International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 03 | March - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Cotton Plant Disease Prediction Using Convolutional Neural Networks (CNN) and Flask

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Abstract - This document presents a deep learning-based approach for the early detection of cotton plant diseases using Convolutional Neural Networks (CNN). Cotton is a crucial cash crop, but its yield is significantly affected by various plant diseases, leading to economic losses for farmers. Traditional disease detection methods rely on manual inspection, which is time-consuming, error-prone, and requires expert knowledge. To address this challenge, we propose an automated system that leverages CNNs for image classification and Flask for web deployment.

The CNN model is trained on a dataset of cotton leaf images and classifies diseases such as Bacterial Blight, Powdery Mildew, and Target Spot. The model is designed with multiple convolutional layers that extract intricate features from images, ensuring high classification accuracy. Image preprocessing techniques such as normalization and augmentation are applied to enhance model performance. The trained model is then integrated into a web-based platform using Flask, allowing users to upload images for real-time disease prediction. The application is designed to be user-friendly, making it accessible to farmers and agricultural researchers.

Experimental results demonstrate that the CNN model achieves high accuracy compared to traditional machine learning methods. This system enhances early disease detection, reduces dependency on experts, and improves crop yield by providing timely diagnosis and intervention measures. Additionally, the scalability of the proposed model allows for further expansion to detect more plant diseases and integrate real-time field monitoring. The adoption of AI-driven disease detection in agriculture can significantly contribute to sustainable farming and improved food security.

Key Words: *Cotton plant, disease detection, convolutional neural network, deep learning, image classification, Flask*.

1. INTRODUCTION

Cotton is one of the most widely cultivated crops globally and plays a vital role in the agricultural economy. However, its yield is often affected by plant diseases, which reduce both quality and productivity. Cotton diseases such as Bacterial Blight, Powdery Mildew, and Target Spot can severely impact cotton farming, causing economic losses for farmers. Traditional methods of detecting these diseases rely on manual inspection by agricultural experts, which is labor-intensive, time-consuming, and susceptible to errors. Furthermore, many small-scale farmers lack access to expert advice, leading to delayed or incorrect diagnoses.

With recent advancements in artificial intelligence and deep learning, automated disease detection systems have emerged as a viable solution to address these challenges. Deep learning models, particularly Convolutional Neural Networks (CNNs), have demonstrated remarkable performance in image recognition tasks, making them well-suited for plant disease classification. CNNs are capable of extracting deep hierarchical features from images, enabling precise identification of plant diseases. By leveraging these technologies, this paper proposes a system that can automatically detect cotton plant diseases from images and provide real-time predictions to farmers.

This paper presents a CNN-based cotton plant disease detection system that processes leaf images to identify infections accurately. The key objectives of this study are:

- To develop an automated disease detection system that provides accurate results.
- To train a CNN model using a dataset of diseased and healthy cotton leaves.
- To integrate the trained model into a Flask-based web application for real-time use.
- To enhance accessibility for farmers and researchers by providing an easy-to-use interface.

By utilizing deep learning techniques, this system aims to improve precision agriculture by enabling early detection of plant diseases. Early diagnosis allows farmers to take timely action, preventing the spread of infections and reducing the need for excessive pesticide use. Additionally, automated disease detection can minimize dependency on human experts, making crop monitoring more accessible and cost-effective for farmers across various regions.

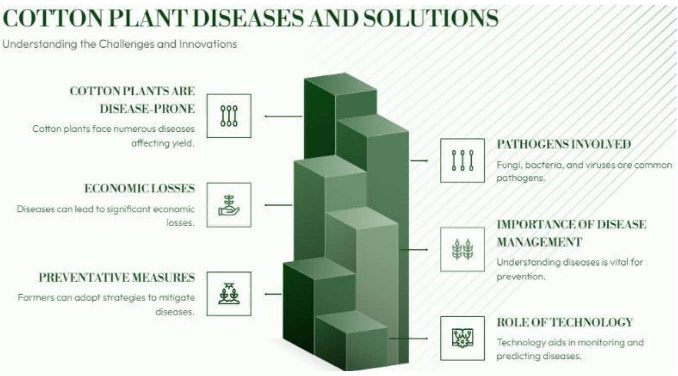
1.1 Importance of Early Disease Detection

Cotton plant diseases can spread rapidly if not detected at an early stage, leading to severe economic losses. If left untreated, these diseases can reduce fiber quality and overall crop yield, significantly affecting the agricultural economy. Early detection enables timely intervention, reducing the need for excessive pesticide use and mitigating the risk of widespread crop failure. AI-based solutions enhance detection accuracy and ensure proactive measures can be taken before significant damage occurs. This technology empowers farmers with real-time insights into their crop health, allowing them to take appropriate action before the disease spreads uncontrollably.

1.2 Role of Deep Learning in Agriculture

Deep learning, a subset of artificial intelligence, has revolutionized various domains, including agriculture. Convolutional Neural Networks (CNNs) are particularly effective for image classification tasks due to their ability to automatically extract relevant features from images without manual intervention. Traditional machine learning techniques require extensive feature engineering, whereas CNNs learn hierarchical patterns directly from data. This ability makes CNNs highly efficient in detecting plant diseases, even in complex scenarios where symptoms may vary due to environmental conditions.

By leveraging CNNs, our system provides a scalable and reliable approach for identifying cotton plant diseases. The trained model can classify multiple disease types based on visual symptoms, providing farmers with precise and instant feedback. Furthermore, by integrating this model into a web-based application, we ensure that farmers can access disease detection tools from their smartphones or computers, making precision agriculture more widely available.



2. Body of Paper

2.1 Literature Review

Traditional plant disease detection methods involve visual assessment, requiring expertise and labor-intensive efforts. Recent studies have explored the application of machine learning and deep learning in agricultural disease detection. CNN-based models have demonstrated superior accuracy in plant disease classification compared to traditional techniques such as Support Vector Machines (SVM) and Random Forests. Prior research has also shown that integrating AI with mobile and web applications can significantly enhance accessibility and efficiency for farmers.

2.2 Proposed Solution

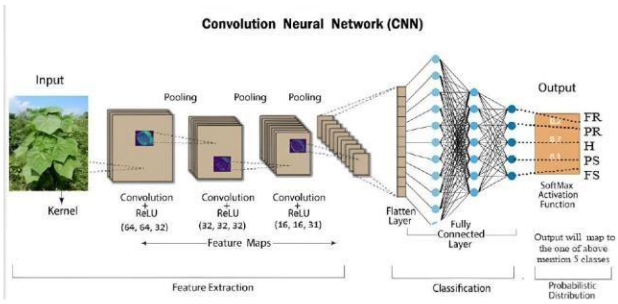
The proposed system consists of three main components:

1. **Data Collection and Preprocessing:** A dataset of cotton plant leaf images is collected and preprocessed by resizing, normalizing, and augmenting the images to improve model performance.
2. **CNN-Based Classification Model:** The deep learning model is trained using TensorFlow and Keras, utilizing multiple convolutional layers for feature extraction and classification.
3. **Web Application Deployment:** The trained model is integrated into a Flask-based web application where users can upload images and receive instant disease predictions.

2.3 System Architecture

The system follows a three-tier architecture:

- **Frontend:** Developed using HTML, CSS, and JavaScript to provide a user-friendly interface for image uploads.
- **Backend:** Built using Flask to handle image processing and communicate with the trained CNN model.
- **Machine Learning Model:** A CNN-based classifier trained to detect and classify cotton plant diseases from images.



2.4 Model Training and Evaluation

The CNN model is trained using a dataset comprising images of healthy and diseased cotton leaves. The dataset is split into training, validation, and testing subsets. Key steps in training include:

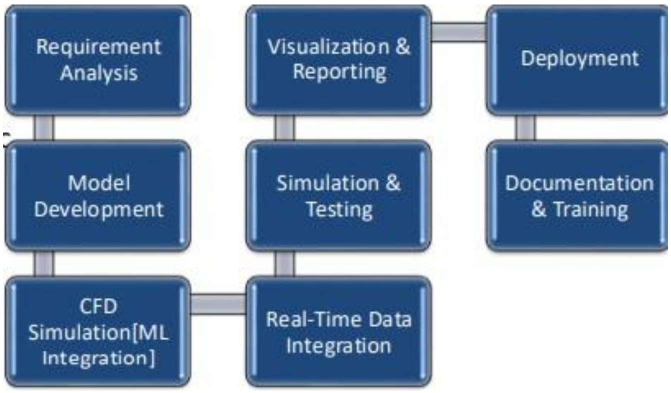
- Applying data augmentation techniques to enhance model generalization.
- Using cross-entropy loss and Adam optimizer for efficient learning.
- Evaluating performance using accuracy, precision, recall, and F1-score.

The model undergoes extensive hyperparameter tuning to optimize its performance, ensuring it generalizes well across different conditions. The inclusion of dropout layers helps prevent overfitting, while batch normalization stabilizes learning. Testing is conducted on independent datasets to verify real-world applicability.

2.5 Web Application Implementation

The web application is designed to be intuitive and accessible to users with minimal technical knowledge. Key features include:

- Image upload functionality for farmers to submit leaf images.
- Real-time processing and disease classification.
- Display of disease name, confidence score, and recommended actions.
- Secure user authentication and history tracking for long-term monitoring.



3. CONCLUSIONS

The research presented in this paper highlights the effectiveness of Convolutional Neural Networks (CNN) in the detection and classification of cotton plant diseases. By integrating deep learning techniques with a web-based application, the proposed system provides an accessible and efficient tool for farmers and agricultural professionals. The model's ability to classify diseases such as Bacterial Blight, Powdery Mildew, and Target Spot with high accuracy allows for early disease detection and timely intervention, ultimately improving crop yield and reducing economic losses.

One of the major advantages of this system is its scalability and adaptability. With the continuous advancement in deep learning methodologies, the system can be enhanced further by incorporating more disease classes and improving model accuracy through transfer learning and larger datasets. Future improvements could include real-time monitoring via drone integration, mobile application deployment, and expansion to other crops beyond cotton.

Furthermore, implementing AI-driven solutions in agriculture fosters sustainable farming by reducing the need for excessive pesticide usage, minimizing environmental impact, and optimizing resource allocation. The integration of this technology ensures that even small-scale farmers with limited access to agricultural experts can benefit from precision farming techniques. Ultimately, this research contributes to the broader vision of leveraging artificial intelligence for smarter and more efficient agricultural practices.

ACKNOWLEDGEMENT

The successful completion of this research would not have been possible without the support and guidance of several individuals and institutions. We would like to express our sincere gratitude to the Department of Information Science at RYMEC, Ballari, for providing the necessary resources and academic support throughout this project.

A special thank you to our project guide, Prof. Sheela B.P., whose continuous mentorship, valuable insights, and constructive feedback were instrumental in shaping this study. Her expertise in deep learning and agricultural technology greatly contributed to the development of this project.

We are also grateful to our peers and colleagues for their encouragement and discussions that provided new perspectives and ideas. Additionally, we extend our appreciation to the developers and contributors of open-source machine learning libraries such as TensorFlow and Keras, whose frameworks enabled us to build and implement the CNN model effectively.

Finally, we acknowledge the contributions of agricultural researchers and farmers who have provided valuable insights into the challenges of plant disease detection. Their feedback and real-world experiences have been vital in ensuring that the proposed system meets practical agricultural needs. This research is dedicated to the advancement of AI-driven solutions for sustainable and efficient farming practices.

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