Multiple Rice Leaf Disease Prediction for MO4 Rice Leaf Variety in Dakshina Kannada Using Deep Learning Technique

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Received: 21-11-2024 Revised: 10-12-2024 Accepted: 30-12-2024

ABSTRACT

Rice serves as a staple food for millions worldwide, yet its productivity and quality are often compromised by diseases. This challenge is particularly evident in Dakshina Kannada, Karnataka, a region renowned for cultivating the MO4 rice variety. MO4 rice is especially susceptible to diseases like bacterial leaf blight, sheath blight, and neck blast, which can lead to significant crop losses if not addressed promptly. Early and accurate disease detection is critical for effective management strategies and ensuring agricultural sustainability.[3] To tackle this issue, we propose a deep learning-based system that leverages convolutional neural networks (CNNs) for the detection and classification of rice leaf diseases. Our study involved compiling an extensive and meticulously annotated dataset of MO4 rice leaf images, representing both healthy and diseased samples.

The CNN model was fine-tuned to achieve high accuracy, precision, recall, and F1 scores, demonstrating its effectiveness in disease detection. Rigorous testing under diverse conditions ensures the model's robustness and suitability for real-world applications. This system offers a practical tool for farmers and agricultural officers, enabling early diagnosis and timely intervention. By facilitating proactive disease management, it helps reduce crop losses, improve productivity, and support sustainable agriculture. Our experimental results underscore the potential of this deep learning-based approach to revolutionize rice disease management, particularly in Dakshina Kannada. The proposed system contributes to the broader vision of intelligent agriculture, enhancing food security and empowering farmers with advanced technological tools.[1]

Keywords— Convolutional Neural Networks (CNNs), Deep Learning, MO4 Rice Variety, Rice Disease Detection

I. INTRODUCTION

Agriculture serves as the lifeblood of many communities, supporting livelihoods, feeding nations, and contributing significantly to the global economy. In regions like Dakshina Kannada, India, rice cultivation plays a crucial role in food security and cultural heritage. Among the varieties grown, the MO4 rice variety is favoured for its resilience, yield, and acceptance among farmers and consumers. However, rice crops are highly susceptible to diseases such as sheath rot, brown spot, blast, and bacterial leaf blight, which can significantly impact productivity and quality if not managed effectively. Traditional disease detection methods are labour-intensive, subjective, and prone to errors, creating a need for advanced technologies. Deep learning, particularly convolutional neural networks (CNNs), has revolutionized agricultural disease detection by enabling precise image-based analysis [2]. EfficientNetB5, a state-of-the-art CNN architecture, is particularly effective for identifying and classifying diseases in complex and varied images. By training this model on annotated images of healthy and diseased MO4 rice leaves, a highly accurate system can be developed to detect and categorize diseases early.

The rice plant itself is uniquely adapted to flooded environments, with hollow stems for nutrient transport and long, narrow leaves optimized for photosynthesis. These leaves play a critical role in capturing sunlight and facilitating gas exchange through stomata [4]. Flowers, emerging from panicles, are essential for reproduction, leading to grain formation. The grains, which vary in type and colour, are the ultimate product harvested for consumption.

By integrating deep learning with the biology of the rice plant, this approach not only enhances disease management but also supports sustainable agriculture, offering significant benefits to farmers in regions like Dakshina Kannada.[4]

II. METHODOLOGY

The successful implementation of the proposed design is a critical phase in the system development life cycle, transforming the conceptualized design into a fully operational system. In this context, implementation refers to converting a new or revised system into a functional one. The system uses Convolutional Neural Networks (CNNs), a key algorithm in deep learning. CNNs are multi-layer perceptron's designed to simulate local perception and efficiently map inputs to outputs. These networks extract features at different scales through convolution and pooling layers. Key characteristics of CNNs include local connections and shared weights, reducing the network's complexity and mitigating the risk of overfitting. The architecture of CNNs typically includes convolutional, pooling, and fully connected layers. In the convolutional process, local features are extracted, with multi-level cascading enhancing the capture of complex feature correlations.[5]

The workflow begins with pre-processing, where the dataset, sourced from Kaggle, is cleaned and resized to 150x150 pixels for consistency. The data is then split into training (90%) and testing (10%) sets, ensuring the training set includes accurate labels, known as target attributes. The machine learning model is trained with labeled data, enabling the algorithm to learn patterns that map input attributes to target outputs. The model is then optimized for maximum accuracy. Once trained, the model is stored using the pickling process, allowing future use without retraining.[6] This approach enhances efficiency by eliminating the need for re-training during subsequent classifications, making the system more practical and efficient for ongoing use.

III. OUR APPROACH

Our approach aims to develop an automated deep learning-based system to detect and classify diseases in the M04 rice leaf variety, primarily grown in Dakshina Kannada, India. Rice cultivation is vital to the region's economy, but diseases such as Bacterial Leaf Blast, Leaf Blast, Sheath Blight, and Neck Blast threaten crop yield and quality. Early and accurate disease detection is crucial for timely intervention and effective disease management.
Our system utilizes cutting-edge image analysis techniques to identify and categorize diseases in high-resolution rice leaf images. It employs Convolutional Neural Networks (CNNs) trained on a comprehensive dataset of rice leaf images representing various disease stages and environmental conditions. This ensures high accuracy and robustness in disease identification.[7]

The workflow begins with data collection, where images of both healthy and diseased leaves are gathered. These images are pre-processed to remove backgrounds, enhance quality, and standardize size. Data augmentation techniques, such as rotation, flipping, and noise addition, are used to increase dataset diversity and prevent overfitting. The pre-processed and augmented images are then fed into the CNN for feature learning, where the model learns to extract key characteristics like colour patterns and textures indicative of disease. Feature reduction techniques are applied to simplify the model.

During training, labelled images are used to map features to specific diseases. After training, the model is tested on a separate dataset, and its performance is evaluated using accuracy, precision, and recall metrics. Finally, the trained model predicts disease types or identifies healthy leaves when new images are introduced, providing farmers with a reliable tool for efficient disease management.[9]

This approach significantly reduces the reliance on traditional, time-consuming, and error-prone manual inspection methods, promoting sustainable agriculture in the region.

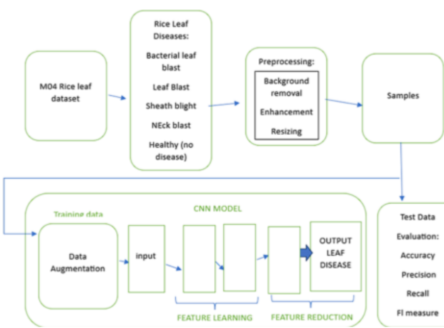

Figure 1: Workflow of Rice Leaf Disease Detection using Convolutional Neural Network (CNN)

The Figure 1 illustrates the workflow for detecting rice leaf diseases using a Convolutional Neural Network (CNN). The process begins with **data collection**, where images of M04 rice leaves, including healthy and diseased leaves (affected by diseases such as Bacterial Leaf Blast, Leaf Blast, Sheath Blight, and Neck Blast), are gathered. After data collection, **preprocessing** steps are applied, including **background removal** to eliminate irrelevant elements, **enhancement** to improve image quality for better feature extraction, and **resizing** to ensure uniformity across all images. Next, **data augmentation** techniques are employed to increase the diversity of the dataset and reduce overfitting, by generating new images through transformations such as rotation, flipping, and adding noise. The preprocessed and augmented images are then input into the CNN model, where **feature learning** occurs.[8] The CNN extracts essential features such as color patterns, textures, and shapes, which are indicative of the various diseases. **Feature reduction** techniques are applied to select the most important features, optimizing the model's performance. The model is trained using the labeled dataset, allowing it to map specific features to disease categories.

After training, the model is tested with a separate set of images (test data) to evaluate its accuracy, precision, recall, and F1 measure. Finally, when a new rice leaf image is introduced, the trained model analyzes it and predicts whether the leaf is healthy or diseased, categorizing the disease if present. This automated workflow enhances disease detection in rice farming, promoting timely interventions and better crop management [9].

V. CONCLUSION

The detection and classification of multiple diseases in the M04 rice variety using deep learning represents a significant advancement in agricultural technology. With rice farmers in Dakshina Kannada facing increasing challenges from diseases such as bacterial leaf blast, sheath blight, and neck blast, the proposed model provides a timely and effective solution. By leveraging the power of EfficientNetB5, a state-of-the-art Convolutional Neural Network (CNN), our system achieves high precision and efficiency in disease detection. This capability is crucial in minimizing crop loss and enhancing food security.

A major outcome of this research is the ability to offer early and accurate disease diagnoses, enabling timely interventions by farmers. The system’s use of a well-curated dataset containing both healthy and diseased rice leaves, combined with fine-tuned model validation, ensures its readiness to handle real-world challenges. This research is not only relevant to Dakshina Kannada but also offers valuable insights and tools that can be adapted to other regions facing similar agricultural challenges.

By integrating deep learning into agricultural practices, this project contributes to improving the resilience and productivity of rice farming. This innovation plays a vital role in securing food resources to meet the growing global population's demands and addressing the impacts of climate change. Looking forward, future studies should focus on developing this model into an integrated mobile application or decision-support system, enabling farmers to access real-time disease diagnostics and management tools, further enhancing precision agriculture and supporting sustainable farming practices.

REFERENCES

[1] Shital Pawar. (2022). Leaf disease detection of multiple plants using deep learning. *Conference Paper*.
[2] Ahmad Rofiqul Muslikh. *Rice disease recognition using transfer learning*.
[3] Dogra, R., Rani, S., Singh, A., Albaharf, M. A., Barrera, A. E. & Alkhayyat, A. *Deep learning model for detection of brown spot rice leaf disease with smart agriculture.*
[4] Tugrul, B., Elfatimi, E. & Eryigit, R. *Convolutional neural networks in detection of plant leaf diseases: A review.*
[5] Pawar, S. (2022). Leaf disease detection of multiple plants using deep learning. *Conference Paper*.
[6] Muslikh, A. R. *Rice disease recognition using transfer learning.*
[7] Simhadri, C. G., Kondaveeti, H. K., Vatsavayi, V. K. & Mitra, A. *Deep learning for rice leaf disease detection: A systematic literature review on emerging trends, methodologies, and techniques.*
[8] Udayananda, G. K. V. L., Shyalika, C. & Kumara, P. P. N. V. *Rice plant disease diagnosing using machine learning techniques: A comprehensive review.*
[9] Narmadha, R. P., Sengottaiyan, N. & Kavitha, R. J. *Deep transfer learning based rice plant disease detection model.*