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A Review of the Literature on The Implementation of Image Processing and Machine Learning Techniques for The Detection and Classification of Different Areca nut Diseases

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Abstract - *The Areca nut tree is a type of straight-trunk tree that can grow up to 30 meters tall and 25 to 40 centimeters in diameter. The normal life expectancy is up to 60 years, with some species living up to 100 years. It is believed that Sulawesi (Celebes), Indonesia, Malaysia, and New Guinea are the natural habitats of this plant. Its range encompasses areas of East Africa, the Pacific, and the tropics in Asia. The areca nut goes by various names, including catechu, betel palm nut, and Areca nut. This plant can adapt to creeks, wetlands, and the borders of swamp forests. Almost every part of this plant is commercially valuable for humans. In terms of plant morphology, the pinnate leaves of areca nuts range in length from one to 1.5 meters. The midrib leaf's base is crown-shaped and gray in color. Branched flower stalks emerge from beneath the crown stalk and extend to a maximum length of one meter. The fruit has red or orange seeds that are 4-5 cm wide and 5-6 cm long, and it might be round or somewhat flat in shape. Pinang belongs to the Order Arecales, Family Ericaceae, Division Spermatophyta, Monocotyledon class, and Genus Areca in taxonomy.*

Key Words: Arecanut diseases, Multi-gradient images, ResNet model, Convolutional Neural Networks (CNNs), Backpropagation Neural Network (BPNN), Support Vector Machine (SVM), Grey-Level Co-occurrence Matrix (GLCM), Fruit rot disease, Grey-Level Difference Matrix (GLDM), Support Vector Machine Regression (SVMR), Random Forest Classifier (RFC), Multilayer perceptron regression, Random Forest Regression (RFR), Support Vector Regression (SVR), Gated Recurrent Unit (GRU).

1.INTRODUCTION

Arecanut is a crop that is widely cultivated in India. Karnataka, Kerala, and Assam are the major states that produce Arecanut in India. Karnataka produces the largest quantity of Arecanut in India, with a total cultivation area of 218,010 hectares and a production of 457.560 tones.

Arecanut is mainly grown in the southern and coastal districts of India under assured irrigation. The crop thrives well in areas with a temperature range of 20-34°C and an annual rainfall of 2000-5000 mm. The crop is grown as a garden crop and is usually intercropped with coconut, cocoa, pepper, and other crops. The crop is used in various forms, such as raw, boiled, or roasted, and is consumed as a mouth freshener. It is also used in Ayurvedic medicine for its medicinal properties. Since it has several importance in India and it is also a major commercial crop there are some challenges to cultivate this crop. In that challenge occurrence of Disease is a major challenge due to changes in temperature and climatic conditions.

2. LITRATURE SURVEY

B. Mallikarjuna et al. [5], the authors employ a novel approach using multi-gradient images to identify diseases in Areca nut fruit. These multi-gradient images undergo augmentation and are converted into arrays before being fed into a ResNet (Residual Network) model for both training and testing. The ResNet model, renowned for its efficiency and popularity in image processing, boasts up to 152 layers, enabling effective feature extraction and representation. Notably, the ResNet architecture addresses the vanishing gradient problem, enhancing its suitability for complex tasks like disease identification. The proposed model achieves an accuracy of 80.02% for normal images and 82% for multi-gradient-direction images, demonstrating its efficacy in Areca nut disease detection.

Meghana D R et al. [6], the authors propose a method for identifying diseases in Areca nut plants using Convolutional Neural Networks (CNNs). CNNs are deep learning systems specifically designed for image recognition tasks. The authors created a dataset consisting of 620 images depicting healthy and diseased Areca nuts, which were divided into training and testing sets. Their model was developed using accuracy as the evaluation metric, Adam as the optimizer function, and categorical cross-entropy as the loss function. During the training process conducted over 50 epochs, the model aimed to achieve high validation and test accuracy with minimal loss. The results indicated that the proposed method achieved an accuracy of 88.46% in detecting diseases in Areca nuts, with a focus on specific disorders such as Yellow Leaf spot, Stem Bleeding, and Mahali Disease (Koleroga). This suggests the efficacy of the CNN model in accurately identifying and classifying different diseases affecting Areca nut plants, offering potential applications for timely treatment interventions.

Dhanuja K C et al. [7], the authors focus on the automated detection of diseases in Areca nut plants utilizing image processing technology. The classification method employed a combination of imaging techniques, deep learning (DL) algorithms, and Backpropagation Neural Network (BPNN) classification. The features used for classification included three color characteristics, six geometrical features, and the spot areas in the images. The dataset consisted of 48 images classified as Great, 46 as Poor, and 49 as Bad. The results demonstrated a high consistency in the classifications for the grades of Excellent, Good, and Bad, with accuracies of 91.7%, 89.1%, and 91.8%, respectively. This suggests the effectiveness of the proposed approach in accurately identifying and classifying the health status of Areca nut plants based on image features. The integration of image processing, DL algorithms, and BPNN classification showcases a comprehensive method for automated disease detection in Areca nut cultivation, providing potential assistance in timely interventions to manage and control plant diseases.

Anilkumar M G et al. [8], the authors introduce a Convolutional Neural Networks (CNN) tool for early-stage detection of diseases in Areca nut plants, specifically identifying Mahali Koleroga, Stem bleeding, and yellow leaf spot. The CNN algorithm employed in their study achieved an accuracy rate of 88.46% in accurately identifying Areca nut diseases. The dataset used for training and testing comprised 241 images, encompassing both diseased and healthy specimens. The primary objective of the proposed tool is to empower farmers by providing a reliable means for early disease detection. Early identification enables farmers to implement timely precautionary measures and apply appropriate pesticides, thereby improving the chances of effectively managing and controlling the diseases. This, in turn, has the potential to enhance crop yield and overall agricultural productivity. The utilization of CNN technology in disease detection serves as a valuable tool in modern agriculture, offering farmers an advanced and automated approach to monitor and safeguard their crops, contributing to sustainable agricultural practices.

Mamatha Balipa et al. [9], the authors compare the classification performance and accuracy of Support Vector Machine (SVM) and Convolutional Neural Network (CNN) models for detecting diseases in Areca nut plants. The study utilized a self-created dataset containing 200 original images taken in Shivamogga, which were further augmented for training and testing purposes. The diseases considered included Koleroga, bud rot, yellow leaf disease, stem bleeding, among others. The authors converted the images into Grey-Level Co-occurrence Matrix (GLCM) and Grey-Level Difference Matrix (GLDM) matrices to serve as input data for both the CNN and SVM models. The SVM model yielded an accuracy of 0.75 (75%), as denoted by equation (1), while the CNN model achieved a higher accuracy of 0.9 (90%) under the same experimental conditions. This result suggests that CNN outperforms SVM in the context of image processing models for Areca nut disease detection. The findings underscore the effectiveness of deep learning techniques, specifically CNNs, in achieving higher accuracy rates compared to traditional machine learning approaches like SVM in agricultural disease identification and classification.

Mohammed Khalid Kaleem et al. [10], the authors present a comprehensive approach for predicting the occurrence of Mahali/Koleroga/Fruit Rot disease in areca nut crops. The study integrates machine learning algorithms, specifically Support Vector Machine Regression (SVMR) and Random Forest Classifier (RFC), with image processing techniques. The research was conducted in the areca fields of the Vittal region in Dakshina Kannada, Karnataka, India, spanning from January 2018 to April 2019, and involved the incorporation of historic weather data. Environmental conditions conducive to disease occurrence were identified, including frequent rain splashes, humidity exceeding 90%, low temperatures ranging from 20 °C to 23 °C, and intermittent sunshine and rain hours, typically occurring 15-20 days after the onset of the monsoon. Various environmental parameters such as temperature, rainfall, humidity, soil conditions, and wind speed were monitored using sensors like DHT-11 and soil humidity sensor. The collected data was processed and converted into a tabular format to serve as the input dataset for the machine learning models. The proposed algorithm involved calculating differences between consecutive data values, identifying patterns, and predicting disease occurrence. The outcomes of this study offer valuable insights for implementing preventive measures and controlling diseases, contributing to improved areca nut crop productivity. This approach not only demonstrates the integration of image processing and machine learning for disease prediction but also highlights the potential of such methods in precision agriculture for enhancing crop management strategies.

Rajashree Krishna et al. [11], the authors propose an approach for predicting Areca nut crop diseases based on historical weather data collected from the Udupi weather station. The dataset is meticulously created by integrating weather data with information on fruit rot diseases obtained from agriculturists, disease management recommendations, and existing research literature. The primary objective is to empower farmers with the ability to take preventive measures against crop diseases, especially those caused by heavy rainfall and high relative humidity. The study employs various machine learning models, including decision tree regression, multilayer perceptron regression, Random Forest Regression (RFR), and Support Vector

Regression (SVR), to validate and compare the dataset. Feature selection techniques such as principal component analysis, branch and bound, and wrapper methods are applied to identify the most significant weather parameters for accurate disease prediction. The results highlight the effectiveness of the random forest regression model, which yields the lowest mean absolute error (MAE) of 0.9, indicating its superior predictive performance. On the other hand, the support vector regression model shows a higher error of 1.7 MAE after feature selection. These findings suggest the potential of machine learning models, particularly random forest regression, in leveraging weather parameters to predict and manage Areca nut crop diseases. The approach not only aids in disease prevention but also underscores the importance of incorporating weather data in precision agriculture for enhanced crop management strategies.

K. Rajashree et al. [12], the authors focus on predicting Areca nut crop diseases by leveraging historical weather data collected from the Udupi weather station and integrating it with fruit rot disease data. The primary objective is to assist farmers in taking timely preventive measures against crop diseases, particularly those influenced by heavy rainfall and high relative humidity. The study employs various machine learning models to validate and compare the dataset, and the random forest regression model emerges as the most effective, yielding the lowest mean absolute error (MAE) of 0.9. Additionally, the study explores the application of deep learning techniques in predicting Areca nut crop diseases based on weather data. The vanilla Gated Recurrent Unit (GRU) model is employed, providing the lowest error value of 1.3 Mean Squared Error (MSE). The results underscore the potential of the proposed approach in predicting Areca nut crop diseases and mitigating their spread. The combination of machine learning and deep learning models showcases the versatility of these techniques in leveraging weather parameters for accurate disease prediction. This approach not only aids in enhancing agricultural practices by preventing crop diseases but also highlights the importance of integrating advanced technologies for more precise and effective crop management strategies in the context of changing weather patterns.

L. Vinod Kanan et al. [13], the authors propose a disease prediction system addressing challenges in the agricultural industry, particularly the growth of diseases affecting essential crops, leading to food supply scarcity. The system aims to predict the occurrence of diseases in Areca nut plants by considering various environmental factors, including temperature, humidity, rainfall, wind flow, and soil moisture. The study analyzes the interrelationships among these environmental factors and provides early warnings about disease occurrence. The system also introduces a mechanism to predict the susceptibility of Areca nut plants to disease infection. This is achieved by comparing data values obtained from IoT sensors, such as DHT-11 and soil humidity sensors, with historical data on conditions that have led to diseases in plants. A regression algorithm is applied to identify similarities in patterns of conditions, and a scoring range is established for the results. The output is manually verified with experiential data to enhance the model's effectiveness. The system aims to provide timely warnings to farmers regarding the potential occurrence of diseases, enabling them to take necessary precautions. By leveraging IoT and machine learning, this approach not only contributes to disease prevention but also emphasizes the integration of advanced technologies to enhance precision agriculture. Overall, the proposed system presents a proactive solution to mitigate the impact of diseases on Areca nut yield and subsequently address food supply challenges in the agricultural sector.

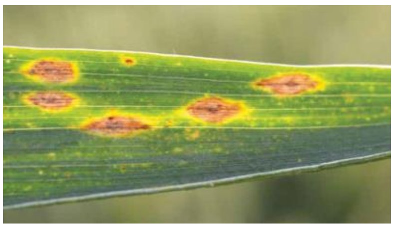
Table 1: Related papers on disease detection, quality, and grading on different fruits and vegetables

Name of paper	Year of publication	Aim	Model used	Results
Detection of Diseases in Areca nut Using Convolutional Neural Networks	2021	detecting the diseases of areca nut, leaves, and its trunk using Convolutional Neural Networks and suggest remedies for it.	CNN	CNN-88.46%
Image Processing based Arecanut Diseases Detection Using CNN Model	2022	detecting the diseases of areca nut, leaves, and its trunk using Convolutional Neural Networks	CNN	Accuracy-93.3%
Arecanut Yield Disease Forecast using IoT and Machine Learning	2021	A proposal is established where the innate relationship between crop disease and surrounding environmental conditions are identified and monitored continuously to predict the possibilities of a disease infection. The collected data can be used to mine further information and provide suitable counter measures to accomplish the aforementioned tasks	SVMR and RFC models	The score is 8 range between 1 to 10

Arecanut bunch segmentation using deep learning techniques	2022	propose and develop an efficient and accurate technique for the segmentation of arecanut bunches by eliminating unwanted background information	Mask Region-Based Convolutional Neural Network (Mask R-CNN) and U-Net	
Detection and classification of areca nut diseases	2021	Detecting the disease that affected to the Areca nut fruit using decision tree classifier.	Decision Tree Classifier, GLCM	Accuracy-90%
Exploring the Impact of Climatic Variables on Areca nut Fruit Rot Epidemic by Understanding the Disease Dynamics in Relation to Space and Time	2022	To understand the spatio-temporal dynamics and the effect of climate on fruit rot occurrence in arecanut plantations	linear regression model, GLM negative regression model	
Areca Nut Disease Detection using Image Processing Technology	2020	automated detection of disease that may be present in areca nuts by using images of areca nuts and bunches.	Local binary (LBP), Gray Level Difference Matrix (GLDM) and Gray Level Co-Occurrence Matrix (GLCM)	
Multi-gradient-direction based deep learning model for arecanut disease identification	2021	a new combination of multi-gradient-direction and deep convolutional neural networks for arecanut disease identification namely rot, split and rot-split.	multi-gradient directional image, ResNet-based model	Original image-ResNet 80.7% MGD-ResNet 82.3%
A Modern Approach for Detection of Leaf Diseases Using Image Processing and ML Based SVM Classifier	2021	a modern approach for detection of leaf diseases using Image processing and Machine learning (ML) based Support Vector Machine (SVM) classifier	K-means clustering, SVM classifier	
Smart Plant Disease Detection System	2021	detection of plant diseases by just capturing the images of the leaves and comparing it with the data sets available	CNN Algorithm	
Early Prediction of Yellow Leaf Disease in Areca tree	2022	An algorithm for early prediction of disease in leaves	ID3 algorithm	Accuracy-Not mentioned
AESA BASED IPM PACKAGE FOR ARECANUT	2014	all information about arecanut plants and diseases. Used as a data set for our experiments.	dataset	
Areca nut Disease Detection Using CNN and SVM Algorithms	2022	To detect various Areca nut diseases using SVM and CNN algorithm and comparison.	SVM and CNN	SVM accuracy 0.75 eq(1) CNN accuracy 0.9 eq(1)
Prediction of fruit rot disease incidence in Arecanut based on weather parameters	2022	Monitoring and early prediction of the occurrence of the disease would be very helpful for prevention and therefore more crop production	Vanilla LSTM, Vanilla GRU, stacked LSTM, and Bidirectional LSTM)	Naive Bayes, KNN, and decision trees-98.4%, CNN model-95.48%, RFR Model-0.9 MAE

The following are the few major image processing and machine learning algorithms used by the authors in recent years.

Table 2: Different types of diseases in Areca nut

Areca Nut Images	Types of disease	Overview
	Koleroga or Fruit rot	Mahali is one of the major diseases of Areca nut caused by phytophthora Palmivora, a fungal species. This is the major cause of losses in Areca nut farming and it causes decolorization of fruits and early falling of seeds
	Yellow Leaf Disease	Yellow leaf disease, as the name suggests, is a disease which affects the leaves of Areca nut, it changes the green pigmented leaf into a yellow one. This is caused by a Phytoplasma pathogen. It spreads through plant hoppers.
	Anabe	The fungus Ganoderma is the cause of Anabe disease. It affects the roots of the plants which causes weak stems in Areca nut trees.
	Yellow Leaf spot	This disease is found in young plants due to exposure to sun. This majorly occurs in the summer months and remains till monsoon. Brown spots are commonly found on leaves. Shedding drying and drooping of leaves also occur when the plant is affected heavily.

	Nut spilling	This disease causes weight loss and occurs in fruits. The fruits start cracking leading to no yield from the diseased seeds. The symptoms are early yellowing of seeds and the fruits develop a crack on the underside. This is a fairly common disease in areca nut plants.
	Inflorescence die-back and Button shedding	The trees infected with this disease cause significant shedding of thumb buttons. The rachis starts yellowing and drying, the female flowers and buttons start shedding.

3. SUMMARY AND OBSERVATION

Based on the literature survey, previous research has demonstrated the application of various deep learning models for disease detection, albeit with a focus on specific diseases. This current work aims to enhance disease detection across a broader spectrum by utilizing the Res-Net model. The choice of ResNet is attributed to its incorporation of skipping connections, effectively mitigating the vanishing gradient problem and thereby improving detection accuracy. The significance lies in assisting Arecanut farmers with early disease detection, enabling them to make informed preparations and ultimately reducing yield loss. The model has achieved an impressive accuracy rate of 97.5 percent, demonstrating its efficacy. Furthermore, there is potential for extending this approach to address various diseases affecting Areca nut and other crops.

3. CONCLUSIONS

Areca nut cultivation is a thriving commercial activity, particularly in coastal districts such as Dakshina Kannada, Udupi, Uttara Kannada, Shimoga, Chikmagalur, and Davanagere. Despite its high demand, the crop is susceptible to diseases induced by spraying, climate changes, and chemical fertilizers, leading to financial burdens for farmers. In our study, we focus on employing machine learning and image processing to identify Areca nut infections early and develop effective preventative measures. By reducing farmers' reliance on conventional methods, this approach aims to enhance their understanding of specific diseases, ultimately bolstering profits. Emphasizing early detection to circumvent unnecessary spraying during the monsoon, the model exhibits a strategic approach. This research holds significant potential to discover and implement efficient technologies for overall agricultural development in the broader farming landscape.

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