**Automated leaf disease detection using GAN with transfer learning in multiple crops**

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***ABSTRACT: Since leaf diseases directly affect crop output and food security, their prompt detection is crucial for sustainable agriculture. In addition to transfer learning techniques across diverse crops, this study introduces an automated approach for leaf affliction detection that uses Generative Adversarial Networks (GANs). We overcome the problem of little labelled data for valuable diseases by using GANs to create synthetic images that improve the preparation dataset. This enriched dataset is used to fine-tune a pre-trained convolutional networked system (CNN) to increase categorization accuracy. Veracity, precision, recall, and F1 score are among the common metrics used to assess the efficacy of the proposed method, which demonstrated better performance than well-known detection techniques. Our findings show that the model can accurately identify a range of leaf diseases, making it a useful tool for early detection. In addition to highlighting the potential of deep learning in land practices, this study provides a scalable solution for real-time disease monitoring, which will ultimately enhance crop management and agricultural sustainability.***

***KEYWORDS: Convolutional neural network (CNN), Crop diseases, Deep Learning, Rice crop disease.***

INTRODUCTION

Crop health has a direct impact on agricultural productivity, and agriculture is essential to the world's food security. Crop infections are one of the biggest threats among the many difficulties, frequently resulting in large production losses. Because leaves are susceptible to bacterial, viral, and fungal infections, leaf illnesses are very common. Early disease detection is crucial for controlling outbreaks and maintaining crop health, which safeguards farmers' livelihoods and promotes the stability of the food supply. Leaf diseases have an impact on the quality of the food in addition to lowering crop yield. Infected crops, for example, might not grow to their full potential, producing tiny fruits and vegetables that are less aesthetically pleasing and possibly less nutrient-dense. Furthermore, if left unchecked, several diseases have the potential to spread quickly throughout fields and result in significant losses in agriculture. These illnesses can have disastrous economic effects, particularly for small-scale farmers that depend on a single crop for revenue. Farmers and agronomists have historically used visual indicators like yellowing, patches, or moldy growths in conjunction with manual inspection to detect leaf diseases. Although this approach is simple, it can be subjective and time-consuming, particularly when used to huge fields. Furthermore, manual inspections need for skill because it might be difficult to make an accurate diagnosis because different diseases can appear with identical symptoms. Additionally, traditional approaches could overlook early disease indicators, letting the illness worsen before treatment can take place. Advances in technology have made automated disease detection techniques feasible and are revolutionizing farming systems. Based on pictures of leaves, technologies like computer vision, deep learning, and machine learning have demonstrated potential in recognizing and categorizing diseases. Farmers can use these techniques to quickly and precisely identify diseases, even in their early stages, enabling more prompt responses. In large-scale agriculture, when manual inspection is unfeasible, these automated techniques are very beneficial.

More farmers across the world can now detect leaf diseases thanks to mobile applications. These applications enable farmers to take smartphone photos of impacted leaves, which are subsequently processed in the cloud or by machine learning models built into the app. These apps give farmers immediate input, advising them about potential diseases and offering potential treatments. Without the need for specialist equipment, these gadgets enable farmers—particularly those in distant areas—to obtain professional illness diagnosis. Leaf disease detection will become more precise, available, and effective as AI and imaging technologies advance. A more proactive approach to crop health management may be made possible by future technologies that include automated treatment recommendations, real-time disease tracking, and predictive analytics. Crop yields may be increased, disease transmission could be stopped, and resources could be optimized by integrating AI-based detection systems with farm management software. Smarter, data-driven disease management techniques, fuelled by technological and artificial intelligence breakthroughs, are probably going to define the future of agriculture.

OBJECTIVE

In order to improve classification accuracy across multiple crops, a pre-trained CNN will be fine-tuned, synthetic images of damaged leaves will be added to the training dataset, and an automated method for detecting leaf illnesses utilizing GAN and transfer learning will be developed.

LITERATURE SURVEY

**[1]. Improving Disease Detection Using Weight Initialization and Residual Links Using LeafNet for Peanut Leaf Diseases Authors: Nirmala Paramanandham, Shyam Sundhar, P. PRIYA YEAR: 2024 Contents:** Peanuts are a global culture and faces the yield significantly reduced due to leaf disease. This is essential for prompt identification of these diseases to ensure continuous agricultural productivity.

**[2]. Multi-Step Preprocessing With UNet Segmentation and Transfer Learning Model for Pepper Bell Leaf Disease Detection Authors: Aisha Ahmed AlArfaj, Abdulaziz Altamimi, Turki Aljrees, Shakila Basheer, Muhammad Umer, Md. Abdus Samad Year: 2023 Content:** Agricultural production is a cornerstone of national economies, and the prevalence of plant diseases poses a significant threat to crop yields. Rapid disease detection is essential to mitigating these risks, but manual methods of facility monitoring are labor-intensive and time-consuming, necessitating a shift to automated solutions. This research addresses the pressing problem of identifying plant diseases by utilizing advanced image processing techniques.

**[3]. A simple grape leaf disease detection method based on improved YOLOv8 Authors: Zuxing Chen, Junjie Feng, Kun Zhu, Zhenyang Yang, Yanhong Wang, Mingyue Ren Year: 2024 Contents:** Grape root rot, black measles and downy mildew are three common diseases of grape leaves that have a great impact on grape yield. However, current research lacks methods to detect grape leaf diseases in real time, which cannot guarantee the healthy growth of grape plants. In order to increase the accuracy of grape leaves detection and secure a small development of models on a mobile device, this study provides a small method to detect grape garden illness based on improved YOLOV8. I will do it.

**[4]. Towards Sustainable Agriculture: A Novel Approach for Rice Leaf Disease Detection Using dCNN and Augmented Dataset Authors: Mehedi Hasan Bijoy, Nirob Hasan, Mithun Biswas, Suvodeep Mazumdar, Andrea Jimenez, Faisal Ahmed Year: 2024 Content:** Rice is one of the essential crops. It is the cereal that feeds almost half of the world's population and is cultivated worldwide. Identifying rice leaf diseases is a chronic problem for farmers and crop specialists. These diseases make it increasingly difficult to meet the growing demand for rice. Therefore, automatic detection of rice leaf diseases is essential to improve productivity.

**[5]. Machine training for the author's classification and detection: Vasileios Balafas, Emmanouil Karatoumanis, Malamati Louta, 2023 Content:** Nikolaos is a quick solution. It is the departure area. Machine learning serves as the state of the art in this field, enabling advanced disease detection and classification methods. In this paper, we specifically explore the application of machine learning and deep learning techniques to plant disease detection and classification.

**[6]. Leaf disease detection based on lightweight deep residual network and attention mechanism Authors: Zhiyong Xiao, Yunge Shi, Gailin Zhu, Jianping Xiong, Jianhua Wu Year: 2023 Content:** In the current context of leaf disease detection, accuracy is essential. Existing machine learning-based methods are often highly dependent on the size of the region of interest and the distribution of the lesions. Developing specialized foliar disease detection tools continues to pose challenges in terms of accuracy and ease of use.

**[7]. Multi-Class Classification of Plant Leaf Diseases Using Deep Convolutional Neural Networks and Feature Fusion of Local Binary Models Author: Khalid M. Hosni, Walaa M. Elhadi, Farid M. Samy, Eleni Vrochidou, George A. Papakostas Year: 2023 Content:** Plant diseases significantly reduce the quality and quantity of agricultural production. As plant structures and cultivation methods evolve, new diseases often emerge. Accurate classification and early detection of plant foliage diseases helps to limit the spread of infection and support the development of healthy plant production.

**[8]. Plant Disease Detection and Classification Using Deep Learning – A Review Authors: Lily Li, Shujuan Zhang, Bin Wang Year: 2021 Contents:** Deep learning, a branch of artificial intelligence, has attracted significant attention in recent years due to its automatic feature extraction capabilities. It is widely applied in various fields such as image and video processing, voice processing, and natural language processing.

**[9]. Deep Learning in Leaf Disease Detection (2014-2024): A Visualization-Based Bibliographic Analysis Authors: Jyotismita Chaki, Dibyajyoti Ghosh Year: 2024 Content:** The agricultural industry plays a vital role in providing high-quality food and contributes significantly to economic growth, which can be harmed by plant diseases. In this article, we present a visualization-based bibliographic analysis to illustrate the research trends in deep learning based leaf disease detection from 2014 to January 2024 using publications collected from the database Scopus.

**[10]. Crop Disease Detection Algorithm Based on Channel Attention Mechanism and Lightweight Upsampling Operator Authors: Wei Chen, Lijuan Zheng, Jiping Xiong Year: 2024 Content:** Crop diseases and pests cause significant economic losses in agriculture every year, so accurate identification is crucial. Traditional methods require agricultural experts and can be labor intensive. This study explores how computer vision technology and artificial intelligence can enable automated disease detection, facilitating accurate real-time monitoring and rapid preventive measures against crop diseases.

**[11]. YR2: Efficient Learning Technology Author: Efficient Learning Technology Author: CHUNDURI MADHURYA, Emerson AjitH Jubilson Year: 2024 Contents:** Many plant diseases indicate symptoms that are observable and recognize these diseases. The method is visually estimated the affected leaves. In this study, we propose a model designed to accurately extract features, thereby improving the success rate of the classification task in plant leaf disease detection and classification.

**[12]. A Review on Leaf Disease Detection and Classification Using Deep Learning Authors: Assad Suleiman Dutum, Bulent Tugrul Year: 2023 Content:** Leaves play a vital role in producing nutrients through photosynthesis and supporting plant growth. However, diseases caused by bacteria and other pathogens can negatively impact crop yields. Therefore, rapid and early diagnosis of these diseases is essential to maintain plant health and ensure optimal crop production.

**[13]. Early and Intelligent Detection of Maize Leaf Diseases Using Internet of Things and Multi-Deep Learning Models Authors: Rubina Rashid, Waqar Aslam, Romana Aziz, Ghadah Aldehim Year: 2024 Content:** Plant leaf diseases can occur for various reasons. They can cause serious health issues at harvest time. Early and precise detection and classification of these diseases are crucial to promote a production of healthy crops. Recently, smart agricultural systems have drawn attention to their ability to improve efficiency through the deployment of sensor networks and internet objects (IOT) that collect and analyze environmental data. However, the conventional method of detecting plant diseases is often manual to consume time to manage data complexity and dynamism.

**[14]. GrapeLeafNet: A Two-Way Feature Fusion Network with Inception-ResNet and Shuffle-Transformer for Accurate Identification of Grape Leaf Diseases Authors: R. Karthik, R. Menaka, S. Ompirakash, P. Bala Murugan, Meenakashi, Sindhia Lingaswamy Year: 2024 Content:** Grape is a culture cultivated in the horticultural industry and is known for its unique flavors and nutritional advantages. However, this crop is highly susceptible to a variety of diseases that can cause significant yield and quality declines, resulting in considerable economic losses.In this study, we propose GrapeLeafNet, a bidirectional feature fusion network that combines Inception-ResNet and Shuffle-Transformer architectures, to improve the accuracy of grape leaf disease identification.

**[15]. Precision Agriculture with Deep Learning: Recognizing Multiple Diseases in Tomato Plants Using CNN and Enhanced YOLOv7 Authors: Muhammad Umar, Saud Altaf, Shafiq Ahmad, Haitham Mahmood, Adamali Shah Noor Mohamed, Rashid Ayub Year: 2024 Content:** Accurate Identification of Tomato Leaves Field conditions are essential for early assessment of crop yield, especially given the growing importance of precision agriculture. However, distinguishing between diseases can be challenging due to symptom overlap between the various conditions affecting tomato plants. In this study, we explore the use of Convolutional Neural Networks (CNNs) and improved YOLOv7 models for recognizing multiple diseases in tomato plants to improve detection accuracy and support better crop management.

PROPOSED SYSYTEM

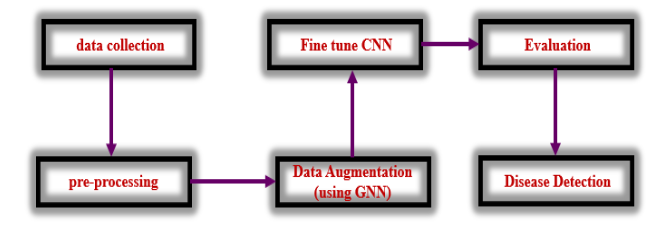
A dataset of photos displaying both healthy and diseased leaves from different crops will be gathered. To enhance the dataset's quantity and diversity, **Conditional Generative Adversarial Networks (cGANs)** will be used to generate synthetic images of leaves with various diseases. A pre-trained Convolutional Neural Network (CNN) will be fine-tuned to improve its classification accuracy for leaf diseases. This system aims to assist farmers in managing their crops by detecting diseases early and efficiently. To make this technology accessible, a user-friendly application will be developed for real-time disease detection and analysis.

**Advantages of the Proposed System**

* **High Accuracy**
* **Time Efficiency**
* **Early Detection**

ARCHITECTURE DIAGRAM

It is a simple graphical system used to symbolize a gadget in phrases of facts input into a computer, various methods performed on that data, and data generated through the machine. Modelling gadget additives. These additives are the method of the gadget, the facts utilized by the manner, the outside entity related to the gadget, and the facts flowing into the gadget. Shows how statistics moves in a gadget and how it undergoes a chain of adjustments. It is a graphical method of depicting facts flow and the changes used even as taking facts from enter to output.

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MODULES

* Dataset Collection
* Data Augmentation with GANs
* Model Training
* Model Evaluation
* Application Development.

1. ***Dataset Collection:***

To begin, a large collection of photos showing both healthy and damaged leaves from different crops must be gathered. The model is trained using this dataset as the basis.

1. ***Data Augmentation with GANs:***

Generative adversarial networks (GANs) will be used to generate synthetic images in order to increase the dataset's size and diversity. This phase enhances the model's capacity to generalize and helps alleviate problems associated with insufficient data.

1. ***Model Training:***

The updated dataset will be used to fine-tune a convolutional neural network (CNN) that has already been trained. By utilizing transfer learning, this method improves the accuracy of leaf disease classification using the enriched dataset.

1. ***Model Evaluation:***

To guarantee the model's dependability in practical applications, its performance will be thoroughly assessed following training utilizing metrics including accuracy, precision, and recall.

1. ***Application Development:***

Lastly, a user-friendly real-time disease detection application will be created. By giving users immediate feedback on the health of their leaves, this app seeks to help farmers manage their crops more efficiently.

*PROPOSED ALGORITHM*

Generative Adversarial Networks (GANs) are a transformative deep learning approach used for generating realistic images and enhancing visual data analysis. GANs consist of a Generator, which creates synthetic images, and a Discriminator, which distinguishes between real and synthetic images, working in an adversarial framework. Conditional GANs (cGANs), an extension of GANs, condition the generation process on specific labels, ensuring relevance to the classification task. In crop disease detection, GANs play a crucial role in augmenting datasets by generating diverse and realistic synthetic images of healthy and diseased leaves, addressing the challenge of data scarcity. This enriched dataset is then used to train a Convolutional Neural Network (CNN), which extracts hierarchical features such as edges, patterns, and textures, ultimately enabling the classification of leaf health. By leveraging the adversarial training process of GANs to produce high-quality synthetic data and the feature extraction capabilities of CNNs, the system achieves high accuracy, time efficiency, and early detection of diseases. The combination of GANs and CNNs enhances model robustness, generalization, and real-time disease detection, empowering farmers with actionable insights and improving agricultural productivity. This approach revolutionizes disease detection by addressing data limitations and advancing the reliability of deep learning-based systems.

RESULT & DISCUSSION

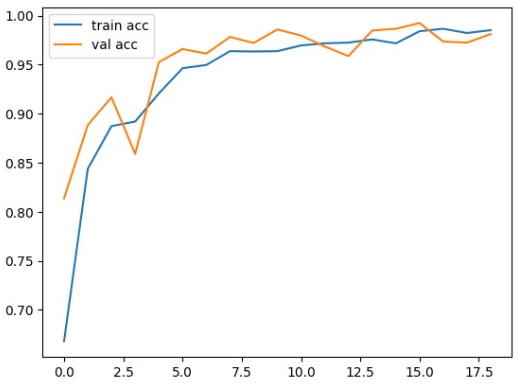
It is possible to visually assess Cycle GAN's performance. This displays the dataset's unique cassava leaf photos as well as synthetic cassava leaf images produced by the Cycle GAN model. We load the image categories for classification purposes after obtaining the images produced by GAN algorithms for various categories. Images of cassava leaves are classified into various categories using a combination of CNN, VGG16, and Resnet34 models. There are 12880 photos in the dataset. 1023 photos were used for testing, while 11587 images were used for training displays the original image inverted.

TABLE

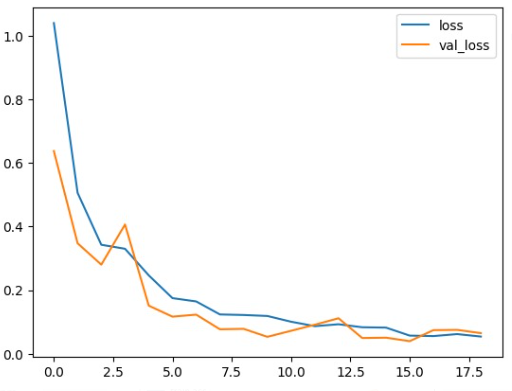
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| --- | --- | --- | --- |
| Type | Classification | Advantages of the Proposed System | References |
| Apple disease | Faster CNNs | Higher accuracy and faster detection speed | [19] |
| Tomato disease | Conditional GAN(cGAN) | Better accuracy | [20] |
| Five crops diseases | Conditional GAN(cGAN) | The multi-crop diseases can be classified | [21] |
| Rice | ID3, backpropogation, Naïve Bayes and multiclass SVM | Better accuracy | [22] |
| Multiple plant species | ResNet | Lowers computational cost | [23] |
| Tomato | InceptionResNetV2, Autoencoder | Better accuracy | [24] |
| Cassava | Conditional GAN(cGAN) | Lower computational cost | [25] |
| Cassava | Random Forest, SVM and SSCN | Better accuracy | [26] |

***1.1 Table of Leaf Disease Classification with Proposed Method***

GRAPHS



***1.1 A graph with excellent precision***



***1.2 The accuracy graph of loss an illustration***

CONCLUSION

In conclusion, our study proposes a unique approach for automated leaf disease identification by fusing GANs with transfer learning techniques. By using pre-trained CNNs and producing synthetic images, the proposed method aims to overcome the shortcomings of traditional methods and significantly increase the accuracy and efficiency of disease identification across diverse crops. The results of this study will not only encourage improved agricultural practices but also assist farmers in making educated decisions that will protect their crops and increase yields. This study opens the way for future advancements in the management and monitoring of plant health by showcasing the transformative potential of deep learning technology in agriculture.

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