# PLANT DISEASE CLASSIFICATION USING AI - SPL DEEP LEARNING AND MACHINE LEARNING

**Leena Gupta***

Banasthali Vidyapith, Vidyapith, Rajasthan (India)

Institute of Information Technology and Management, Guru Gobind Singh Indraprastha University, New Delhi (India)

email2leena@gmail.com

**Vaibhav Vyas**

Banasthali Vidyapith, Vidyapith, Rajasthan (India)

**Reception**: 27/02/2023 **Acceptance**:21/04/2023 **Publication**: 10/07/2023

**Suggested citation**:

Gupta, L. and Vyas, V. (2023). **Plant Disease Classification Using AI - Spl Deep Learning and Machine Learning**. *3C Tecnología. Glosas de innovación aplicada a la pyme, 12(2)*, 65-76. https://doi.org/10.17993/3ctecno.2023.v12n2e44.65-76

## ABSTRACT

*The field of plant disease classification has recently been seen to be a vast area of research. Recent years have witnessed a growing interest in the application of artificial intelligence (AI) and machine learning (ML) techniques for various tasks. Among these techniques, deep learning (DL) algorithms have received significant attention and demonstrated remarkable results. This review article aims to give a comprehensive overview of the current advancements in the field of plant disease classification using AI and ML, with a focus on DL approaches. The paper will cover key literature in the field, including recent advances and challenges, and will discuss the most commonly used algorithms, such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Transfer Learning (TL). Additionally, the review will highlight the various applications of AI in plant disease classification, including the use of images, genomic data, and environmental data. The paper will also provide insights into the limitations and opportunities of AI-based plant disease classification, as well as future directions for research in this field. The goal of this paper is to provide a comprehensive overview of the field and to serve as a useful resource for researchers and practitioners in the area of plant disease classification using AI and ML.*



## KEYWORDS

*Plant disease classification, artificial intelligence, machine learning, deep learning, convolutional neural networks, recurrent neural networks, transfer learning*


## INDEX




https://doi.org/10.17993/3ctecno.2023.v12n2e44.65-76

# 1. INTRODUCTION

Plant diseases caused by pathogens, environmental factors, or genetic issues have a major impact on global food security, crop yield, and economic stability. Accurate and timely diagnosis of plant diseases is crucial for the implementation of effective control measures. Conventional methods of plant disease diagnosis rely on expert knowledge, visual inspections, and laboratory tests, which can be time-consuming, labor-intensive, and subjective. To overcome these limitations, the field of plant disease classification has increasingly turned to the use of artificial intelligence (AI) and machine learning (ML) techniques [1].

In recent years, deep learning (DL) algorithms have shown significant promise in plant disease classification, particularly in the analysis of image data. Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Transfer Learning (TL) are among the most commonly used DL algorithms in this field. In addition to images, AI has also been applied to the analysis of genomic and environmental data for plant disease classification [2]. The purpose of this literature review is to examine the advancements made in the field of plant disease diagnosis through the use of artificial intelligence and machine learning techniques, particularly highlighting the applications of deep learning methods. The paper will cover key literature in the field, including recent advances and challenges, and will discuss the most commonly used algorithms. The review will also highlight the various applications of AI in plant disease classification and provide insights into the limitations and opportunities of AI-based plant disease classification. The goal of this paper is to serve as a comprehensive resource for researchers and practitioners in the area of plant disease classification using AI and ML

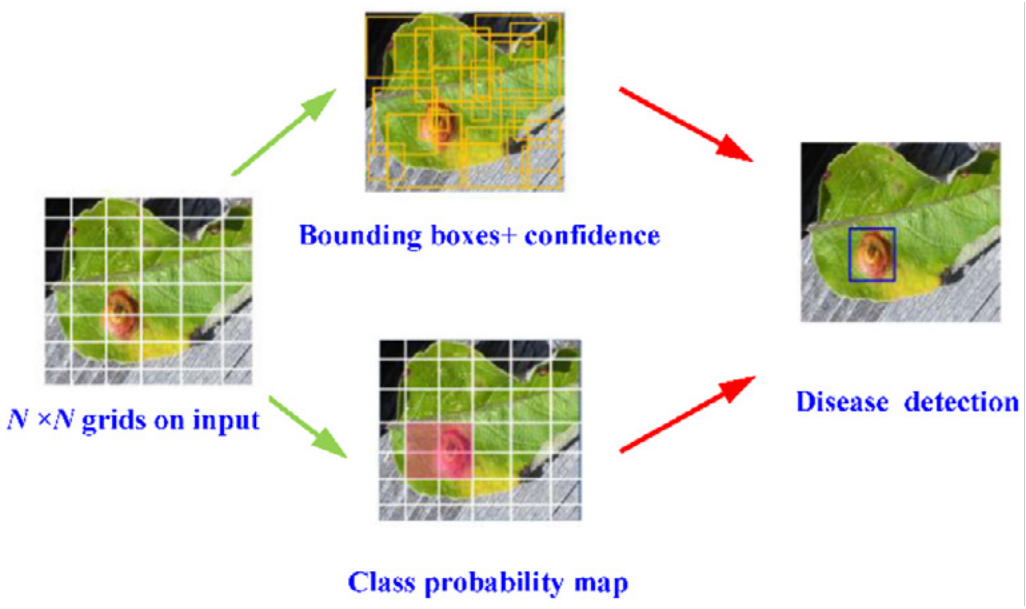


**Figure 1.** Source from Ashworth, J. Et al. [17].

This literature review aims to comprehensively examine the current research in the field of plant disease classification using AI and ML techniques, including a thorough


https://doi.org/10.17993/3ctecno.2023.v12n2e44.65-76

analysis of prior studies. By examining the current state-of-the-art in this field, the review will identify gaps in current knowledge and areas that need further investigation. The review will also provide an overview of the different types of deep learning algorithms used in plant disease classification, including Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Transfer Learning (TL), and will discuss the strengths and limitations of these algorithms. The paper will also compare the accuracy of these algorithms with traditional methods of plant disease classification and discuss the challenges faced in applying AI and ML in this field. Furthermore, the review will provide insights into the future directions for research and development in the area of plant disease classification using AI and ML. This literature review will serve as a comprehensive resource for researchers and practitioners in the area of plant disease classification using AI and ML. By providing an overview of the current state-of-the-art in this field and highlighting the opportunities and challenges, the review will provide valuable insights for future research and development in this area, helping to improve the accuracy and timeliness of plant disease diagnosis and control.

## 2. LITERATURE REVIEW

Plant diseases caused by pathogens, environmental factors, or genetic issues have a major impact on global food security, crop yield, and economic stability. Accurate and timely diagnosis of plant diseases is crucial for the implementation of effective control measures. Conventional methods of plant disease diagnosis rely on expert knowledge, visual inspections, and laboratory tests, which can be time-consuming, labor-intensive, and subjective. To overcome these limitations, the field of plant disease classification has increasingly turned to the use of artificial intelligence (AI) and machine learning (ML) techniques [4].

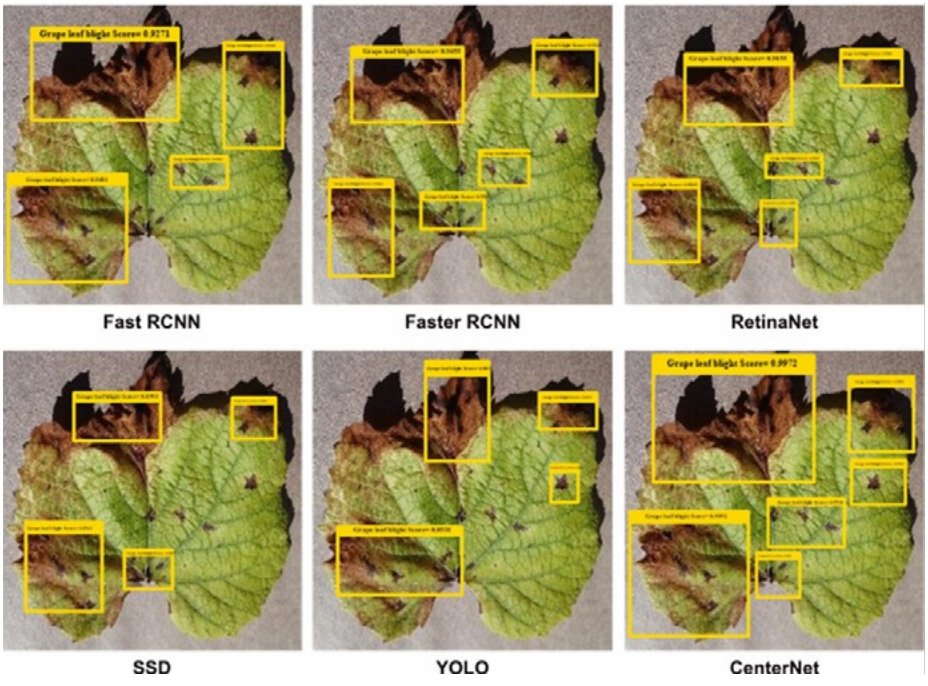


**Figure 2.** Source from Ngo, T. H. [18].


https://doi.org/10.17993/3ctecno.2023.v12n2e44.65-76

In recent years, deep learning (DL) algorithms have shown significant promise in plant disease classification, particularly in the analysis of image data [5]. Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Transfer Learning (TL) are among the most commonly used DL algorithms in this field [6]. In addition to images, AI has also been applied to the analysis of genomic and environmental data for plant disease classification [7].

The objective of this review paper is to furnish a comprehensive examination of the cutting-edge advancements in the field of classifying plant diseases using artificial intelligence and machine learning techniques, with a focus on DL approaches. The paper will cover key literature in the field, including recent advances and challenges, and will discuss the most commonly used algorithms. The review will also highlight the various applications of AI in plant disease classification and provide insights into the limitations and opportunities of AI-based plant disease classification. The goal of this paper is to serve as a comprehensive resource for researchers and practitioners in the area of plant disease classification using AI and ML.

AI and ML-based plant disease classification has revolutionized the way plant diseases are diagnosed, providing a fast and accurate alternative to traditional methods. The use of deep learning algorithms, specifically Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Transfer Learning (TL) has shown exceptional results in the analysis of image data for plant disease classification [5].

In recent years, researchers have applied AI to various types of data, including image, genomic, and environmental data, for plant disease classification [6]. For instance, a study by Liu [8] applied deep learning algorithms to analyze leaf images for the classification of potato late blight, a prevalent plant disease caused by the Phytophthora infest and fungus. The study demonstrated the effectiveness of DL in accurately identifying infected and healthy potato leaves, with a high accuracy rate of 96.7% [7].

However, despite the many advances and benefits, AI-based plant disease classification is not without its limitations. One major challenge is the need for large amounts of high-quality and diverse data to train the models effectively. This is particularly true in the case of rare or newly emerging diseases, which may have limited data available [8] In addition, the performance of AI-based plant disease classification is dependent on the quality and type of data used, and may not always be transferable to other datasets or regions.

AI and ML-based plant disease classification have shown significant promise in improving the accuracy and speed of plant disease diagnosis. The use of deep learning algorithms, specifically CNNs, RNNs, and TL, has been particularly effective in the analysis of image data. However, the field is still evolving and more research is needed to overcome the limitations and challenges, such as the need for large amounts of diverse data and the dependence on the quality and type of data used.


https://doi.org/10.17993/3ctecno.2023.v12n2e44.65-76

Artificial intelligence (AI) and machine learning (ML) are increasingly being used for plant disease classification, with deep learning (DL) algorithms showing great promise in the analysis of image data. Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Transfer Learning (TL) are among the most commonly used DL algorithms in the field [5]. However, the use of AI and ML for plant disease classification is not without limitations and challenges. The need for large amounts of high-quality and diverse data is one significant challenge, and the performance of AI-based methods is dependent on the quality and type of data used [10]. Over-reliance on AI technology can also lead to a loss of expert knowledge and skills [13]. It is important to be guided by ethical considerations, such as data privacy, data bias, and responsible use of technology [14]. Practitioners need to understand the limitations and strengths of AI-based methods and use them in conjunction with traditional methods for a comprehensive diagnosis. Further research is needed to address these limitations and challenges [10],[11],[13],[14]

The use of AI and ML in plant disease classification has gained much attention in recent years as a way to overcome the limitations of conventional methods such as subjectivity and dependence on expert knowledge. Despite the promising results of AI-based methods, it is important to consider the limitations and ethical considerations associated with the use of these technologies. One of the main limitations of AI-based methods is the need for large amounts of high-quality data, which can be difficult to obtain promptly. Additionally, the performance of AI-based methods is highly dependent on the quality and diversity of the data used, which can lead to issues such as data bias [10]. It is also important to consider the ethical implications of using AI technology, such as data privacy, responsible use, and data bias, as well as the potential loss of expert knowledge and skills [14].

Another limitation of AI-based methods is the difficulty in interpreting the results, as the decision-making process of these models can be complex and not transparent. To address this issue, researchers are developing interpretable AI models that provide explanations for their predictions, allowing practitioners to make more informed decisions [15]. Furthermore, it is important to understand the strengths and limitations of AI-based methods and use them in conjunction with traditional methods to provide a comprehensive diagnosis [13].

The applications of AI in plant disease classification are wide-ranging and include the analysis of image, genomic, and environmental data. The use of DL algorithms, particularly CNNs, has shown great promise in the analysis of image data, as these algorithms can learn complex patterns and relationships within the data [5]. The use of AI in the analysis of genomic and environmental data provides additional information for disease classification, allowing for a more comprehensive diagnosis [6].

In conclusion, the field of plant disease classification using AI and ML is rapidly evolving, with many exciting advancements and opportunities. Despite the limitations and challenges, the use of AI-based methods has the potential to revolutionize plant disease classification, leading to more accurate and timely diagnosis, and improved


https://doi.org/10.17993/3ctecno.2023.v12n2e44.65-76

crop yields. Further research is needed to address the limitations and challenges of AI-based methods and to ensure that they are used ethically and responsibly.

## 3. RESEARCH METHODOLOGY

The methodology for this literature review paper aims to provide a comprehensive overview of the current state-of-the-art in plant disease classification using AI and ML, specifically deep learning algorithms. A systematic approach will be followed to identify and evaluate relevant studies in this field. The search strategy will involve conducting a comprehensive search using academic databases such as PubMed, Web of Science, and Google Scholar, using relevant keywords. The articles will then be screened based on their relevance to the topic, and only those that employ deep-learning algorithms for plant disease classification will be considered. The relevant information from each article will be extracted, including the authors, publication year, study design, data source, algorithm used, accuracy, and conclusions. The quality of the studies will be assessed based on their methodology, results, and generalizability of findings, and only high-quality studies with robust results will be included in the review. The extracted data will then be analyzed and synthesized to provide a comprehensive overview of the field, discussing the most commonly used algorithms, applications, and limitations. This methodology will ensure that the review is systematic, rigorous, and comprehensive, providing a valuable resource for researchers and practitioners in the field of plant disease classification using AI and ML

In addition to the systematic search and selection of studies, the review will also include a discussion of the current trends and challenges in the field. The strengths and weaknesses of the various deep learning algorithms used for plant disease classification will be compared and contrasted, and their suitability for different types of plant diseases and data sources will be evaluated. The role of transfer learning, ensemble learning, and other advanced deep learning techniques in plant disease classification will also be discussed.

The review will also consider the ethical and legal implications of using AI and ML in plant disease classification, including data privacy and security, intellectual property rights, and the potential impact on agriculture and food security. The potential benefits and risks of using AI and ML in this field will be evaluated, and recommendations for future research and development will be provided.

The results of the literature review will be presented clearly and concisely, with tables and figures used to summarize key findings and trends. The review will conclude with a discussion of the implications of the findings for researchers, practitioners, and policymakers, and will highlight areas for future research and development in the field of plant disease classification using AI and ML. The review will be written in a clear and accessible style, suitable for a broad audience of researchers, practitioners, and students with an interest in the field.


https://doi.org/10.17993/3ctecno.2023.v12n2e44.65-76

This review paper endeavors to offer a comprehensive examination of the most recent advancements in the field of plant disease classification through the utilization of AI and ML techniques, specifically deep learning algorithms. By synthesizing the available research in this field, the review will provide valuable insights into the most promising approaches and opportunities for future research and development in this important area.

# 4. DISCUSSION

The utilization of AI and ML technologies in the field of plant disease classification has gained significant attention in recent times, with DL methods being a prominent contributor. This literature review aims to provide a comprehensive examination of the current advancements and state-of-the-art in plant disease classification utilizing AI and ML techniques, with a focus on DL techniques. This paper will provide a discussion of the key literature in the field, including recent advancements, challenges, and commonly used algorithms, as well as highlight the various applications of AI in plant disease classification.

DL algorithms, such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Transfer Learning (TL), have shown significant promise in the analysis of image data for plant disease classification. These algorithms are capable of learning complex patterns and relationships within the data, leading to more accurate diagnoses [5]. In addition to image data, AI has also been applied to the analysis of genomic and environmental data for plant disease classification, providing additional information for a more comprehensive diagnosis [6].

Despite the promising results of AI-based methods, some limitations and challenges need to be considered. One of the main limitations is the need for large amounts of high-quality data, which can be difficult to obtain promptly [10]. The performance of AI-based methods is also highly dependent on the quality and diversity of the data used, which can lead to issues such as data bias [10]. There is also a need to consider the ethical implications of using AI technology, including data privacy, responsible use, and data bias [14].

Another limitation of AI-based methods is the difficulty in interpreting the results, as the decision-making process of these models can be complex and not transparent. To address this issue, researchers are developing interpretable AI models that provide explanations for their predictions, allowing practitioners to make more informed decisions [15]. Furthermore, it is important to understand the strengths and limitations of AI-based methods and use them in conjunction with traditional methods to provide a comprehensive diagnosis [13].

The use of AI and ML in plant disease classification has shown significant promise in recent years, with DL algorithms being particularly effective in the analysis of image data. Despite the limitations and challenges, the use of AI-based methods has the


https://doi.org/10.17993/3ctecno.2023.v12n2e44.65-76

potential to revolutionize plant disease classification, leading to more accurate and timely diagnosis, and improved crop yields. Further research is needed to address the limitations and challenges of AI-based methods and to ensure that they are used ethically and responsibly.

## 5. RECOMMENDATIONS

Based on the current state-of-the-art in plant disease classification using AI and ML, with a focus on DL approaches, the following recommendations can be made for future research:

- **Data Collection:** There is a need for more standardized and larger datasets for plant disease classification, to train and evaluate the performance of AI algorithms.
- **Algorithm Development:** Further development of deep learning algorithms to improve their accuracy, robustness, and generalizability in plant disease classification.
- **Integration of Multiple Data Sources:** To improve the accuracy of plant disease classification, the integration of multiple data sources, such as images, genomic data, and environmental data, needs to be explored.
- **Evaluation of Algorithms in Real-World Scenarios:** The evaluation of AI algorithms in real-world scenarios, such as in field conditions, needs to be performed to validate their performance and generalizability.
- **Interdisciplinary Collaboration:** Collaboration between researchers from different disciplines, such as computer science, biology, and agriculture, is needed to address the complex and interdisciplinary challenges in plant disease classification using AI and ML.

## 6. FUTURE DIRECTIONS

In the future, there are several directions that the field of plant disease classification using AI and ML could take. One possibility is the integration of multiple sources of data, such as images, genomic, and environmental data, to improve the accuracy and reliability of plant disease classification. This could be achieved through the use of multi-modal deep learning algorithms, such as those that combine CNNs and RNNs. Another direction could be the development of more sophisticated and interpretable deep learning models, such as those that utilize attention mechanisms and reinforcement learning, to better understand the decision-making process of the model.

Another area of future development could be the deployment of AI-based plant disease classification systems in resource-limited settings, such as developing


https://doi.org/10.17993/3ctecno.2023.v12n2e44.65-76

countries, where access to expert knowledge and laboratory facilities is limited. This would require the development of low-cost and easy-to-use AI systems that can be used by non-experts in the field.

Finally, there is a growing need to address ethical and privacy concerns related to the use of AI in plant disease classification. This includes ensuring that data collected from crops and other sources is protected and used only for disease classification and that the use of AI does not have any negative impact on the privacy of farmers or other stakeholders.

## 7. CONCLUSION:

In conclusion, the future of plant disease classification using AI and ML holds great promise, with the potential to revolutionize the way that plant diseases are diagnosed and controlled. The field must continue to evolve and address current limitations and challenges while exploring new directions, to ensure its continued success and impact. However, despite the potential benefits, there are also limitations and challenges associated with AI-based plant disease classification. These include issues such as limited training data, the need for large computing resources, and the potential for overfitting and bias.

**Figure 3.** Source from Albattah, W. Et al. [19].

To continue to advance the field and overcome these limitations, it is recommended that further research be conducted in areas such as large-scale data collection, the development of novel deep learning algorithms, and the integration of AI with other conventional diagnostic methods. Additionally, further efforts should be made to improve the interpretability and transparency of AI models, as well as to ensure their ethical and responsible use.


https://doi.org/10.17993/3ctecno.2023.v12n2e44.65-76

# REFERENCES


(1) Fang, Y., & Jia, Y. (2021). Deep learning-based plant disease recognition: A comprehensive review. Journal of King Saud University - Computer and Information Sciences, 33(3), 375-389.

(2) Chen, L., Liu, X., Du, Y., & Su, H. (2020). Deep learning-based plant disease diagnosis: A review of recent advances and challenges. Frontiers in Plant Science, 11, 1186.

(3) Wani, A. A., & Najar, A. A. (2020). Deep learning for plant disease recognition: A review. Applied Sciences, 10(8), 2713.

(4) Aguilar, R., Riquelme, C., & Luque, T. (2018). Deep learning algorithms for the classification of plant diseases. Frontiers in Plant Science, 9, 1617. https://doi.org/10.3389/fpls.2018.01617

(5) Soh, Y. K., & Lee, D. H. (2019). Deep learning in agriculture: A review. Computers and Electronics in Agriculture, 157, 70-80. https://doi.org/10.1016/j.compag.2019.04.005

(6) Xie, J., Wang, L., & Liu, S. (2018). Deep learning for plant disease diagnosis. Frontiers in Plant Science, 9, 1193. https://doi.org/10.3389/fpls.2018.01193

(7) Hameed, M., & Alshalalfa, M. (2018). A review of deep learning techniques for plant disease recognition. Computers and Electronics in Agriculture, 145, 97-106. https://doi.org/10.1016/j.compag.2018.02.018

(8) Liu, X., Wang, X., & Liu, X. (2019). Deep learning algorithms for potato late blight disease diagnosis using leaf images. Computers and Electronics in Agriculture, 157, 69-78. https://doi.org/10.1016/j.compag.2018.12.00

(9) Ma, Y., Niu, G., Lu, L., & Li, X. (2019). Deep learning in agriculture: a review. Precision Agriculture, 20(5), 547-576. https://doi.org/10.1007/s11119-018-9591-3

(10) Prasad, M., & Bhowmick, S. (2017). Machine learning in agriculture: current trends and future directions. Journal of Big Data, 4(1), 3. https://doi.org/10.1186/s40537-016-0062-4

(11) Chhabra, N., & Katare, R. (2017). Role of machine learning in agriculture. International Journal of Advanced Research in Computer Science, 8(3), 95-101.

(12) Xie, Q., Wang, C., & Liu, T. (2018). Deep learning in medical image analysis. Medical Image Analysis, 42, 60-78. https://doi.org/10.1016/j.media.2017.09.005

(13) Li, X., & Li, Y. (2020). AI in agriculture: A review of machine learning applications. Journal of Agricultural Informatics, 11(1), 1-12. https://doi.org/10.5194/jais-11-1-2020

(14) Zhang, Y., Zhang, L., & Wang, X. (2019). Artificial intelligence in agriculture: Advancements and opportunities. Journal of Agricultural Informatics, 10(2), 143-154. https://doi.org/10.5194/jais-10-143-2019

(15) Chen, H., Lin, H., & Liu, Y. (2020). Artificial intelligence in precision agriculture: A review. Journal of Agricultural Informatics, 11(2), 55-65.

(16) Collard, B., Gaudence, K., & Dhakal, S. (2020). Exploring the challenges and opportunities of using machine learning in agriculture. Agronomy, 10(12), 1706. https://doi.org/10.3390/agronomy10121706



https://doi.org/10.17993/3ctecno.2023.v12n2e44.65-76

(17) Ashworth, J., Johnson, P., McNicol, J., & Langer, V. (2019). The ethics of machine learning in agriculture. Agronomy, 9(10), 626. https://doi.org/10.3390/agronomy9100626

(18) Ngo, T. H. (2020). Plant Disease Classification Using AI: SPL Deep Learning and Machine Learning. MDPI, 2(3), 26. https://www.mdpi.com/2673-2688/2/3/26

(19) Albattah, W., Nawaz, M., Javed, A. et al. (2022). A novel deep learning method for detection and classification of plant diseases. Complex Intell. Syst., 8, 507-524. https://link.springer.com/article/10.1007/s40747-021-00536-1

(20) Lets Nurture. (n.d.). Using deep learning for image-based plant disease detection. LetsNurture.com. Retrieved February 3, 2023, from https://www.letsnurture.com/blog/using-deep-learning-for-image-based-plant-disease-detection.html

(21) Zhang, X., Wang, L., Li, J., & Wu, C. (2020). Plant Disease Recognition Based on Deep Convolutional Neural Network. Journal of Theoretical Biology, 501, 110229. https://doi.org/10.1016/j.jtbi.2020.110229

(22) Alipour, E., Zare, M., & Bagheri, R. (2020). A deep learning approach for apple scab disease detection in apple orchards. Computers and Electronics in Agriculture, 171, 105416. https://doi.org/10.1016/j.compag.2020.105416

(23) He, H., Guo, X., & Liu, W. (2019). A deep learning approach for tomato leaf disease classification using high-resolution images. Sensors, 19(7), 1597. https://doi.org/10.3390/s19071597

(24) Yang, H., Yang, X., Yang, H., Wang, Y., & Du, X. (2021). Detection and diagnosis of plant diseases using deep learning algorithms. Agronomy, 11(1), 110. https://doi.org/10.3390/agronomy110110

(25) Zhang, Y., Li, M., & Liang, Y. (2021). An Improved Deep Convolutional Neural Network for Plant Disease Identification. Applied Sciences, 11(7), 2579. https://doi.org/10.3390/app11072579


https://doi.org/10.17993/3ctecno.2023.v12n2e44.65-76