Techniques for Rice Leaf Disease Detection using Machine LearningAlgorithms

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***Abstract*— Rice (Oryza Sativa) is a kind of cereal grain that is consumed as staple food by almost half of the world's population, more specifically in Africa and Asia. The Crops of Oryza Sativa are exposed to both abiotic stresses such as cold, drought, salinity, etc., and biotic stresses such as insects, pests, bacterial, viral and fungal diseases. Furthermore it has become most challenging task for the farmer to identify the kind of disease the crop has affected with and which in fact affects the yield of the crop if not timely detected. This paper provides the possible solutions using various machine learning techniques and the comparative analysis of algorithms diagnosing the type of disease which has affected the crop based on the crops image data and more over it presents recently presented techniques with their performance measure.**

Keywords—Rice; Leaf disease detection; Machine Learning; Deep Learning; Artificial Intelligence

I. INTRODUCTION

Today across the world and specifically in India Rice is considered as best source of food. During the cultivation process the Paddy crop, usually it passes through various diseases in different stages of cultivation. Through early detection of such diseases and remedial steps taken timely can avoid huge loss and can yield good crop that is high in quantity and best in quality. The best expert guidance in agriculture is not accessible in remote areas as time is not sufficient to reach such remote locations.

The aim of research in agriculture is to improve the productivity and quality of the crop yielded with less expenditure and good yield. The crop can be managed effectively with the timely diagnosis of the disease and implementation of the possible solution within the best possible time for effective control over the factors effecting the productivity and quality of the crop. Diagnosing manually is a hectic task as it involves various parameters. Hence the implementation of Automated Systems is a mandate requirement to reach the farmers to help them in early detection of the diseases with improved accuracy. During this process the advanced techniques of machine learning play a key role in the disease classification process [1], [2].

II. RICE LEAF DISEASE TYPES

Oryza leaves affected with a disease can cause damage to plant to a great extent which can lessen the yield. These diseases are mainly caused because of bacteria, fungi and viruses with their infection spread rapidly once affected which in fact affects the entire crop if not timely diagnosed. The various diseases which affect rice crop are numerous. Some of the significant diseases affecting the O. Sativa crop are detailed as follows:

A. Brown Spot(BS)

A fungal disease which infects the entire crop that can be easily identified in the early stages as it appears on the initial seedling leaves like brown oval or circular spots. The reason behind this is Bipolaris Oryzae a type of fungi, which not only drops yield but also affects grain quality which is shown in Fig1. It spreads across the field from plant to another plant through air [3], [4].

Fig. 1: Brown Spot(BS) Disease

B. Leaf Blast(LB)

It is due to Magnaporthe oryzae, which affects the crop by forming lesions on the plant leaves and also on other areas of the plant like stems, roots, seeds, etc., [5], [6].

Unlike the brown spot, the patches found on the leaves in this case are boat shaped, with centre in grey along with a thick outline of brown as shown in Fig. 2.

Fig. 2: Rice Leaf Blast Disease

C. Sheath Blight(SB)

Symptoms noticed in initial stage of sheath blight can be seen near water level on sheaths of leaf. Greenish grey spots on the sheath of leaf either in oval or elliptical are formed irregularly (Fig. 3). The enlarged spots become grey combined with white with an outline border in purple brown or blackish brown can be seen. The infection on the plants upper portion spread rapidly from waterline which reaches the flag end of the leaf. Similarly the infection penetrates into the inner sheath which leads to the death of the plant.

Majorly the said sheath blight can be suspected more in older plants and sheaths aged five to six weeks, this affects the crop at large where the grain is produced with weak formation. The major reason behind the above problem is due to excess consumption of fertilizers containing nitrogen [3].

Fig. 3: Sheath Blight Disease

D. Bacterial Leaf Blight(BLB)

The bacterial leaf blight is bacterium which penetrates through hyadathodes cutting wounds in the tip of leaf leading to the death of seedling (Fig. 4). The wounds enlarge with margin in wave shape which turns the straw into yellow within few days. The lesions turn the entire leaf into white or straw coloured upon the progress of the disease. The wounds may be seen on sheath of leaves, the dew drops with bacterial masses can be seen on fresh lesions early in the morning[1],[6].

Fig. 4: Bacterial Leaf Blight Disease

E. Sheath Rot(SR)

The formation of small seized black lesions found on the sheath of outer leaf close to water line[3], which spread to the sheath of inner leaf resulting in rotting of tissues. It is shown in the below Fig. 5.

When the crop is infected by SR we can observe several spots on the leaf. Spots overtime enlarge, merge or grow along with the crop covering almost entire leaf sheath. Panicles may partly come out or retain inside the sheath. Leaflets that are affected may contain a good amount of white powdery fungal development called mycelium, appearing on the external surface[6].

Fig. 5: Sheath Rot Disease

F. Leaf Smut(LS)

Leaf smut, it can be identified by the vertical scratches found on leaf blades in slight black colour, because of LS even the leaf tips may change to grey and become dry[7][8].

In fact it is not a considerable major disease but it can create a scope for other diseases by its nature of creating an environment that can promote and encourage the growth of fungi. The wounds of LS on the leaves may be in oval in shape or circular in shape or irregular shape with a kind of rough surface as depicted in below Fig. 6[9].

Fig. 6: Leaf Smut Disease

III. RELATED WORK

Plant Diseases are recognized efficiently with the help of automated systems. The techniques used for processing ranges from application of various Image Processing, Computer Vision, Fuzzy Logic, Soft Computing, ML, DL and many more.

Method presented by authors in [6] is used to diagnose and correctly classify given leaf samples into LB, BS, BLB and SR diseases. Significant features are extracted by processing the images and which are then used for classification with the help of MDC and k-NN resulting with accuracy of 0.89 and 0.87 respectively.

Authors of [10] provided with comparative analysis of various techniques such as segmentation, clustering and classifiers based on ANNs, Naives Bayes, Fuzzy Logic, PSO, Membership Function, Combined classifiers, OPDPA, Evaluation Theory on the basis of Minimum Path, Fractal Dimensions, SVM, Discriminant Analysis, AdaBoost Algorithm and Rule Set Theory for finding diseases of different plants with accuracy ranging from 0.70 to 1.0.

Solution given by [11], applies image processing and ANN mechanisms to detect diseases in various commonly grown plants resulting with an accuracy of 0.89. Technique of [12], detects diseases of Beans and Tea plants applying image processing followed by back propagation NN.

Proposed technique of [13] has two phases. Phase-I deals with model training which includes leaf images gathering, preprocessing, feature extraction followed by ANN. Phase-II is testing phase which includes preprocessing steps followed by K-Means for segmentation process followed by classification with ANN. At last grading of disease is performed based on the amount of defected portion with the help of Fuzzy Logic.

Paper presented in [14], provides a comparative study of various image processing along with soft computing techniques for disease recognition and classification into following four categories, Fungal, General, Bacterial, and Deficiency classes where accuracy ranges from 0.90 to 1.0.

Different ML/ DL techniques were presented to detect diseases especially in rice plants by the papers [15] to [24], [25], [26], and [27] for which accuracy spans from 0.73 to 1.0.

IV. MACHINE LEARNING ALGORITHMS FOR DISEASE IDENTIFICATION

Application of advanced Machine Learning methods has simplified the process of disease type recognition at the early stage accurately. In this section the most recent proposed solutions that are outperforming for types of disease identification of O. Sativa crops are presented along with their performance measure (Table I).

TABLE I: Comparative Analysis of most outstanding ML/ DL Algorithms for leaf disease identification of O. Sativa

	Diseases Identified	***ML/DL Technique***	***Performance Measure and score***	***Referred Paper***
1.	BLB, LB, BS, and Tungro	Deep feature based SVM	Accuracy: 0.97 F1 score: 0.98	Prabira Kumar Sethy et al(2020) [15]
2.	LB, False smut, BS, Bakanae disease, SB, SR, BLB, Bacterial sheath rot,Seeding blight and Bacterial wilt	Deep CNN	Accuracy: 0.95	Yang et al(2017) [16]
3.	LB	SVM-SFFS	Mean Accuracy: 0.98	Long Tian et al(2021) [17]
4.	BLB, LB, and SB	CNN model with high level fusion	Accuracy: 1.0	Lei Feng et al(2020) [18]
5.	LB, Red blight, Stripe blight, and SB	CNN with SVM	Accuracy: 0.96	F. Jiang et al(2020) [19]
6.	a)LS, BLB and BS	Extreme gradient boosting(XGBoost)	Accuracy: 0.86 F1 score: 0.87	Muhammad Anwarul Azim et al(2020) [9]
7.	LB	Probabilistic Neural Network(PNN)	Accuracy: 0.91 F1 score: 0.92	Li-Wei Liu et al(2021)[20]
8.	BS, BLB and LS	AlexNet neural network	Accuracy: 0.99	Md. Mafiul Hasan Matin et al(2020)[7]
9.	LS, BLB and BS	Decision Tree(j48)	Accuracy: 0.97 F Score: 0.97	Kawcher Ahmed et al(2019) [8]
10.	Stackburn, bacterial leaf streak, False smut, LS, Leaf scald, White tip, LB, Stem rot, Sheath spot, SR, Grain spotting and peck, Kernel smut, and SB	Deep_Transfer Learning	Accuracy: 0.98	Junde Chen et al(2020)[21]
11.	LB, BLB and BS	CNN_Transfer Learning	Accuracy: 0.92	Shreya Ghosal et al(2020)[1]
12.	LS and BS	ANN	Accuracy: 0.79	P A Gunawan et al (2021)[22]
13.	LB, BS and Hispa	Faster_RCNN	Mean Accuracy: 0.987	Bari et al(2021)[23]
14.	SB, LB,False Smut, BS, and Stem Rot.	Minimum Distance Classifier(MDC)	Accuracy: 0.81	Vikas Sharma et al(2020)[3]
15.	BLB, LB, BS and SR	Deep Neural Network_ Jaya Optimization Algorithm(DNN_JOA)	Mean Accuracy: 0.95	Ramesh et al(2019)[24]

It is observed that Deep Learning method CNN with its variations such as deep_CNN, CNN_SVM, CNN_High level Fusion, CNN_Transfer Learning, Faster_RCNN are performing better in terms of testing accuracy. Further it is noticed that the basic ML technique, the Decision Tree is outperforming with an accuracy of 0.97 detecting LS, BLB and BS diseases. The AlexNet_Neural Network has shown significant improvement in testing accuracy for diseases LS, BLB and BS.

Techniques of [2] and [10] are covering wide span of diseases while providing promising accuracy of 0.95 and 0.98 respectively. Fig. 7 shows F1-score along with Accuracy of the solutions presented in [1], [6], [7] and [9]. It is perceived that solution of [1] is expressing better F1-score than all other solutions and at same time maintaining the accuracy that of solution [9] which is the maximum observed accuracy among others.

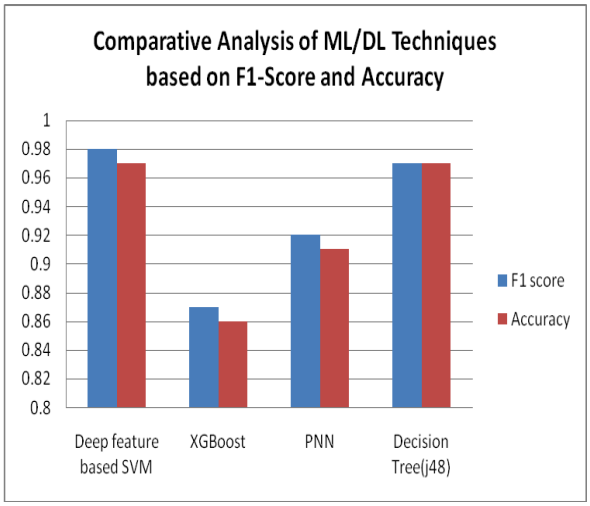

Fig. 7: Comparative Analysis of ML/DL Techniques based on F1-Score and Accuracy

CONCLUSION

Rice crop suffers from various types of diseases and their detection at early stage can be automated with a better accuracy using application of recent proposed Machine Learning and Deep Learning techniques. This paper presents more recent and outperforming solutions. It is observed that CNN model with high level fusion technique is the best solution with test accuracy exhibiting 1.0 for the three common diseases of rice plant i.e., LS, BLB and BS. The solution AlexNet_Neural Network resulting with 0.99 accuracy standing as second best technique over other contemporary outperforming solutions. It is also observed that, Deep feature based SVM method is exhibiting better F1-score along with Accuracy among other methods.

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