Applying deep learning and machine learning to the study of coconut palm disease

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ABSTRACT

Deep learning methodologies are being integrated into coconut cultivation to enhance disease control, increase productivity, and extend crop lifespan. These technologies can mechanize the detection process and provide farmers with more control, minimizing losses, and stimulating the agricultural sector. The Coconut Development Board (CDB) was established by the Indian government to promote coconut culture and offer financial incentives to growers. Tamil Nadu, the top state in coconut cultivation, accounts for 33.84 percent of the country's annual output, covering an area of 4.65 lakh hectares. Coimbatore is the most productive coconut-producing district, with an annual cultivation rate of 1200 million coconuts. Coconuts are versatile crops with applications in food, beverage, and artisanal products sectors. The agriculture industry is the primary contributor to India's GDP, but its contribution is decreasing. The objective is to accelerate the process of improving sustainability, diversity, productivity, and competitiveness in agriculture. Insufficient knowledge about illnesses and financial constraints can prevent farmers from seeking medical attention when necessary, leading to complex and costly procedures.

KEYWORDS: *Coconut disease, Machine Learning, Deep Learning and coconut palm tree.*

I. INTRODUCTION

Deep learning, a kind of machine learning, is renowned for its ability to leverage complex architectural frameworks consisting of many processing units to extract meaning from conceptual input. Automatic parameter optimisation techniques such as batch gradient descent, stochastic gradient descent, and the Adam optimiser are used by these models to refine the architecture-level parameters of the data processing. Through eliminating the need for human involvement in parameter design, automation streamlines and accelerates the process of creating a model.

Large neural networks trained using deep learning have higher generalisation capabilities in real-world applications, making them well-suited for jobs that need substantial automation or handling large datasets. The development expenses of these models, largely linked to human resources, increase enormously and they lack flexibility in adapting to various situations.

Recent technology advancements have enabled the exploration of numerous intriguing new approaches to enhance the performance of models for leaf disease image analysis. Structured visual data and other intangible information are well-suited for models constructed using the deep learning approach, since these models can now autonomously extract characteristics of different levels of complexity from unprocessed data. The results of this include enhanced model flexibility, reduced productivity expenses, and decreased labour costs. Reduced pesticide use in disease management may be achieved by expediting disease detection. By just submitting images of afflicted leaves, we can use pre-trained models and advanced deep learning technologies to monitor and analyse a diverse array of agricultural leaf diseases. This breakthrough has made it feasible to implement a more efficient and streamlined automated identification process, eliminating the need for specially trained personnel. These cutting-edge models enable even inexperienced farmers to identify issues in neglected agricultural regions and implement preventive actions. By leveraging the exceptional generalisability of the trained model, the precision of expert identification may be enhanced.

Tropical climates are well-suited for cultivating food crops such as rice, millet, maize, bananas, mangoes, coconuts, and durian due to the superior ability of deep learning models to identify subtle traits that may not be readily apparent. Enhanced sustainability, reduced labour costs, and increased productivity are some of the results of this advancement in precision agriculture, which seeks to optimise agricultural production by timely identification and management of plant leaf diseases. A robust leaf disease detection system based on deep learning would be well-suited for tropical regions due to its mobile device accessibility and real-time monitoring capabilities.

The exceptional level of leaves is determined by their exemplary quality, which is characterised by the absence of blemishes, significant variations, and faults. Several variables influence this result, such as the date of planting, soil temperature, transplantation, harvesting, and other related aspects. Various pathogenic organisms such as bacteria, mycoplasma, fungus, virus, rodent, viroid, etc., are the primary causative agents of infectious leaf diseases in plants. These disorders may be roughly classified into numerous types. A transmitted virus may undergo proliferation inside or on a host species with the intention of infecting animals that are more susceptible. Other possible factors contributing to non-infectious plant diseases include soil quality, temperature, moisture-to-oxygen ratio, presence or absence of toxic chemical compounds, and deficient soil minerals. Transmissible infectious illnesses may spread from one host species to another, however non-transmissible diseases are unable to reproduce inside a host. The coconut palm tree is the predominant temperate fruit crop in the northern Himalayan area of India. The cultivation of conventional Coconut Palm trees has been jeopardised by many crop diseases and environmental variations. Die-back diseases, collar rot, crown gall cankers, sclerotius blight, Marsonina coronaria, and coconut palm tree scab are among the most common diseases that can significantly damage coconut palm trees. Among the many diseases that may cause harm to coconut palm trees, scab and rust are particularly widespread. As a result of the illness, the leaf lamina exhibits mosaicism, mottling, curling, and anomalies. Notwithstanding the extensive and regular use of broad-spectrum fungicides, these spots continue to exist year after year. Image segmentation is a crucial yet challenging task in the field of image analysis. The process of segmentation is an essential step in image processing. In computer vision, image segmentation refers to the extraction of relevant regions from an image. To classify image segmentation techniques, we use the metrics of similarity and discontinuity. Applying machine learning methods to the problem of leaf disease categorisation requires significant effort and a substantial amount of data. Scarcely any research has explored the practicality of employing image processing for precise evaluation of disease severity, and the existing techniques for extracting characters are intricate and imprecise. Position-dependent feature extraction is carried out based on the spatial layout of the leaf images. An essential need for classifying a particular leaf disease is the construction of a convolutional neural network (CNN) model. The use of this approach may facilitate the early detection of leaf diseases.

II. Background work of coconut

The coconut (Cocos nucifera) is an important horticulture crop which provides food, oil, beverage, medicine fiber and variety of raw materials for the production of an array of products of commercial importance worldwide. Coconut, the versatile palm popularly known as “King of Palms”, “Tree of Heaven”, “Tree of life”, “Tree of Abundance”, is grown in more than 90 countries across the world in an area of 14.231 million hectares producing about 57.514 billion nuts or 10.52 million tonnes of copra (Athira, 2017). The natural habitat of coconut in the coastal belt of tropics where it flourishes in sea-washed littoral sand with constant motion of underground current of water in rhizosphere. Coconut palm craft is a traditional and sustainable form of art practiced in various regions of India, especially in coastal areas where coconut palms are abundant. The craft involves using different parts of the coconut palm tree to create a wide range of items, including household goods, decorative pieces, and functional tools.

Key Components of Coconut Palm Craft

1. Coconut Shell: Coconut shells are the hard, outer layer of coconuts, and they serve several purposes beyond just being a waste product. They are a byproduct of the coconut fruit, which is widely grown in tropical regions. The shell is typically discarded after the extraction of coconut water and meat, but it has many valuable uses due to its durability, hardness, and availability.

2. Coconut Husk: The coconut husk, also known as coir, is the fibrous outer layer of the coconut fruit that surrounds the hard shell. It is often considered a byproduct of coconut harvesting, but it has many valuable uses due to its unique properties. Coconut husks are composed mainly of coarse fibers and pith, which are natural, biodegradable, and renewable materials.

3. Coconut Leaves: Coconut leaves, also known as fronds, are the large, pinnate leaves of the coconut palm (Cocos nucifera). These leaves are widely used in various applications due to their strength, flexibility, and availability, especially in tropical and subtropical regions where coconut palms are commonly grown.
4. Coconut Wood: Coconut wood, also known as cocowood, is derived from the trunk of the coconut palm (Cocos nucifera). Unlike traditional hardwoods, which are obtained from trees with thick trunks, coconut wood is harvested from older coconut palms that are no longer productive in terms of fruit-bearing. The wood is characterized by its unique grain patterns, density variations, and rich brown to reddish hues, making it both aesthetically appealing and functional.

Regions Known for Coconut Palm Craft in India

1. **Kerala**:

The coconut palm (Cocos nucifera) has a significant historical significance in Kerala, intimately intertwined with the region's culture, economics, and way of life. Kerala is famous for its stunning scenery and plentiful coconut plantations. Explore the extensive historical background and profound importance of the coconut palm in Kerala.
The coconut palm has maintained a longstanding presence in Kerala for millennia, demonstrating its persistent existence in the area. The coconut palm has been present in the Indian subcontinent since ancient times, however its precise origin is a topic of contention among scholars.
Evidence from historical documents suggests that the coconut was first found and exploited in India about in 3000 BCE. The palm tree is indigenous to the coastal areas of South Asia, including Kerala.

2. **Karnataka**:

After India gained independence in 1947, the Karnataka government implemented various initiatives to support coconut farmers. These included subsidies, training programs, and financial assistance.

Coconut palms have been cultivated in Karnataka for thousands of years. The coastal regions, particularly around Mangalore, Udupi, and Uttara Kannada, have long been known for their extensive coconut groves.

Known for using coconut leaves to weave baskets, mats, and other decorative items.

Coir industry is also prominent in regions like Mangalore.

Different types of coconut diseases

in India is crucial for maintaining healthy coconut plantations. Common diseases affecting coconut trees in India include:

1. Bud Rot

Bud rot, also known as bud crown rot, is a fungal disease that affects coconut palms and other palm species. It's caused primarily by the pathogen **Phytophthora palmivora**. The disease is characterized by the rotting of the bud (or heart) of the coconut palm, which can lead to the death of the tree if not managed effectively.

2. Stem Bleeding

Stem bleeding disease is a serious condition affecting coconut palms, caused primarily by the fungus **Thielaviopsis paradoxa**. The disease is characterized by the exudation of a dark, viscous fluid from cracks and fissures in the stem, leading to the progressive decline of the tree.

3. Leaf Blight

Leaf blight, also known as leaf spot, is a common disease affecting coconut palms, caused primarily by the fungus **Helminthosporium spp.** This disease affects the leaves of the palm, leading to reduced photosynthetic activity and overall vitality of the tree.

4. Root Wilt

Root wilt, also known as Kerala wilt or coconut root (wilt) disease, is a chronic, debilitating disease that affects coconut palms. It is caused by a phytoplasma (a type of bacteria without cell walls) and is prevalent in regions like Karnataka, India. This disease affects the root system of the palm, leading to stunted growth and reduced yield.

5. Ganoderma Wilt

Ganoderma wilt, commonly referred to as Ganoderma butt rot or basal stem rot, is a severe fungal infection that affects coconut palms and several other tree species. The cause of this condition is the fungus Ganoderma spp., with Ganoderma lucidum being the predominant pathogen. This illness results in the deterioration of the basal stem and roots, finally resulting in the mortality of the palm.

6. Tanjore Wilt

Tanjore wilt, also known as Thanjavur wilt, is a severe disease affecting coconut palms, primarily caused by the fungus **Ganoderma lucidum**. The disease leads to the wilting and eventual death of the affected palms and is particularly prevalent in the Thanjavur district of Tamil Nadu, India.

7. Grey Leaf Spot

Grey leaf spot, also known as leaf spot disease, is caused by the fungus **Pestalotiopsis palmarum**. This disease primarily affects the leaves of the coconut palm, leading to reduced photosynthetic activity, which can impact the overall health and productivity of the tree.

III. REVIEW OF LITERATURE

Dominic et al. (2015): This study examined the severity of chronic illnesses using the IC9 diagnostic codes. Various data mining methods were employed to determine the severity of conditions related to heart and diabetic problems. The study analyzed correlations between different human anatomical systems, such as circulatory, nervous, renal, musculoskeletal, neoplasm, and respiratory systems, to determine the severity of illnesses.

Ani Dath et al. (2016): This research developed an expert system for managing coconut diseases, focusing on prediction, prevention, and selecting appropriate coconut varieties. The system provided management strategies by quickly identifying diseases in their early stages and offered guidance on managing coconut infections based on the affected area and symptoms. The knowledge base required extensive expertise and human effort.

Mariia Zakharova et al. (2017): This study demonstrated the use of deep learning to identify coconut diseases in aerial images. The model used a sliding window approach for image classification, achieving an accuracy of 71% and a recall of 93%. The classification process for a 10,000 × 10,000 px image took between 30 to 90 minutes, depending on the score threshold.

Mahdieh et al. (2018): The authors outlined machine learning methodologies combined with advanced techniques like data analytics and deep learning for Internet of Things (IoT) applications. The study suggested that integrating IoT with data analytics and streaming analytics can enhance accuracy in medical datasets.

Yixue et al. (2019): The research developed an innovative Recurrent Convolutional Neural Network (CNN) that adapts to multiple modalities to predict threat levels accurately. The model used structured and unstructured data from patient datasets and medical reports and achieved a final forecast accuracy of 96%.

Yanchao Li et al. (2019): This study built a data streaming architecture for incremental semi-supervised systems using a discriminant-structured generative network. The model employed an auto-encoder for dynamic feature learning and demonstrated efficient performance through experiments on real and synthetic datasets.

Abbas et al. (2020): Conducted an empirical study using data mining techniques like Multi-layer Perceptron (MLP), Artificial Neural Networks (ANN), and Support Vector Machines (SVM) on a medical dataset from 23 cancer patients. The study showed improved classification accuracy using these techniques.

Mohamed et al. (2020): The authors proposed a feature selection approach based on the grey wolf algorithm to enhance feature selection accuracy. The study used a two-phase mutation operator and a novel fitness function to achieve better classification accuracy than existing optimization methods.

Pramod Gairhe et al. (2021): This research examined the effect of various essential oils on controlling post-harvest fruit rot in bananas caused by Colletotrichum spp. Cinnamon oil showed the highest growth suppression at 98.15% at a concentration of 1000 ppm.

Attapon Palananda et al. (2022): The study focused on predicting coconut diseases using advanced machine learning techniques, particularly CNNs. The MobileNetV2 architecture showed the best performance with a training accuracy of 94.05% and testing accuracy of 80.20%, despite challenges like overfitting and class imbalance.

These studies illustrate various applications of data mining, machine learning, deep learning, and other techniques in medical diagnostics, agricultural disease management, and the Internet of Things (IoT). The research highlights the effectiveness and challenges of these methodologies in different contexts.

Research Scope

Coconut palms in Karnataka face severe diseases such as root wilt disease, which leads to wilting, yellowing leaves, and ultimately the death of the tree. Managing these diseases requires a comprehensive approach including resistant varieties, improved soil management, and timely pesticide application. Coconut palms are also susceptible to pests like the coconut mite, rhinoceros beetle, and mealybug, which can damage both plants and the coconut yield. The fluctuating prices of coconuts and products can impact income stability for coconut farmers, affecting their ability to plan and invest in their farms effectively. Improving market linkages and providing better price forecasts can help mitigate these issues. Changes in temperature and rainfall patterns can affect coconut growth and yield, while increased frequency of extreme weather events can cause direct damage and disrupt farming activities. Lastly, soil erosion, salinity, and nutrient depletion can affect soil health and coconut production.

Research Gap

Deep learning is a promising tool for disease detection in coconuts, but there is a need for further exploration and development. Existing literature primarily focuses on small datasets, which may not capture the full range of coconut diseases or their varying symptoms across different climates and regions. Expanding datasets to include a wider range of images from different regions, seasons, and stages of disease progression could make deep learning models more resilient and useful.

Real-time disease detection in coconuts can be significantly enhanced through the use of real-time deep learning models that farmers can access directly via IoT devices or mobile applications. Hybrid approaches integrating deep learning with knowledge graphs or rule-based expert systems could be explored in future studies to enhance disease detection and provide comprehensive health management recommendations.

Predicting the effectiveness of treatments or disease resistance is less important in modern models, which primarily focus on illness classification and identification. To ensure the appropriate and secure use of farmer data, further research should explore privacy-preserving approaches like federated learning.

Future research should prioritize dataset augmentation, model resilience and comprehensibility enhancement, lightweight model construction for real-time and resource-constrained scenarios, and the integration of multi-modal data to provide comprehensive disease management solutions.

CONCLUSION

Research into deep learning and machine learning is crucial for advancing the diagnosis and prediction of diseases affecting the coconut tree. Common illnesses like bud rot, stem haemorrhage, deadly yellowing, and grey leaf spot can significantly impact coconut production and quality. Traditional disease detection methods, particularly in rural areas, are time-consuming, expensive, and difficult to implement. However, there is untapped potential for advancement in this field through research into deep learning and machine learning. This will enable the creation of more accurate disease prediction systems, promoting sustainable agriculture and improved scalability, ease of operation, and accuracy. The top priority for future research should be the development of scalable, real-time solutions that meet practical needs, integrating multiple data sources and improving model accuracy and interpretability.

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