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Identification And Classification of Rice Leaf Disease Using Hybrid Deep Learning

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ABSTRACT

Agriculture is the primary source of income and livelihood in India as well as in many countries. Rice crop is considered one of the most cultivated grain crops in India. Rice crop is most essential crop for human consumption. Around half of the global population relies on cereal as a primary food source. Now a days this crop is susceptible to various types of illnesses at different stages of production, this can be effect yield and quality of rice crops. As a result, automation of identification and early diagnosis of rice leaf disease is widely needed in the agriculture field. Using CNN-VGG algorithm the suggested system has been used to identify disease in rice crop. In this study we focus on three well know rice leaf disease such as brown spot, leaf blast and leaf blight, the total dataset of 1800 images of 4 classes are taken. When compared to existing model our experimental result analysis of CNN with Transfer learning has a higher accuracy of 95.60%, and the same data set is also applied to CNN without transfer learning has achieved an 85.62%. The proposed model attained a higher accuracy.

Keywords: Rice leaf, deep learning, CNN Algorithm, VGG 16

I. INTRODUCTION

Rice is a crucial staple food for over half of the global population, playing a vital role in food security and economic stability in many countries. However, rice plants are susceptible to a wide range of diseases caused by fungi, bacteria, viruses, and environmental factors. These diseases can significantly reduce yield and affect the quality of the crop, posing a substantial threat to food production. Traditional methods of disease identification, which rely on visual inspection by experts, are often time-consuming, labor-intensive, and subject to human error. With the growing demand for sustainable agriculture and the need for efficient disease management practices, there is an urgent need for accurate, automated, and scalable solutions.

Rice farming is vital to India's economy, with rice being a staple food. However, diseases like Rice Leaf Blast, Brown Spot, Sheath Blight, Rice Neck Blast, Tungro, and Bacterial Leaf Blight significantly affect crop growth and quality. Among these, Rice Blast is particularly severe, causing substantial losses—up to 37% of the rice crop annually. Farmers struggle to detect these diseases early due to limited knowledge, impacting their harvest and economic returns [1].An Extensive amount of equipment is required to identify disease in paddy crops. The Proposed System uses high resolution photos captured by drones, camera or cell phones, along with cutting-edge technology like machine Learning and computer vision, to look for any indications of crop illness. Additionally, these photos are then analyzed using cutting-edge algorithms designed to increase the detection accuracy rates by offering a thorough examination of any potential inconsistencies within each image taken under various environmental conditions. Important features are recovered from images at the feature extraction stage using advanced methods like Convolutional Neural Networks (CNNs) and other machine learning algorithms [2]. Rice leaf disease detection and classification is extremely hard because of the vast amount of land under the control of farmers, the vast collection of diseases, and the detection of many diseases in the same plant. Expert knowledge regarding agriculture is very difficult to find in remote places and it is a time-consuming operation. As a result, Automated Systems are necessary. To help farmers in their distress and increase the plan disease recognition accuracy, different ML approaches have been proposed, such as (SVM) Support Vector Machine [1-3] and ANN [4] are used in this research. The (CNN) convolutional neural networks-based studies have made significant advances in image identification by minimizing the requirement for image preprocessing and enabling intrinsic feature selection [3].

The rice leaf disease detection, using machine learning gives the accuracy of such systems is highly dependent on feature selection techniques. Recent research on convolutional neural networks has provided great breakthrough in image-based recognition by eliminating the need for image preprocessing as well as providing inbuilt feature selection. Another challenge is that it is very difficult to obtain large sized dataset for such problems. For cases where size of the dataset is relatively small, it is preferable to use a model which is pretrained on a large dataset. This is called Transfer Learning [4]. Farmers in India value agricultural land and water to produce high-quality and quantity food. Climate change, water constraints, and leaf diseases have all had an impact on rice output. As a result of various sources, the rice plant leaf became infected with a range of diseases. Rice plant leaf diseases have an impact on total rice crop productivity. The impact of rice plant leaf diseases affects overall rice crop production. As a result, Artificial Intelligence is a powerful technology that can be used by a variety of farmers to discover concerns, diagnose diseases, and reduce the spread of diseases caused by various leaf diseases at an early stage; in Machine Learning is a subset of AI technology. There are about 14 different forms of machine learning, which are divided into four categories: learning problems, hybrid learning problems, and machine learning problems [5].

1.1 PROBLEM STATEMENT

A larges hare of the population relies on rice as a main source of nutrition. of the global population, making it essential for food security. However, rice crops are vulnerable to various diseases caused by fungi, bacteria, viruses, and environmental factors, which can drastically reduce yield and quality. Traditional methods of disease identification, relying on manual inspection by experts, are time-consuming, labour-intensive, and prone to human error, leading to delays in detection and intervention. Existing models may also struggle to generalize across diverse agricultural environments, limiting their practical use.

This Model proposes using hybrid transfer learning to address these challenges. By leveraging pre-trained (CNNs) and fine-tuning them with rice-specific data, we aim to develop a robust and efficient model for accurately detecting and classifying rice plant diseases. The objective is near provide a reliable tool for timely and precise disease management, protecting rice crops and ensuring optimal yields.

II. LITERATURE REVIEW

Rukhsar and Upadhyay [1] proposed a method for rice leaf disease detection and classification using transfer learning techniques. Their approach utilized pre-trained models and achieved improved accuracy in identifying various diseases affecting rice leaves, demonstrating the effectiveness of transfer learning in agricultural disease classification.

Kavin Kumar et al. [2] explored disease classification in paddy crop leaves using deep learning. The study employed Convolutional Neural Networks (CNNs) to classify different leaf diseases, achieving significant accuracy improvements over traditional methods.

Hanif Tunio et al. [3] presented a hybrid transfer learning approach for identifying and classifying rice plant diseases. Their model combined multiple transfer learning techniques to enhance classification performance and provide robust disease identification.

Ghosal and Sarakar [4] utilized CNN with transfer learning for rice leaf disease classification. The study demonstrated that leveraging pre-trained CNN models can significantly improve classification accuracy for various rice leaf diseases.

Rukhsar and Upadhyay [5] developed a deep transfer learning-based model using InceptionV3 for rice leaf disease diagnosis and classification. Their model achieved high performance by fine-tuning the InceptionV3 architecture to the specific task of rice disease detection.

Hussain and Balaji Srikanth [6] introduced VGG19-enhanced convolutional neural networks for paddy leaf disease detection. Their approach showed that VGG19, a well-known CNN architecture, could be effectively adapted for accurate disease classification.

Gautam Rana et al. [7] conducted a comprehensive study on paddy leaf disease detection using CNN and Random Forest. Their combined approach utilized CNN for feature extraction and Random Forest for classification, resulting in a robust detection system.

Aggarwal et al. [8] explored the classification of rice leaf diseases using both machine learning and deep learning techniques. The study compared various algorithms and highlighted the advantages of deep learning in achieving higher accuracy for disease classification.

Pothen and Pai [9] focused on rice leaf disease detection using image processing techniques. Their research highlighted the role of advanced image processing methods in enhancing the detection capabilities for different leaf diseases.

Rawat et al. [10] applied deep learning techniques for rice leaf disease classification. Their study demonstrated the potential of deep learning models in improving classification accuracy and efficiency.

SyedMusthafa et al. [11] proposed a transfer learning approach for detecting Oryza Sativa leaf diseases. Their model utilized transfer learning to improve disease detection accuracy, showing promising results in agricultural applications.

Andrianto et al. [12] developed a smartphone application for deep learning-based rice plant disease detection. The application integrated deep learning models to provide on-the-go disease identification, enhancing accessibility and usability for farmers.

Pal [13] explored the identification of paddy leaf diseases using supervised neural networks. The study demonstrated that supervised learning techniques can effectively classify various leaf diseases with high accuracy.

Win Lwin and Htwe [14] utilized the AlexNet model for rice leaf disease image classification. Their research highlighted the effectiveness of AlexNet in handling complex disease classification tasks.

Banerjee and Sadhukhan [15] used CNN and transfer learning models for identifying rice leaf diseases. Their study showcased the benefits of combining CNN with transfer learning to achieve accurate disease classification.

Shanuja et al. [16] predicted rice leaf diseases using KSC techniques. Their approach highlighted the application of KSC methods in disease prediction and classification, contributing to improved disease management.

Kumar et al. [17] developed a model for rice leaf disease detection using MobileNet and Inception V3. Their study demonstrated that combining MobileNet with Inception V3 could enhance disease detection capabilities on mobile platforms.

Barakala et al. [18] applied deep residual learning for rice plant leaf disease classification. Their research showed that deep residual networks could provide superior performance in classifying rice leaf diseases.

Bhaskar et al. [19] proposed a hybrid deep learning approach for automated leaf disease identification in paddy crops. Their model integrated various deep learning techniques to enhance the accuracy of disease identification.

Kaur et al. [20] utilized the InceptionV3 transfer learning model for rice leaf disease detection. Their study demonstrated that InceptionV3, when combined with transfer learning, could effectively improve disease detection accuracy.

III. METHODOLOGY

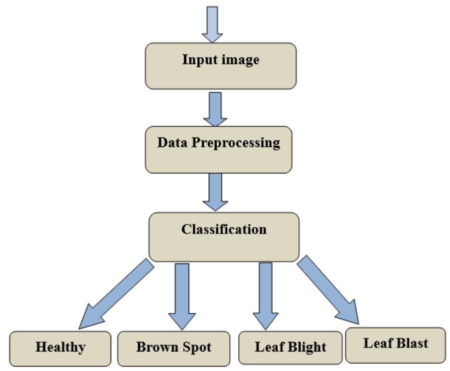

Fig-1 Procedure of rice plant disease prediction

The above methodology for rice plant disease predication consists of four main stages. Fiest, input images are collected and preprocessed to enhance quality, then passed to a classification model. The model analyzes the images and categorizes them into one of four classes as Healthy, Brown Spot, Leaf Blight or Leaf Blast.

1. Data Collection and Preprocessing

Data Collection:

Gather a large and diverse dataset of rice plant images from various sources such as agricultural databases, field surveys and from Kaggle. Ensure the dataset includes images of healthy rice plants as well as plants affected by a wide range of diseases (e.g., fungal, bacterial, viral) and at various stages of infection. The augmented dataset contains 4 types of leaf disease. Such as Brown Spot, Leaf Blast, Leaf Blight and Healthy.

Data Preprocessing:

Standardize the image dimensions and resolutions to ensure consistency across the dataset. Enhance image quality using techniques such as noise reduction, contrast adjustment, and normalization. Label the images with appropriate disease categories to facilitate supervised learning.

2. Model Development

Selection of Pre-trained Models:

Choose suitable pre-trained convolutional neural networks (CNNs) such as ResNet, VGG-16, or Inception, known for their strong feature extraction capabilities.

Hybrid Deep Learning:

Apply Hybrid learning techniques by freezing the initial layers of the pre-trained models to retain the general feature extraction abilities. Fine-tune the later layers of the models using the rice-specific disease dataset to adapt the models to the specific task of rice plant disease classification.

03. Training and Validation

Dataset Splitting:

Split the dataset into training, validation, and test sets, ensuring a balanced representation of all disease categories in each subset.

Model Training:

Train the hybrid deep learning models on the training set, employing techniques such as data augmentation (e.g., rotation, flipping, scaling) to increase the diversity of training samples and prevent overfitting. Use appropriate loss functions and optimization algorithms to guide the training process.

4. Convolutional Neural Networking (CNN):

Convolutional neural networking is also called Covent it was first developed by Yaan le-can. Convolutional Neural Network (CNN) is a class deep learning algorithm which is mainly used for understanding visual data like images.

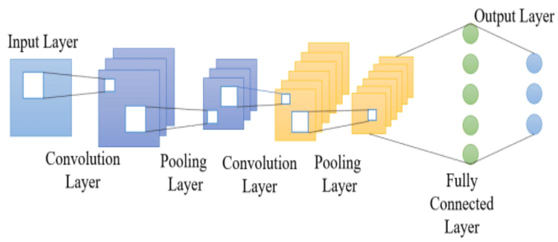

Fig 2: CNN Architecture

The CNN is made up of different layers, each with its own job:

1. Input Layer: This is where the network first sees the raw data, like a pixelated image.
2. Convolutional Layer: Here, the network breaks down the image into smaller parts and analyses each part for specific features, like edges or textures.
3. Pooling Layer: This layer simplifies the information from the convolutional layer, keeping the important details while reducing complexity.
4. Dense (Fully Connected) Layer: This layer helps in making sense of all the features extracted by the previous layers and connects them to the final output.
5. Output Layer: Finally, this layer gives the prediction or classification based on the processed information from the previous layers.
6. Dense layer: this is also called fully connected layers it is used to connect all the previous neuron with current neurons. The output layer contains some hidden layers which are used to predict the result. This all the layers are used in my project while training a model. We have used the sequential Convolutional neural network model. Which means each layer connects only to each other.

VGG-16:

The VGG-16 model is a convolutional neural network (CNN) architecture that was proposed by the Visual Geometry Group (VGG) at the University of Oxford. It is characterized by its depth, consisting of 16 layers, including 13 convolutional layers and 3 fully connected layers. VGG-16 is renowned for its simplicity and effectiveness, as well as its ability to achieve strong performance on various computer vision tasks, including image classification and object recognition.

IV. RESULT AND DISCUSSION

Table 1: Test results and description

Test Case ID	Test Case Descriptions	Expected Results	Actual Result
TC01	Upload image (Healthy rice leaf)	Image is uploaded successfully without errors. Identifies as 'healthy leaf'.	Pass
TC02	Upload image of rice plant leaf with Bacterial Leaf Blight	System correctly identifies as 'Bacterial Leaf Blight'.	Pass
TC03	Upload image of rice leaf with Brown Spot	System correctly identifies as 'Brown Spot'.	Pass
TC04	Upload image of rice leaf with Rice Blast	System correctly identifies as 'Rice Blast'.	Pass
TC05	Upload unsupported file format (e.g., DOCX)	System displays appropriate error message.	Pass
TC06	Upload corrupted rice leaf image	System handles the corrupted file and displays an error message.	Pass

In Table 4 (Test Results), the outcomes of various test cases for disease detection application using hybrid transfer learning are documented. Each test case is designed to evaluate the system's performance across different scenarios. For TC01, the system successfully uploads an image of healthy rice leaf, as expected. Test cases TC02 through TC04 confirm that the system accurately identifies and classifies images of rice plants with specific diseases. TC05 verifies that the system correctly handles unsupported file formats by displaying an appropriate error message. Finally, TC06 ensures that the system efficiently processes corrupted images and provides an error message as required. All test cases passed, indicating that the system operates reliably and meets the expected performance standards.

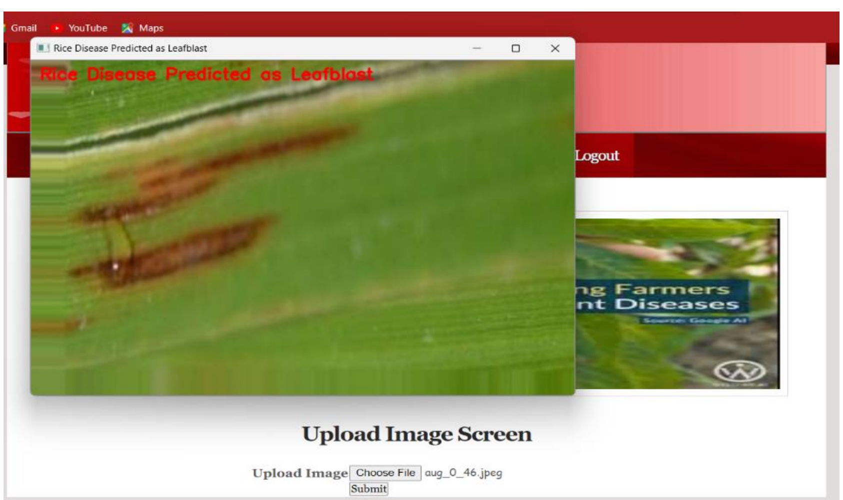

Fig 3: Result of rice leaf predicted as leaf blast

The above figure 3 describes test case result TC04. Identifying the images and predicted as rice leaf blast and the test case result is Pass

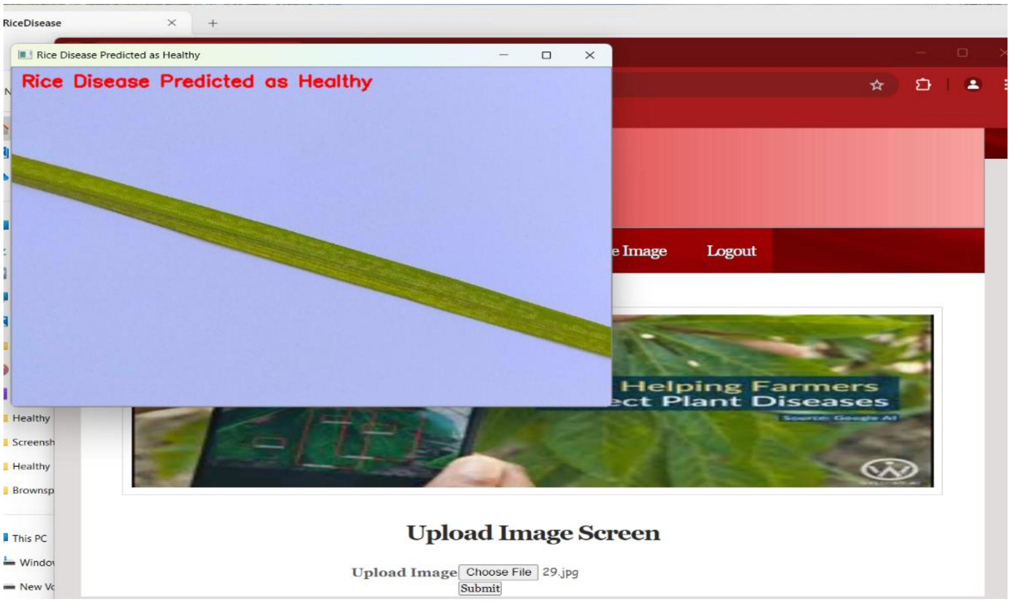

Fig 4: Result of rice leaf is predicted as healthy

The above figure 4 describes the TC01 test case as when we upload the healthy rice leaf image, it uploads successfully, and accurate result is passing.

V. CONCLUSION

Rice Crop is considered as one of the most widely grown crops in world as well as in India. While growing stage the rice leaves are infected with various diseases to protect from these diseases demonstrate a significant advancement in agricultural technology by combining the two algorithms for higher accuracy. CNN is a class of deep learning architecture which is used for learning the features from input. The dataset is augmented; the augmented dataset is trained using VGG-CNN algorithm. The system's rigorous testing confirmed its robustness and reliability, with all test cases passing. This reliability ensures that the system can be trusted to provide timely and accurate disease diagnostics, contributing to better crop management and increased yield. By enabling early and precise disease detection, the system supports sustainable farming practices and enhances food security. Future developments could further expand its capabilities and adapt it to different agricultural contexts, reinforcing its role as a crucial asset in agricultural technology. The proposed model accuracy obtained is 95.60% using hybrid transfer leaning.

VI. FUTURE ENHANCEMENT

Looking to the future, several key enhancements. Firstly, expanding the dataset to include a broader variety of rice diseases and plant conditions can enhance the model's accuracy and generalizability. Adding several more information sources, including outpost descriptions and environmental data, could also provide a more comprehensive view of disease dynamics and contribute to more accurate predictions. Additionally, integrating advanced techniques such as real-time data streaming and edge computing could allow the system to process and analyze images directly on mobile devices or remote sensors, reducing latency and making the technology more accessible in field conditions. Exploring collaborations with agricultural researchers and institutions could also drive innovation and application of the technology in different crop types and farming scenarios. Overall implementing above enhancements can lead to more efficient and ultimately contributing to better crop management and yield.

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