



CNN-Based Framework for Maize leaf Disease Detection and Crop Monitoring

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Abstract: Maize is an agricultural crop but its productivity is significantly affected by diseases that are often hard to notice at an early stage. Traditional ways of identifying diseases depend on people looking at the plants, which can take a lot of time and needs someone who knows a lot about plants. This paper shows a Smart Maize Crop Monitoring and Disease Detection System that uses machine learning and image processing to help with identifying and managing diseases on maize leaves. The system uses a Convolutional Neural Network to sort images of maize leaves into four groups: Healthy, Common Rust, Blight and Gray Leaf Spot. The images are changed in size. Made different in ways to help the model work better when the pictures are in different positions or under different conditions. The model that was trained is part of a web app built with Flask so people can send images of maize leaves. Get predictions about the disease through an easy way to use. Also the system gives information about how to treat the disease advice on what stage the crop's in and tips on watering the plants. Testing showed that the system could correctly say what the disease was 92% of the time which shows that this way of doing things can be a tool, for growing maize. The system is meant to help find diseases stop people from using the wrong treatments and make growing crops better.

Keywords: Maize Disease Detection, Convolutional Neural Network (CNN), Image Processing, Machine Learning, Smart Agriculture, Flask Web Application.

I. INTRODUCTION

Agriculture is very important for making food and helping the economy grow especially in places where a lot of people rely on farming to make a living. Maize is one of the grown crops and it is used for eating, for animals and for many other uses.. Growing maize is not easy because there are many things that can go wrong. One of the difficulties is plant diseases. Diseases can harm the plants, causing lower yields. Some examples of the diseases include Common Rust, Northern Leaf Blight, and Gray Leaf Spot that damage the leaves of the plants, making them weaker. Hence, it is crucial to identify such diseases for effective crop management and prevent food loss.

In the past, farmers or people knowledgeable about agriculture would examine plants in order to determine whether or not they are diseased. Such an approach can be used; however, it will take time and depend on who is examining the plant. Moreover, it is not accurate. There may be no experts of plant diseases in some regions, and in case of the use of incorrect medicine or delay in assistance, it will only worsen the situation. All the above-mentioned proves the necessity of the disease identification technique that would be quick and convenient. This report claims that manual examination is not a good solution due to its non-real-time nature.

Innovative approaches like machine learning and computer vision have been quite useful. Traditional machine learning models such as Support Vector Machine, K-Nearest Neighbors, and Random Forest require feature extraction by humans in the form of shape and color.. One of the machine learning models known as Convolutional Neural Network can perform feature extraction automatically. Thus, they can be useful in diagnosing plant disease in an image format. Research has demonstrated the effectiveness of Convolutional Neural Networks in detecting plant disease. It is also stated that having data and preprocessing data plays an important role in the process.

Despite all of these developments, some issues persist. Factors such as illumination, image quality, orientation of leaf, and background affect the accuracy of the model. Lack of diversity and sufficient amount of data can also affect the



performance of the model in the real-world setting. According to the research presented in this paper, these two factors present challenges.

In order to solve these problems a Smart Maize Crop Monitoring and Disease Detection System has been proposed in this research paper that utilizes a Convolutional Neural Network and website for this purpose. The system captures images of four varieties of maize leaves namely Healthy, Common Rust, Blight and Gray Leaf Spot. These images are enhanced along with their augmentation prior to the training of model. After training the model is placed within a website created using Flask. Users can upload an image of maize leaf and receive information regarding the disease along with the management strategy. The system has a user interface, a website server, parts that prepare the data the machine learning part and a data part.

The model worked well and had an overall accuracy of 92%. For each type of leaf the accuracy was 98% for Healthy 94% for Common Rust 89% for Blight and 88% for Gray Leaf Spot. The lower scores, for Blight and Gray Leaf Spot are because the symptoms look similar. This shows that using learning with a website can help find maize diseases faster and better. It helps with taking care of the crops in time.

II. LITERATURE SURVEY

In recent times, the efficiency of deep learning and machine learning methods in automated detection of diseases in maize has been proved. A maize plant disease recognition system using the CNN approach was proposed based on image processing methods like CLAHE, log transformation, and RGB to HSV color space conversion. In this study, the maximum accuracy attained was 96.76% [1].

The literature on classification of diseases in maize shows that the use of deep learning, especially CNN-based systems, leads to superior performance compared to conventional machine learning models because of their ability to learn features automatically from images. This review also pointed out the issues associated with the size of the data set, performance of the model, real-time implementation, and generalization in agriculture [2].

In a hybrid model known as PRF-SVM, Bachhal et al. combined PSPNet for segmentation, ResNet50 for deep feature extraction, and Fuzzy SVM for classification. The system was tested on several types of diseases in maize and obtained an average accuracy of 96.67%. The study revealed the effectiveness of combination of segmentation, deep feature extraction, and classification, especially when symptoms of diseases have similarities [3].

Gülmez provided a detailed literature survey of CNN based maize disease detection and discussed various datasets, preprocessing techniques, CNN architectures, evaluation metrics, and optimization techniques. The study focused on the fact that preprocessing and optimization of models may lead to better performance in disease detection and highlighted the issues of diverse dataset, environment variation, and model robustness for future work [4].

To address the issue of classifying similar diseases, CASF-MNet proposed a multi-scale approach that uses RGB and HSV information, cross-attention, and spatial feature fusion. It provided an accuracy of 97.02% and an F1 score of 97.17% on a self-constructed dataset. Additionally, it performed well on public datasets as well. These results prove that color and texture information may help in maize disease classification [5].

Timilsina et al. conducted a literature survey of 82 papers that were published from 2020 to 2024 regarding maize leaf disease detection, segmentation, and classification. According to the survey, classification was the most researched topic, and CNNs, transfer learning, lightweight models, and computer vision techniques were widely used. Also, disease severity estimation, lightweight models, and performance in real-field conditions were the areas where more work could be done [6].

In this paper, Nakatumba-Nabende and Murindanyi conducted a study regarding the performance of different deep learning algorithms for in-field diagnosis of maize diseases through image analysis, based on practical farming conditions. Custom CNNs, MobileNetV2, InceptionResNetV2, Vision Transformers, as well as classical machine learning algorithms have been tested. 97% accuracy was reached by MobileNetV2, while techniques for explainable AI, such as Grad-CAM and LIME, have been utilized to make the model more interpretable. Moreover, models were implemented in a mobile app [7].

The authors of [8] designed an interpretable and lightweight CNN-based model for four different classes of maize leaves: Healthy, Gray Leaf Spot, Common Rust, and Northern Leaf Blight. 94.97% accuracy has been reached by the model with a micro-average AUC of 0.99. LIME and SHAP have been used for interpreting results [8].

Research Gap

From these studies, CNN and hybrid deep learning methods have been proven to perform very well in classifying maize diseases. But there are still problems with the variations in environmental conditions, similar diseases, dataset variations, disease severity analysis, and implementation [3], [4], [6], [7]. Hence, this research aims to create a relatively simple CNN-based system that can classify Healthy, Common Rust, Blight, and Gray Leaf Spot and then integrate the system with a web-based application and suggested treatment. This method achieved an overall test accuracy of 92%.



III. PROBLEM STATEMENT

Maize crops suffer from various diseases including Blight, Common Rust, and Gray Leaf Spot, which can affect the productivity of the crops. Recognizing the symptoms of such diseases is quite challenging and time-consuming. An automated solution to detect such diseases in maize leaves and suggest remedies is therefore highly desirable.

IV. OBJECTIVES

The key objectives of the proposed Smart Maize Crop Monitoring and Disease Detection System are:

1. To design an automated system for maize leaf disease detection using machine learning and image processing.
2. To classify maize leaf images into four categories that are, Healthy, Common Rust, Blight, and Gray Leaf Spot.
3. To design a CNN-based classifier using TensorFlow/Keras to accurately detect any disease.
4. To suggest disease specific suggestions including treatment and prevention measures.

V. METHODOLOGY

The Smart Maize Crop Monitoring and Disease Detection System that has been proposed makes use of a machine learning method based on images for the identification of diseases in maize leaves. The method involves carrying out dataset collection, carrying out image preprocessing, applying data augmentation, using a CNN for classification, integrating the system with a web interface, and then validating the system.

Images of maize leaves in the dataset were sourced through publicly available images from Kaggle and were categorized into four groups: Healthy, Common Rust, Blight, and Gray Leaf Spot. To improve the efficiency of the model in varying real-life situations, these images underwent preprocessing using Pillow, Numpy, and OpenCV. Each image was resized to 128 by 128 pixels and data augmentation methods such as rotation and flipping were used to increase the variety of the training samples.

A Convolutional Neural Network (CNN) was created with the help of TensorFlow and Keras in order to carry out disease classification. This CNN is able to automatically learn the important visual features from images of maize leaves, such as edges, textures, colour patterns, and disease spots, so that there is no need for manual feature extraction. The last layer of the network applies the Softmax activation function in order to classify each input image into one of the four pre-defined disease categories.

The Flask-based web application was equipped with the trained model so as to offer a user-friendly interface for detecting diseases. A user is able to upload an image of a maize leaf, after which the image is processed by the backend and sent to the trained CNN model for prediction. The system will display the disease predicted, along with information regarding its seriousness and advice on treatment. The performance of the whole system was evaluated using the conventional classification measures of accuracy, precision, recall, and F1-score.

VI. IMPLEMENTATION

Python was the language used in the implementation of the proposed system. For the training of the convolutional neural network used in the classification of the diseases, TensorFlow and Keras were used while for preprocessing of images, Pillow, NumPy, and OpenCV libraries were used. Flask library was used for integrating the model into the web application and HTML and CSS were used for designing the user interface. Below is the workflow involved in the implementation process.

Image Upload → Preprocessing → CNNPrediction → Disease Classification → Treatment Recommendation → Result Display When a user uploads an image of the maize leaf, the Flask server handles it. The image is resized to 128 × 128 pixels using the Pillow library and converted into a numerical array using NumPy so that it can be processed by the trained model. The preprocessed image is then provided as input to the trained CNN model, `maize_model.h5`, to predict the corresponding disease class.

The prediction result is displayed in the web interface, along with relevant disease information and treatment recommendation. The application also provides water recommendation and fungicide dosage information that support farmers in making appropriate crop-management decisions.

VII. RESULTS

The proposed CNN model reached an overall test accuracy of 92%. The model was trained for 15 epochs and reached a validation loss of 0.15. The overall precision, recall, and F1-score for the proposed CNN model amounted to approximately 91%, 90%, and 90%, respectively.

The CNN model demonstrated the best performance for Healthy and Common Rust leaves. The recognition of Blight and Gray Leaf Spot proved to be more challenging, likely because of the similarity of their visual appearance. Overall,



the quality of input images significantly affected the prediction outcome, with clear and well-lit pictures producing accurate results and motion-blurred and underexposed ones resulting in incorrect predictions.

Conclusively, the results of the current study prove that it is possible to effectively detect common maize leaf diseases and provide fast web-based access to the pertinent information.

TABLE I EVALUATION METRICS BY DISEASE CLASS

Class	Accuracy	Precision	Recall	F1-score
Healthy	98%	97%	96%	96%
Common Rust	94%	93%	92%	92%
Blight	89%	90%	88%	89%
Gray Leaf Spot	88%	87%	86%	86%

The CNN model demonstrated the best performance for Healthy and Common Rust leaves. The recognition of Blight and Gray Leaf Spot proved to be more challenging, likely because of the similarity of their visual appearance. Overall, the quality of input images significantly affected the prediction outcome, with clear and well-lit pictures producing accurate results and motion-blurred and underexposed ones resulting in incorrect predictions.

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VIII. CONCLUSION

A Smart Maize Crop Monitoring and Disease Detection System is a deep learning model used for detecting common leaf diseases of maize plants. The Smart Maize Crop Monitoring and Disease Detection System was created to resolve inspection limitations, which involve time consumption and possible human errors during diagnoses by analyzing the images of maize leaves offering a reliable means of detecting the crops disease.

The Smart Maize Crop Monitoring and Disease Detection System segments the maize leaf images into four classes: Healthy, Common Rust, Blight, and Gray Leaf Spot. The experiments comprised of cleaning the data, augmentation, and deploying a convolutional neural network (CNN) classifier for enhancing diagnostic accuracy.

An accuracy of ninety-two percent was achieved by using the Smart Maize Crop Monitoring and Disease Detection System. The Smart Maize Crop Monitoring and Disease Detection System recorded ninety-eight percent healthy, ninety-four percent common rust, eighty-nine percent blight, and eighty-eight percent gray leaf spot. Generally, the results demonstrate that the Smart Maize Crop Monitoring and Disease Detection System had the ability to detect and classify the maize leaf diseases effectively. The low accuracy for blight and gray leaf spot resulted from the visual similarities of the two classes.

The Smart Maize Crop Monitoring and Disease Detection System was deployed in a flask web application as a user-friendly interface for predicting maize leaf diseases. The Smart Maize Crop Monitoring and Disease Detection System also provides management options for the detected diseases, such as the treatment dose, recommended intervention time, and monthly water requirements for a healthy crop yield.

Therefore, the Smart Maize Crop Monitoring and Disease Detection System goes beyond the diagnosis and serves as a reminder for effective crop management.

To sum up, the current research paper shows how CNN learning and image processing can be used in the detection and control of plant diseases, including leaf disease in maize plants.

With the help of the Smart Maize Crop Monitoring and Disease Detection System, the manual process is reduced, and fast results are obtained for proper crop management.

However, despite successful results, there are some difficulties when it comes to applying the system in practice, which may affect its performance.

For example, image quality, lighting, and ambiguous vision in disease detection may be the major ones.

Moreover, further research should include implementation of the model in the edge with the use of AI features such as Grad-CAM, multilingualism, and consulting experts to improve the system's performance, reliability, and applicability in farming.

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