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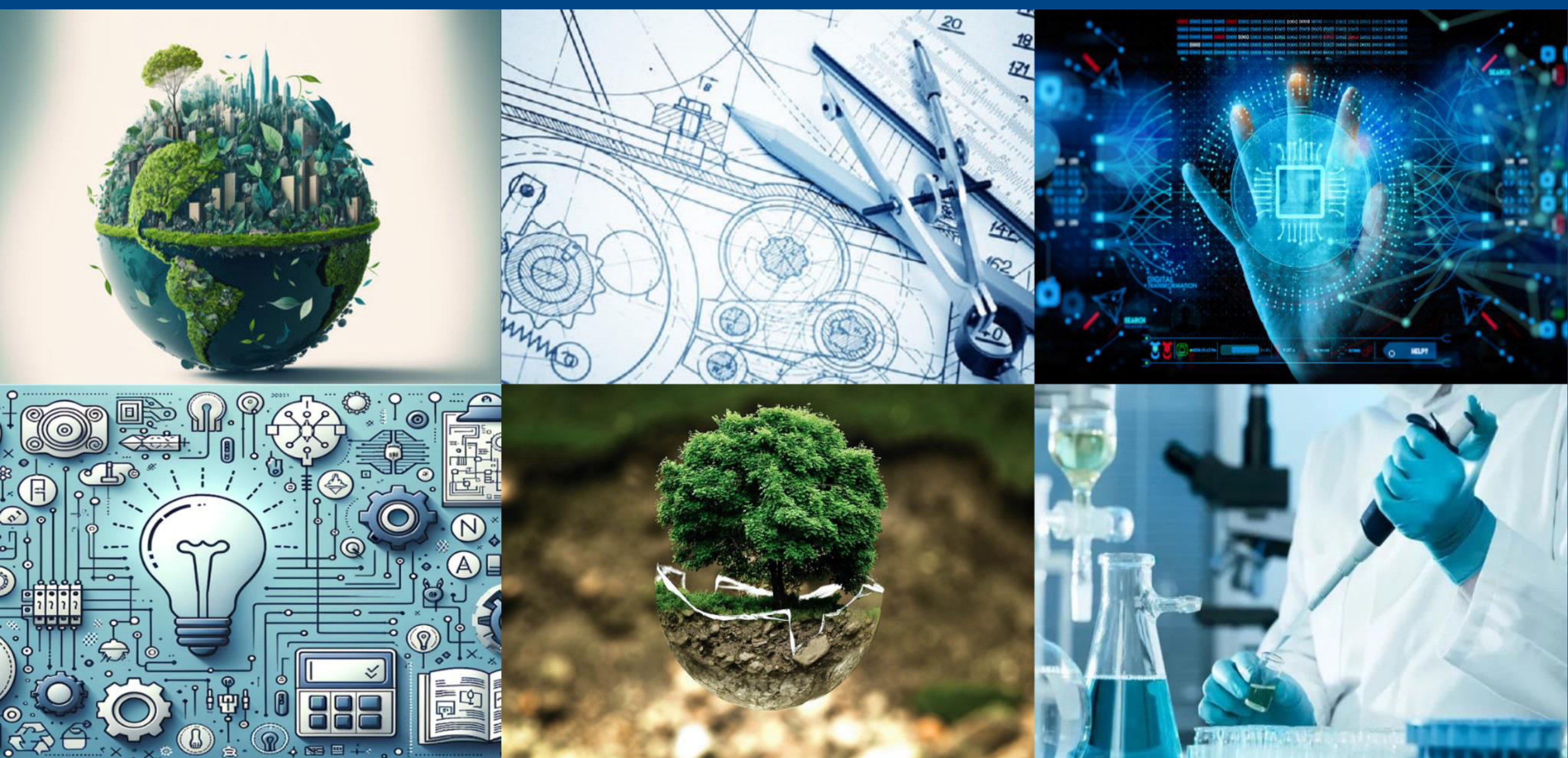

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Sugarcane Disease Detection Using Deep-Learning and LIME

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ABSTRACT: Crop diseases pose several challenges in the agricultural industry. Plant diseases can have a devastating impact on both yield and quality loss. This project presents a deep-learning based sugarcane disease classification and alert system to facilitate machine detection of disease, as well as actions to take in response to diagnosis. A dataset of images of sugarcane leaves, was modified through advanced pre-processing techniques such as cropping, rotating, image enhancement, detections edges, and adjusting for wavy images. The techniques used for data augmentation helped address class imbalance as well as overfitting. The classification model implemented for this project is the EfficientNet architectures to produce better feature extraction and predictions. The classification model was trained on the pre-processed and augmented dataset and reached 97 percent accuracy on the test data after 150 epochs. The explainability of the classifying model was provided through LIME (Local Interpretable Model-Agnostic Explanations), which allowed users to see the explanation for classification for an individual image. The smart classifying system was developed as a web application (UI) and allows users to input their image to be diagnosed. Once diagnosed, the model classifies the disease and detail actions, including: recommended treatments and precautionary actions. This system shows the power of artificial intelligence to enhance management of diseases in agriculture, while providing a scalable user-friendly environment to help faciliate on farm decision-making regarding crop health and yield.

KEYWORDS: Sugarcane, Deep Learning, EfficientNet, LIME, Image Processing, Disease Detection, Explainable AI

I. INTRODUCTION

Agriculture is the backbone of India's economy, with sugarcane among the most important commercial crops. Grown on a large scale in states such as Uttar Pradesh, Maharashtra, Tamil Nadu, and Karnataka, sugarcane goes into the manufacture of sugar, ethanol, and biofuels, sustaining millions of livelihoods. Nevertheless, sugarcane production is now exposed to numerous diseases like red rot, smut, mosaic, and yellow leaf disease that cut yields and quality dramatically, impacting finally the financial sustainability of the agricultural community.

Conventional disease identification techniques based on visual inspection and laboratory testing are usually time-consuming, subjective, and impractical at large scales. These deficiencies necessitate the use of contemporary technologies such as artificial intelligence (AI) and image processing to enhance disease detection accuracy and speed. Notably, deep learning methods have been highly promising in processing images of plants to automatically and accurately detect disease symptoms, minimizing the reliance on human expertise and diagnostic delays.

This paper introduces an AI-based system for image processing and deep learning-based sugarcane disease detection. Utilizing EfficientNet and explainable AI methods such as LIME, the system provides real-time, explainable predictions via a simple web interface. The initiative seeks to close the technology divide in the agricultural sector by equipping farmers with affordable tools for early disease management, encouraging sustainable agriculture and better yields.

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II. LITERATURE SURVEY.

The project rests on several basic works that are missing in Sugarcane disease detection using deep-learning alternatives Manavalan (2021) provided a comprehensive review of intelligent techniques used in sugarcane disease detection. The paper outlined multiple deep learning and hybrid machine learning approaches, underscoring the role of preprocessing, segmentation, and explainable AI in improving classification outcomes.

Hernandez et al. (2022) implemented a CNN-based system and tested it on sugarcane images, highlighting the model's ability to classify leaf diseases with high precision and speed, making it ideal for real-time usage in the field.

Kunduracıoğlu and Paçal (2024) focused on evaluating various EfficientNet models for sugarcane leaf disease detection. Their work emphasized the efficiency of the EfficientNet family in terms of both accuracy and computational performance, making it suitable for resource-constrained agricultural applications.

Degadwala and Dave (2024) also contributed a review that documented recent progress in sugarcane leaf defect identification, comparing multiple CNN architectures, and advocating for lightweight, scalable models suitable for deployment.

Patil and Patil (2024) explored deep learning techniques for both classification and analysis of sugarcane leaf diseases. Their study proposed a structured framework integrating CNNs for feature extraction, disease classification, and performance evaluation based on accuracy, recall, and F1-score. They highlighted the importance of balancing precision with computational efficiency for real-time agricultural applications.

Author(s)	Year	Approach/Model	Focus Area	Highlights	Drawbacks
Patil & Patil	2024	Deep Learning (CNN)	Classification and Analysis Framework	Integration of feature extraction with performance metrics	Limited discussion on real-time deployment and user interface
Degadwala & Dave	2024	CNN Model Comparison	Sugarcane Defect Detection Techniques	Comparative analysis, lightweight model suggestions	Review-based, no experimental validation or field deployment
Kunduracıoğlu & Paçal	2024	EfficientNet (DL)	Model Evaluation of EfficientNet variants	High accuracy, resource-efficient, suitable for mobile deployment	Limited to EfficientNet family, lacks comparative field testing
Hernandez et al.	2022	CNN-based DL	Real-time Classification of Sugarcane Leaf Diseases	Fast inference, strong performance in field simulations	Smaller dataset, limited disease variety
Manavalan	2021	Review (Hybrid ML/DL)	Survey of intelligent approaches	Highlights preprocessing, segmentation, explainable AI	Lacks practical implementation/testing of proposed approaches

Table II.1 Literature survey review

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III. METHODOLOGY

The designed sugarcane disease detection system is based on a multi-stage pipeline integrating image pre-processing, deep learning, and explainable AI methods. Sugarcane leaf images, both healthy and diseased, are first obtained from public datasets and agricultural research institutions. Pre-processing operations like resizing, normalization, CLAHE, gamma correction, and Multi-Scale Retinex are applied to the images in order to boost disease-specific characteristics. For enhanced model generalization and handling of class imbalance, data augmentation processes such as rotation, flipping, and brightness variation are utilized. Segmentation with edge detection and HSV color space extracts the areas affected by the disease, to guarantee targeted examination. EfficientNet is used as the base classification model because it offers high accuracy with low computation cost, obtaining a test accuracy of 97%. For interpretability purposes, Local Interpretable Model-Agnostic Explanations (LIME) is incorporated to underline the areas having an effect on model predictions. Lastly, the trained model is implemented on a Flask-based web application so users can upload images of leaves and get real-time disease classification as well as treatment recommendations.

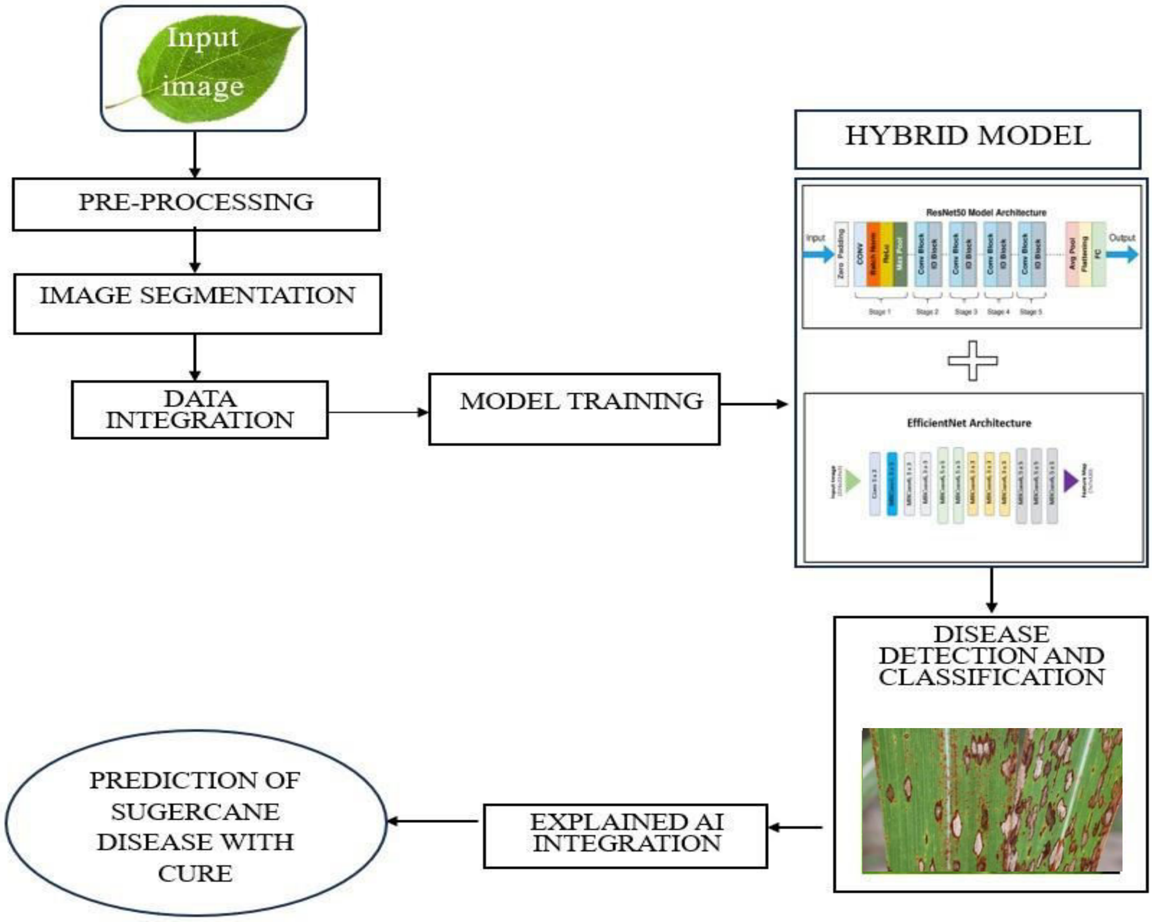

Fig III.1 The Workflow of Sugarcane Disease Detection

IV. IMPLEMENTATION

The dataset was gathered from open repositories and agricultural organizations, comprising healthy and diseased sugarcane leaf images. Preprocessing operations such as resizing, normalization, CLAHE, and MSR were done to improve image quality. Segmentation through HSV conversion and edge detection aided in separating the diseased areas for improved model concentration.

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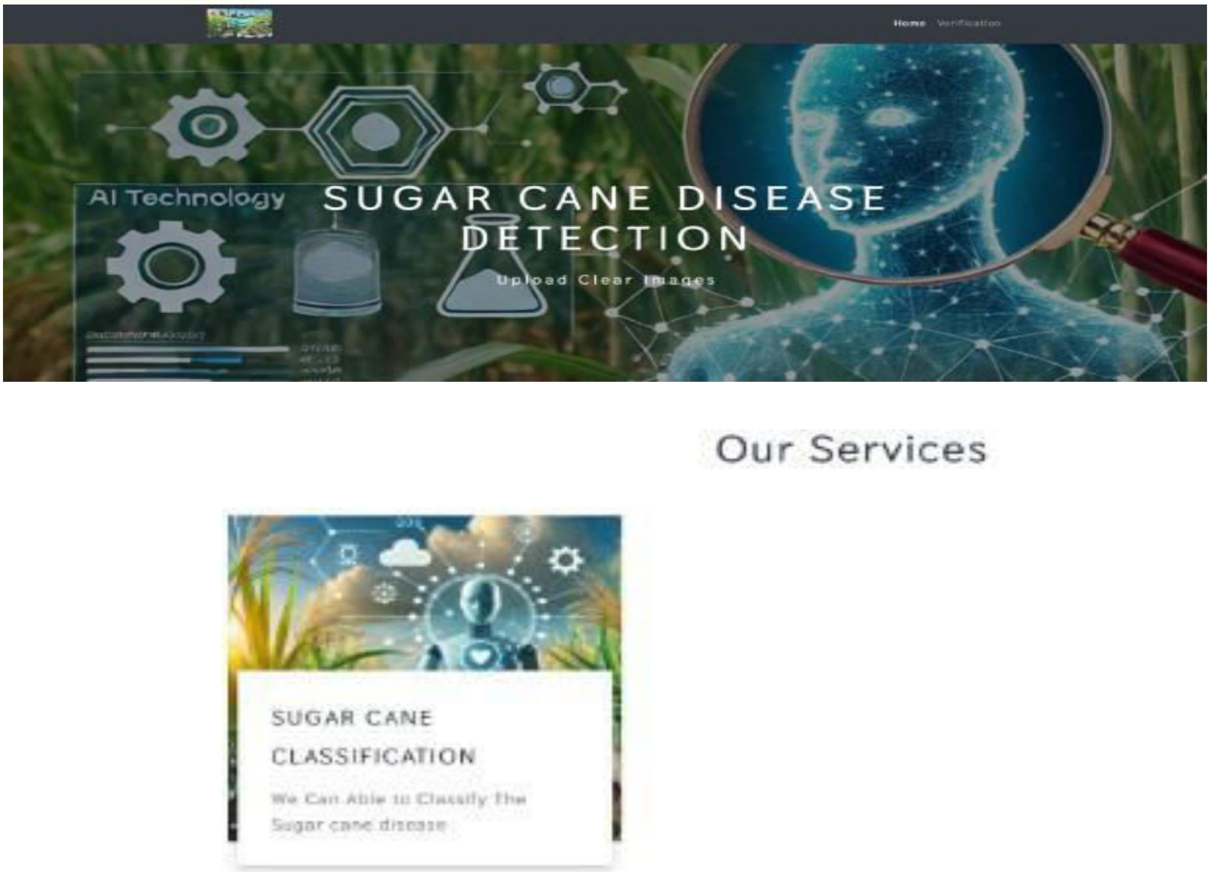

Fig IV.1 Home page and Sugarcane Classifier

Different models were experimented with, such as ResNet50 and a combination (ResNet & EfficientNet) model. EfficientNet on its own proved to be the best with 97% accuracy because of its well-balanced architecture and reduced computational expense. Rotation and flipping were among the data augmentation strategies employed to increase the size of the dataset to avoid overfitting.

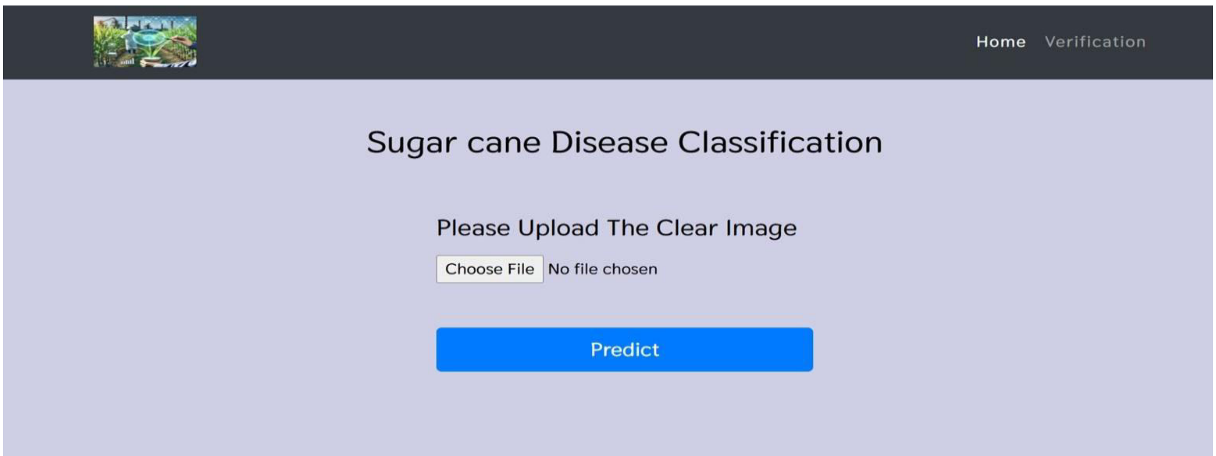

Fig IV.2 Interface for user to select image

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Fig IV.3 Healthy Leaf Prediction

For interpretability purposes, LIME was incorporated to graphically show important regions driving predictions. The resultant model was implemented on a Flask-based web application that accepts image uploads and provides immediate disease classification and treatment recommendations, enabling the system to be accessible and useful for farmers.

V. CONCLUSION AND FUTURE WORK

Sugarcane is a key crop for world agriculture, sustaining millions of livelihoods and making a significant contribution to economic and industrial production. Mosaic virus, smut, and red rot have been a long-standing problem, frequently leading to severe yield loss. This paper explains the revolutionary potential of integrating cutting-edge deep learning technologies with farming practices in the real-world battle against these problems. The hybrid model combining ResNet50 and EfficientNet established in this study which was inefficient because it is difficult to train the model so the overall accuracy was good utilizing EfficientNet alone instead of Hybrid model. With the help of better preprocessing, segmentation, and feature extraction algorithms, the model adapts properly to numerous environmental conditions and also overcomes certain restrictions generated by current datasets. The explainability of the AI systems like LIME is included for the purpose of transparency so that the users can understand and trust the decisions the system is making.

For future research must aim at increasing the dataset for generalization to improve and growing lightweight models for real-time implementation in resource-scarce settings. Improving environmental adaptability and adding IoT for real-time tracking are also essential. The research opens doors to the integration of AI in sustainable agriculture to assist in developing resilient ecosystems and improving food security.

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