



State of Art Survey on Plant Leaf Disease Detection

Akey Sungheetha

Data Science SIG member, Computer Science and Engineering, School of Electrical Engineering and Computing, Adama Science and Technology University, Adama, Nazret, Ethiopia

E-mail: sun29it@gmail.com

Abstract

Benefits of independent learning and extraction of features have received a lot of attention in recent years from both academic and professional circles. A subcategory of artificial intelligence is deep learning. The use of deep learning towards plant disease recognition can prevent the drawbacks associated with crop disease and production losses. In order to identify and characterize the signs of plant diseases, numerous established machine learning and deep learning architectures are used in conjunction with a number of visualization tools. The detection of leaf disease using image processing has been covered in this survey. Leaf disease diagnosis is enhanced when image segmentation is used in combination with deep learning or machine learning models. A big data collection can be segmented with the use of image segmentation, and the output is then fed to the AI algorithms on disease detection. Additionally, this survey covers the performance metrics of prior studies, which offered guidance for future advancements in plant disease detection and prevention methods.

Keywords: Machine learning (ML), Deep learning (DL), Artificial intelligence (AI), Image processing, Image segmentation

1. Introduction

Plant disease that affects agriculture is because of regions with different climate and weather patterns. Climate change-related factors, such as an abundance or lack of rain and unusually hot or cold temperatures, may cause bacterial, fungal, and viral illnesses in crops. The Indian economy's main economic driver is agriculture. Farmers use a variety of technologies to boost the yield of food crops [1]. However, the output is impeded by many factors like the impacts of global warming or the plants may contract a number of illnesses. Several billion people worldwide eat the food that these folks produce. Despite this,

availability to markets and services is restricted, and poverty levels are frequent. For the reasons outlined above, extensive study has been done to develop approaches that will be sufficient in accuracy and available to the farming community [2]. Here, the efficacy of models used in numerous research publications using deep learning and machine learning techniques toward early disease detection in leaves has been examined.

You can spot distinct illnesses that affect different segments of the plant by keeping an eye out for variations in symptoms, spots, colour, etc. The main demand in agriculture to increase crop yield is a less time-consuming, automatic diagnosing technique. Recently, methods for image processing have been employed to address a variety of issues based on agricultural applications, such as the ability to identify diseased fruit, leaves, and stems. Various researchers have reported employing image processing to gauge the severity of leaf disease. With the help of multiple deep learning, machine learning and image processing algorithms, diseases can be quickly identified. Numerous AI techniques are available to identify various leaf diseases and classify them into separate categories, including bacterial spots, Septoria leaf spot, Early blight, Mold, Two spotted spider mite, Yellow Curl Virus, Target Spot, Spider mites and healthy. The detection and classification are done through the following work processes such as image acquisition, image segmentation, feature extraction and classification [3-4]. The outputs are evaluated through various performance metrics related to the quantitative and qualitative analysis.

2. Types of plant leaf diseases

Spot the symptoms of diseases, apply protection and early detection of leaf disease help the plants and crops to be healthy. The first step in a complete approach is to identify the bacterium, that is been achieved by different machine learning and deep learning algorithms [5]. There is a wide variety of plant leaf diseases and few of them are listed below.

Black spot: It is one of the most prevalent diseases affecting roses, and can also affect other attractive and garden plants. On the upper sides of leaves, this fungus disease causes black, rounded patches to appear. Typically, lower leaves become affected initially. Infected leaves turn yellow as well as fall off from the plant.

Powdery Mildew: A fungal disease called powdery mildew damages many of the flowering shrubs, florals, veggies, and berries. The powdery mildew is simple to recognize.

White powdery material will be present on infected plants; it is most noticeable on upper leaf surfaces but can also be seen on stem, flowers, and on fruit.



Figure 1. Black spot disease



Figure 2. Powdery Mildew disease

Canker: An infected wound which has been affected by bacterial or fungal pathogens frequently indicates the presence of canker. While some cankers are harmless, some can be fatal. Canker mostly affects woody plants. On stem, limb, or even the trunks, there may be areas that are depressed, bloated, cracked, or dead.



Figure 3. Canker

Downy Mildew: Understanding the variations between downy and powdery mildews is crucial because they are slightly different from one another. True fungal infections i.e., powdery mildews produce solid white powdery substance on upper leaves. On the bottom surfaces of leaves, downy mildews, which are more closely linked to algae, release spores

that have a grey, fuzzy appearance. The light green or yellow patches on the upper side of older leaves are noticed to diagnose downy mildew.



Figure 4. Downy Mildew

Blight: In comparison to leaf spots, leaf blights typically have larger, more irregularly shaped infected patches. Sometimes a large number of tiny spots combine to give leaves a "blighting" appearance. Common names frequently contain the term "blight".



Figure 5. Blight

3. Leaf disease detection and classification

Digital signal system is a process for obtaining a quick and precise diagnosis of plant leaf diseases. It will lessen several aspects of agriculture and increase output by identifying the relevant disorders [6]. To identify disorders, image of a diseased leaf should review the collection of procedures [7]. The five phases below make up the core of leaf disease detection and classification.

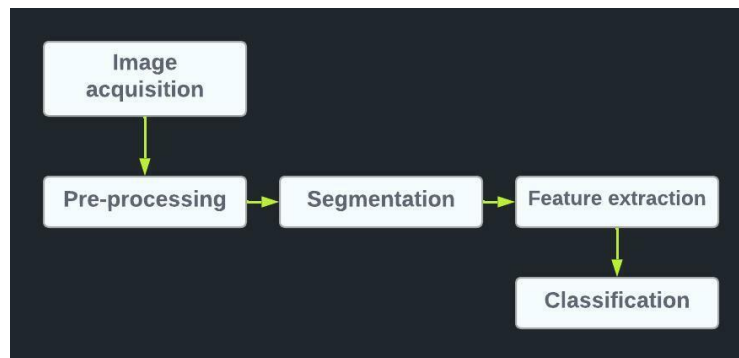


Figure 6. Basic block diagram

Image Acquisition: The process of acquiring images and converting them to the suitable output format is called acquisition. To begin processing, an analogue image is considered and is transformed to a digital image. Digital photographers, scanners, and unmanned aerial vehicles images can all be used to capture high-quality photos of plants.

Image pre-processing: Enhancing the image and removing undesired aberrations are the primary goals of image pre-processing. It is employed in a variety of methods for noise filtering, dynamic picture size and shape, image conversion, and morphological operations. It is also used in a variety of methods for HSI conversion, grayscale conversion, and image enhancement contrast. The steps of picture enhancing, RGB into Lab conversion, filtering, etc., are included in the process of image pre-processing. In this case, picture enhancement is done to boost the contrast [8]. The filtering techniques are used to achieve image smoothing. In image processing, various filtering algorithms are available, including median, Gaussian filtering and average filtering.

Image Segmentation: The method for image segmentation is labelled splitting up a digital image into several pieces. Image is broken up into various components to form cluster. K-means cluster is generally utilized. It is a method for dividing up photos into clusters in which at least one component of the cluster includes a picture of the principal space of the unhealthy component. The algorithm for k-means clustering rule is used to group the entities into K varieties [9].

Feature extraction: After segmentation, a step called feature extraction is carried out. Some aspects of the images should be obtained based on the segmented data and present dataset. Any of statistics, structural, fractal, or digital signal could be used for this extraction. Some techniques used for feature extraction include the Colour Co-occurrence Approach,

Spatial Grey-level Dependence Matrices (SGDM), Gabor Filters, Grey Level Co-occurrence Matrices (GLCM) method, Wavelets Transform, and Principal Component Analysis [10].

Classifiers: Classifiers are used for the training and testing of the datasets. These classifiers may be Support Vector Machine (SVM), k-nearest neighbour, neural network, fuzzy logic based etc [11-13]. These methods are used to classify and detect the leaf diseases. Plant disease is categorised using DL models such as ResNet, VGGNet, GoogLeNet, AlexNet, Inceptionv and XceptionNet. The current trend suggests that increasing the layer depth will strengthen the DL model. For example, AlexNet contains eight layers, VGGNet16 contains sixteen levels, Google Neural Network contains twentytwo layers, Inceptionv3 contains fortyeight layers, ResNet contains fifty layers, and XceptionNet seems to have seventy layers.

Few machine learning classifiers are listed below.

SVM: The popular trending classification algorithm in ML is SVM. The hyper plane-based technique was first exclusively applied to binary classification, but later it was improved to function with a multi - class classification environment [14]. The kinds depend on the SVM and its variants VM uses a variety of linear, polynomial, and radial functions, depending on the kernel type sigmoid, and basis function.

Random forest classification: The RF classifier employs an ensemble apprenticeship method for classification, using several decision trees for training and averaging the results of individual tree predictions. Using this approach, forests with a random assortment of trees is produced. Simple decision tree algorithms are based solely on a set of rules for dataset prediction and are rules-based. In contrast, RF classifiers take into account the root node and randomly partition the functions, as opposed to employing GI or profit knowledge for the root of the tree calculation [15]. Each tree produces a prediction, and the class with the most votes is taken as the outcome. It is frequently used in investigations involving spectral imaging, ecology, and the classification of land cover.

Stochastic Gradient Descendent: The smoothness attributes are utilised in an iterative manner to optimise an objective function. SGD is seen as a substantial alternative plan. In SGD, a randomised point is found algorithmically, then descends its gradient till it affects the bottom the purpose of that function. The gradient is diminishing as it descends, and it is by entering the parameter values, the computed value is updated [16-18]. The scale factor is

computed till the gradient reaches 0. Loss function, regularisation, learning parameters, and multiple iterations are some of the parameters that control the SGD.

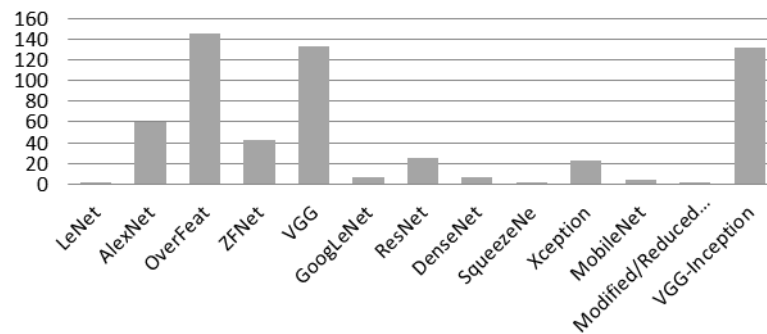


Figure 7. Survey of deep learning models with respect to the parameters

State-of-the-art survey deep learning models with respect to the parameters are shown in figure 7. Table 1 shows the survey on different datasets related to the plant leaf disease.

Table 1. Tabulation of literature review

Ref.	Type of plant leaf	Dataset	Classification method	Accuracy
[19]	Tomato plant leaf	Total number of images: 5550 open access repository of images	AlexNet, GoogLeNet, ResNet	97.28
[20]	Cucumber plant leaf	14,208	SVM, Random forest, AlexNet, CNN	93.4
[21]	Olive plant leaf	299 images of Olea europaea L.	Modified LeNet	98.4
[22]	Soya bean plant leaf	1090 image	3D CNN	95.73, precision 0.92
[23]	Tea plant leaf	299 images	LeafNet, SVM, MLP	Leafnet -90.16 SVM-60.62 MLP-70.77
[24]	Maize and rice plant	579 images	INC-VGGN	92%
[25]	Paddy Leaf	379 images	SVM	92.06

4. Conclusion

Many approaches used to detect plant diseases have been studied in this research. The problem with learning algorithms would be that the spatial information of the leaf image is not handled correctly, which is discussed while discussing AL algorithms. The publication also provides a brief overview of image processing, segmentation, and AI models for identifying leaf diseases.

References

- [1] Farhana Tazmim Pinki, Nipa Khatun, S.M. Mohidul Islam, Content based Paddy Leaf Disease Recognition and Remedy Prediction using Support Vector Machine, 2017 20th International Conference of Computer and Information Technology (ICCIT), 22-24 December, 2017.
- [2] Duraipandian, M. "Performance evaluation of routing algorithm for Manet based on the machine learning techniques." Journal of trends in Computer Science and Smart technology (TCSST) 1, no. 01 (2019): 25-38.
- [3] Miaomiao Ji, Lei Zhang, Qiufeng Wu, "Automatic Grape Leaf Diseases Identification via UnitedModel Based on Multiple Convolutional Neural Networks", Elsevier, Volume 7, Issue 3, September 2020, Pages 418-426.
- [4] JUN SUN, YU YANG, XIAO FEI HE, AND XIAO HONG WU, "Northern Maize Leaf Blight Detection under Complex Field Environment Based on Deep Learning", IEEE, 2020, Volume: 8 Page(s): 33679 – 33688.
- [5] <https://earthsally.com/disease-control/common-plant-diseases.html>
- [6] MohitAgarwalaAbhishekSinghb SiddharthaArjariacAmitSi nhad SuneetGuptaa," ToLeD: Tomato Leaf Disease Detection using Convolution Neural Network", Elsevier, 2020, Volume 167, 2020, Pages 293-301.
- [7] Boikobo Tlhobogang and Muhammad Wannous, Design of Plant Disease Detection System: A Transfer Learning Approach Work in Progress, IEEE International Conference on Applied System Innovation 2018.
- [8] DipteshMajumdar, Dipak Kumar Kole, ArunaChakraborty, An Integrated Digital Image Analysis System for Detection, Recognition and Diagnosis of Disease in Wheat Leaves, 2015

- [9] Vijai Singh, A.K. Misra, Detection of plant leaf diseases using image segmentation and soft computing techniques, *Information Processing in Agriculture*, Volume 4, Issue 1, 2017, Pages 41-49, ISSN 2214-3173,
- [10] Zhang, S., You, Z. & Wu, X. Plant disease leaf image segmentation based on superpixel clustering and EM algorithm. *Neural Comput & Applic* 31, 1225–1232 (2019). <https://doi.org/10.1007/s00521-017-3067-8>.
- [11] Kundu Kashyap Chakraborty, Rashmi Mukherjee, Chandan Chakraborty, Kangkana Bora, “Automated recognition of optical image-based potato leaf blight diseases using deep learning”, *Elsevier*, 2022 Volume 117, January 2022, 101781.
- [12] Balakrishna K Mahesh Rao “Tomato Plant Leaves Disease Classification Using KNN and PNN” *International Journal of Computer Vision and Image Processing* 2019
- [13] Du, X., Chen, B., Shen, T., Zhang, Y., Zhou, Z.: Effect of cropping system on radiation use efficiency in double-cropped wheat–cotton. *Field Crops Res.* 170, 21–31 (2015). <https://doi.org/10.1016/j.fcr.2014.09.013>
- [14] T.T. Wong, P.Y. Yeh, Reliable accuracy estimates from k-fold cross validation, *IEEE Trans Knowledge Data Eng* 32 (8) (2020) 1586–1594.
- [15] S. Hegelich, Decision trees and random forests: machine learning techniques to classify rare events, *Eur Policy Anal* 2 (1) (2016) 98–120.
- [16] W.J. Wilbur, W. Kim, Stochastic gradient descent and the prediction of MeSH for PubMed records, in: *AMIA Annual Symposium Proceedings 2014*, American Medical Informatics Association, 2014, p. 1198.
- [17] Pranjali B. Padol; Anjali A. Yadav,” SVM classifier based grape leaf disease detection”, *CASP*, June 2016, Conference on Advances in Signal Processing (CASP), DOI: 10.1109/CASP.2016.7746160
- [18] Garcia-Ruiz, F., Sankaran, S., Maja, J. M., Lee, W. S., Rasmussen, J., and Ehsani R. (2013). Comparison of two aerial imaging platforms for identification of huanglongbing-infected citrus trees. *Comput. Electron. Agric.* 91, 106–115. doi: 10.1016/j.compag.2012.12.002
- [19] Keke Zhang, Qiufeng Wu, Anwang Liu, Xiangyan Meng, "Can Deep Learning Identify Tomato Leaf Disease?", *Advances in Multimedia*, vol. 2018, Article ID 6710865, 10 pages, 2018. <https://doi.org/10.1155/2018/6710865>
- [20] Ma, J.; Du, K.; Zheng, F.; Zhang, L.; Gong, Z.; Sun, Z. A recognition method for cucumber diseases using leaf symptom images based on deep convolutional neural network. *Comput. Electron. Agric.* 2018, 154, 18–24.

- [21] Cruz, A.C.; Luvisi, A.; De Bellis, L.; Ampatzidis, Y. Vision-based plant disease detection system using transfer and deep learning. In Proceedings of the 2017 ASABE Annual International Meeting, Spokane, WA, USA, 16–19 July 2017; p. 1
- [22] Nagasubramanian, K.; Jones, S.; Singh, A.K.; Singh, A.; Ganapathysubramanian, B.; Sarkar, S. Explaining hyperspectral imaging based plant disease identification: 3D CNN and saliency maps. arXiv 2018, arXiv:1804.08831.
- [23] Cruz, Albert & Luvisi, Andrea & De Bellis, Luigi & Ampatzidis, Yiannis. (2017). Vision-Based Plant Disease Detection System Using Transfer and Deep Learning. 10.13031/aim.201700241
- [24] Junde Chena, Jinxiu Chena, Defu Zhanga, Yuandong Sunb, Y.A. Nanekharana,” Using deep transfer learning for image-based plant disease identification”, Elsevier, June 2020, Volume 173, June 2020, 105393.
- [25] S. Ramesh, D. Vydeki, Recognition and classification of paddy leaf diseases using Optimized Deep Neural network with Jaya algorithm, Information Processing in Agriculture, Volume 7, Issue 2, 2020, Pages 249-260

Author’s biography

Akey Sungheetha is a Smart System Software member and Data Science SIG Secretary, in the department of Computer Science and Engineering, in School of Electrical Engineering and Computing, in Adama Science and Technology University, Adama, Nazret, Ethiopia. Akey Sungheetha has 16 years of academic experience. Her area of research is networking, and she has published in more than 50 international and national journals. She is a life member of International Association of Engineers and Indian Society of Technical Education, and member of IIE, IAENG, IARCP, ISQEM and AIIM.