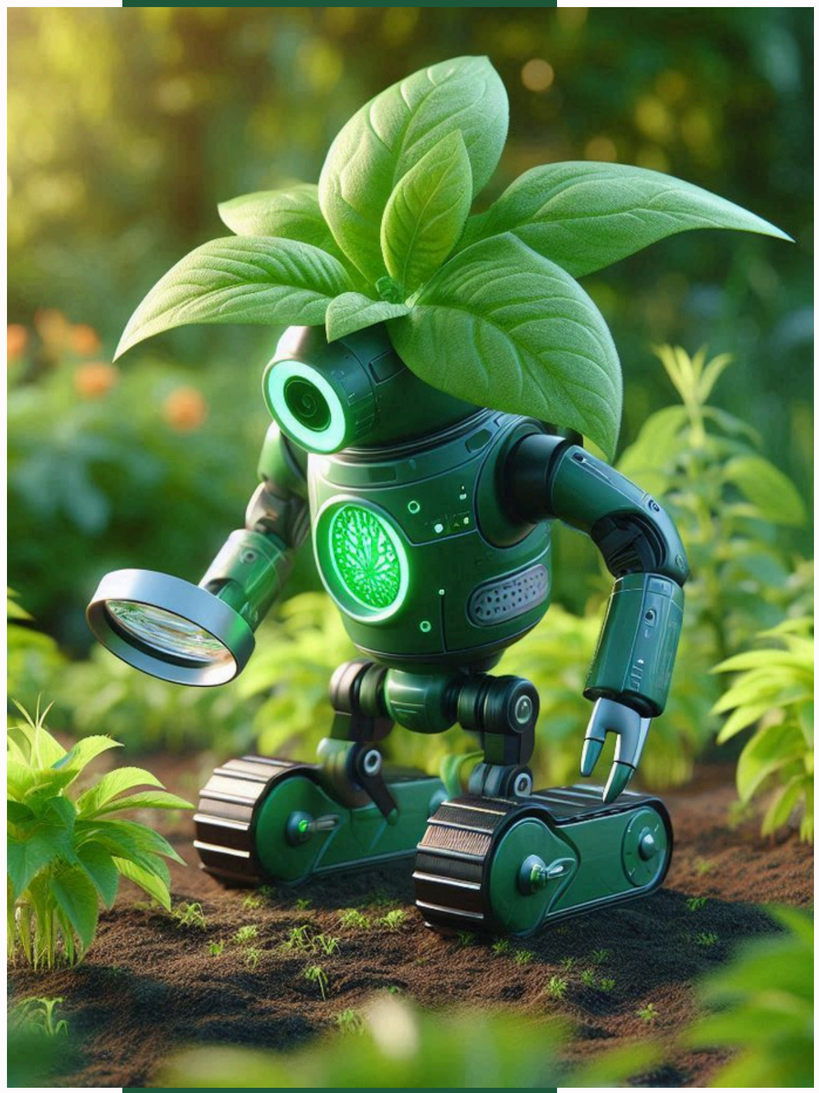
The Catholic University of
Eastern Africa

Plant Patrol

# AI-DRIVEN PLANT DISEASE DETECTION SYSTEM



## Group Name:

PlantPatrol

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## Group Slogan:

Your Plants, Our Priority

## Topic:

AI for Climate Change, Agriculture and Food Security Project

## Title:

AI-Driven Plant Disease Detection System

# Abstract:

Plant diseases pose a significant threat to global food security, leading to crop losses and affecting farmers, especially in developing regions. Traditional detection methods are often inaccessible to small-scale farmers. PlantPatrol proposes an AI-driven plant disease detection system utilizing image recognition technology to offer real-time, accurate disease diagnoses via mobile technology. The system aims to empower farmers with an accessible, scalable, and user-friendly tool, promoting sustainable farming practices and reducing environmental damage.

# Introduction

## Problem Statement:

Plant diseases result in significant crop losses, particularly affecting small-scale farmers in developing regions. Traditional detection methods require expert knowledge and are time-consuming, making them inaccessible for many farmers. This delays intervention, exacerbating disease spread and reducing yields.

# Objective

To develop an AI-based plant disease detection system that provides real-time, accurate diagnoses through image recognition technology, integrated with mobile technology for easy access by farmers.

# Literature Review

Several studies have explored the use of AI for plant disease detection, including the integration of AI models with WhatsApp chatbots.

- **CNN-based Approaches**: CNNs have shown excellent performance in image classification tasks, including plant disease detection. Studies have demonstrated the effectiveness of CNNs in accurately identifying various plant diseases from images.
- **Hybrid Approaches**: Combining multiple AI techniques, such as CNNs and support vector machines, can improve the accuracy and robustness of plant disease detection systems.
- **WhatsApp Chatbot Integration**: Researchers have developed WhatsApp chatbots that utilize AI models for plant disease diagnosis. These chatbots have shown promising results in providing timely and accurate information to farmers.

# Challenges

Despite the advancements in AI-based plant disease detection, several challenges remain:

- **Data Quality**: The accuracy of AI models depends on the quality and quantity of training data. Obtaining high-quality labelled images can be challenging, especially for rare or emerging diseases.
- **Computational Resources**: Training and deploying AI models can be computationally intensive, requiring significant hardware resources.
- **User Experience**: Designing user-friendly interfaces that can effectively interact with farmers of varying technical expertise is essential for widespread adoption.

# Methodology

- **Data Collection:** A diverse dataset of healthy and diseased plant images will be sourced from PlantVillage, Kaggle, and other agricultural databases. This data will be accompanied by metadata like disease severity, plant type, and location.
- **Data Preprocessing:** The images will be standardized and preprocessed to remove noise and ensure uniformity. Data augmentation techniques like rotation and cropping will be applied to increase variability, making the model more robust.

# Methodology

- **Model Development**: A Convolutional Neural Network (CNN) will be employed to detect plant diseases. Transfer learning with models such as VGG16 and ResNet50 will help boost accuracy. Hyperparameter tuning will be conducted to optimize the model.
- **WhatsApp Integration**: A WhatsApp Business API will create a chatbot for farmers to upload images. AWS cloud services will enable real-time image analysis and feedback. The chatbot will guide farmers through image submission and diagnosis.

# Methodology

- **Validation and Testing:** The model will be validated using a separate test set, with metrics like precision, recall, and F1-score guiding performance evaluation. Field tests with farmers will further refine the system based on real-world feedback.
- **Deployment and Scalability:** The solution will be deployed on a scalable cloud platform. Training sessions and support materials will help farmers adopt the system. Continuous monitoring will refine the model. Potential revenue models include partnerships with agricultural institutions or government programs and a subscription-based model for larger farms.

# MODEL AND DATA PREPARATION

- **DATASET COMPOSITION**:
  - THE TRAINING DATASET INCLUDES 14 DIFFERENT PLANTS AND 38 CATEGORIES OF DISEASES (INCLUDING HEALTHY CASES).
  - TOTAL IMAGES AVAILABLE FOR TRAINING: 70,295.
- **BALANCED DATA**: THE DATASET ENSURES THAT ALL DISEASE CATEGORIES HAVE A SIMILAR NUMBER OF IMAGES, REDUCING THE CHANCES OF BIAS IN PREDICTIONS.
- **IMAGE SIZE**: ALL IMAGES ARE RESIZED TO 256X256 FOR UNIFORMITY AND COMPATIBILITY WITH THE MODEL.

# AI MODEL – HOW IT WORKS

- MODEL ARCHITECTURE: USES A RESNET-9 MODEL (A DEEP LEARNING MODEL) THAT EFFECTIVELY CLASSIFIES PLANT DISEASES BY:

1. EXTRACTING FEATURES FROM IMAGES.
2. USING RESIDUAL CONNECTIONS TO SOLVE THE “VANISHING GRADIENT” PROBLEM (ALLOWS DEEPER NETWORKS TO TRAIN).
3. TRAINING PROCESS: THE MODEL ITERATES THROUGH THE DATASET, ADJUSTING PARAMETERS TO MINIMIZE PREDICTION ERRORS.

- TRAINING RESULTS:

1. ACHIEVED 99.2% ACCURACY ON BOTH VALIDATION AND TEST DATA
2. DEMONSTRATED EXCELLENT PERFORMANCE ON THE SMALL TEST DATASET OF 33 IMAGES, WITH ZERO ERRORS IN PREDICTIONS.

# PERFORMANCE METRICS & VISUALIZATION

- **ACCURACY OVER TIME**: RAPID IMPROVEMENT WITH VALIDATION ACCURACY JUMPING FROM 83% IN THE FIRST EPOCH TO 99.2% BY THE END OF TRAINING.
- **TRAINING VS. VALIDATION LOSS**: THE MODEL MAINTAINS LOW ERROR RATES, INDICATING IT GENERALIZES WELL TO NEW DATA.
- **LEARNING RATE MONITORING**: A DYNAMIC LEARNING RATE ADJUSTMENT (ONE CYCLE POLICY) ENSURES EFFICIENT AND STABLE TRAINING WITHOUT OVERFITTING.

# IMPACT AND VISION

- **EMPOWERING FARMERS**: THE SYSTEM PROVIDES NON-TECHNICAL FARMERS WITH INSIGHTS INTO PLANT HEALTH, ENABLING FASTER INTERVENTIONS.
- **PROMOTING SUSTAINABILITY**: REDUCES PESTICIDE USE BY IDENTIFYING DISEASES EARLY AND SUGGESTING TARGETED TREATMENT.
- **LONG-TERM VISION**: AIMS TO ENHANCE GLOBAL FOOD SECURITY BY ENSURING HIGHER YIELDS WITH HEALTHIER CROPS.

# Recommendations

To ensure the PlantPatrol project achieves long-term impact and scalability, here are key recommendations:

1. **Expand Crop and Disease Coverage**:
Add support for more crops and region-specific diseases to serve a wider range of farmers.
Engage users to upload new images to improve the AI model's training with diverse datasets.

## 2. Enhance the Chatbot's Capabilities

- Multi-language Chatbot: Expand the language support for greater inclusivity across different regions.
- Voice Command Integration: Implement voice-based interactions for non-literate users.
- Offline Functionality: Develop features that work even with limited internet connectivity for remote areas.

## 3. Continuous Monitoring and Feedback Loop

- Pesticide Use Tracking: Regularly monitor pesticide usage and measure reductions to assess environmental impact.
- User Feedback Mechanism: Collect ongoing feedback to identify pain points and improve the chatbot interface and disease detection model.

# Conclusion

The PlantPatrol AI-driven disease detection system exemplifies how technology can revolutionize agriculture. It addresses critical challenges such as food security and crop loss by empowering farmers with instant, accessible solutions for plant disease management.

With 99.2% accuracy, the model offers reliable predictions while promoting sustainable practices by reducing unnecessary pesticide use. By enhancing crop yields and farmer productivity, PlantPatrol contributes to economic stability in farming communities, especially in developing regions.

Moving forward, scaling this initiative through regional customization, partnerships, and enhanced AI capabilities will ensure broader adoption and deeper impact. The project envisions a future where technology and agriculture seamlessly merge, leading to healthier crops, empowered farmers, and a more sustainable planet.

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# THANK YOU


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