Harnessing CNNs and Deep Learning for Crop Disease Identification

Lt. Dr. D. Antony Arul Raj
Associate Professor Cum ANO
Department of Software Systems
PSG College of Arts and Science
Coimbatore, India.
antony@psgcas.ac.in

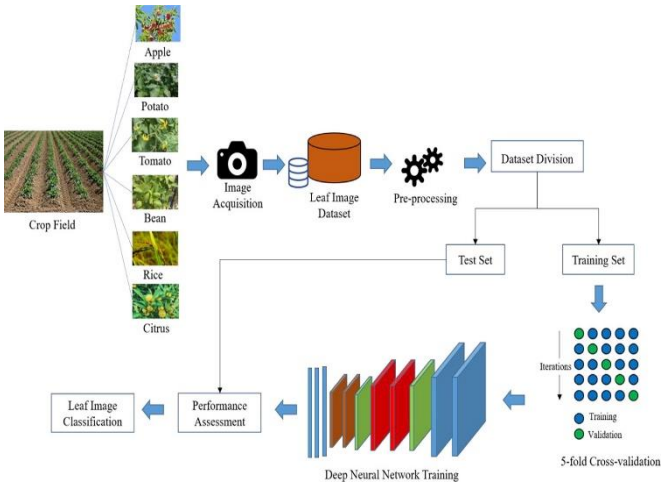
Mr. S. Sakthivel
Department of Software Systems
PSG College of Arts and Science
Coimbatore, India
sakthivel06122@gmail.com

Ms. P. G. Darshana
Department of Software Systems
PSG College of Arts and Science
Coimbatore, India
darshanapsgcas008@gmail.com

Mr. R. Vasanth
Department of Software Systems
PSG College of Arts and Science
Coimbatore, India
vasanthramalingam74@gmail.com

***Abstract*—Automated crop disease detection play a crucial role in increasing agricultural productivity and ensuring food security. This article examines several Convolutional Neural Network (CNN) based approaches proposed for identifying plant diseases accurately and efficiently. Techniques like deformable convolution and lightweight 2D CNN architectures are utilized to enhance disease detection accuracy and efficiency. These models utilize deep learning algorithms to analyze leaf images and provides recommendations to farmers for treatment and disease diagnosis in real time. In Addition, certain systems integrate weather forecasting and pest control suggestions, providing complete support to farmers. These CNN-based methods show promising results, with high accuracies ranging from 94% to 99.60%. Through advancements in image processing and deep learning, these systems aim to reduce crop losses promote sustainable agricultural practices and global food security.**

KEYWORDS—Artificial Intelligence (AI), Convolutional Neural Networks (CNN), Deep Learning, Computer Vision, Image Processing, Disease Detection, Machine learning, Agriculture, Disease Diagnosis, Crops, Feature Extraction, Smart Agriculture.



I. INTRODUCTION

In recent years, the agricultural sector has witnessed a significant surge in the utilization of advanced technologies, particularly in the domain of disease detection and crop management. With the increasing global demand for food production and the persistent threat of crop diseases and pests, there is a pressing need for efficient and reliable methods to identify and manage these challenges. Traditional approaches to disease detection in crops have often been time-consuming, labour-intensive, and reliant on expert knowledge, leading to delays in diagnosis and potential yield losses.

To address these challenges, researchers are adopting artificial intelligence (AI) and deep learning techniques, such as Convolutional Neural Networks (CNNs), for automated disease detection in plants. CNNs have shown remarkable capabilities in image recognition tasks, making them well-suited for analysing images of plant leaves to identify signs of diseases and abnormalities. Using large datasets of annotated images, CNN-based models can be trained to distinguish between healthy and diseased plants with high accuracy and efficiency.

This literature review explores several recent studies that have applied CNNs and other deep learning techniques to detect and classify diseases in various crops, such as rice, corn, tomatoes, cotton, and potatoes. These studies emphasizes the effectiveness of CNN-based approaches in precisely identifying plant diseases, often outperforming traditional methods and achieving high levels of accuracy. Additionally, some research works propose lightweight CNN architectures for mobile platforms leading to real-time disease diagnosis and management right within the field.

Overall, the use of CNN-based models for plant disease detection could make a revolution in agriculture by enabling early and accurate diagnosis, thus empowering farmers to take timely and targeted actions to protect their crops and improve overall agricultural productivity.

A. Motivation

The motivation behind this article lies in addressing the pressing need for efficient disease detection in agriculture, which is essential to maintaining the world's food supply.

With traditional methods proving inadequate and time-consuming, using advanced technologies like Convolutional Neural Networks (CNNs) offers a promising solution. By harnessing CNNs' ability to analyse vast image datasets, researchers aim to develop robust and scalable models capable of accurately identifying diseases across various crops. Moreover, the motivation extends to exploring lightweight CNN architectures suitable for deployment on mobile devices, ensuring accessibility and practicality for farmers in the field. In the end, this research aims to provide farmers with effective instruments for early disease detection, facilitating protecting crop yields to improve global food security worldwide.

B. Problem Statement

The agricultural sector faces significant challenges due to the prevalence of crop diseases, which can severely impact crop health and yield. Conventional disease detection techniques are often time-consuming, labour-intensive, and prone to errors. Furthermore, farmers find it extremely difficult to accurately identify diseases due to their sheer diversity. This article aims to address these challenges by proposing a new approach based on Convolutional Neural Networks (CNNs) for efficient and accurate detection of leaf diseases in multiple plant species. The specific problem involves developing a robust CNN-based model capable of accurately classifying various leaf diseases across different plants. Additionally, the article seeks to explore the feasibility of deploying lightweight CNN architectures suitable for real-time disease detection on mobile devices, thereby enhancing accessibility and usability for farmers in the field.

C. Objectives

The goals of the collected research articles include an in-depth review of various approaches and developments in the field of plant disease detection. The articles focus on enhance understanding and implementation of convolutional neural networks (CNNs) in agricultural contexts by providing a extensive review of image processing methods and machine learning algorithms. They aim to evaluate the effectiveness of various methods, such as deep learning algorithms and CNN-based models, in accurately identifying and categorising crop diseases. The articles also seek to shed light on the application of sophisticated architectures, comparative evaluations of detection algorithms, and UAV imagery integration for enhanced disease detection. The main goal is to support the advancement of reliable, effective, and scalable plant disease detection technologies, which will promote sustainable farming methods and increasing crop yield and quality.

II. BACKGROUND AND CONTEXT

This paper explores a critical aspect of agricultural innovation: the rapid and accurate identification of plant diseases. Global economies are based mostly on agriculture, with India's agricultural sector supporting approximately 65% of its population. However, this sector faces constant threats from various plant diseases intensified by diverse seasonal conditions. Traditional methods of disease detection are often inefficient and labor-intensive, leading to significant crop losses. In response to these challenges, the study adopts a pioneering approach, leveraging Convolutional Neural Networks (CNNs), a subset of deep learning algorithms renowned for their effectiveness in image classification tasks. By harnessing CNNs' capabilities, the research aims to revolutionize disease detection in plants, offering an automated and precise solution that can quickly identify various plant diseases. This advancement promises to empower farmers by enabling them to quickly identify and treat diseases, thereby safeguarding crop health and enhancing agricultural productivity. With technology playing an increasingly pivotal role in agriculture, the integration of CNNs into disease detection processes marks a significant step towards building reliable agricultural systems capable of addressing the evolving challenges of food security and sustainability.

III. SCOPE AND FOCUS

The articles focus on using various deep learning techniques, particularly convolutional neural networks (CNNs), for crop disease detection and classification in agricultural settings. They address the challenges of identifying plant diseases from leaf images, which is crucial for timely interventions to prevent crop damage. The studies propose innovative approaches, such as modifying Alexnet for plant disease detection, using super-resolution CNN models, integrating Mask R-CNN for precise instance segmentation, employing transfer learning for species-specific disease detection, and utilizing UAV imagery for automated disease identification.

They aim to improve crop yield and reduce losses by automating the detection of diseases, which can be challenging to identify accurately and promptly through manual inspection. The studies explore various aspects of CNN-based approaches, including disease identification, comparison of algorithms, detection for multiple plants, and architecture design for efficient learning. The proposed models demonstrate high accuracy in detecting diseases such as Esca, Early Blight, Late Blight, Bacterial Spot, Red Rot, Black Rot, and Leaf Mold, among others, showcasing their potential for practical implementation in smart agriculture and contribute valuable insights to the field of automated plant disease management.

IV. METHODOGY

The methodologies in these articles primarily focus on utilizing deep learning techniques, especially convolutional neural networks (CNNs), for crop disease detection from leaf images. They involve various approaches such as modifying existing CNN architectures like AlexNet for plant disease detection, employing super-resolution CNN models to enhance image quality for better classification, collecting and preprocessing image datasets of diseased and healthy crops, training CNN models (often based on popular architectures like ResNet, Inception, or Faster R-CNN), and evaluating the models' performance in disease detection. Additionally, some studies explore the use of UAV imagery and geo-intelligent techniques for automated disease identification, showcasing the diverse applications of deep learning in agricultural practices and comparing different CNN-based algorithms or architectures for improved accuracy. These articles highlight the importance of automated disease detection in agriculture, emphasizing the need for early diagnosis to prevent crop losses. Overall, these methodologies demonstrate the effectiveness of CNNs in detecting and classifying plant

diseases, contributing to advancements in smart agriculture and crop management.

V. Literature Review

1) *Crop Disease Detection Methods*

I. "Improved Faster R-CNN for Crop Disease Diagnosis"

In Yu's (2023) study presented at the 5th International Conference on Artificial Intelligence and Computer Applications, a novel approach for crop pest and disease diagnosis using an Improved Faster R-CNN framework is introduced. The method focuses on enhancing performance in identifying and combating crop diseases through computer vision technology. By incorporating deformable convolution to handle spatial deformations effectively, the proposed method demonstrates promising results in detecting various crop diseases. This research addresses the critical need for accurate and efficient detection techniques in agriculture, offering potential solutions to mitigate threats to global food production. Yu's study marks a significant step forward in leveraging advanced technologies for crop health management [1].

II. "Multi-Crop Disease Detection using CNN."

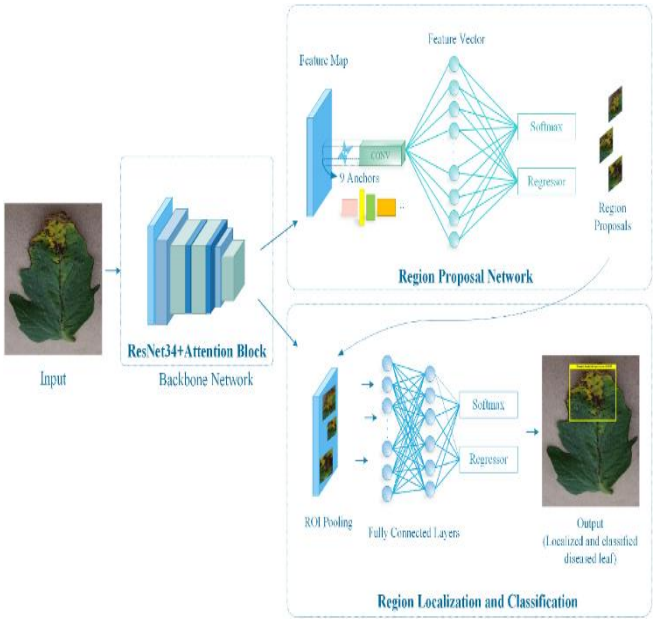
Saeed et al. (2021) presents a groundbreaking method for multi-crop disease detection and classification using Convolutional Neural Networks (CNN) at the International Conference on Robotics and Automation in Industry. Focusing on the agricultural sector's vital need for effective disease detection, the study introduces variants of well-established CNN models, ResNet-152, and Inception-v3, tailored for detecting diseases in essential crops like rice and corn. Through rigorous experimentation and utilizing publicly available datasets, the proposed method achieves impressive accuracy rates, indicating robustness in disease detection across multiple crops. This research contributes significantly to addressing the pressing challenges in agriculture, providing a promising pathway towards enhancing crop health monitoring and management strategies [2].

III. "CNNs for Crop Disease and Weed Detection"

Using Convolutional Neural Networks (CNN), Gupta et al. (2022) present a thorough study on the identification of weeds and crop diseases at the 6th International Conference on Computing, Communication, Control, and Automation. In order to address the critical need for automated detection systems in agriculture, the study evaluates several CNN models for weed and crop disease detection, including MobileNetV2, InceptionV1, and NASNetMobile. The work illustrates the efficacy of InceptionV3 for weed detection and NASNetMobile for agricultural disease detection by doing experiments on datasets covering various crop and weed species. By utilizing cutting-edge deep learning algorithms, the proposed system provides a comprehensive method to improve crop output and modernize agricultural operations. This research contributes valuable insights into the development of intelligent systems for precise disease and weed detection, laying the foundation for sustainable agricultural practices and increased crop productivity [3].

IV. "Crop Disease Diagnosis with CNN"

Mehetre et al. (2023) present a significant contribution to agricultural technology by proposing a method for crop disease diagnosis using Convolutional Neural Networks (CNN) at the 3rd International Conference on Intelligent Technologies. The study addresses the challenges faced by farmers in detecting crop diseases efficiently. By leveraging the capabilities of CNN, particularly ResNet, the proposed model aims to overcome the limitations of traditional disease detection methods, which are often time-consuming and require specialized knowledge. Through rigorous experimentation and validation, the research demonstrates the efficacy of the CNN-based approach in accurately predicting crop diseases based on leaf images. This work holds immense promise for revolutionizing crop health management practices, offering farmers a user-friendly tool to improve crop yields and mitigate the impact of diseases on agricultural production. The findings of this study pave the way for the integration of advanced technologies into agricultural systems, marking a significant step towards sustainable and resilient farming practices [4].



2)Techniques for Plant Disease Detection

I. "Image Processing and CNN for Plant Disease Identification"

Using image processing and Convolutional Neural Network (CNN) techniques, Tandekar and Dongre (2023) present a new approach at the 14th International Conference on Computing Communication and Networking Technologies for diagnosing various diseases in plant leaves. The paper discusses the importance of managing plant diseases as soon as they are discovered, since they have major impacts on agricultural productivity. By employing advanced deep learning methods such as VGG Net 19 and CNN,

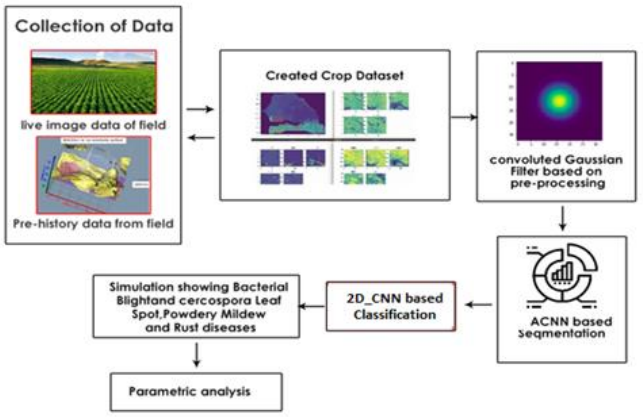
coupled with image processing techniques, the proposed model achieves promising accuracy rates in disease identification. The research underscores the importance of leveraging cutting-edge technologies to combat plant diseases effectively, thereby facilitating early intervention and appropriate management strategies. This work contributes to the advancement of agricultural practices by providing a reliable and efficient tool for farmers to monitor and mitigate the spread of diseases, ultimately leading to improved crop health and yield [5].

II. "Dual-Crop Disease Detection with Lightweight 2D CNN"

In their article published in IEEE Access, Peyal et al. (2023) introduce a pioneering approach for the detection of dual-crop diseases using a lightweight 2D Convolutional Neural Network (CNN) architecture. Focusing on the critical need for efficient disease detection in crops like tomatoes and cotton, the study utilizes advanced deep learning techniques to develop a plant disease classifier. The proposed model outperforms pre-trained models like VGG16 and InceptionV3 despite having fewer parameters, achieving high accuracy rates ranging from 57% to 92%. Moreover, the model's lightweight nature enables swift disease classification, making it highly suitable for real-time applications. By leveraging gradient weighted class activation mapping (Grad-CAM) techniques, the study provides visual insights into the detected diseases, enhancing interpretability and understanding. This research significantly contributes to the advancement of agricultural technology, offering a robust and efficient solution for the early detection and management of crop diseases, thereby promoting sustainable farming practices and improving crop yields [6].

III. "AI-based Crop Recommendation and Disease Detection"

At the 3rd International Conference for Emerging Technology, Shilaskar et al. (2022) proposed a new Artificial Intelligence (AI)-based system for plant leaf disease diagnosis and crop recommendation. This approach addresses the difficulties faced by farmers in accurately diagnosing plant diseases and selecting the best crops. The suggested system achieves high accuracies of 98% for disease detection and 99% for crop recommendation by merging deep learning algorithms such as Convolutional Neural Networks (CNN) for disease detection and Random Forest Algorithm for crop recommendation. Farmers may upload photos of sick plants with ease using the user-friendly web-based interface, and they will receive prompt diagnosis and recommendations. The system also makes online transactions easier and offers weather forecasts, which helps farmers make better decisions and have better access to agricultural resources [7].



3) Deep Learning Models for Crop Disease Identification

I. "Comparison of CNN-Based Algorithms for Plant Disease Identification"

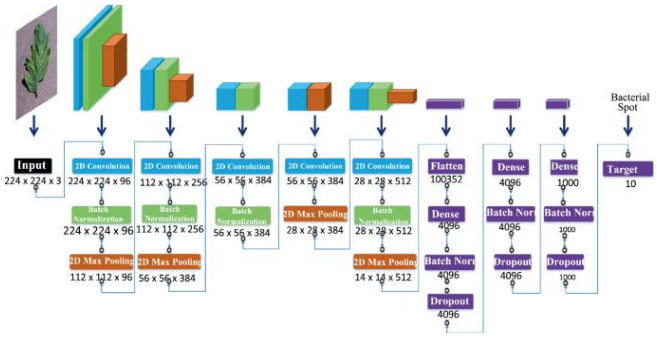
A thorough study comparing CNN-based algorithms for plant disease identification was carried out by Rattan and Shiney (2023) and presented at the Advanced Computing and Communication Technologies for High Performance Applications conference. The study investigates whether CNN and VGG-16 algorithms are suitable for correctly recognising plant illnesses, which is important for prompt agricultural intervention. Using the Plant Village dataset, the paper analyses accuracy and loss measure and finds that although VGG-16 with batch normalisation achieves 94% accuracy, the CNN-based technique achieves 96.77%. These results highlight CNN's accuracy in identifying plant diseases and present an effective way for enhancing crop production. The research provides valuable insights into the performance of deep learning algorithms in agricultural applications, contributing to the development of advanced tools for disease management in crops [8].

II. "Modified AlexNet for Crop Disease Detection"

Using a modified AlexNet architecture, Yeh, Wang, and Chen (2021) present an innovative approach for crop disease detection at the IEEE 3rd Eurasia Conference on Biomedical Engineering, Healthcare, and Sustainability. The study uses deep learning techniques to address the critical need for reliable and accurate disease diagnosis. The suggested method performs better at diagnosing plant illnesses from leaf photos by modifying the AlexNet model to account for changes in image size and angle. By utilising a training corpus with human-labelled data, the research attains promising results, indicating the efficiency of the modified AlexNet approach. By offering a dependable and effective method for early disease identification, this research advances agricultural technology by enabling prompt intervention and mitigation measures. The findings underscore the potential of deep learning techniques in revolutionizing crop management practices, ultimately leading to enhanced agricultural productivity and sustainability [9].

III. “Super Resolution CNN for Crop Disease Detection”

Using a Super Resolution Convolutional Neural Network (SRCNN), Ram et al. (2022) offer a novel method for agricultural disease detection at the 7th International Conference on Communication and Electronics Systems. The study addresses the critical need for accurate and efficient disease detection in agriculture, which is essential to maintaining crop health and yield. The proposed approach shows promising results in reliably identifying crop diseases by using CNN classifier for disease detection and SRCNN to enhance the quality of crop leaf images. Deep learning algorithms are integrated to enable quick and accurate disease diagnosis, enabling farmers to take immediate remedial action. This research represents a major step forward in utilising cutting edge technology to transform crop management strategies, which will ultimately enhance agricultural sustainability and food security. The results highlight how SRCNN-based models may be used to improve disease detection capabilities, opening the way for future developments in precision agriculture [10].



4) Advanced Approaches for Plant Disease Classification

I. “CNN-Based Detection of Leaf Diseases for Multiple Plants”

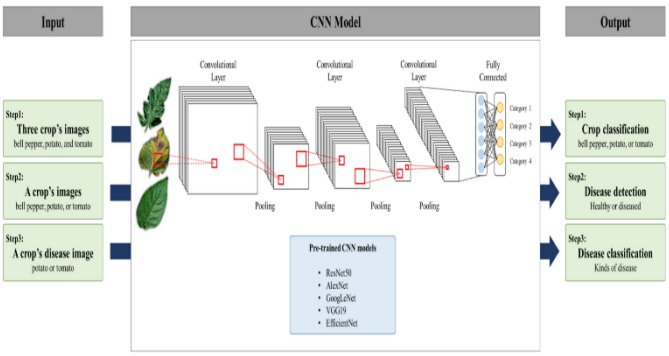
Pawar et al. (2022) presents a groundbreaking study on the detection of leaf diseases across multiple plant species using Convolutional Neural Network (CNN) technology, presented at the 3rd International Conference on Smart Electronics and Communication. Addressing the critical issue of plant health in agriculture, the research offers a comprehensive solution for timely disease detection and management. The proposed CNN-based model demonstrates remarkable accuracy in identifying 21 leaf diseases, facilitating prompt intervention measures to mitigate crop losses. Moreover, the integration of weather forecasting information provides farmers with valuable insights for making informed decisions regarding crop health management. This research represents a significant advancement in leveraging CNN technology for multifaceted disease detection in agriculture, offering a scalable and effective tool for enhancing crop productivity and sustainability. The findings hold immense potential for revolutionizing agricultural practices and fostering resilience against plant diseases across diverse plant species [11].

II. “Crop Disease Diagnosis using Deep Learning Models”.

Haider et al. (2020) contribute to the agricultural domain by proposing a novel method for disease diagnosis in wheat by utilizing deep learning models, presented at the Global Conference on Wireless and Optical Technologies. The study addresses the pressing need for efficient and accurate disease detection to mitigate crop losses. Leveraging deep learning techniques, specifically Convolutional Neural Networks (CNNs), the proposed approach demonstrates promising results in identifying various crop diseases. By training the model on a dataset obtained from online sources, the study achieves significant accuracy in disease diagnosis, providing farmers with valuable insights for timely intervention. The research signifies a crucial step towards the integration of advanced technologies in agriculture, offering a scalable and effective solution for enhancing crop health management. The findings highlight the potential of deep learning models in revolutionizing crop disease diagnosis, paving the way for improved agricultural productivity and sustainability [12].

III. “Two-stage Approach for Plant Disease Classification”

Showrav et al. (2022) introduce an new two-stage approach for plant disease classification, presented at the 12th International Conference on Electrical and Computer Engineering. By incorporating deep neural networks and transfer learning, the study addresses the complex challenges associated with plant disease detection. The proposed methodology divides the classification pipeline into two stages: plant species detection and species-specific disease detection. Leveraging efficient deep convolutional neural network (CNN) architectures, such as EfficientNetB3, NASNetLarge, and DenseNet201, the approach achieves superior performance compared to conventional single-stage methods. Through rigorous experimentation using publicly available datasets, the study demonstrates the effectiveness of the two-stage method in accurately identifying plant diseases. These results highlight the potential of advanced machine learning techniques in revolutionizing plant disease classification, offering a reliable and scalable solution for enhancing agricultural productivity and sustainability [13].



VI. Synthesis And Discussion

These articles reveal a strong focus on using convolutional neural networks (CNNs) for plant disease detection and classification in agriculture. The studies emphasize the importance of early disease detection in improving crop yield and reducing losses. Various CNN architectures, including modified AlexNet, VGG-16, and custom networks, are explored for their effectiveness in detecting and classifying diseases and Faster R-CNN, ResNet, Inception, and MobileNet, are explored for their efficacy in detecting diseases across multiple crops. These approaches demonstrate high accuracy rates, often exceeding 90%, showcasing the potential of deep learning in revolutionizing disease management practices in agriculture. The studies also highlight the practical implications of these systems, such as real-time disease detection and automated treatment suggestions for farmers. Additionally, techniques like transfer learning and region based CNNs are explored to enhance the performance of disease detection models. Overall, these studies contribute to the advancement of automated systems for plant disease management, benefiting farmers and improving agricultural practices. These articles collectively underscore the pivotal role of deep learning, particularly convolutional neural networks (CNNs), in revolutionizing crop disease detection and classification. The integration of computer vision technology and AI algorithms into agricultural practices demonstrates a promising avenue for enhancing crop management and sustainable agriculture.

VII. Conclusion

The integration of advanced technologies such as Convolutional Neural Networks (CNNs) and deep learning models has revolutionized crop disease detection and classification. Through the research presented in the cited articles, it's evident that these methodologies offer promising solutions to address the challenges faced by farmers worldwide. From improved Faster R-CNN frameworks to lightweight 2D CNN architectures and AI-based crop recommendation systems, each study contributes valuable insights into enhancing agricultural practices. Furthermore, the adoption of multi-crop disease detection approaches, coupled with image processing techniques and transfer learning, demonstrates significant strides in accurately identifying and managing plant diseases across various crops and plant species. The proposed two-stage classification methods also offer a novel approach to plant disease classification, leveraging deep neural networks for enhanced accuracy and efficiency. Overall, these advancements signify a transformative shift towards data-driven and technologically empowered agricultural practices. By leveraging CNNs and deep learning models, farmers can make informed decisions, mitigate crop losses, and ultimately contribute to ensuring food security and sustainability in the face of increasing global challenges.

Acknowledgment

We extend our heartfelt gratitude to a few people who have contributed a lot towards the victorious completion for my research paper . We would like to thank Thiru L. Gopalakrishnan, Managing Trustee, PSG & Sons Charities, for providing me prospect and surroundings that made the work possible. We take this opportunity to express our deep sense of gratitude to Dr T. Kannaian, Secretary of PSG College of Arts & Science, Coimbatore for permitting and doing the needful towards the successful completion of this research paper. We express our deep sense of gratitude and sincere thanks to our Principal Dr D. Brindha M.Sc., M.Phil., Ph.D., MA (Yoga)., for her valuable advice and concern on students. We are very thankful to Dr A. Anguraj, M.Sc., M.Phil., Ph.D., Vice Principal (Academics), Dr Jayanthi M M.Com., MBA., M.Phil., Ph.D., Vice Principal (Student Affairs), Dr M. Umarani MBA, M.Phil., Faculty-In-Charge (Student Affairs), for their support towards our research paper. We own our deepest gratitude to Dr K. V. RUKMANI., M.C.A., M.E., Ph.D., Associate Professor & Head, Department of Software Systems, for her encouragement to pursue new goals and ideas. We convey our heartiest thankfulness to Lt. Dr D. Antony Arul Raj, M.Sc.,(CS).,M.Phil., PGDCE., Ph.D., Assistant Professor, Department of Software Systems, for his timely suggestion which had enabled us in completing the research paper successfully. We express our sincere gratitude to all the researchers whose work has been cited in this article. This note of acknowledgement will be incomplete without paying our heartful devotion to my parents, my friends and other people, for their blessings, encouragement, financial support and the patience, without which it would have been impossible for us to complete the job.

References

[1] Z. Yu, "Research on Crop Pest and Disease Diagnosis Method Based on Improved Faster R-CNN," 2023 5th International Conference on Artificial Intelligence and Computer Applications (ICAICA), Dalian, China, 2023, pp. 46-50, doi: 10.1109/ICAICA58456.2023.10405454.J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[2] Z. Saeed, A. Raza, A. H. Qureshi and M. Haroon Yousaf, "A Multi-Crop Disease Detection and Classification Approach using CNN," 2021 International Conference on Robotics and Automation in Industry (ICRAI), Rawalpindi, Pakistan, 2021, pp. 1-6, doi: 10.1109/ICRAI54018.2021.9651409.

[3] B. Gupta, S. Bomble, O. Gaikar, S. Chalekar, S. R. Vispute and K. Rajeswari, "Convolutional Neural Networks for Detection of Crop Diseases and Weed," 2022 6th International Conference On Computing, Communication, Control And Automation (ICCUBEA, Pune, India, 2022, pp. 1-5, doi: 10.1109/ICCUBEA54992.2022.10010772.

[4] S. Mehetre, R. Mangle, P. Karvanje and R. Y. Sarode, "Crop Disease Diagnosis using Convolutional Neural Network," 2023 3rd International Conference on Intelligent Technologies (CONIT), Hubli, India, 2023, pp. 1-7, doi: 10.1109/CONIT59222.2023.10205929.

[5] D. Tandekar and S. Dongre, "Identification of Various Diseases in Plant Leaves Using Image Processing and CNN Approach," 2023 14th International Conference on Computing Communication and Networking Technologies (ICCCNT), Delhi, India, 2023, pp. 1-6, doi: 10.1109/ICCCNT56998.2023.10306979.

[6] H. I. Peyal et al., "Plant Disease Classifier: Detection of Dual-Crop Diseases Using Lightweight 2D CNN Architecture," in IEEE Access, vol. 11, pp. 110627-110643, 2023, doi: 10.1109/ACCESS.2023.3320686.

[7] S. Shilaskar et al., "Artificial Intelligence based Crop Recommendation and Plant Leaf Disease Detection System," 2022 3rd International Conference for Emerging Technology (INCET), Belgaum, India, 2022, pp. 1-6, doi: 10.1109/INCET54531.2022.9824002.

[8] R. Rattan and J. O. Shiney, "Comparison and Analysis of CNN Based Algorithms for Plant Disease Identification," 2023 Advanced Computing and Communication Technologies for High Performance Applications (ACCTHPA), Ernakulam, India, 2023, pp. 1-6, doi: 10.1109/ACCTHPA57160.2023.10083342.

[9] J. -F. Yeh, S. -Y. Wang and Y. -P. Chen, "Crop Disease Detection by Image Processing Using Modified Alexnet," 2021 IEEE 3rd Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability (ECBIOS), Tainan, Taiwan, 2021, pp. 159-160, doi: 10.1109/ECBIOS51820.2021.9510426.

[10] M. S. Ram, N. K. Priya, M. Sujith, S. S. Basha and J. Prashanth, "A Super Resolution CNN based Model for Crop Disease Detection," 2022 7th International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2022, pp. 1532-1537, doi: 10.1109/ICCES54183.2022.9835998.

[11] S. Pawar, P. Thorave, N. Panigrahi, A. P. Jyothi, S. Shedge and S. Sayyad, "Detection of Leaf Diseases for Multiple Plants using Convolutional Neural Network," 2022 3rd International Conference on Smart Electronics and Communication (ICOSEC), Trichy, India, 2022, pp. 1162-1168, doi: 10.1109/ICOSEC54921.2022.9952134.

[12] W. Haider, A. Ur Rehman, A. Maqsood and S. Z. Javed, "Crop Disease Diagnosis using Deep Learning Models," 2020 Global Conference on Wireless and Optical Technologies (GCWOT), Malaga, Spain, 2020, pp. 1-6, doi: 10.1109/GCWOT49901.2020.9391605.

[13] T. T. Showrav, S. Bain, M. Hossain, K. I. Ahmed, S. A. Fattah and S. Ahmed, "A Two-stage Approach for Plant Disease Classification Based on Deep Neural Networks and Transfer Learning," 2022 12th International Conference on Electrical and Computer Engineering (ICECE), Dhaka, Bangladesh, 2022, pp. 469-472, doi: 10.1109/ICECE57408.2022.10088587.