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DETECTION AND CLASSIFICATION OF DISEASE FROM MANGO FRUIT USING CONVOLUTIONAL RECURRENT NEURAL NETWORK WITH METAHEURISTIC OPTIMIZER

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Abstract - *Mangoes (Mangifera indica) have been grown for more than 4,000 years, with their roots in South Asia. Throughout history, mangoes have established themselves as a key fruit in tropical and subtropical areas around the world, playing a significant role in global agricultural economies. However, in spite of their economic and nutritional value, mango crops are highly vulnerable to various diseases that can greatly affect both yield and quality. As the worldwide demand for mangoes continues to grow, maintaining the health of mango orchards has become a crucial issue for farmers and the agricultural sector. The detection and classification of diseases in mango fruits are critical for ensuring agricultural productivity and food safety. This study proposes a novel approach leveraging a Convolutional Recurrent Neural Network (CRNN) integrated with a metaheuristic optimizer to enhance the accuracy of disease identification in mangoes. The CRNN combines convolutional layers for feature extraction with recurrent layers for sequence prediction, effectively capturing both spatial and temporal patterns in images. The dataset consists of a diverse range of mango images, categorized based on various disease conditions. Experimental results demonstrate that the proposed CRNN framework outperforms traditional machine learning methods, achieving higher accuracy and lower misclassification rates. This research not only contributes to the field of agricultural technology but also offers a scalable solution for real-time monitoring and early intervention in mango cultivation, ultimately aiding farmers in reducing crop losses and enhancing fruit quality.*

Key Words: *Convolutional Recurrent Neural Network (CRNN), Image Processing, Precision agriculture, Image Classification, Feature extraction.*

1. INTRODUCTION

Mango is among the most widely grown and economically important tropical fruits, playing a significant role in the agricultural economies of numerous nations. Originally from South Asia, the cultivation of mangoes has spread worldwide over the years, making it an essential crop in both tropical and subtropical climates. Nonetheless, despite its popularity and economic significance, mango crops are highly susceptible to various diseases, such as anthracnose, powdery mildew, and bacterial black spots. These diseases pose a substantial risk to the yield and quality of mangoes, resulting in considerable losses for crops. Timely detection and precise identification of these diseases are vital for applying effective control measures that protect both fruit quality and farmers' livelihoods.

Recent developments in machine learning, particularly Convolutional Recurrent Neural Networks (CRNNs) paired with metaheuristic optimizers, present promising solutions to these problems. CRNNs combine the feature extraction strengths of Convolutional Neural Networks (CNNs) with the sequential processing capabilities of Recurrent Neural Networks (RNNs), creating a powerful framework for image-based disease detection and classification.

Additionally, metaheuristic optimizers enhance the effectiveness of CRNNs by fine-tuning their parameters, resulting in improved accuracy, efficiency, and predictive capabilities. This research proposes an automated and scalable method for disease detection and classification in mangoes, utilizing CRNNs alongside metaheuristic optimization techniques.

Automating the disease identification process offers farmers and agricultural stakeholders a dependable, swift, and effective solution for managing mango diseases. Background of the Work

1.1 Background Work

Mangoes are vulnerable to several significant diseases, including anthracnose, powdery mildew, and bacterial black spot, which can drastically reduce yield and fruit quality. Anthracnose, caused by Colletotrichum species, can lead to severe economic losses, while powdery mildew and bacterial black spot also compromise the health of the plants. Traditional methods for disease detection, primarily reliant on manual examination, face challenges such as time consumption, high costs, and subjective accuracy issues.

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1.2 Motivation and Scope of the Proposed Work

The goal of this project is to develop an advanced automated system that can accurately identify and categorize diseases affecting mango fruits. By utilizing Convolutional Recurrent Neural Networks (CRNNs), the system seeks to effectively detect disease symptoms in mangoes, differentiating between healthy and infected fruits. The model is trained on an extensive dataset containing images of mangoes suffering from various diseases, including anthracnose, powdery mildew, and bacterial black spot. These diseases adversely affect both the yield and quality of mango crops, making timely and accurate detection essential for efficient management and intervention. Alongside the CRNN, a metaheuristic optimization method, such as Genetic Algorithm or Particle Swarm Optimization, is employed to refine model parameters, enhancing accuracy while reducing computation time and resource usage. The metaheuristic optimizer adjusts the model's hyperparameters, facilitating quicker convergence and improving classification accuracy, thereby enhancing overall performance. This automated solution is designed to be user-friendly and scalable, making it suitable for widespread application in real-world agricultural settings like farms, sorting houses, and processing facilities. The aim is to make the solution accessible on multiple platforms, including mobile devices, to allow for practical on-site utilization by farmers and agricultural workers. By providing precise, early detection of diseases, this system has the potential to significantly lower post-harvest losses, enhance the quality and yield of mango production, and ultimately support more sustainable agricultural methods and increased productivity in the mango sector.

2. METHODOLOGY

The Methodology for the proposed mango disease detection system present a thorough approach to accurately identifying and classifying diseases that impact mango fruits. This organized process includes every essential phase, from gathering datasets to deploying in real-world scenarios, guaranteeing that the model is both precise and effective. The system is designed to offer a strong solution for agricultural experts. This methodical approach underscores the significance of each phase in improving the overall effectiveness and practicality of the disease detections systems.

The identification and categorization of diseases in mangoes are essential for preserving quality and enhancing yield, considering the economic importance of mango production. Existing methods encounter various obstacles, particularly the challenge of differentiating between diseases that show similar symptoms. For instance, conditions like anthracnose and powdery mildew may look alike on mango foliage, which complicates precise identification. Moreover, conventional manual inspection techniques are labor-intensive and time-consuming, requiring specialized knowledge that may not be accessible to all growers.

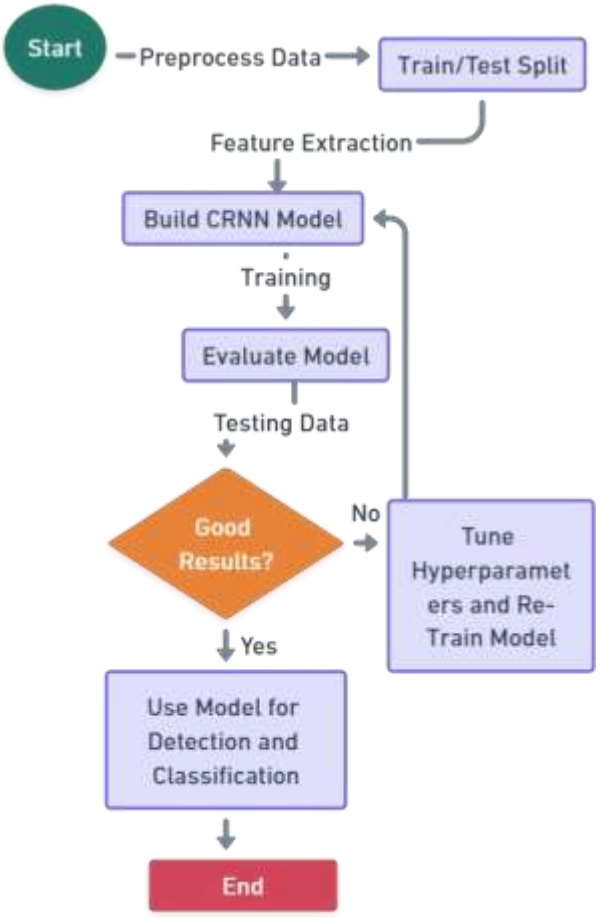

Fig -1- Flowchart

2.1 Design Phase: Disease Detection in Mango

The design phase starts with creating a solid system architecture that combines different elements for efficient disease detection and classification. This architecture generally includes several important modules: image capture, preprocessing, feature extraction, model training, and classification. Every module is essential for guaranteeing the overall effectiveness and performance of the system.

2.2 Image Acquisition and Preprocessing

This phase involves selecting appropriate techniques for capturing images. To ensure the model's ability to generalize effectively, high-quality images of mango fruits need to be taken in different lighting conditions. This may require the use of digital cameras or smartphones with high-resolution features. The design should also contemplate the implementation of controlled settings to reduce external factors that might impact image quality.

2.3 Feature Extraction Techniques

This section Feature extraction plays a vital role in identifying and classifying diseases in mango fruits. This process entails recognizing and measuring the significant traits of images that can assist in differentiating healthy specimens from those that are diseased. Different methods can be utilized for feature extraction, each offering its own benefits and applications.

2.4 User Interface

The implementation of a mango disease identification system utilizing a Convolutional Recurrent Neural Network (CRNN) marks a notable leap forward in agricultural technology. The approach for deploying the system on web frameworks using Python, thereby improving accessibility and enabling real-time disease diagnosis for farmers and agricultural experts.

3. CONCLUSION

This study presents the detection and classification of diseases in mango fruits using a Convolutional Recurrent Neural Network (CRNN) with a metaheuristic optimizer has shown promising results in improving the accuracy and efficiency of disease identification. By leveraging the power of convolutional layers for feature extraction and recurrent layers for temporal and contextual analysis, the proposed model successfully captured both spatial and sequential patterns in mango fruit images. The integration of a metaheuristic optimizer further enhanced the model's performance by optimizing the hyperparameters and improving convergence speed, resulting in a robust system for early disease detection. This approach has significant potential for real-time applications in agricultural monitoring, enabling timely interventions to prevent crop loss and improve fruit quality.

Suggestions for Future Work

1. **Expanding Data Diversity**: Training the model on a broader range of Mango fruits types and conditions can enhance its adaptability to different environments and Disease.

2. **Implementing on Edge Devices**:
   The web framework could be formed into a convenient gadget for on-location finding in the field, decreasing the reliance on unified frameworks and empowering constant sickness observation in distant regions and climatic conditions.

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