungal diseases.
3	[18]	Decision tree	Bacterial blight, Brown spot, leaf smut.	87.50%	Detected the plant disease using Decision Tree algorithm.	The collected data is not a real-time data.
4	[7]	ANN	Blast disease	90%	Detected the infected leaf in a early stage using ANN.	The dataset images have been captured manually.
5	[12]	SVM	Bacterial Blight, Rice blast	91.23%	Classified the plant disease and result is sent through the mobile application	Considered only shape and color features.
6	[27]	SVM	Bacterial blight, Rice blast, sheath blight.	94.65%	Classified the plant disease using color features.	Less number of images have been taken.
7	[8]	SVM with CNN	Rice blast, Bacterial blight, false smut,	97.5%	Classified the plant disease using the combination of	Collected dataset from the Kaggle website.

			Brown spot, leaf smut, sheath blight, tungro, leaf scald, red stripe.		SVM and CNN.	
8	[3]	Decision Tree	Leaf smut, brown spot, bacterial blight.	97.9%	Classified the plant disease using the Decision Tree.	Not considered any ensemble methods.

From the Table I we can infer that Nilay Ganatra et al classified the rice plant disease using RF algorithm and achieved an accuracy 73.38% but when a large dataset was used the performance of the algorithm was reduced and Suresha et al classified the blast and brown spot disease with a large dataset using KNN algorithm and achieved an accuracy of 76.59% which classified only the fungal diseases. Jyoti Mahajan et al classified the Bacterial blight, leaf smut and brown spot using decision tree algorithm and attained an accuracy of 87.50% but the collected data was taken from an online website. S.Ramesh et al classified the blast disease with the real time dataset using Artificial neural network and achieved an accuracy of 90% but the dataset was collected manually. SALA KRISHNA RAO et al classified the Bacterial blight and rice blast disease with the real time data using Support vector machine and achieved an accuracy 91.23% but they considered only the shape and color features. Vimal K. Shrivastava et al classified the bacterial blight, rice blast and sheath blight with texture, shape and color features using Support vector machine with an accuracy of 94.65% but the dataset contained a smaller number of images. Md. Jahid Hasan et al classified the Bacterial blight, brown spot, rice blast, leaf smut, false smut, sheath blight, tungro, leaf scald, red stripe using the combination of Support vector machine and CNN with a large dataset containing images of nine diseases with an accuracy of 97.5% but the dataset was collected from the Kaggle website. Finally, Kawcher Ahmed et al classified the Bacterial blight, brown spot, leaf smut diseases using decision tree with real-time dataset and achieved an accuracy of 97.9%.

Most of the researches have used the dataset from the Kaggle website and the real-time dataset which accounts to only a small amount of data. In addition to that, when large dataset was given to train the algorithm the overall performance of the model was reduced.

The study found that the performance of a model can be increased when a large amount of dataset is collected from the real-time agriculture field with an ensemble method of the combination of decision tree and CNN which gives higher accuracy and predict the occurrence of disease in an early stage. Thus, the farmers can comprehend the presence of disease and avoid the spreading of disease.

Conclusion

Machine Learning plays a major role in the area of agriculture. Machine Learning based agriculture is very important to solve the main problems of farmers like crop management, crop yield management, crop disease, climate and weather monitoring etc. The use of Machine Learning techniques can automize the processes and reduce human intervention in agricultural field. This paper provides detail information about various types of diseases which affect the rice plants and the factors that cause these diseases. This paper also provides a detailed survey on various ML Algorithms which can be utilized to solve and predict the disease occurrences along with the comparison of performance of the ML algorithms. From the above table it is proposed that using the real time data of rice Plant Diseases and the combination of decision tree and Convolutional neural network algorithm may

provide a better solution to predict the disease occurrences that helps in improvising the quantity and quality of the rice plant. Also for further improvement, the model can be automated by integrating the algorithm with IoT devices to avoid human intervention and the diseases can be classified using Image Processing techniques.

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