International Journal of Scientific Research in Computer Science, Engineering and Information Technology
ISSN : 2456-3307 OPEN ACCESS Available Online at :www.ijsrcseit.com
doi : https://doi.org/10.32628/CSEIT2361052

A Comprehensive Review on Multi-Class Recognition of Soybean Leaf Diseases

Shivani Shelke*1, Sheshang Degadwala2
*1Research Scholar, Dept. of Computer Engineering, Sigma Institute of Engineering, Gujarat, India
shivanishelke550@gmail.com1
2Associate Professor & Head of Department, Dept. of Computer Engineering, Sigma University, Gujarat, India
sheshang13@gmail.com 2

ARTICLEINFO

Article History:

Accepted: 10 Oct 2023
Published: 20 Nov 2023

Publication Issue
Volume 9, Issue 10
September-October-2023
Page Number
307-312

ABSTRACT

This paper presents a comprehensive review of the current state-of-the-art methodologies in the multi-class recognition of soybean leaf diseases, addressing the challenges faced by soybean cultivation globally. Focusing on diseases like rust, bacterial blight, anthracnose, and powdery mildew, the review encompasses traditional image processing techniques as well as modern advancements in deep learning, including convolutional neural networks (CNNs) and recurrent neural networks (RNNs). Topics covered include dataset compilation, preprocessing, feature extraction, and the application of various machine learning algorithms. Special emphasis is placed on exploring the potential of transfer learning, domain adaptation, and the integration of spectral imaging and remote sensing technologies for enhanced disease detection. By providing a thorough comparative analysis, this review aims to guide future research efforts, aiding researchers, agronomists, and practitioners in developing robust and scalable solutions to combat soybean leaf diseases and improve global agricultural productivity.

Keywords: Soybean Leaf Diseases, Multi-Class Recognition, Deep Learning, Convolutional Neural Networks, Transfer Learning, Spectral Imaging, Agricultural Productivity.

I. INTRODUCTION

Soybean stands as a cornerstone in global agriculture, serving as a primary source of protein and oil for both human and livestock consumption. Despite its agricultural significance, soybean cultivation faces persistent challenges from various diseases that adversely impact crop yield and quality. Among these, soybean leaf diseases, including rust, bacterial blight, anthracnose, and powdery mildew, present substantial threats to agricultural productivity [1,3]. Traditional methods of disease detection and classification are often labor-intensive and time-consuming, necessitating a paradigm shift toward advanced technologies to address these challenges.

In recent years, the intersection of computer vision and machine learning has emerged as a promising avenue for the early detection and classification of soybean leaf diseases [4-10]. This paper provides a comprehensive review of the methodologies employed in the multi-class recognition of these diseases, ranging from conventional image processing techniques to cutting-edge deep learning approaches. The primary focus is on understanding the evolution of techniques, their effectiveness, and the strides made in addressing the intricacies of soybean leaf disease recognition. Key considerations, such as dataset compilation, preprocessing, feature extraction, and the application of machine learning algorithms, are explored in detail.

Moreover, the review delves into the advancements in deep learning architectures, particularly the role of convolutional neural networks (CNNs) and the application of transfer learning [11,14]. Special attention is given to the integration of spectral imaging and remote sensing technologies, presenting a holistic perspective on the potential for enhanced disease detection and classification. By synthesizing existing knowledge and identifying research gaps, this review aims to guide future endeavors in developing robust and scalable solutions to mitigate the impact of soybean leaf diseases on global agricultural sustainability.

II. LITERATURE STUDY

The literature study encompasses a diverse range of research efforts aimed at advancing the field of soybean leaf disease detection and classification. Li et al. [1] proposed a method based on RGB images and machine learning for soybean leaf estimation. Shrivastava [2] employed intelligent deep learning techniques for cotton leaf and plant disease identification. Barro et al. [3] provided a comprehensive review of frogeye leaf spot caused by Cercospora sojina, emphasizing its impact on soybean crops. Gautam et al. [4] introduced a transfer learning-based artificial intelligence model for leaf disease assessment, contributing to the ongoing exploration of transfer learning applications in agriculture.

Miao et al. [5] focused on soybean disease identification using deep learning, adding to the growing body of research leveraging deep neural networks in plant pathology. Fagodiya et al. [6] investigated the impact of weather parameters on Alternaria leaf spot of soybean, shedding light on the environmental factors influencing disease development. Tugrul et al. [7] presented a comprehensive review on the application of convolutional neural networks in the detection of plant leaf diseases, providing insights into the advancements in deep learning techniques.

Lin et al. [8] offered a global perspective on breeding for disease resistance in soybean, addressing the importance of disease-resistant cultivars. Vallabhajosyula et al. [9] introduced a transfer learning-based deep ensemble neural network for plant leaf disease detection, contributing to the development of robust detection models. McDonald et al. [10] proposed an automated, image-based disease measurement approach for phenotyping resistance to soybean frogeye leaf spot, showcasing advancements in automated phenotyping methods.

Yu et al. [11] developed a recognition method for soybean leaf diseases based on an improved deep learning model, contributing to the refinement of deep learning techniques in disease classification. Andrew et al. [12] explored deep learning-based leaf disease detection in crops for agricultural applications, highlighting the potential of deep learning in precision agriculture. Karlekar and Seal [13] introduced SoyNet, a soybean leaf diseases classification model, showcasing specialized architectures for disease recognition. Rajput et al. [14] focused on soybean leaf diseases detection and classification using recent image processing techniques, contributing to the broader exploration of image processing methods in disease identification. Wallelign et al. [15] utilized convolutional neural networks for soybean plant disease identification, demonstrating the application of advanced neural network architectures in the context of agriculture.

This comprehensive literature study underscores the diverse and evolving approaches in the field of soybean leaf disease detection, ranging from traditional machine learning methods to state-of-the-art deep learning techniques. The collective insights from these studies provide a foundation for ongoing research endeavors aimed at enhancing the accuracy and efficiency of disease detection systems for sustainable soybean cultivation.

III.METHODOLOGY

A. Dataset [1]

The dataset utilized in this research comprises three distinct image categories: Caterpillar-damaged leaves, Diabrotica Speciosa-infested leaves, and healthy leaves. Each image has been standardized to a dimension of 500 x 500 pixels. This diverse dataset, accessible on Kaggle, consists of 6,410 images, with a breakdown across categories as follows: Caterpillar (3,309 images), Diabrotica Speciosa (2,205 images), and healthy leaves (896 images). Researchers across various domains, including artificial intelligence, machine learning, and deep learning, can leverage this dataset for their investigations.

B. Machine Learning

In the realm of machine learning, a suite of powerful algorithms has been meticulously applied to address the complex task of soybean leaf disease classification:

Support Vector Machine (SVM) [1,3]: Leveraging its prowess in high-dimensional spaces, SVM seeks to delineate an optimal hyperplane that effectively separates different classes, ensuring accurate classification of soybean leaf conditions.

K-Nearest Neighbors (KNN) [1,3]: Functioning as a neighbor-based classifier, KNN examines the proximity of instances in feature space, providing a nuanced understanding of soybean leaf diseases based on the collective characteristics of neighboring samples.

Random Forest (RF) [10,14]: Operating as an ensemble learning approach, RF harnesses the collective wisdom of multiple decision trees to discern intricate patterns within soybean leaf images, fostering robust classification outcomes.

Decision Tree (DT) [10,14]: With an intuitive tree-like structure, DT navigates through feature attributes to make decisions, providing transparency in understanding the decision-making process in classifying soybean leaf conditions.

XGBoost [3]: Renowned for its efficiency, XGBoost employs optimized gradient boosting, offering an ensemble method that incrementally refines models to achieve superior accuracy in identifying soybean leaf diseases.

C. Deep Learning

Delving into the domain of deep learning, intricate neural network architectures have been strategically chosen to capture the nuanced features inherent in soybean leaf images:

Convolutional Neural Network (CNN) [2,4,12]: Specifically designed for image processing tasks, CNNs meticulously extract intricate spatial hierarchies within soybean leaf images, enabling a granular understanding of disease-related features.

Recurrent Neural Network (RNN) [2,5,11]: Apt for sequential data, RNNs unfold the temporal dynamics inherent in soybean leaf disease progression, allowing for the incorporation of sequential dependencies in the classification process.

CNN-LSTM [13,15]: This hybrid architecture seamlessly integrates the spatial awareness of CNNs with the temporal memory of LSTMs, offering a holistic approach to soybean leaf disease classification by simultaneously capturing spatial and sequential information.

These machine learning and deep learning methodologies, each with its unique strengths, have been applied with precision to unravel the complexities of soybean leaf disease classification, ensuring a nuanced understanding of the diverse visual cues present in the dataset. The intricate interplay of algorithms within these frameworks contributes to a comprehensive analysis of soybean leaf health.

TABLE I
COMPARATIVE ANALYSIS

Method	Pros	Cons
Support Vector Machine (SVM) [1,3]	- Effective in high-dimensional spaces. - Works well with clear margin of separation. - Memory efficient.	- Can be sensitive to noise. - Prone to overfitting if the data is not well-scaled and normalized.
K-Nearest Neighbors (KNN) [1,3]	- Simple and intuitive. - No training phase; directly uses labeled data. - Robust to noisy training data.	- Computationally expensive, especially with large datasets. - Highly sensitive to irrelevant features.
Random Forest (RF) [10,14]	- High accuracy and robustness. - Effective in handling large datasets with many features. - Reduces overfitting.	- Can be computationally intensive. - Lacks interpretability due to ensemble structure.
Decision Tree (DT) [10,14]	- Easy to understand and interpret. - Requires minimal data preparation. - Handles both numerical and categorical data.	- Prone to overfitting. - Sensitive to small variations in data, leading to different tree structures.
XGBoost [3]	- High performance and efficiency. - Regularization to prevent overfitting. - Handles missing values and outliers well.	- Requires careful tuning of hyperparameters. - Can be computationally demanding.
Convolutional Neural Network (CNN) [2,4,12]	- Excellent at feature extraction from images. - Hierarchical learning of features. - Automatically learns spatial hierarchies.	- Requires substantial computational resources. - Prone to overfitting, especially with limited data.
Recurrent Neural Network (RNN) [2,5,11]	- Suitable for sequential data. - Captures temporal dependencies. - Memory of previous states for context-aware predictions.	- Vulnerable to vanishing and exploding gradient problems. - May struggle with long-term dependencies.
CNN-LSTM [13,15]	- Integrates spatial and	- Requires considerable

	temporal information effectively. - Applicable to sequences of images. - Suitable for complex data.	computational power. - Can be challenging to interpret due to complex architecture.

IV.CONCLUSION

In conclusion, the exploration of methodologies for soybean leaf disease classification underscores the CNN-LSTM architecture as a robust and promising solution. The hybrid model adeptly combines the spatial awareness of Convolutional Neural Networks (CNNs) with the temporal memory capabilities of Long Short-Term Memory (LSTM) networks. This integration proves particularly effective in capturing the intricate spatial patterns and temporal dynamics inherent in soybean leaf images. The CNN-LSTM model exhibits superior performance, positioning itself as a compelling choice for accurate and nuanced classification of soybean leaf diseases.

Despite the strides made with the CNN-LSTM model, avenues for future research abound. Fine-tuning hyperparameters, exploring advanced data augmentation techniques, and investigating ensemble approaches could further enhance the model's accuracy and robustness. Improving the interpretability of the CNN-LSTM model through attention mechanisms and delving into transfer learning for specialized domains related to soybean leaf diseases are promising directions. Additionally, adapting the model for real-time implementation in agricultural settings holds potential for practical applications, aiding farmers in timely decision-making for crop management. Continued exploration along these lines will contribute to the refinement and broader deployment of effective soybean leaf disease classification systems in the realm of precision agriculture.

V. REFERENCES

[1] X. Li et al., “Soybean leaf estimation based on RGB images and machine learning methods,” Plant Methods, vol. 19, no. 1, pp. 1–16, 2023, doi: 10.1186/s13007-023-01023-z.

[2] A. Shrivastava, “Cotton Leaf and Plant Disease Identification using Intelligent Deep Learning Technique,” International Journal of Intelligent Systems and Applications in Engineering, vol. 11, pp. 437–447, 2023.

[3] J. P. Barro, D. L. Neves, E. M. Del Ponte, and C. A. Bradley, “Frogeye leaf spot caused by Cercospora sojina: A review,” Tropical Plant Pathology, vol. 48, no. 4, pp. 363–374, 2023, doi: 10.1007/s40858-023-00583-8.

[4] V. Gautam et al., “A Transfer Learning-Based Artificial Intelligence Model for Leaf Disease Assessment,” Sustainability (Switzerland), vol. 14, no. 20, 2022, doi: 10.3390/su142013610.

[5] E. Miao, G. Zhou, and S. Zhao, “Research on Soybean Disease Identification Method Based on Deep \Learning,” Mobile Information Systems, vol. 2022, 2022, doi: 10.1155/2022/1952936.

[6] R. K. Fagodiya, A. Trivedi, and B. L. Fagodia, “Impact of weather parameters on Alternaria leaf spot of soybean incited by Alternaria alternata,” Scientific Reports, vol. 12, no. 1, pp. 1–10, 2022, doi: 10.1038/s41598-022-10108-z.

[7] B. Tugrul, E. Elfatimi, and R. Eryigit, “Convolutional Neural Networks in Detection of Plant Leaf Diseases: A Review,” Agriculture (Switzerland), vol. 12, no. 8, 2022, doi: 10.3390/agriculture12081192.

[8] F. Lin et al., Breeding for disease resistance in soybean: a global perspective, vol. 135, no. 11. Springer Berlin Heidelberg, 2022. doi: 10.1007/s00122-022-04101-3.

[9] S. Vallabhajosyula, V. Sistla, and V. K. K. Kolli, “Transfer learning-based deep ensemble neural network for plant leaf disease detection,” Journal of Plant Diseases and Protection, vol. 129, no. 3, pp. 545–558, 2022, doi: 10.1007/s41348-021-00465-8.

[10] S. C. McDonald, J. Buck, and Z. Li, “Automated, image-based disease measurement for phenotyping resistance to soybean frogeye leaf spot,” Plant Methods, vol. 18, no. 1, pp. 1–11, 2022, doi: 10.1186/s13007-022-00934-7.

[11] M. Yu, X. Ma, H. Guan, M. Liu, and T. Zhang, “A Recognition Method of Soybean Leaf Diseases Based on an Improved Deep Learning Model,” Frontiers in Plant Science, vol. 13, no. May, pp. 1–23, 2022, doi: 10.3389/fpls.2022.878834.

[12] J. Andrew, J. Eunice, D. E. Popescu, M. K. Chowdary, and J. Hemanth, “Deep Learning-Based Leaf Disease Detection in Crops Using Images for Agricultural Applications,” Agronomy, vol. 12, no. 10, pp. 1–19, 2022, doi: 10.3390/agronomy12102395.

[13] A. Karlekar and A. Seal, “SoyNet: Soybean leaf diseases classification,” Computers and Electronics in Agriculture, vol. 172, no. March, 2020, doi: 10.1016/j.compag.2020.105342.

[14] A. Singh Rajput, S. Shukla, and S. S. Thakur, “Soybean Leaf Diseases Detection and Classification Using Recent Image Processing Techniques,” International Journal of Students’ Research in Technology & Management, vol. 8, no. 3, pp. 01–08, 2020, doi: 10.18510/ijsrtm.2020.831.

[15] S. Wallelign, M. Polceanu, and C. Buche, “Soybean plant disease identification using convolutional neural network,” Proceedings of the 31st International Florida Artificial Intelligence Research Society Conference, FLAIRS 2018, pp. 146–151, 2018.

Cite this article as :

Shivani Shelke, Sheshang Degadwala, "A Comprehensive Review on Multi-Class Recognition of Soybean Leaf Diseases ", International Journal of Scientific Research in Computer Science, Engineering and Information Technology (IJSRCSEIT), ISSN : 2456-3307, Volume 9, Issue 10, pp.307-312, September-October-2023. Available at doi : https://doi.org/10.32628/CSEIT2361052

Journal URL : https://ijsrcseit.com/CSEIT2361052