International Journal of Research Publication and Reviews, Vol 5, no 4, pp 1423-1428 April 2024

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Leaf Disease Prediction Using Deep Learning

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ABSTRACT:

Leaf diseases in plants pose significant challenges to global agriculture, impacting crop yield, quality, and food security. In response, this study proposes an innovative approach combining Convolutional Neural Networks (CNNs) for leaf disease prediction with recommendations for preventative methods and fertilizer application. A diverse dataset comprising images of healthy and diseased leaves is collected and preprocessed for CNN-based analysis. A custom CNN architecture is designed and trained on the dataset to accurately predict leaf diseases. Furthermore, preventative measures, including cultural practices, biological controls, and chemical treatments, are suggested based on disease characteristics and environmental factors. Additionally, tailored fertilizer recommendations aimed at strengthening plant immunity and resilience against diseases are provided. Experimental evaluations demonstrate the effectiveness of the CNN model in predicting leaf diseases, while the integrated preventative measures and fertilizer strategies aim to reduce disease incidence and severity. This holistic approach contributes to sustainable agriculture by empowering farmers with proactive disease management tools and promoting resilient crop production systems.

Keywords: Deep Learning, CNN, Training, Validation, Testing, Preprocessing, Accuracy

I. INTRODUCTION

Leaf diseases represent a critical challenge in agriculture, exerting detrimental effects on crop productivity, quality, and global food security. With the increasing prevalence and complexity of these diseases, there is a pressing need for effective and timely management strategies to mitigate their impact. Traditional methods of disease identification and control often rely on manual inspection and reactive measures, which can be labor-intensive, costly, and insufficient in addressing emerging threats.

In recent years, the integration of advanced technologies, particularly machine learning and computer vision, has revolutionized disease management practices in agriculture. Among these technologies, Convolutional Neural Networks (CNNs) have emerged as powerful tools for automated image analysis and classification tasks. By leveraging large datasets of labeled images, CNNs can learn intricate patterns and features, enabling accurate and efficient detection of leaf diseases from visual data.

This paper presents a novel approach to leaf disease prediction by harnessing the capabilities of CNNs, complemented by recommendations for preventative methods and fertilizer application. The primary objective is to develop an integrated framework that not only identifies diseased plants but also provides proactive strategies to mitigate disease spread and enhance plant health. By combining predictive modeling with preventative measures and targeted fertilization, this approach aims to empower farmers with actionable insights for sustainable disease management and crop production.

The remainder of this paper is structured as follows: Section 2 provides an overview of the current challenges and limitations in leaf disease management, highlighting the need for innovative solutions. Section 3 introduces the methodology, including data collection, preprocessing, CNN model architecture, and training procedures. Section 4 discusses preventative methods, including cultural practices, biological controls, and chemical interventions, alongside tailored fertilizer recommendations to bolster plant immunity. Section 5 presents experimental results demonstrating the efficacy of the integrated approach in predicting leaf diseases and mitigating their impact. Finally, Section 6 concludes the paper and outlines future research directions in automated disease management and sustainable agriculture.

Through this interdisciplinary approach, we aim to bridge the gap between advanced technology and practical agricultural solutions, ultimately contributing to resilient farming systems and global food security in the face of evolving disease threats.

1.1 Plant Disease Identification And Classification

Computer vision is a subdomain of AI that allows machines to counterfeit the human visual system and precisely draw out, inspect, and recognize real-world images in the same way that humans do. ML techniques have been used to detect and classify plant diseases, but with advancements in a subset of ML, DL, this area of research appears to have considerable potential in terms of increasing accuracy. Many developed DL architectures were used, along with various visualization techniques, to detect and classify plant disease symptoms accordingly. Medical diagnosis, espionage, satellite images, and agribusiness are just a few of the rapidly increasing industries that have already shown the benefits of computer vision-based technologies. Computer vision-enabled systems can be used in agriculture to detect and classify plant diseases based on different features or symptoms that have been extracted. It uses a well-defined series of steps beginning with image acquisition and continuing with various image-processing tasks such as scaling, filtering, segmentation, feature extraction, and selection, and finally, detection and classification are performed using ML or DL technique.

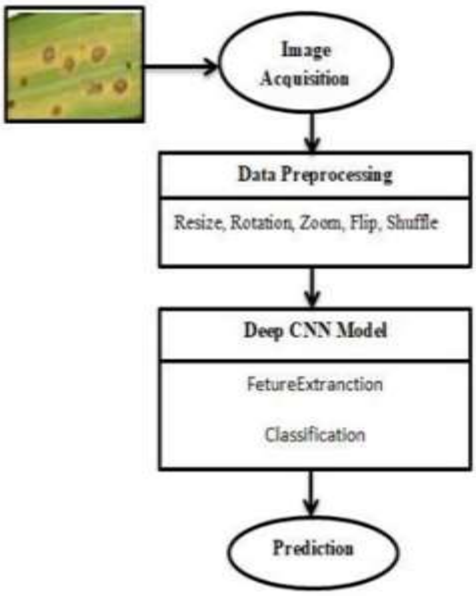

Figure 1: Current Leaf Disease prediction Scenario

1.2 Factors Responsible For Plant Diseases

A wide range of agricultural diseases can arise at various stages of plant development and harm the plant's development, which can have a negative impact on overall crop production. Plant diseases are caused by a variety of conditions at various phases of plant growth. As summarized in paper, crop disease-causing factors are categorized into two: biotic factors and abiotic factors. Biotic factors such as viruses, fungi, bacteria, mites, and slugs emerge as a result of microbial infection in plants, whereas abiotic variables such as water, temperature, irradiation, and nutritional deprivation damage plant growth [9, 25]. Accordingly, some sample plant leaf images with different diseases from the Plant Village dataset and different images from other datasets showing healthy and diseased plant leaves have been included in the study [21] and different images from other datasets showing healthy and diseased plant leaves have been summarized in the works of [29] and [30] accordingly. Additionally, the detail computer vision-based techniques and proccsses including field crops, image acquisition, leaf image datasets, image preprocessing (test set, training set, and validation sets), data splitting, and performance assessment methods) for plant disease detection and classification have been clearly indicated in the work**.**

II. LITERATURE REVIEW

A literature review on leaf disease prediction using CNN models and preventative measures with fertilizers would encompass a range of studies spanning machine learning applications in agriculture, plant pathology, and agronomy. Here's a condensed overview of the existing research:

1. Machine Learning Applications in Agriculture: Numerous studies have explored the application of machine learning techniques, including CNNs, in various agricultural domains such as crop yield prediction, weed detection, and disease diagnosis. CNNs have gained popularity for their effectiveness in analyzing visual data, making them particularly suitable for tasks like plant disease detection from images. Key research works demonstrate the potential of CNNs in accurately classifying leaf diseases across different plant species and environmental conditions.

2. Leaf Disease Detection Using CNNs: Research efforts have focused on building CNN-based models capable of detecting and classifying leaf diseases based on image datasets. Studies often involve the collection of large-scale datasets containing images of healthy and diseased leaves across multiple crop types. CNN architectures are tailored to extract relevant features from leaf images, facilitating accurate disease prediction.

3. Preventative Measures and Fertilizer Strategies: Agronomic research provides insights into preventative measures for disease management, including cultural practices (crop rotation, sanitation), biological controls (biocontrol agents, resistant cultivars), and chemical treatments. Fertilizer application plays a crucial role in plant health and disease resistance. Studies examine the impact of nutrient deficiencies or imbalances on susceptibility to diseases and propose fertilizer regimes to enhance plant immunity.

4. Integrated Approaches for Disease Management: Recent studies emphasize the importance of integrated pest management (IPM) strategies, which combine various control methods, including biological, cultural, and chemical interventions, to minimize disease incidence and severity. Integrated

approaches leverage both conventional agronomic practices and modern technologies, such as machine learning, to develop holistic solutions for disease management.

5. Challenges and Future Directions: Despite significant progress, challenges remain in deploying machine learning models in real-world agricultural settings, including data collection, model interpretability, and scalability. Future research directions may focus on improving model robustness, integrating remote sensing data for disease monitoring, and optimizing preventative strategies for specific crop-disease combinations.

Overall, the literature highlights the potential of CNN-based approaches in leaf disease prediction and management, alongside the importance of integrated strategies encompassing preventative measures and fertilizer applications. Collaborative efforts between researchers, agronomists, and farmers are essential to translating these advancements into practical solutions for sustainable agriculture.

III. METHODOLOGY OF PROPOSED SYSTEM

Predicting leaf diseases using deep learning methodologies involves leveraging neural network architectures to analyze images of plant leaves and classify them into healthy or diseased categories. Here's a basic outline of steps you might take:

1. Data Collection: Gather a dataset of images of plant leaves, both healthy and diseased. Make sure the images cover a variety of plant species and diseases. Fot training Dataset has 61486 images . For testing we have taken images by **USB** Web Camera

Dataset link: https://data.mendeley.com/datasets/tywbtsjrjv/1

2. Data Preprocessing: Preprocess the images to ensure they are standardized and ready for input into the neural network. This may include resizing, normalization, and data augmentation techniques to increase the diversity of the dataset.

3. Model Selection: Choose a deep learning model architecture suitable for image classification tasks. Convolutional Neural Networks (CNNs) are commonly used for this purpose due to their ability to extract features from images effectively.*Deep learning (DL) techniques or algorithms:* The CNN Technique Deep feed-forward neural networks are used by the CNN to analyze multidimensional data. The CNN learns channels that are activated after it classifies a particular highlight at some spatial positioning information [19, 21, 24]. The number of epochs utilized in the implementation of various convolution filters with dimensions of 2×2 and 3×3 determines their accuracy. This is contingent upon the filter's dimensions. Several pre-trained architectures, including VGG16, VGG19, ResNet50, ResNet152, InceptionV3, InceptionNet, and DenseNet121, are available for use with the CNN approach.

4. Model Training: Split your dataset into training, validation, and testing sets. Use the training set to train the model and the validation set to tune hyperparameters and prevent overfitting. Monitor the model's performance on the validation set during training. Splitiing data into training and testing data.

Length of train size :36584

Length of test size :24902

Loss function: this project is multiclass classification type problem so we used categorical cross entropy (this include softmax + cross entropy loss)

optimizer : adam,

activation function=Relu

5. Model Evaluation: Evaluate the trained model on the testing set to assess its performance in classifying healthy and diseased leaves. Metrics such as accuracy, precision, recall, and F1 score can be used to evaluate the model's performance. Accuracy metric is used. Train Accuracy : 96.7, Test Accuracy : 98.9, Validation Accuracy : 98.7

6. Fine-tuning and Optimization: Fine-tune the model and optimize hyperparameters to improve performance if necessary. This may involve adjusting learning rates, batch sizes, or exploring different architectures.

7. Deployment: Once satisfied with the model's performance, deploy it in a local server using flask.

8. Monitoring and Maintenance: Continuously monitor the model's performance in the deployed environment and update it as needed to adapt to changes in the data distribution or to improve performance over time.

Here are some popular deep learning frameworks and libraries that can be used for implementing leaf disease prediction models: TensorFlow, Keras, PyTorch, Caffe, MXNet

By following these steps and leveraging deep learning methodologies, you can develop an effective leaf disease prediction system that can help farmers detect and mitigate plant diseases early, thus improving crop yield and food security.

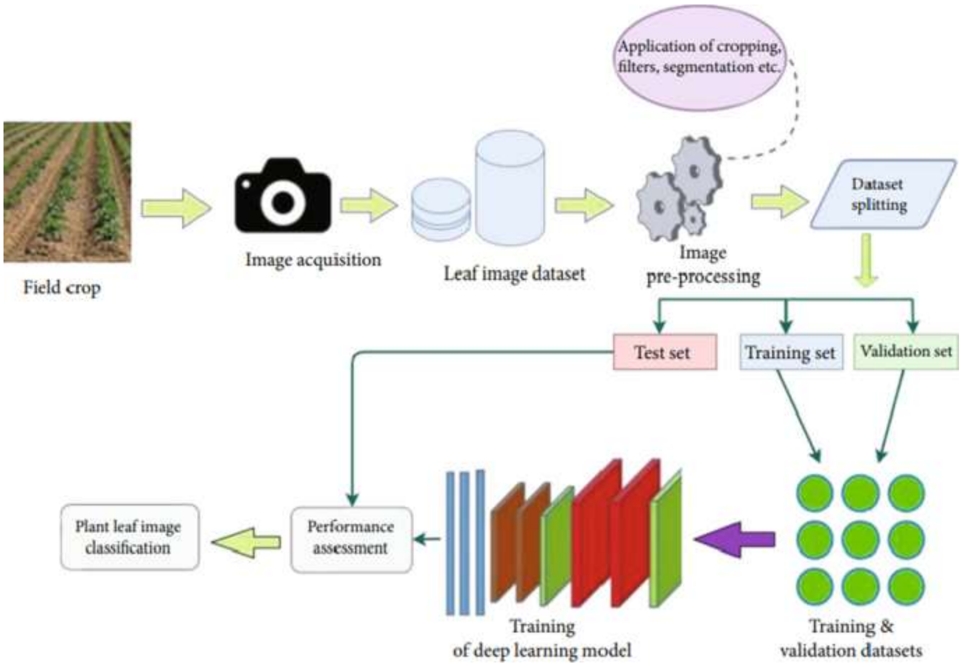

Figure 2: Proposed System Architecture

IV. EXPERIMENTAL RESULT

Train Accuracy : 96.7

Test Accuracy : 98.9

Validation Accuracy : 98.7

Figure 3: Dashboard After Getting Result

V. CONCLUSION AND FUTURE WORK

In conclusion, utilizing deep learning methodologies for leaf disease prediction presents a promising approach to addressing agricultural challenges, such as crop disease management and yield optimization. By leveraging neural network architectures, particularly Convolutional Neural Networks (CNNs), researchers and practitioners can develop robust models capable of accurately classifying plant leaves as healthy or diseased based on image data.

Through the outlined steps of data collection, preprocessing, model selection, training, evaluation, fine-tuning, deployment, and monitoring, a comprehensive framework for developing and deploying leaf disease prediction systems can be established. Leveraging popular deep learning frameworks and libraries facilitates the implementation process and enables scalability and flexibility in model development.

The deployment of such systems in real-world agricultural settings can empower farmers with timely and accurate information, allowing for proactive disease management strategies and ultimately leading to improved crop yield, reduced economic losses, and enhanced food security. Continuous monitoring and maintenance ensure the reliability and effectiveness of the deployed models over time, further contributing to their practical utility and impact.

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