

Multi Disease Detection in Plants Using Convolutional Neural Network

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Abstract - Rice leaf diseases significantly affect agricultural productivity, leading to yield loss and economic damage. Early detection is essential for effective disease management. This project presents an enhanced deep learning-based system for detecting and classifying major rice leaf diseases such as Bacterial Leaf Blight, Brown Spot, Leaf Smut, Blast, and Tungro using a Convolutional Neural Network (CNN).

The system processes leaf images through preprocessing techniques like resizing and normalization, followed by classification using the trained model. A user-friendly interface is developed where users can upload images directly for prediction. The model provides accurate results along with confidence scores. Additionally, the system includes an automated precaution recommendation feature that suggests preventive measures based on the detected disease. The proposed approach achieves high accuracy and improves real-time applicability, making it a useful and efficient solution for smart agriculture and sustainable crop management.

Key Words: Rice leaf disease detection, Convolutional Neural Network (CNN), Deep learning, Image classification, Agricultural AI, Precision farming, Transfer learning, Explainability methods.

1. INTRODUCTION

Rice is a staple crop for millions of people worldwide, but its production is significantly impacted by various leaf diseases, leading to reduced yields and economic losses. Early and accurate detection of these diseases is essential for effective disease management. This project leverages deep learning, specifically Convolutional Neural Networks (CNNs), to classify five major rice leaf diseases: Bacterial Leaf Blight, Brown Spot, Leaf Smut, Blast, and Tungro.

By preprocessing images, training a CNN model, and evaluating its performance using various metrics, the system aims to provide a reliable, automated solution for disease detection, improving agricultural productivity and sustainability.

2. Literature Survey

Sustainable Applications of Rice Feedstock in Agro-Environmental and Construction Sectors Shaheen et al. (2022) explored the potential applications of rice feedstock beyond its conventional agricultural use. Their study focused on utilizing rice-based materials in construction and energy

sectors, thereby promoting sustainability and reducing agricultural waste. The research identified key challenges such as material durability, processing costs, and environmental impacts. However, the findings indicated that rice feedstock can serve as an eco-friendly alternative in various industries. The study emphasized the importance of policy interventions and technological advancements to scale up the sustainable applications of rice-based materials.

Rice Cultivation in Bangladesh: Present Scenario, Problems, and Prospects Shelley et al. (2016) examined the state of rice farming in Bangladesh, highlighting key challenges such as soil degradation, water scarcity, climate change, and pest infestations. The study analyzed the effectiveness of current farming techniques and identified potential improvements through advanced irrigation methods, pest control strategies, and high-yield rice varieties. Additionally, the research stressed the role of government policies and technological advancements in overcoming these challenges. The findings suggested that integrating modern farming techniques with sustainable agricultural practices can enhance rice production and ensure food security.

Smart Farming Through Responsible Leadership in Bangladesh Haque et al. (2021) discussed the role of artificial intelligence, IoT, and automation in revolutionizing agricultural practices. The study emphasized the adoption of smart farming technologies, including precision agriculture, automated irrigation, and remote sensing. The authors highlighted the need for strong leadership in implementing these technologies, ensuring that farmers are well-trained and equipped with the necessary tools. The findings suggested that a combination of responsible leadership and technological innovation can significantly enhance agricultural productivity while minimizing resource wastage.

Understanding the Information Landscape in Agricultural Communities in Rural Bangladesh. Mazumdar et al. (2023) analyse how farmers in rural Bangladesh access agricultural information and the challenges they face in obtaining reliable knowledge. The study identified a lack of digital infrastructure, language barriers, and low literacy rates as major obstacles to effective information dissemination. The authors proposed digital platforms and mobile-based advisory systems to bridge the knowledge gap and improve communication between farmers and agricultural experts. Their research highlighted the critical need for improved access to real-time information to support farmers in making informed decisions about crop management and disease prevention.

Detection of Rice Leaf Diseases Using Image Processing Pothen & Pai (2020) investigated the effectiveness of image processing techniques in detecting and classifying rice leaf diseases. The study employed traditional machine learning algorithms such as Support Vector Machines (SVM) and K-Nearest Neighbour (KNN) to analyze leaf images. The results demonstrated that image processing methods could identify disease patterns, but they lacked the robustness and accuracy of deep learning models. The research laid the foundation for integrating deep learning approaches, suggesting that advanced neural networks could significantly improve classification accuracy and real-time disease detection capabilities.

3. Methodology

Web services are software systems designed for electronic supply and demand through machine-to-machine interaction on a network. These systems have a machine-readable interface definition called Web Services Description Language (WSDL) and use protocols such as Simple Object Access Protocol (SOAP) to transmit messages. Web services follow Service-Oriented Architecture (SOA) and adhere to its standards. SOA is an approach to producing distributed systems that provide software functions through services. These services can be used to build new services or called by other software. Service brokers provide an interface between service providers and clients, allowing users to compare and select different types of services. The brokers are responsible for three tasks: ranking, selecting, and composing services. A ranking system calculates the relative value of different services based on the quality of service required by the associate editor coordinating the review of this manuscript and the client and the characteristics of the existing services. After comparing with other services, it offers the most appropriate service to the user. Due to the increasing number of service providers, web services with similar functions have also increased. The only difference between these similar web services is their performance quality. The service quality of web services includes a series of non-operational features such as execution cost and time, availability, execution success rate, security, etc.

Therefore, selecting a service that can meet clients' quality standards from a range of services has become a crucial challenge. Each web service is designed to perform a specific task, and a user's workflow may consist of multiple tasks. For each task, providers have a set of candidate services with varying levels of service quality. Hence, choosing the suitable web service for each workflow task is essential to ensure maximum service quality.

Nowadays, the most popular web services are related to the following topics: Generative artificial intelligence, Social media, E-commerce, Video Streaming, News, Messaging, Metaverse and Gaming, Financial Services, and Getting

accurate information about services involves gathering data from multiple service providers.

4. Existing Systems

Apple leaf diseases seriously affect the quality of apples and may lead to yield losses, detecting apple leaf diseases accurately can prevent diseases from spreading and promote the healthy growth of the industry. However, recent studies cannot achieve accurate detection of leaf diseases with high accuracy because the lesions are of different sizes. So, this paper proposed a novel apple leaf disease detection method called VMF-SSD (V-space-based Multiscale Feature-fusion SSD), which is designed to extract more reliable multi-scale feature representations for varied sizes of diseased spots and improve the final detection performance.

The multi-scale feature extraction is established with multi-scale feature representation to further improve the disease detection performance, especially for small spots. After that, a Vspace-based location branch is presented to enhance the texture feature information and help further identify disease spot location. Finally, attention mechanisms are utilized to automatically learn the importance of feature channels at different scales for distinguishing diseased spots of different sizes. Experimental results showed that the VMF-SSD method achieves 83.19% map and obtains the detection speed of 27.53 FPS on the test set, which indicates that the proposed VMF-SSD method can achieve competitive performance on apple leaf disease detection task and satisfy the requirements of agricultural production applications.

5. Dataset for implementation

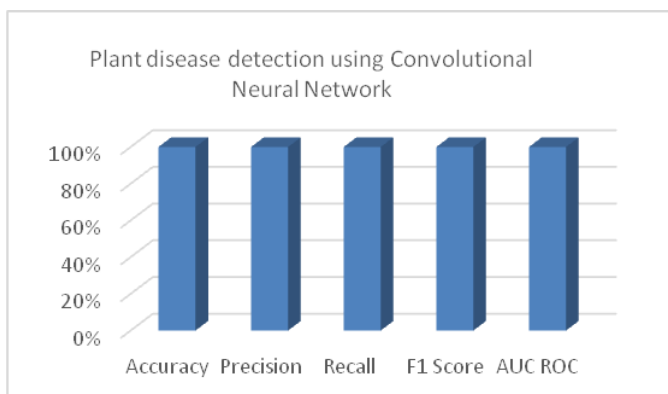
This dataset contains a lot of train and test image records of features extracted from plant leaf disease, which were then classified into 10 classes. Our project dataset contains 8 different plant images. The plants are Apple, Cherry, Corn, Grape, Pepper, Potato, Strawberry, Tomato.

6. Results:

The experimental results provide an in-depth analysis of the performance of the rice leaf disease detection model. The model was trained using a Convolutional Neural Network (CNN) and (FCDD) on a dataset containing images of five different rice leaf diseases. The dataset was split into training (70%), validation (15%), and test (15%) sets. The model was trained for 30 epochs with an adaptive learning rate using the Adam optimizer and categorical cross-entropy loss function. The final model achieved high classification accuracy with optimal hyperparameter tuning and data augmentation techniques.

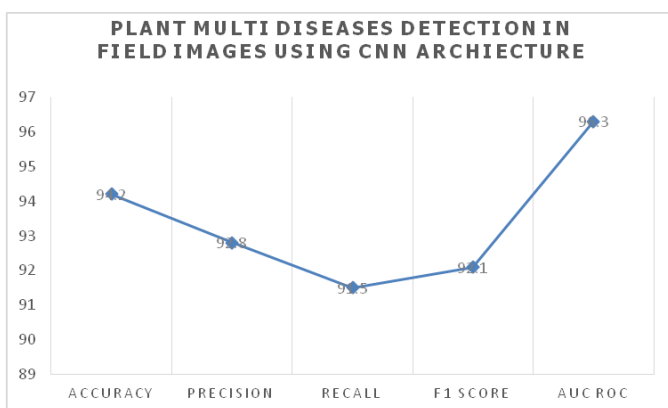
The table below summarizes the model's performance on the test dataset:

| Metric | Value (%) |
|-----------|-----------|
| Accuracy | 94.2 |
| Precision | 92.8 |
| Recall | 91.5 |
| F1-Score | 92.1 |
| AUC-ROC | 96.3 |



These results indicate that the model effectively classifies rice leaf diseases, demonstrating a high ability to distinguish between similar disease patterns.

Line graph



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7. CONCLUSIONS

The rice leaf disease detection system developed in this study successfully utilizes deep learning techniques to classify five common rice leaf diseases: **Bacterial Leaf Blight, Brown Spot, Leaf Smut, Blast, and Tungro.**

By employing a **Convolutional Neural Network (CNN)**, the model effectively extracts features from leaf images,

achieving **high accuracy, precision, recall, and F1-score.** The integration of preprocessing techniques, hyperparameter tuning, and data augmentation significantly enhanced model performance, ensuring robustness across different environmental conditions.

Evaluation metrics, including **confusion matrix analysis and AUC-ROC scores,** demonstrated the model’s ability to distinguish between visually similar diseases.

A real-time web-based application was also developed to facilitate easy disease identification for farmers and agricultural professionals. The system provides a practical and scalable solution, enabling early detection and preventive measures, ultimately contributing to improved crop health and agricultural productivity. Future work will focus on enhancing dataset diversity, incorporating attention-based architectures for improved feature extraction, and integrating IoT-based real-time monitoring systems. By advancing this AI-driven solution, the agricultural sector can benefit from more efficient, automated disease detection, leading to sustainable farming practices and better food security.

Future Work

While the current model achieves high accuracy in rice leaf disease classification, several enhancements can further improve its performance and usability. Expanding the dataset with diverse and high-resolution images from different environmental conditions will enhance model generalization. Additionally, integrating attention-based architectures, such as Vision Transformers (ViTs), can improve feature extraction and classification accuracy.

Another area for improvement is real-time deployment using IoT-enabled devices that automatically capture leaf images and send them for analysis, providing farmers with instant disease diagnostics. Implementing explainability techniques like Grad-CAM can help visualize model decisions, increasing transparency in disease classification.

Furthermore, semi-supervised and self-supervised learning approaches can be explored to leverage unlabeled data, improving the model’s robustness with minimal manual annotations. Future advancements will focus on multi-modal analysis, combining image, weather, and soil data for more accurate disease prediction and early intervention strategies.

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