A Review of Image Processing and Machine Learning for Plant Leaf Disease Identification

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ABSTRACT
One of the main factors affecting crop output reduction globally is plant disease and crop losses must be avoided through early detection of these diseases. Automating the identification of plant diseases has been demonstrated to be highly promising when using image processing and machine learning approaches. In the present work, fusion techniques were utilised to combine data from several sources to increase the reliability and accuracy of identifying plant leaf diseases. Fusion approaches combine information from several sources, such as various pictures or feature kinds, to produce a more complete view of the plant leaf and its illness.

Constructing a trustworthy and accurate system that can automatically recognise the symptoms of diseases in tomato leaves utilising several sources of data including pictures, spectral reflectance, and environmental parameters is the major objective of tomato leaf disease detection using machine learning. This approach can assist farmers and agricultural professionals in identifying the disease early, stopping it from spreading and acting quickly to reduce crop losses.

General Terms
Plant leaf disease, Accuracy, Image processing.

Keywords
Hybrid approach, segmentation, Image Processing, Masking, Fusion Technique.

1. INTRODUCTION
Any illness that damages a plant's leaves is referred to as plant leaf disease. One of a plant's most crucial components is its leaves, which are in charge of photosynthesis, the process through which the plant transforms sunlight into energy. The health and productivity of the plant as a whole might be impacted by any injury to the leaves. Numerous agents, such as fungi, bacteria, viruses, and environmental stressors, can lead to plant leaf diseases. Different symptoms associated with these diseases include discolouration, wilting, spots, lesions, and deformations. The disease's severity can range from minor to severe, and it even has the potential to kill the plant. When favourable conditions like excessive humidity, warm temperatures, and poor air circulation exist, plant leaf diseases can spread swiftly. It is crucial to act quickly to stop the spread of diseases because they can quickly infect nearby leaves and plants after infecting one.

Plant leaf diseases can be prevented and managed using a variety of techniques. Planting disease-resistant types of plants, following good crop rotation practises, maintaining appropriate soil moisture levels, and making sure there is enough air movement around the plants are some useful preventative strategies. To stop the spread of leaf diseases, farmers can also utilize bactericides, fungicides, or other chemical treatments. To protect the environment and unintended organisms, chemical treatments should be used with prudence.

Cultural actions like pruning diseased leaves, clearing away dead plant matter, and sanitising tools can also assist stop the spread of plant leaf diseases in addition to the treatments mentioned above. Additionally, it's crucial to regularly check plants for disease symptoms and act quickly to stop the spread. In order to stop the illness from spreading and seriously harming the plant, early detection and management are essential. The symptoms and severity of the various diseases that can harm tomato leaves might differ based on the particular disease and environmental conditions. Here are a few typical ailments affecting tomato leaves:

1. Early blight: A fungus called early blight often strikes tomato plants later in the growing season. Small, dark spots on the lower leaves are the first indications of early blight. These spots can enlarge and combine to form larger lesions. If the disease is not treated, it can spread to the top leaves and fruit. Affected leaves may become yellow and eventually die.

2. Late blight: Another fungus that can harm tomato plants is late blight. Brownish-black lesions on the leaves stems, and fruit are among the signs of late blight, which can cause the plant to wilt and die. In rainy, chilly weather, late blight can spread quickly and is very devastating.

3. Fusarium wilt: A fungus that can infect tomato plants is the cause of the soil-borne illness known as fusarium wilt. Yellowing of the lower leaves, which may eventually turn brown and die, is one of the signs of Fusarium wilt. Additionally, the plant might wilt and die, especially in hot weather.

2. LITERATURE REVIEW
In 2022, Sunil S. Harakannanavar a,∗ , Jayashri M. Rudagi b, Veena I Puranikmathb, Ayesha Siddiquaa, R Pramodhin suggested a model employing pre-processing methods such as RGB to gray scale conversion, HE, K-means clustering, and contour tracing. The descriptive features of the leaf samples are extracted using a variety of descriptors, including the Discrete Wavelet Transform, Principal Component Analysis, and GLCM. SVM, K-NN, and CNN are three machine-learning techniques that are used to differentiate between sick and healthy leaves.

In 2022, Zhang, Y., Guo, W., Zhang, Y., Li, H., Li, X., & Cui, J. Used deep learning methods for disease detection of tomato leaves automatically - This study suggests a technique for employing deep learning algorithms to automatically diagnose illnesses of tomato leaves. To categorise tomato leaf photos into groups that represented healthy or diseased leaves, the

scientists gathered a sizable collection of tomato leaf photographs and trained a CNN (Convolutional Neural Network). The scientists claim that the model has good accuracy rates and that using their method could be a quick and affordable technique to identify diseases affecting tomato leaves.

In 2022, Chen, X., Liu, Y., Zhu, L., Zhang, Y., & Ma, Y. performed Tomato leaf disease detection and categorization using machine learning- In this study, the scientists created a machine learning-based method for identifying and categorising illnesses of tomato leaves. On a dataset of tomato leaf images, the authors trained many machine learning algorithms, such as random forests, support vector machines, and neural networks. They state that their method had excellent rates of accuracy for both the identification and categorization of tomato leaf diseases.

In 2022, Li, X., Huang, Y., Chen, C., Zhao, X., Wang, Y., & Han, Y.used hybrid MLmodels for Tomato leaf disease identification. This study suggests a mixed machine-learning strategy for detecting illnesses in tomato leaves. To choose the most useful features from a dataset of tomato leaf photos, the authors mix a genetic algorithm and a support vector machine. They claim that their method has good accuracy rates for identifying diseases, and they speculate that it might be useful for precision farming.

In 2021, Raju, T.S., Prasad, P., & Reddy, M.R. used ML models for Automated diagnosis of tomato leaf diseases. The automated system for diagnosing tomato leaf diseases proposed in this study makes use of machine learning techniques like decision trees, support vector machines, and k-nearest neighbours. The technology is capable of detecting four prevalent tomato leaf diseases with an accuracy of up to 96.22 percent.

In 2021, Ahmed, N.S., Alshehri, A., & Tariq, A. used deep learning for the Identification and classification of tomato leaf diseases. In this study, a deep learning-based method is suggested for identifying and categorising six different tomato leaf diseases. The system achieves an accuracy of up to 97.5 percent using a CNN architecture.

In 2021, Iqbal, M., Tariq, R., & Shahzad, M. used ML for the automated detection and classification of tomato leaf diseases. The automated identification and categorization of five tomato leaf diseases using machine learning techniques including random forests, k-nearest neighbours, and decision trees are proposed in this study. Up to 94.5 percent accuracy is achieved by the technology.

In 2021, Wu, Y., Zhang, H., & Zhou, S. used ML and IT technologies for Tomato leaf disease identification. In this study, a system for diagnosing tomato leaf diseases utilising machine learning and Internet of Things (IoT) technologies is proposed. The system has an accuracy of up to 96.7 percent and uses a CNN architecture to identify diseases. The system is remotely monitored and managed using IT technologies.

3. COMPARISON OF PLANT LEAF DETECTION ALGORITHMS

Table 1: Comparison of plant leaf disease detection Algorithms

Algorithm	Prediction Time	Accuracy	Key Parameters
Support Vector Machine	Fast Algorithm	Moderate	Kernel function, regularization parameter, and kernel coefficient
Random Forest	Fast Algorithm	High	Number of decision trees, the depth of decision trees
CNN	CNNs are slower than SVM and RF	Moderate	Depth of the network, the number of filters
RNN	Slower than CNN	High	The type of activation function used in each layer, and the number of hidden units in each layer
DBNs	Slower than CNNs and RNN	Low	Depth of the network, the number of hidden layers

4. CHALLENGES IN PLANT LEAF DETECTION USING FUSION TECHNIQUE

A new area of agricultural research focuses on detecting tomato plant leaves utilising fusion techniques to increase the reliability and accuracy of detection algorithms. While previous research has looked at the use of machine learning techniques for tomato plant leaf detection, more research is required to determine whether fusion techniques are effective at enhancing detection performance. Fusion techniques are the merging of information or data from several sources to produce a more precise and trustworthy analysis or decision-making process. To train a model to identify between healthy and diseased leaves, the fusion technique may entail extracting features from both the spectral reflectance data and the pictures. The model's accuracy could be increased by including environmental elements like temperature and humidity.

5. ROLE OF MACHINE LEARNING INTHE DETECTION LEAF DISEASE

Constructing a trustworthy and accurate system that can automatically recognise the symptoms of diseases in tomato leaves utilising several sources of data including pictures, spectral reflectance, and environmental parameters is the major objective of tomato leaf disease detection using machine learning. This approach can assist farmers and agricultural professionals in identifying the disease early, stopping it from

spreading and acting quickly to reduce crop losses. The system can learn from previous data and continuously increase its accuracy by being trained using machine learning algorithms, making it a useful tool in modern agriculture. Significant crop damage from tomato leaf diseases can lead to poorer yields, worse-quality produce, and financial losses for producers. Effective illness management and control depend on early disease detection. However, visual examination of crops for disease symptoms can be labor-intensive, time-consuming, and frequently irrational. The automated detection of illnesses on tomato leaves is a promising use of machine learning techniques. Machine learning algorithms can learn to distinguish between the distinctive characteristics of healthy and diseased tomato leaves by employing a variety of data sources, including pictures and spectral reflectance. Following that, these algorithms can be trained to recognise the signs of various diseases, including bacterial spots, early blight, and late blight. The capability of machine learning to swiftly and effectively handle vast amounts of data is one of the key benefits of utilising it to identify tomato leaf diseases. This can enable crop monitoring in real-time, assisting in the early detection of the disease and halting its spread.

6. CONCLUSION

The application of image processing and machine learning is widespread in many industries, including transportation, banking, and healthcare. Growing interest has been shown recently in applying these methods to agriculture, particularly for identifying plant diseases. Various plant diseases, including fungal, bacterial, and viral infections, have been successfully identified using the fusion technique of image processing and machine learning. In this method, leaf images are pre-processed, features are extracted, and machine learning models are trained using the retrieved features to diagnose illnesses. The fusion technique has also demonstrated encouraging results in terms of accuracy, speed, and robustness, making it appropriate for use in practical applications. With the development of portable and affordable devices, farmers may now use them to diagnose plant diseases on-site thanks to developments in hardware and software technology.

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