Implementation of Synthetic Image Generation and Augmentation Using Conditional GANs for Rice Disease Identification and Expert System Design

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Abstract

Rice is one of the most important staple foods in the world. It plays a significant role in global food security. Crop productivity and quality are severely affected by various rice diseases. Traditional disease identification methods are time-consuming and expert-dependent. This conference paper presents the outcome of implementing a Conditional Generative Adversarial Network (cGAN)-based framework for synthetic image generation and augmentation to improve rice disease classification performance. The implemented methodology integrates synthetic image generation, hybrid dataset augmentation, and deep learning-based disease classification. A novel Convolutional Termite Life Cycle Network (CTLCN) architecture is introduced to optimize feature extraction and disease prediction.

Keywords

Conditional GAN, Rice Disease Detection, Deep Learning, CTLCN, Expert System, Image Augmentation, Agriculture AI

Introduction

Rice (Oryza sativa) is a staple food in many Asian and African countries and supports approximately half of the world's population [1]. Diseases such as rice blast, bacterial blight, sheath blight, and brown spot severely affect the productivity of rice crops [2]. Early disease identification plays an essential role in minimizing crop loss. Traditional disease identification approaches rely on manual observation by experts, which is expensive, subjective, and unsuitable for large-scale monitoring.

Recent advancements have provided opportunities to automate the disease identification process using a combination of Artificial Intelligence (AI), Deep Learning (DL), and Computer Vision through image-based analysis [1], [3]. Deep learning systems require large and balanced datasets for effective training. However, agricultural datasets often suffer from data imbalance and insufficient disease samples. The implemented work provides an approach for using Conditional Generative Adversarial Networks (cGANs) to generate synthetic disease images and improve dataset diversity.

Methodology

The implementation consists of four main stages. Initially, rice disease datasets are collected from publicly available agricultural repositories and Kaggle datasets. To improve consistency and remove noise, the collected images are preprocessed, resized, and normalized. The Conditional Generative Adversarial Network (cGAN) models are trained to generate class-specific synthetic disease images in the second stage. This process helps manage data scarcity and class imbalance problems. The synthetic images are combined with the original datasets to create an augmented training dataset in the third stage. The implemented Convolutional Termite Life Cycle Network (CTLCN) architecture is used for feature extraction and disease identification. In the final stage, the trained classification model is integrated into an intelligent expert system to support disease diagnosis and decision-making.

Results and Discussions

CTLCN attains 98.67% F1 score, 98.67% recall, 98.67% accuracy, and 98.98% precision, clearly outperforming the non-optimized CNN variant depicted in Table 1. Results confirm that CTLCN significantly contributes to the improvement of classification performance, showing its efficacy in increasing learning ability, stability, and overall model robustness for rice leaf disease identification tasks.

Table 1: Overall performance of CTLCN

Performance of CTLCN	
Metrics	**Performance**
Recall	98.67%
Precision	98.68%
Accuracy	98.67%
F1-Score	98.67%

Conclusion

The automated rice disease detection system effectively combined cGAN-based data augmentation, CNN-based feature extraction, Termite Life Cycle Optimization, and expert system-based decision support to improve disease classification performance. The developed model achieved high accuracy, precision, recall, and F1-score, outperforming existing approaches by approximately 3%. Future work will focus on reducing computational and memory requirements while maintaining high classification performance.

References

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