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Classification of Cashew Plant Diseases Using Hyperspectral Imaging

By A U T H O R⋆, *Mitali .M. Sawant, Neha .N. Sawant, Prachi .P. Murari, Zeba .A. Shaikh, Prof. Chaitali Haldankar, Prof.Needhi Gaonkar*

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A B S T R A C T

Cashew plant Diseases can reduce crop yields and quality.Diseases can hurt the plants and reduce the amount of cashews they produce.To help farmers, we are detect diseases in cashew plants using hyper-spectral imaging. This is a new and exciting way to keep plants healthy.Hyperspectral imaging capture images that can see things that are not visible to the human eye. We used different models, including ResNet 50, ResNet 18, and AlexNet, to compare their performance.We also used LabelMe to segment images of cashew plants, which helped us to focus on specific areas of the plant affected by disease.We tested our method on many cashew plants images and it worked very well. We were able to detect diseases accurately and quickly. With our method, they can detect diseases early and take action to stop them from spreading. This means they can grow healthier plants and produce more cashews.Our method is also good for the environment. By detecting diseases early, farmers can reduce the amount of chemicals they use. This helps to keep the soil and water clean.This helps farmers and the planet.

Keywords: *in this paper, in this paper, in this paper.*

1. Introduction

Cashew plants are important for people living in tropical areas.They're a great source of income people earn money by producing nuts.The big problem here is, cashew plants get sick easily, which affects the number and quality of nuts they produce. farmers usually check their plants by looking at them. But this method is slow and not always accurate.It is very important to detect sickness in plants early, so that farmers can take action to help them recover.ordinary cameras can't detect sickness in plants before symptoms appear. That makes it tough for farmers to take action early and prevent the spread of disease.

some common sicknesses that affect cashew plants are:- 1. Anthracnose - a fungus that causes black spots on leaves and stems. 2. Powdery Mildew - a fungus that covers leaves in white powder. 3. Yellow Spot - bacteria or fungi that cause small spots on leaves. With deases detection We have also trained our model to detect a Healthy leave (green and fresh) and Dead leave (brown and dry).So, farmers can know if their plants are sick, and also know which leaves are healthy or dead.

The plant can be sick due to various factors, such as:- 1. Too much water - extra moisture helps fungi and bacteria grow. 2. Bad soil - poor soil weakens plants. 3. Pests - insects like aphids and spider mites can spread disease. 4. Bad weather - extreme weather stresses plants, making them sick. we're working on a new way to detect diseases in plants i.e using hyperspectral imaging. It's like taking pictures of the plants, but not that we can see. We're also capturing light that's invisible to the human eye.Normal images capture only three colour i.e red green and blue but Hyperspectral imaging uses hundreds of different colours.Hyperspectral imaging basically captures a lot of information about the plant. This helps us understand what's going on inside the plant, so we can detect sickness before symptoms appear. And the best part, We don't have to hurt the plant to do it.

We're using three powerful computer models - ResNet-50, ResNet-18, and AlexNet - to understand the data from hyperspectral imaging. These models help us identify diseases in cashew plants. 1.ResNet-50 is great for finding small changes in the plant's spectral signatures. 2.ResNet-18 is effective at recognizing patterns in the data. 3. AlexNet is excellent for tracking changes in plants over time. Using these models, we've created a system that can automatically detect diseases in cashew plants. This system can help farmers quickly find and fix problems before they spread.

Our goal is to make it easier and faster for farmers to identify diseases in cashew plants. By detecting diseases early, farmers can stop them from spreading and save their crops. This can help farmers grow more cashews and make more money.

⋆ Corresponding author.
e-mail: xxx

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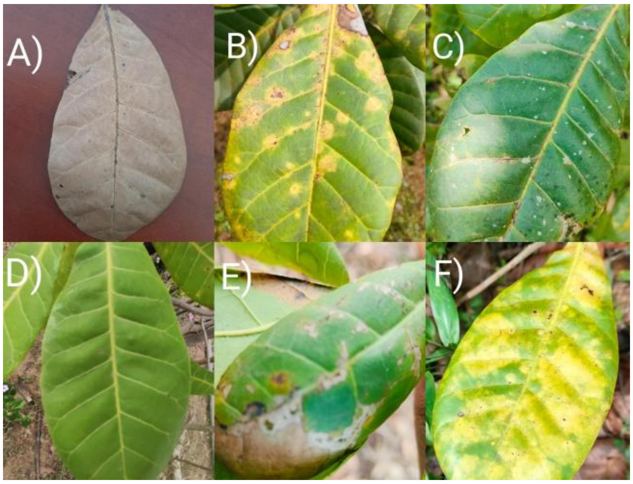

Fig. 1. Original Images.

Hyperspectral imaging technology can be used on a large scale to monitor cashew farms. We can also use artificial intelligence to help farmers know what diseases their plants have. This study wants to help cashew farmers find diseases quickly and easily, so they can grow more cashews and make a better living.

2. Literature Review

1. A Review of Imaging Techniques for Plant Disease Detection Vijai Singh , Namita Sharma, Shikha Singh(2020). Early detection of plant diseases is essential for better crop yields and economic stability. Different imaging methods like thermal, hyperspectral, fluorescence, multispectral, and 3D imaging help identify diseases more accurately and at an early stage. However, high costs and sensor limitations are challenges to their widespread use.Machine learning techniques such as SVM, K-means clustering, and deep learning have improved disease detection when combined with imaging technologies. Hyperspectral imaging, in particular, has proven effective in spotting plant diseases by analyzing specific wavelengths, especially in the near-infrared range. These methods make automated detection more reliable and interpretable.These advancements support precision agriculture by improving crop monitoring and management. However, cost-effective and efficient sensors are still needed to make these systems more practical. Future research should focus on scalable solutions that work across different farming environments.imaging and AI technologies are revolutionizing plant disease detection, making it more precise and automated. Continued innovation in sensors and data analysis is key to improving plant health monitoring and supporting sustainable farming practices(Vijai Singh , Namita Sharma, Shikha Singh).

2. Plant disease identification using explainable 3D deep learning on hyperspectral images Koushik Nagasubramanian1, Sarah Jones 2, Asheesh K. Singh, Soumik Sarkar, Arti Singh2and Baskar Ganapathysubramanian1(2019).This study explores the use of hyperspectral imaging and deep learning for detecting charcoal rot in soybean crops. A 3D deep convolutional neural network (DCNN) was developed, achieving a high accuracy of 95.73

3. A comprehensive review of 3D convolutional neural network-based classification techniques of diseased and defective crops using non-UAV-based hyperspectral images Nooshin Noshiri, Michael A. Beck, Christopher P. Bidinosti, and Christopher J. Henry(2023).The paper ”A Comprehensive Review of 3D Convolutional Neural Network-Based Classification Techniques of Diseased and Defective Crops Using Non-UAV-Based Hyperspectral Images” . It discusses how hyperspectral imaging (HSI) combined with 3D convolutional neural networks (3D-CNNs) can effectively detect crop diseases by analyzing both spatial and spectral data. This approach offers better accuracy than traditional 1D and 2D CNNs. However, challenges like limited HSI datasets, high computational requirements, and the high cost of HSI equipment limit its widespread use. The authors suggest that more investment in data collection and sharing, optimizing 3D-CNN models, and developing affordable multispectral systems are needed to make this technology practical for precision agriculture. Future research should address data shortages and computational limitations to enhance automated disease detection and classification(Nooshin Noshiri, Michael A. Beck, Christopher P. Bidinosti, and Christopher J. Henry).

4. Hyperspectral Imaging: A tool for plant disease detection Koushik Nagasubramanian, Sarah Jones, Asheesh K. Singh, Arti Singh, Baskar Ganapathysubramanian, and Soumik Sarkar.(2023).The article ”Hyperspectral Imaging: A Tool for Plant Disease Detection” discusses how hyperspectral imaging can identify plant diseases early, aiding in better crop management. By analyzing light reflected from plants across various wavelengths, this method detects stress signs before they become visible. Techniques like spectral information divergence classification and Simplex Volume Maximization have improved the accuracy of disease detection. This approach offers a faster and more precise alternative to traditional methods, enhancing sustainable agriculture practices(Koushik Nagasubramanian, Sarah Jones, Asheesh K. Singh, Arti Singh, Baskar Ganapathysubramanian, and Soumik Sarkar).

5. Artificial Intelligence based drone for early disease detection and precision pesticide management in cashew farming Manoj Kumar Rajagopal and Bala Murugan MS, (2023).This study explores the use of AI-powered drones to detect diseases like anthracnose in cashew crops and optimize pesticide application. By employing edge computing, the system processes data in real-time, enabling efficient crop monitoring. The researchers found that a quantized INT8 model offered faster processing and reduced memory usage compared to an unquantized FLOAT32 model, making it more suitable for environments with limited resources. The study underscores the potential of UAV-based disease detection and precision agriculture

techniques to enhance productivity, reduce costs, and support small-scale farmers(Manoj Kumar Rajagopal and Bala Murugan MS).

6. Cashew Dataset Generation Using Augmentation AND RaLSGANANDA Transfer Learning Based TINYML Approach Towards Disease Detection Varsha Jayaprakash, Akilesh K, Ajay Kumar, Balamurugan M. S., and Manoj Kumar Rajagopal.(2023). This study introduces a dataset of 20,127 images of healthy and anthracnose-infected cashew leaves and fruits to improve disease detection. The researchers enhanced the dataset using image augmentation techniques and RaLSGAN, a type of Generative Adversarial Network, to increase diversity. They applied transfer learning with MobileNet and Inception models, achieving classification accuracies of 97.7

7. Plant Health Monitoring using Digital Image Processing K. Anitha, G. Keerthiga, and A. Hema Malini(2019).The research titled "Plant Health Monitoring using Digital Image Processing" focuses on automated methods to detect and classify plant diseases by analyzing leaf images. The study employs techniques such as K-means clustering for image segmentation and Support Vector Machine (SVM) classifiers, achieving a classification accuracy of 93.79

8. From visual estimates to fully automated sensor-based measurements of plant disease severity: status and challenges for improving accuracy Clive H. Bock, Joa˜o G.A. Barbedo, Emerson M. Del Ponte, David Bohnenkamp, and Anne-Katrin Mahlein(2020).This research examines the shift from traditional visual assessments to automated sensor-based methods for evaluating plant disease severity. While visual estimates are common, they can be inaccurate. Sensor technologies, such as hyperspectral and multispectral imaging, offer more precise measurements, especially in controlled environments. However, their effectiveness in field conditions requires further validation. The study emphasizes the need for extensive image databases and standardized protocols to enhance AI-driven assessments. Despite technological advancements, visual assessments remain important, suggesting a combined approach that integrates AI with expert knowledge for better disease monitoring(Clive H. Bock, Joa˜o G.A. Barbedo, Emerson M. Del Ponte, David Bohnenkamp, and Anne-Katrin Mahlein).

9. Artificial Intelligence based drone for early disease detection and precision pesticide management in cashew farming Varsha Jayaprakash, Akilesh K, Ajay Kumar, Balamurugan M.S, and Manoj Kumar Rajagopal.(2023).The research focuses on creating a comprehensive dataset of over 20,000 images of healthy and anthracnose-infected cashew leaves and fruits to improve disease detection. To enhance the dataset's diversity, the team applied various image augmentation techniques, including photometric and geometric transformations, as well as RaLSGAN. They utilized transfer learning with MobileNet and Inception architectures, achieving classification accuracies of 97.7

10. Convolutional neural networks for leaf image-based plant disease classification Sachin B. Jadhav, Vishwanath R. Udupi, and Sanjay B. Patil,(2019).The research focuses on identifying soybean diseases using pre-trained convolutional neural networks (CNNs) such as AlexNet, GoogleNet, VGG16, ResNet101, and DenseNet201. The team trained these models on a dataset of 1,200 images of healthy and diseased soybean leaves, achieving high classification accuracies: 95

11. Classification of Plant Leaf Disease Recognition Based on Self-Supervised Learning Y. Wang, Y. Yin, Y. Li, T. Qu, Z. Guo, M. Peng, S. Jia, Q. Wang, W. Zhang, and F. Li.(2024).This research addresses the challenge of identifying plant diseases with limited labeled data. The authors propose a model that combines a masked autoencoder (MAE) with a convolutional block attention module (CBAM) to enhance feature extraction from plant leaf images. This approach leverages self-supervised learning to reduce dependence on extensive labeled datasets. The model achieved high accuracy rates of 95.35

12. Convolutional neural networks for leaf image-based plant disease classification Sachin B. Jadhav(2018).Researchers tested pre-trained CNN models like AlexNet, GoogleNet, VGG16, ResNet101, and DenseNet201 on a dataset of 1,200 soybean leaf images, achieving high accuracy. GoogleNet and VGG16 performed best, reaching 96.4

13. Early detection of plant virus infection using multispectral imaging and spatial–spectral machine learning Yao Peng, Mary M. Dallas, Jose´ T. Ascencio-Iba´n˜ez, J. Steen Hoyer, James Legg, Linda Hanley-Bowdoin, Bruce Grieve, and Hujun Yin.(2022).This research introduces a handheld active multispectral imaging (A-MSI) device combined with machine learning to detect cassava brown streak disease (CBSD) early. The device enhances spectral signal quality, allowing for the identification of infected plants as early as 28 days post-infection. Detection accuracy reached up to 98.5

14. ELDA: enhanced linear discriminant analysis for cashew crop disease detection using precision agriculture S. Palaniappan and K. Pazhamalai,(2024).The study presents an improved method called Enhanced Linear Discriminant Analysis (ELDA) for detecting diseases in cashew crops using precision agriculture techniques. This model improves classification accuracy by analyzing both spectral and spatial data, helping to identify diseases early. By combining ELDA with precision farming, farmers can detect plant health issues more efficiently, allowing for timely intervention and reducing losses. The research suggests that this method could be applied to other crops, offering a reliable and scalable solution for disease monitoring in agriculture(S. Palaniappan and K. Pazhamalai).

15. Machine learning as a tool to predict potassium concentration in soybean leaf using hyperspectral data Renato Herrig Furlanetto, Lu´ıs Guilherme Teixeira Crusiol, Joa˜o Vitor Ferreira Gonc¸alves, Marcos Rafael Nanni, Adilson de Oliveira Junior, Fa´bio Alvares de Oliveira, and Rubson Natal Ribeiro Sibaldelli.(2023).The study explores how machine learning can predict potassium levels in soybean leaves using hyperspectral data. Instead of traditional chemical tests, this method provides a fast and non-destructive way to measure nutrient lev-

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els. The results show that combining hyperspectral imaging with predictive models can help farmers monitor plant health in real time. This approach can improve fertilizer use, enhance crop growth, and support precision agriculture(Renato Herrig Furlanetto, Lu´ıs Guilherme Teixeira Crusiol, Joa˜o Vitor Ferreira Gonc¸alves, Marcos Rafael Nanni, Adilson de Oliveira Junior, Fa´bio Alvares de Oliveira, and Rubson Natal Ribeiro Sibaldelli).

16. Feature Combination with Morphological Transformations and SIFT Key Point Jiraporn Thomkaew and Sarun Intakosum.(2023).The study explores a method that combines morphological transformations with Scale-Invariant Feature Transform (SIFT) key points to improve image analysis. This approach enhances feature extraction and object recognition, leading to more accurate classification. The results show that using both techniques together improves how features are represented, making the method useful for image processing, pattern recognition, and computer vision tasks. This technique can be applied in real-world scenarios to enhance classification accuracy(Jiraporn Thomkaew and Sarun Intakosum).

17. Automation of Crop Disease Detection through Conventional Machine Learning and Deep Transfer Learning Approaches Houda Orchi, Mohamed Sadik, Mohammed Khaldoun, and Essaid Sabir.(2023).The study compares conventional machine learning with deep transfer learning for detecting crop diseases. It finds that deep learning models perform better, offering higher accuracy and reliability. By using pre-trained models, the approach reduces the need for large labeled datasets while improving disease classification. The research highlights the potential of automated disease detection in agriculture, helping farmers identify issues early and improve crop management efficiently(Houda Orchi, Mohamed Sadik, Mohammed Khaldoun, and Essaid Sabir).

18. A sugar beet leaf disease classification method based on image processing and deep learning Adem, Kemal, O¨ zgu¨ven, Mehmet Metin, and ALTAS¸, Ziya.(2022).The study introduces a method for classifying sugar beet leaf diseases using image processing and deep learning. By enhancing disease features through image preprocessing and applying deep learning models, the approach achieves high accuracy in identifying healthy and diseased leaves. The results show that combining these techniques improves precision in disease detection, offering a reliable tool for better crop management and increased yield(Adem, Kemal, O¨ zgu¨ven, Mehmet Metin, and ALTAS¸, Ziya).

19. A novel framework for image-based plant disease detection using hybrid deep learning approach Anuradha Chug, Anshul Bhatia, Amit Prakash Singh, and Dinesh Singh(2022).This study introduces a framework that combines convolutional neural networks (CNNs) with advanced machine learning techniques to enhance the accuracy and robustness of plant disease classification. The approach involves image preprocessing, feature extraction, and classification stages, leveraging hybrid deep learning models to improve disease identification performance. Experimental results indicate that this method achieves high accuracy in detecting various plant diseases, surpassing traditional methods. The research underscores the potential of hybrid deep learning in automated plant disease detection, contributing to precision agriculture and improved crop management(Anuradha Chug, Anshul Bhatia, Amit Prakash Singh, and Dinesh Singh).

20. FF-PCA-LDA: Intelligent Feature Fusion Based PCA-LDA Classification System for Plant Leaf Diseases Safdar Ali, Mehdi Hassan, Jin Young Kim, Muhammad Imran Farid, Muhammad Sanaullah, and Hareem Mufti(2022).The study introduces an advanced classification system called FF-PCA-LDA for detecting plant leaf diseases. It combines Principal Component Analysis (PCA) for reducing data complexity and Linear Discriminant Analysis (LDA) for better classification accuracy. This method helps in selecting important disease-related features while keeping computational costs low. The research shows that FF-PCA-LDA performs better than traditional machine learning models in identifying plant diseases. The study highlights how intelligent feature fusion techniques can support early disease detection in crops, improving agricultural productivity and management(Safdar Ali, Mehdi Hassan, Jin Young Kim, Muhammad Imran Farid, Muhammad Sanaullah, and Hareem Mufti).

21. Leaf Images Classification for the Crops Diseases Detection Yashwant Kurmi, Suchi Gangwar, Vijayshri Chaurasia, and Aditya Goel(2022).The study presents a method for detecting crop diseases by analyzing leaf images using machine learning and deep learning techniques. The process includes image preprocessing, feature extraction, and classification to accurately identify diseases. Convolutional Neural Networks (CNNs) and other models are used to improve disease recognition accuracy. Results show that this method effectively distinguishes between healthy and diseased leaves, making it a useful tool for early disease detection. The study highlights the importance of automated leaf classification in improving crop health monitoring and disease management in agriculture(Yashwant Kurmi, Suchi Gangwar, Vijayshri Chaurasia, and Aditya Goel).

22. Review on Emerging Trends in Detection of Plant Diseases using Image Processing with Machine Learning Punitha Kartikeyan and Gyanesh Shrivastava(2021).The study discusses recent advancements in detecting plant diseases using image processing and machine learning. It covers different techniques, including traditional machine learning and deep learning, for analyzing leaf images to identify diseases. The paper highlights the role of CNNs and transfer learning in improving accuracy while also addressing challenges like dataset limitations and computational costs. It emphasizes the need for integrating IoT and cloud computing to develop real-time monitoring systems, making plant disease detection more efficient for modern agriculture(Punitha Kartikeyan and Gyanesh Shrivastava). 23. Leaf Disease Detection Using Machine Learning Parul Sharma and Yash Paul Singh Berwal,(2018).The study explores machine learning techniques for detecting leaf diseases to support better

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farming practices. It examines classification methods like SVM, KNN, and deep learning to identify plant diseases using leaf images. Feature extraction methods, including color, texture, and shape analysis, help improve accuracy. The results show that machine learning can detect diseases early, making it a useful and cost-effective tool for farmers. The study also highlights challenges like limited datasets and the need for real-time applications, suggesting future improvements with advanced deep learning and better data collection(Parul Sharma and Yash Paul Singh Berwal).

24. Tomato Leaf Disease Classification using Multiple Feature Extraction Techniques Jagadeesh Basavaiah and Audre Arlene Anthony,(2020).The study presents a method for classifying tomato leaf diseases using different feature extraction techniques. It combines color, texture, and shape analysis with machine learning models like Support Vector Machines (SVM), K-Nearest Neighbors (KNN), and Artificial Neural Networks (ANN) to improve classification accuracy.The results show that using multiple feature extraction methods gives better disease identification compared to single techniques. The study highlights challenges such as changes in lighting, background noise, and variations in leaf appearance that can affect accuracy. It suggests further improvements using deep learning and better feature selection methods to enhance precision in real-world farming applications(Jagadeesh Basavaiah and Audre Arlene Anthony).

25. Sunflower leaf diseases detection using image segmentation based on particle swarm optimization Vijai Singh(2019).The study introduces a method for detecting sunflower leaf diseases using image segmentation with Particle Swarm Optimization (PSO). This technique improves segmentation accuracy by optimizing threshold values, leading to better feature extraction.The approach combines image processing with machine learning to classify different sunflower leaf diseases. Results show that PSO-based segmentation performs better than traditional methods, achieving higher accuracy in disease detection. The study highlights its usefulness in precision agriculture for early disease detection and better crop management. Future improvements may include deep learning models to enhance classification accuracy(Vijai Singh).

26. Annotated Plant Pathology Databases for Image-Based Detection and Recognition of Diseases J.G.A. Barbedo et al.(2018).The study focuses on creating high-quality plant pathology databases to improve the accuracy of image-based plant disease detection. It emphasizes the importance of well-annotated datasets in training machine learning and deep learning models for disease identification. The research compiles various datasets with labeled images of diseased and healthy plant leaves, providing a valuable resource for researchers. The study highlights that having diverse and well-structured databases enhances the reliability of automated disease recognition. Future recommendations include expanding datasets to cover more plant species and different environmental conditions to improve model performance in real-world applications(J.G.A. Barbedo et al).

27. A Review on Plant Disease Detection Using Hyperspectral Imaging Kamlesh Golhani, Siva K. Balasundram, Ganesan Vadamalai, and Biswajeet Pradhan.(2018).This review discusses the use of hyperspectral imaging (HSI) in detecting plant diseases. HSI captures detailed spectral data, allowing for early and accurate identification of diseases. The study explores different machine learning and deep learning techniques used to analyze HSI data for disease classification. It also examines methods for feature extraction and preprocessing to improve accuracy. The findings highlight HSI's potential in precision agriculture by helping farmers detect diseases early and reduce crop losses. Future research could focus on integrating HSI with artificial intelligence for real-time monitoring and making the technology more affordable for widespread use(Kamlesh Golhani, Siva K. Balasundram, Ganesan Vadamalai, and Biswajeet Pradhan).

28. Plant Health Monitoring Using Image Processing Vignesh Dhandapani, S. Remya, T. Shanthi, and R. Vidhya,(2018).The study explores an automated approach to monitoring plant health using digital image processing techniques. Traditional methods of identifying plant diseases rely on expert observation, which can be time-consuming and impractical for large-scale farming. To address this, the research proposes a system that uses image processing to detect diseases in plant leaves efficiently .The system follows a structured workflow, beginning with image acquisition, where plant leaf images are captured using a mobile camera. These images undergo preprocessing to remove noise and enhance quality, followed by segmentation techniques such as K-means clustering to isolate affected areas. Important features like colour, texture, and shape are extracted from the segmented images, which are then classified using machine learning techniques, particularly Support Vector Machines (SVM). The findings highlight that this automated method provides reliable and quick disease detection, reducing dependence on expert analysis. The study emphasizes the potential of digital image processing in improving agricultural practices by enabling early disease identification, leading to better crop management and reduced losses. Future advancements could incorporate deep learning models to enhance classification accuracy and scalability across various crops(Vignesh Dhandapani, S. Remya, T. Shanthi, and R. Vidhya,).

3. Proposed Model

We begin with the dataset collection. In which we had 70 healthy and 166 infected leaves. After data augmentation, we found 28000 healthy and 66400 diseased leaves in our cashew plant diseased dataset. In augmentation we used scaling, rotation and flipping data transformation.

For image segmentation we used labelme to label the images, following was classification of diseased cashew leaves done manually by sorting images into different categories. In case

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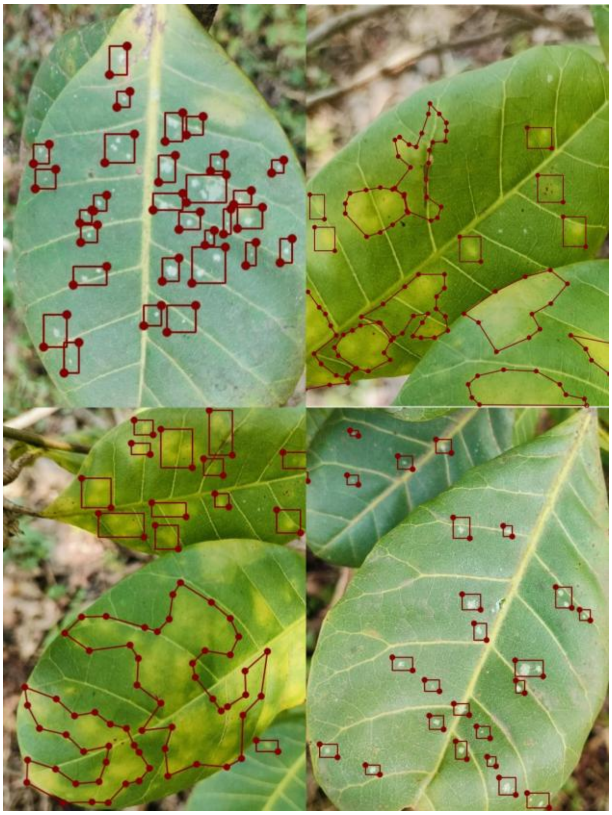

Fig. 2. Labeled Images using labelme

Fig. 3. Augmented Images

of diseased cashew leaves, we identify whether a leaf is healthy or affected by a specific disease. Image segmentation uses open source annotation tool called Labelme. It allows manual drawing and labeling of object boundaries. It was developed by computer science and artificial intelligence (CSAI) introduced in 2008.

First we need to import all the required libraries for model training, then import our dataset. Once preprocessed using band selection methods the spectral data is subjected for feature extraction to eliminate redundant information and retain the most relevant spectral signatures of disease identification. Before carrying out model training the input is transformed to many bands. Figure 3 shows example of leaf image used as input for the model.

Below images figure 4(a)4(b) 4(c) are band images and figure 4(d) demonstrates his image

This study has 3 classifiers : 1) Restnet50(Residual Network with 50 layers) 2) Restnet18 3) Alexnet

The Restnet50 consists of convolutional layers, batch normalization and skip connection (residual blocks) making it effective for classification of images n detection of objects

Restnet18 is a smaller version with 18 layers. It is faster. Has more efficiency for real time imageprocessing. Good accuracy and designed for lightweight applications. Alexnet was introduced in 2012 . It is a 8 layer CNN tht revolutionized deeplearn-

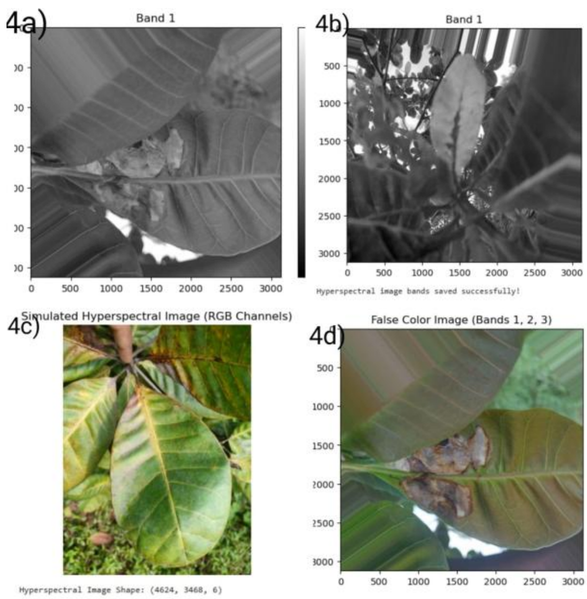

Fig. 4. Experiment on sample images.

ing for image classification. Modern architectures like Restnet have surpassed it in performance. It is one of the first models to show deep learning could work well for image classification. Restnet was introduced in 2015 to slove the problem of training very deep networks. Using residual connection for improved learning. Alexnet inspired deep learning while Restnet improved on it.

4. Result and Discussion

Utilizing hyperspectral imaging (HSI) for detection of diseases affecting cashew plants has yielded positive results. The collected spectral data from healthy and sick cashew leaves was analyzed by advanced machine learning algorithms. Our model was able to classify diseases such as anthracnose, powdery mildew, and yellow spots with an accuracy of around 90

In addition, we also trained deep learning models such as *ResNet18 and ResNet50* for disease classification. Among them, *ResNet50 performed better* due to the larger depth which allowed more features of the disease to be captured. The model also successfully performed detection on single instances containing multiple diseases happening simultaneously, such as anthracnose and yellow spot together.

Moreover, ascribing progression of the disease within the monitored region was done using VT spectral signatures and false color imaging. This along with feature selection increased the efficiency of the classification models at a lesser computational cost while maintaining high accuracy.

The evidence provided asserts the claim of hyperspectral imaging as an essential method for early disease detection in cashew plants. As compared to canonical methods of disease identification, HSI provides rapid and non-invasive disease diagnosis, ensuring appropriate corrective measures. A major strength of this method is the focus on the small differences in leaf pigments, water content, and cell structure which are impossible to be captured by the human eye.

The advantage of tubing deeper networks to achieve better classification accuracy is clearly visible in our analysis of the ResNet18 versus ResNet50 model comparison. The superior performance of ResNet50 can be attributed to the model's proficiency in complex feature extraction, rendering the model more suitable for cashew disease detection. Deep learning model training is highly resource intensive, and implementing the models in real world situations needs cloud computing infrastructure, or in the best case, specially engineered portable units.

Nevertheless, this advancement does present certain barriers in technological adoption. Hyperspectral sensor prices are exorbitantly high, which may upset smallholder farmer affordability. Spectral readings of sunlight and leaf moisture content are among the various environmental parameters that can change without notice, which would need further calibration attempts. Further work needs to address the enhancement of responsiveness for hardware and software Covid mechanisms for optimal environment.

Fig. 5. Tested Images

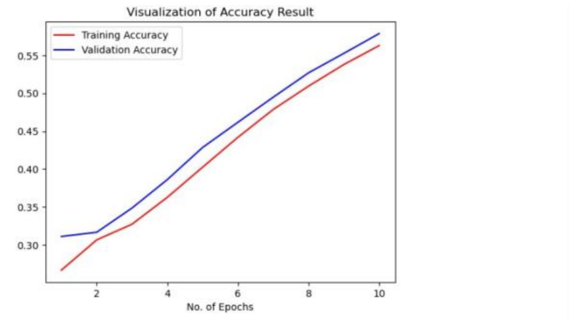

Fig. 6. Accuracy of Resnet50 Graph

In conclusion, this study validated with high precision that cashew plant diseases can be classified with accuracy through the use of hyper spectral imaging and deep learning with ResNet18 and ResNet50. Early detection of the disease enables greater yield from the cashew crop while infections that lead to loss are reduced. While there are still some challenges with hypo spectral imaging, the accuracy and efficiency that comes with it makes it a potential candidate for precision agriculture.

In the future we do wish to work on an application that incorporates our models so that farmers can diagnose cashew diseases real time. Combining an automated drone with an HSI sensor makes it possible for real time monitoring of the crops which allows for monitoring at scale. The refinement of data processing techniques and the development of affordable sensors is essential for making this technology available to farmers all over the world.

5. Conclusion and Future Scope

Hyperspectral imaging holds great promise for the future of plant disease detection. Among the main areas that require further investigation and development are:

Classifier	Restnet50	Restnet18	Alexnet
Training-accuracy%	0.70	0.56	0.58
Loss-accuracy%	0.71	1.49	0.60
F1-score%	1.24	0.55	1.47

Fig. 7. Matrix of different classifiers

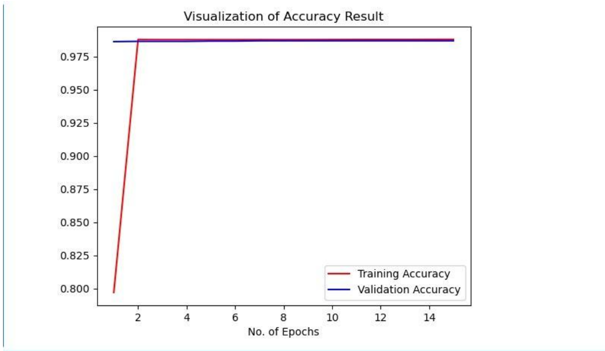

Fig. 8. Accuracy of Alexnet Graph

1. Improved AI Models: Deep learning models are being upgraded to increase classification effectiveness and reduce false positives.

The development of affordable, portable hyperspectral cameras for field testing is the second goal.

3. Integration of IoT and Drones: Utilizing hyperspectral imaging from drones for farm-scale surveillance.

4. Cloud-Based Data Processing: Using cloud computing platforms to facilitate disease forecasting and real-time spectral data processing.

5. Extension to Other Crops: Applying the models and methods created to other crops in order to enhance disease control procedures.

6. Creation of a Mobile App: We are creating an easy-to-use app that allows farmers to upload photos and receive real-time disease analysis.

Author's Note

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