© July 2026 | IJIRT | Volume 13 Issue 2 | ISSN: 2349-6002

VerduraScan: Plant Disease Detection Using ML

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***Abstract*—Agriculture is essential for food security, but plant diseases can significantly reduce crop yield and quality. VerduraScan is a Deep Learning-based plant disease detection system that uses Convolutional Neural Networks (CNNs) to identify diseases from leaf images. Developed using Python and deployed through Streamlit, the system provides real-time disease predictions and uses Grad-CAM to highlight affected regions of the leaf for better interpretability. VerduraScan enables early disease detection, helping farmers reduce crop losses and improve agricultural productivity.**

***Index Terms*—Plant Disease Detection, Machine Learning, Deep Learning, Convolutional Neural Networks, Computer Vision, Agriculture, Streamlit, Grad-CAM, Image Processing, Crop Health Monitoring.**

I. INTRODUCTION

1.1 Background

Plant diseases represent one of the major challenges in modern agriculture. Disease outbreaks can spread rapidly and affect large agricultural areas if not detected at an early stage. Farmers often struggle to identify diseases accurately due to limited access to agricultural experts and diagnostic laboratories.

Machine Learning and Computer Vision technologies provide opportunities for developing automated disease diagnosis systems. These systems can analyze digital images of plant leaves and identify disease symptoms based on learned patterns. Deep Learning models, particularly CNNs, have demonstrated exceptional performance in image classification tasks and are increasingly used in agricultural applications.

VerduraScan leverages these technological advancements to create an efficient disease detection system capable of supporting farmers and agricultural professionals.

1.2 Problem Statement

Plant diseases significantly impact crop yield and agricultural productivity. Traditional disease diagnosis relies on manual inspection and expert knowledge, which can be time-consuming and inefficient. Therefore, there is a need for an automated, accurate, and user-friendly system that can detect plant diseases from leaf images and assist farmers in early disease identification.

1.3 Research Objective

- To develop an intelligent plant disease detection system using Deep Learning.
- To train a CNN model capable of classifying healthy and diseased plant leaves.
- To provide real-time disease diagnosis through a Streamlit-based interface.
- To incorporate Grad-CAM visualization for explainable predictions.
- To support sustainable agricultural practices through early disease detection.

1.4 Scope

The scope of VerduraScan includes image-based disease diagnosis for multiple plant species using Deep Learning techniques.

The system supports:

- Detection of various plant diseases.
- Real-time image analysis.
- Disease information and recommendations.
- Explainable AI through Grad-CAM visualization.
- Web-based accessibility using Streamlit.

Future versions can incorporate mobile deployment, IoT integration, and cloud-based disease monitoring systems.

1.5 Limitations of the study

Although VerduraScan demonstrates strong performance, several limitations remain:

- Prediction accuracy depends on image quality.
- Only diseases included in the training dataset can be detected.
- Environmental variations may affect classification performance.
- Continuous retraining may be required for newly emerging diseases.
- Internet access may be required for cloud-based deployment.

II. LITERATURE REVIEW

Advancements in Artificial Intelligence, Machine Learning, and Computer Vision have significantly improved automated plant disease detection systems. Researchers have explored numerous techniques to identify diseases from leaf images and assist farmers in crop management.

2.1 Role of Image Processing in Plant Disease Detection

Image processing forms the foundation of automated disease diagnosis systems. Before classification, images undergo several preprocessing operations including resizing, normalization, filtering, and enhancement.

In VerduraScan, uploaded images are resized and normalized before being passed to the CNN model for classification.

2.2 Role of Convolutional Neural Networks (CNN)

CNNs automatically extract relevant features from images without requiring manual feature engineering. The architecture consists of convolution layers, activation functions, pooling layers, and fully connected layers. These components work together to identify disease patterns and classify leaf images accurately.

VerduraScan employs a CNN model trained on thousands of healthy and diseased leaf images to achieve reliable disease recognition.

2.3 Role of Data Augmentation

Data augmentation is used to increase dataset diversity and improve model generalization.

These transformations help the model become more robust against variations in image orientation, lighting conditions, and environmental factors.

In VerduraScan, augmentation techniques are applied during training to reduce overfitting and improve real-world performance.

2.4 Deep Learning in Agriculture

Deep Learning technologies have transformed agricultural applications including disease detection, crop classification, yield prediction, and weed identification.

Compared to traditional machine learning methods, deep learning models can process large datasets and learn complex visual patterns automatically.

VerduraScan leverages these advancements to provide an efficient and scalable disease diagnosis solution.

III. EXISTING SYSTEM

Plant disease detection has traditionally relied on manual observation and expert consultation. Farmers visually inspect crops for symptoms such as leaf discoloration, spots, lesions, wilting, and fungal growth. In cases where diseases are difficult to identify, agricultural experts or laboratory testing are required for accurate diagnosis. While effective, these methods can be time-consuming, costly, and dependent on the availability of skilled professionals.

To automate disease detection, several computer-based systems have been developed using image processing and machine learning techniques such as image segmentation, color analysis, texture extraction, Support Vector Machines (SVM), Decision Trees, Random Forests, and K-Nearest Neighbors (KNN). Although these methods provide reasonable accuracy, they often require manual feature extraction and perform poorly under varying real-world conditions such as changes in lighting, background, and image quality. Additionally, many existing systems lack user-friendly interfaces and explainable predictions, limiting their practical use for farmers.

3.1 Limitations of Existing system

- Manual Feature Extraction: Traditional methods rely on handcrafted features such as color, texture, and shape, making the process time-consuming and less efficient.

- Poor Generalization: Many models perform well on laboratory images but show reduced accuracy on real-world images with varying lighting, backgrounds, and image quality.
- Expert Dependency: Accurate disease diagnosis often requires validation by agricultural experts, limiting the system's independent use.
- High Computational Cost: Some deep learning models require significant computational resources, making them difficult to deploy on low-cost devices.
- Limited Accessibility: Many solutions are not designed with user-friendly interfaces, reducing their accessibility for farmers and non-technical users.

3.2 Proposed System

The proposed system, VerduraScan, is an intelligent plant disease detection platform that uses a Convolutional Neural Network (CNN) to automatically identify diseases from plant leaf images. The system is deployed as a Streamlit-based web application, allowing users to upload leaf images and receive real-time disease predictions. To improve transparency, VerduraScan integrates Grad-CAM to highlight the infected regions and provides disease information along with preventive and treatment recommendations.

Key Features include:

1. Automatic Feature Learning: CNN automatically extracts disease features from leaf images.
2. Real-Time Prediction: Provides instant disease diagnosis through a Streamlit web interface.
3. Explainable AI: Uses Grad-CAM to visualize disease-affected regions on the leaf.
4. Disease Information: Provides disease descriptions, preventive measures, and treatment recommendations.
5. User-Friendly Interface: Simple and accessible for farmers, students, and researchers.
6. Scalable Design: Can be extended to support additional crops and diseases in the future.

3.2.1 Advantages of Proposed System

Improved Decision-Making: Provides accurate disease information to help users take timely corrective actions.

Time Saving: Delivers disease diagnosis quickly, reducing the time required for manual inspection.

Enhanced Reliability: Produces consistent results by minimizing human errors in disease identification.

Better Transparency: Enables users to understand the prediction through visual explanations using Grad-CAM.

Easy Accessibility: Can be accessed through a web browser without installing complex software.

Supports Sustainable Farming: Promotes efficient disease management, reducing unnecessary pesticide usage.

Reduced Crop Losses: Facilitates early intervention, helping to protect crop health and yield.

Flexible and Expandable: Can be enhanced to include new crops, diseases, and advanced AI techniques.

Cost Efficient: Reduces dependence on frequent expert consultations and laboratory analysis.

3.3 Data Flow and Architecture

The architecture of VerduraScan consists of multiple interconnected modules that work together to perform disease detection and visualization.

The workflow begins when a user uploads a plant leaf image through the web application. The uploaded image is preprocessed to standardize dimensions and improve image quality.

The processed image is then passed through the CNN model, which extracts relevant features and classifies the disease. After classification, Grad-CAM generates a heatmap highlighting the regions responsible for the prediction.

Finally, the system displays the disease name, confidence score, heatmap visualization, disease information, preventive measures, and treatment recommendations.

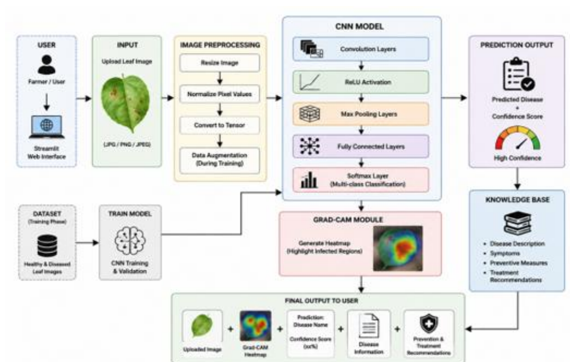

Fig 1. SYSTEM ARCHITECTURE

3.3.1 Flow of Information

1 Image Acquisition Module

The image acquisition module is responsible for collecting plant leaf images from users. Images are uploaded through the Streamlit interface and serve as the primary input to the system.

2 Image Preprocessing Module

Preprocessing prepares images for analysis by removing inconsistencies and improving image quality.

The preprocessing operations include:

- Image resizing.
- Pixel normalization.
- Noise reduction.
- Data standardization.

The resized images are converted into a format suitable for CNN processing.

3 CNN Classification Module: The CNN module serves as the core component of VerduraScan.

The network automatically learns hierarchical image features from training data. Early layers identify basic patterns such as edges and textures, while deeper layers learn disease-specific characteristics.

The final layer classifies the image into one of the predefined disease categories.

4 Grad-CAM Visualization Module: Grad-CAM improves model interpretability by generating heatmaps that highlight regions contributing most significantly to the prediction.

3.4 Technologies Used

1. Python: Python is the primary programming language used in VerduraScan. Its simplicity, readability, and extensive library support make it ideal for machine learning applications.
2. TensorFlow: TensorFlow is an open-source Deep Learning framework developed by Google. It is used for constructing, training, and evaluating the CNN model used in VerduraScan. TensorFlow provides optimized computational performance and GPU acceleration support.
3. Keras: Keras is a high-level neural network API built on top of TensorFlow. It simplifies CNN implementation by providing user-friendly functions for creating layers, compiling models, and performing training operations.
4. OpenCV: OpenCV is a powerful computer vision library used for image manipulation and preprocessing. In VerduraScan, OpenCV is used for image resizing, normalization, and visualization operations.
5. NumPy: NumPy is used for numerical computations and matrix operations. Since images are represented as multidimensional arrays, NumPy plays a critical role in data preprocessing and model training.
6. Matplotlib: Matplotlib is used for generating visual outputs, including Grad-CAM heatmaps and performance plots. The library helps users understand prediction outcomes through graphical representations.
7. Streamlit: Streamlit is an open-source framework used to create interactive web applications. VerduraScan uses Streamlit to provide a simple and intuitive interface where users can upload images and view disease predictions.

3.5 Algorithms Used

The proposed VerduraScan system primarily uses a Convolutional Neural Network (CNN) for plant disease detection and classification. Supporting techniques such as the ReLU activation function, Max Pooling, Softmax, and Gradient-weighted Class Activation Mapping (Grad-CAM) are integrated within the model to improve feature learning, prediction accuracy, and result interpretability. Together, these algorithms enable accurate, real-time, and explainable plant disease diagnosis.

1. Convolutional Neural Network (CNN)

Application: Used as the primary algorithm for plant disease classification.

Description: The Convolutional Neural Network (CNN) is a Deep Learning algorithm designed for image classification tasks. It automatically learns disease-related features from plant leaf images through convolution, activation, pooling, and fully connected layers, eliminating the need for manual feature extraction.

Working:

The uploaded leaf image is preprocessed and resized.

Convolution layers extract important image features.

- Pooling layers reduce feature dimensions while preserving essential information.

- Fully connected layers classify the image into the corresponding disease category.

Justification: CNN provides high classification accuracy, automatically extracts image features, and performs effectively on large-scale plant disease datasets.

2. ReLU (Rectified Linear Unit) Activation Function

Application: Used in the hidden layers of the CNN to introduce non-linearity.

Description: ReLU is an activation function that outputs the input value if it is positive; otherwise, it returns zero. It enables the network to learn complex patterns from plant leaf images.

Working:

Receives the output from convolution layers.

Applies the function ReLU(x) = max (0, x).

Passes only positive values to the next layer.

Justification: ReLU accelerates model training, improves computational efficiency, and helps overcome the vanishing gradient problem.

3. Max Pooling

Application: Used after convolution layers to reduce feature map dimensions.

Description: Max Pooling selects the maximum value from each pooling region, preserving the most important features while reducing computational complexity.

Working: Divides the feature map into small regions.

Selects the maximum value from each region.

Generates a smaller and more robust feature representation.

Justification: Max Pooling reduces computation, minimizes overfitting, and improves feature robustness.

4. Softmax Function

Application: Used in the output layer for multi-class disease classification.

Description: The Softmax function converts the network outputs into probability values for each disease class.

Working:

Computes probability scores for all disease classes.

Ensures the probabilities sum to one.

Selects the class with the highest probability as the final prediction.

Justification: Softmax is widely used for multi-class classification and provides confidence scores for predicted diseases.

5. Gradient-weighted Class Activation Mapping (Grad-CAM)

Application: Used to generate visual explanations for disease predictions.

Description: Grad-CAM is an Explainable Artificial Intelligence (XAI) technique that highlights the regions of the leaf image responsible for the CNN's prediction by generating heatmaps.

Working:

- Computes gradients from the final convolution layer.
- Determines the importance of feature maps.
- Produces a heatmap highlighting disease-affected regions on the leaf.

Justification: Grad-CAM improves model transparency, increases user confidence, and enables easier validation of disease predictions by visually explaining the model's decisions.

IV. FUTURE ENHANCEMENTS

To further improve the system, the following features can be added:

- Mobile Application Development -A dedicated Android and iOS application can increase accessibility for farmers.
- IoT Integration - Smart sensors can be integrated for real-time crop monitoring.
- Cloud-Based Deployment - Cloud infrastructure can support large-scale agricultural monitoring systems.
- Drone-Based Disease Detection - Drone imagery can be analyzed to monitor large agricultural fields.
- Multilingual Support - Supporting multiple languages will improve usability among diverse farming communities.
- Treatment Recommendation System - AI-based recommendation engines can suggest pesticides, fertilizers, and disease management strategies.
- Real-Time Field Monitoring - Live camera feeds can be integrated for continuous disease surveillance.

V. CONCLUSION

Agriculture is essential for global food security, but plant diseases significantly affect crop yield and quality. This research presented VerduraScan, a Deep Learning-based plant disease detection system that uses a Convolutional Neural Network (CNN) for accurate disease classification and Grad-CAM for explainable predictions. The Streamlit-based web application enables real-time and user-friendly disease diagnosis.

Experimental results demonstrate that the proposed system achieves high classification accuracy across multiple disease categories. By integrating Explainable Artificial Intelligence (XAI), VerduraScan improves prediction transparency and user confidence. Overall, the system provides an effective solution for early plant disease detection and supports sustainable agricultural practices.

REFERENCES

[1] Mohanty, S. P., D. P. Hughes, and M. Salathé, "Using deep learning for image-based plant disease detection," Frontiers in Plant Science, vol. 7, Art. no. 1419, 2016.

[2] Ferentinos, K. P., "Deep learning models for plant disease detection and diagnosis," Computers and Electronics in Agriculture, vol. 145, pp. 311–318, 2018.

[3] Kamilaris, A., and F. X. Prenafeta-Boldú, "Deep learning in agriculture: A survey," Computers and Electronics in Agriculture, vol. 147, pp. 70–90, 2018.

[4] Too, E. C., L. Yujian, S. Njuki, and L. Yingchun, "A comparative study of fine-tuning deep learning models for plant disease identification," Computers and Electronics in Agriculture, vol. 161, pp. 272–279, 2019.

[5] Selvaraju, R. R., et al., "Grad-CAM: Visual explanations from deep networks via gradient-based localization," in Proc. IEEE Int. Conf. Computer Vision (ICCV), 2017, pp. 618–626.

[6] TensorFlow Documentation. Available: https://www.tensorflow.org. Accessed: [insert access date].

[7] Keras Documentation. Available: https://keras.io. Accessed: [insert access date].

[8] Streamlit Documentation. Available: https://streamlit.io. Accessed: [insert access date].

[9] PlantVillage Dataset. Available: https://plantvillage.psu.edu. Accessed: [insert access date].

[10] Goodfellow, I., Y. Bengio, and A. Courville, Deep Learning. Cambridge, MA: MIT Press, 2016.