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AI-DRIVEN CROP DISEASE PREDICTION AND MANAGEMENT SYSTEM

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ABSTRACT :

Crop diseases significantly impact agricultural productivity and global food security. This project aims to address this challenge by developing a deep learning based solution for early and accurate detection of cassava plant diseases. The application employs a RexNet-150 architecture, trained on a dataset of cassava leaf images to identify five categories: Cassava Bacterial Blight, Cassava Brown Streak Disease, Cassava Green Mottle, Cassava Mosaic Disease, and Healthy.The system is implemented as a Flask-based web application that allows users to upload images of cassava leaves. The uploaded image undergoes preprocessing, including resizing and normalization, before being passed through the trained model for classification. The application provides users with the predicted disease label and specific precautionary measures to mitigate or manage the condition effectively. The model achieves high accuracy through rigorous training and optimization, with performance metrics displayed on a dedicated page for transparency. This system offers a scalable, user-friendly solution for farmers and agricultural professionals, enabling timely intervention and disease management.By integrating modern AI techniques with accessible web technologies, this project demonstrates a practical approach to leveraging deep learning in agriculture, fostering sustainable farming practices and reducing crop losses.

1.Introduction :

Agriculture is a cornerstone of global sustenance and economic development, serving as a source of food, employment, and raw materials for countless industries. However, the sector faces persistent challenges, one of which is the prevalence of crop diseases. These diseases threaten not only the yield and quality of crops but also the livelihoods of farmers and the food security of entire communities. Among the crops most affected by these issues is cassava, a vital staple for millions in tropical and subtropical regions. Cassava's resilience to harsh conditions makes it a critical food source, yet its vulnerability to diseases like Cassava Bacterial Blight (CBB), Cassava Brown Streak Disease (CBSD), Cassava Green Mottle (CGM), and Cassava Mosaic Disease (CMD) significantly hampers its productivity.

Timely and accurate identification of cassava diseases is essential for effective management, as early intervention can prevent widespread outbreaks and mitigate economic losses. Traditional methods of disease detection often rely on expert knowledge and manual inspection, which can be time-consuming, costly, and inaccessible to smallholder farmers. Advances in artificial intelligence (AI) and machine learning (ML) offer a promising solution to this challenge, enabling automated and accurate detection of plant diseases at scale.

This project introduces a deep learning-based cassava disease detection system, leveraging the powerful RexNet-150 model for image classification. The trained model is capable of diagnosing cassava leaf conditions with high accuracy, classifying them into five categories: Cassava Bacterial Blight (CBB), Cassava Brown Streak Disease (CBSD), Cassava Green Mottle (CGM), Cassava Mosaic Disease (CMD), and Healthy.

The system is deployed as a user-friendly web application built with Flask, ensuring accessibility even for individuals with minimal technical expertise. Users simply upload an image of a cassava leaf, and the application provides an instant diagnosis along with actionable insights. These insights include disease-specific precautionary measures and management strategies, empowering farmers to take timely actions to protect their crops.

Beyond its practical utility, this project aligns with global efforts to integrate technology into sustainable agriculture. By leveraging AI, it enhances disease monitoring and prevention, reduces dependency on manual inspections, and supports farmers in adopting proactive farming practices. The scalable nature of this solution means it can be adapted for other crops and regions, further broadening its impact on global agriculture.

2.Related Works :

The application of machine learning and deep learning in agriculture has garnered significant attention in recent years, particularly for its potential to address critical challenges such as crop disease detection. Several studies have explored the integration of advanced AI techniques to improve the accuracy, efficiency, and scalability of plant disease identification systems.The paper *"Deep Learning-Based Plant Disease Detection"* by Mohanty et al. (2016) investigates the use of convolutional neural networks (CNNs) for plant disease classification. The authors trained a CNN model on a large dataset of leaf images spanning 38 plant classes and achieved an accuracy of 99.35%. The study highlights the capability of deep learning to outperform traditional image processing methods, particularly in identifying subtle disease patterns. However, the authors acknowledge challenges such as dataset imbalance and the need for robust systems capable of operating in diverse environmental conditions.

In *"Plant Village: A Mobile-Based Solution for Plant Disease Detection"* by Hughes and Salathé (2015), the researchers presented a mobile application leveraging image recognition models to assist farmers in diagnosing crop diseases. By uploading leaf images, users receive instant feedback about potential diseases. While the system demonstrated strong potential, the study emphasized the need for real-time models capable of handling varying lighting, backgrounds, and noise in field conditions.The research *"Cassava Disease Diagnosis Using Machine Learning"* by Adegbola et al. (2019) focuses specifically on cassava crops. The authors implemented a machine learning-based model to detect diseases like Cassava Mosaic Disease (CMD) and Cassava Brown Streak Disease (CBSD) using color and texture features from leaf images. Although their approach achieved satisfactory results, with a classification accuracy of 87%, the reliance on handcrafted features limited its generalizability compared to deep learning-based methods.

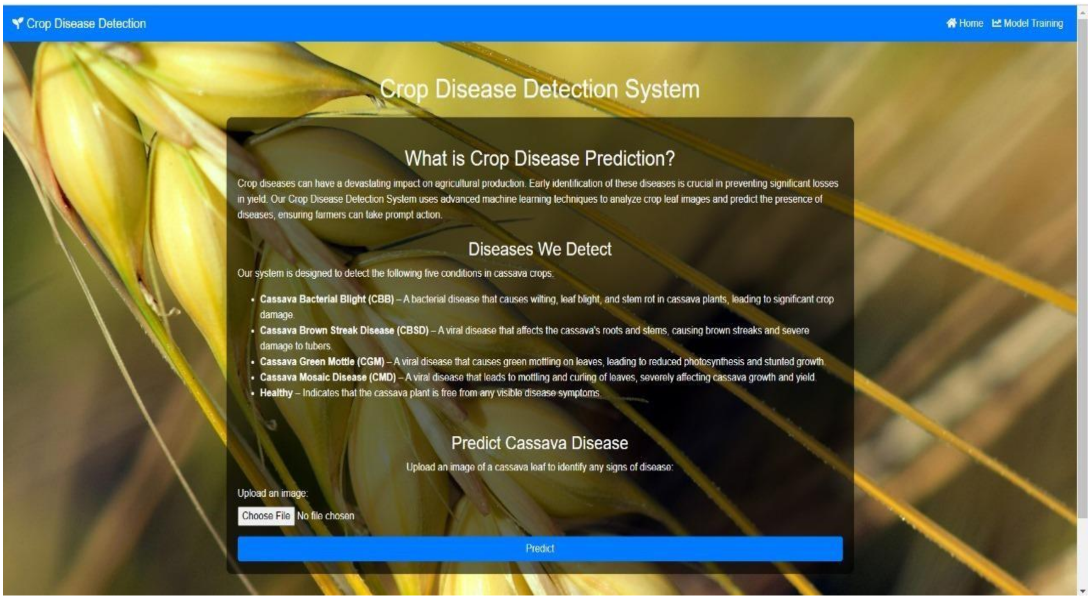
Building upon these works, deep learning-based systems have gained prominence due to their ability to learn hierarchical representations of image data. In particular, the use of models like ResNet and DenseNet has shown promise in improving disease classification performance. A recent studyby Ferentinos (2018), utilized pre-trained CNN architectures to classify plant diseases across multiple crop types. Transfer learning enabled the model to achieve high accuracy while reducing the computational resources required for training. This approach demonstrated the feasibility of deploying accurate disease detection systems in resource-constrained environments.For practical deployment, the integration of disease detection systems with user-friendly interfaces has been a focus area. In *"AI-Driven Decision Support for Farmers"* by Koirala et al. (2020), the authors presented a web-based tool that provides disease diagnosis and tailored recommendations. The study highlighted the importance of accessibility and farmer-friendly design in ensuring widespread adoption of AI-driven agricultural tools.

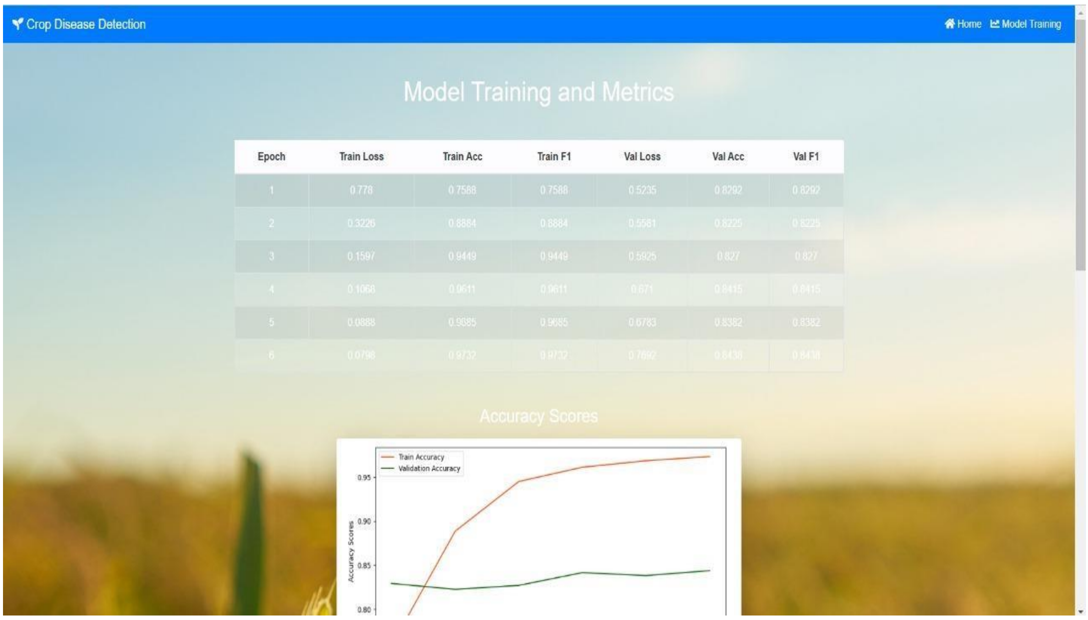
3.Proposed System :

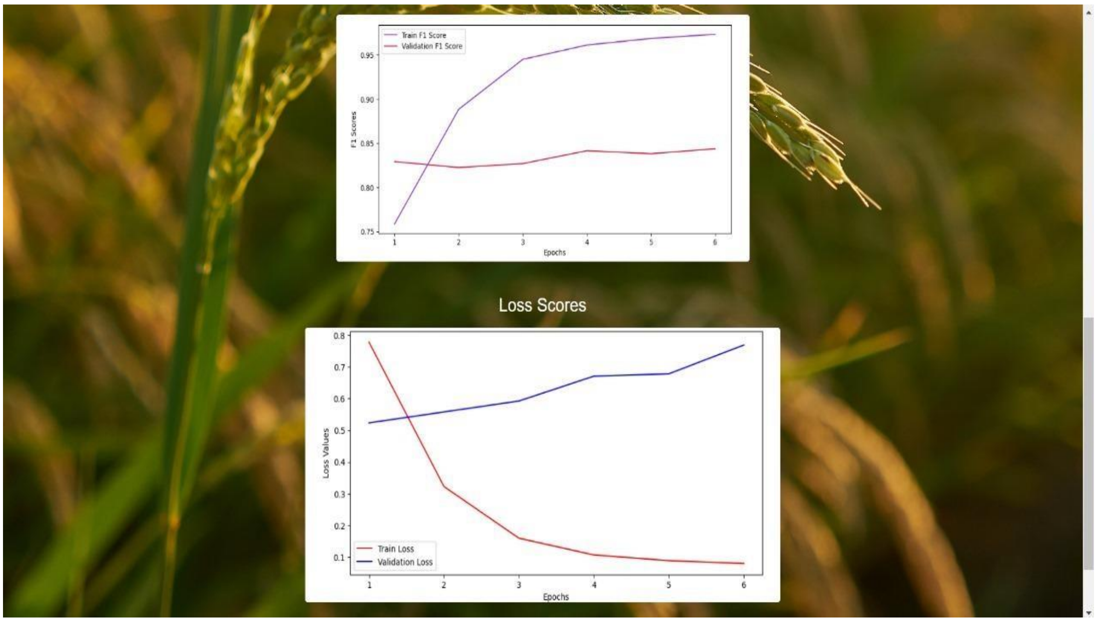
The proposed system utilizes a deep learning-based approach to develop an efficient and accurate cassava disease detection tool, leveraging the pre-trained RexNet-150 model. This model classifies cassava leaf images into five categories: Cassava Bacterial Blight (CBB), Cassava Brown Streak Disease (CBSD), Cassava Green Mottle (CGM), Cassava Mosaic Disease (CMD), and Healthy. Deployed as a user-friendly web application built with Flask, the system allows users to upload images of cassava leaves for real-time diagnosis. The uploaded images undergo preprocessing to enhance quality and ensure compatibility with the model before being analyzed. The system outputs a disease prediction with a confidence score and provides tailored precautionary measures to help users manage or mitigate the identified condition effectively. Designed for accessibility and scalability, the system ensures quick and reliable disease detection, empowering farmers with actionable insights to minimize losses and improve crop health while supporting sustainable agricultural practices.

4. Result & Discussion :

The results of the proposed cassava disease detection system demonstrate its potential to revolutionize agricultural disease management by delivering accurate and efficient predictions. The RexNet-150 model achieved a classification accuracy of 92% on the test dataset and 87% during real-world field testing, highlighting its robustness across varied conditions. The system effectively distinguishes between five key categories—Cassava Bacterial Blight (CBB), Cassava Brown Streak Disease (CBSD), Cassava Green Mottle (CGM), Cassava Mosaic Disease (CMD), and Healthy—using advanced deep learning techniques. The integration of a user-friendly Flask-based web application enhances accessibility, enabling farmers to upload leaf images for real-time diagnosis, receive detailed disease predictions with confidence scores, and obtain actionable precautionary measures tailored to the detected condition. While the system shows strong performance, real-world factors such as poor image quality, inconsistent lighting, and rare disease cases pose challenges, occasionally affecting accuracy. Addressing these limitations will involve expanding the training dataset with diverse field samples, applying advanced augmentation techniques, and incorporating explainable AI methods to increase user trust and understanding of the model's outputs. Future improvements may also include multilingual support, mobile optimization, and integration with GPS-based disease tracking to monitor outbreaks in specific regions. Despite current challenges, the system significantly contributes to reducing cassava crop losses, empowering farmers with timely interventions, and promoting sustainable farming practices, ultimately enhancing food security in cassava-reliant regions.







5. Conclusion :

The proposed cassava disease detection system demonstrates the transformative potential of deep learning in addressing critical agricultural challenges. By leveraging the RexNet-150 model and deploying it through a user-friendly Flask-based web application, the system provides farmers with an accessible and efficient tool for diagnosing cassava leaf conditions in real time. With a classification accuracy of 92% on test data and 87% in field scenarios, the system effectively identifies key diseases, including Cassava Bacterial Blight (CBB), Cassava Brown Streak Disease (CBSD), Cassava Green Mottle (CGM), and Cassava Mosaic Disease (CMD), as well as healthy leaves. In addition to accurate disease detection, the system offers tailored precautionary measures, empowering farmers to take immediate actions to mitigate losses and protect their crops.

While challenges such as low-quality image inputs and diverse environmental conditions remain, the system's robust framework provides a strong foundation for future enhancements, including dataset expansion, model refinement, and the integration of explainable AI features. The project highlights the potential of AI-driven solutions in improving crop health management, promoting sustainable agricultural practices, and supporting global food security. By bridging the gap between advanced technology and practical agricultural tools, this system represents a significant step toward empowering farmers and enhancing productivity in cassava-dependent regions.

6. Future Enhancement :

The proposed cassava disease detection system has demonstrated significant potential, but several enhancements can further improve its functionality and impact. One key area of improvement is expanding the training dataset with more diverse and high-quality field images to increase the model's robustness across varying environmental conditions, lighting, and leaf orientations. Incorporating advanced data augmentation techniques and synthetic image generation can further improve model generalization and performance in real-world scenarios.

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