PLANT DISEASE DETECTION TECHNIQUES BASEDON DEEP LEARNING MODELS: A REVIEW

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ABSTRACT

Plants must be checked at an early stage of their life cycle in order to avoid illnesses. Visual observation, which takes longer, and costly expertise are the conventional approach utilised for this monitoring. Therefore, illness detection systems need to be automated in order to speed up this procedure. This study analyses the possibility of technologies for the identification of pest leaf diseases in plants to support agricultural growth. It covers many processes, such as image retrieval, image segmentation, extraction of features and classification. Two key phases comprise plant disease detection technology: segmentation of an open input to detect the ill portion and an extraction approach to extract the image feature and classify the functionality that is removed using different classifiers. The technology consists of two important steps. In this study, segmentation, characteristic removal, and classification approaches are examined and clarified from the perspective of different parameters.

KEYWORDS

Plant disease detection, image processing, image acquisition, segmentation, feature extraction.

1. INTRODUCTION

Plant diseases are described as any disruption of a plant's normal physiological function that results in noticeable symptoms. A symptom is an event that occurs in relation to something and is used to prove its existence. Pathogens that cause plant disease may be present in plant leaves, stems, bulbs, fruit, and roots. Changes in the size, shape, and appearance of leaves, branches, flowers, and fruits are all symptoms of disease. Fig.1 depicts the leaf diseases of soybean, potato, and maize. It depicts how the disease has altered the green sheet, including colour, form, and rough texture transitions.

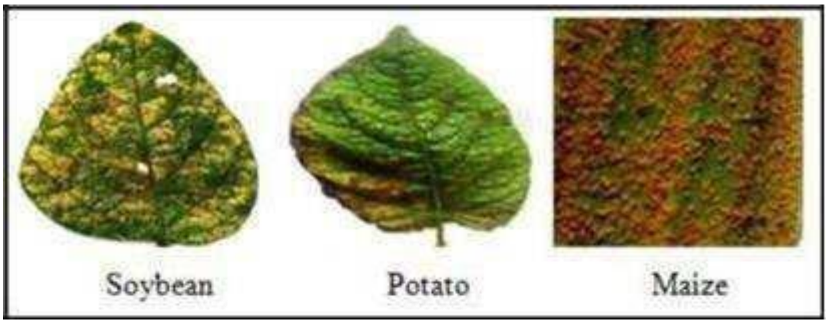

Figure 1. Different plant diseases

Plant diseases are classified into various groups based on their frequency, severity, and cause. The type of plant disease is classified as either localised or systemic. On the basis of natural propagation and mode of infection, plant disease is often classified as soil-borne disease, airborne disease, or seed-borne disease. A variety of diseases are included in a classification category based on symptoms. Rust, smuts, spotting leaves, mildew, powdery mildew, and so on are examples. By host plant, plant diseases are also known as cereal, vegetable, fruit, and forest diseases. On the basis of agriculture, plant diseases are referred to as maize diseases, soybean diseases, and so on. Root and fruit diseases, foliage diseases, and shooting diseases are the three types of plant diseases classified by organ. Plant diseases are classified as chronic, epidemic, seasonal, or pandemic depending on the occurrence and spread of the disease. It is widespread in a particular area when a disease is consistently moderately present year after year. Epidemic disease manifests itself in a severe form in large crop areas on a regular basis. Sporadic illness manifests itself in sporadic and unpredictable ways. It's formed in a mild to serious way. Pandemic diseases have spread throughout the continent. Pathogen production distinguishes monocyclic, polycyclic, and polyetic diseases. For example, smut in meat, while polycyclic diseases occur several times in a cropping season (e.g., Late Blight in Potatoes). Polyetic diseases are polycyclic diseases with a disease cycle of more thana year (e.g. Rust Apple).On the basis of cause, vegetable diseases are commonly referred to as fungal diseases, bacterial diseases, and so on. Nutritional deficiencies are also a cause of certain herbal diseases. Khaira in rice disease, for example, is caused by a lack of zinc. Plant disease is unavoidable, and in the field of agriculture, the understanding of such diseases plays a significant role. Plant pathology, also known as phytopathology, is the study of plant diseases. Emerging plant health issues are disrupted. "Herb means phyton, disease/ailment means pathos, and discourse/knowledge means logos. Phytopathology is a branch of agriculture that studies the causes and effects of disease. Plant pathology is the scientific study of plant parasites, diseases, and conservation factors. It is also possible to explain the study of nature, as well as the causes and prevention of plant diseases. Disease is a form of plant state disorder that interferes with normal functions like poisoning, sweating, photosynthesis, germination, and impregnation. Plant pathology is consumed in order to achieve the key objectives. To investigate the causes of illnesses, living and non-living, as well as recyclable materials, Instruments for studying disease development to investigate the relationship between plants, pathogens, and environmental factors in order to improve plant monitoring methods. Plant pathologists focus on a variety of crop and plant diseases, as well as mitigating losses caused by transferable agents. They were supposed to get rid of the agent that caused the lesion.

1.1. Potato Late Blight

It is one of the most dangerous diseases that can affect potatoes. Figure 2 depicts the effect on a potato leaf. In the mid-nineteenth century, Ireland was afflicted with the disease (1845-1847). At that time, approximately 1.5 million people died of hunger. About 1.5 million people have been forced out of Ireland into other countries at the same time.

Figure 2. Potato late blight

1.2. Citrus Canker

It has been dubbed one of citrus's most dangerous diseases. It's common in places like Florida, Alabama, Georgia, Louisiana, South Carolina, Texas, Brazil, and Mississippi, to name a few. Many countries have started to combat devastation since 1915. Between 1999 and 2008, 2,327,772 plants were destroyed.

Furthermore, over 116 million dollars have been spent in the last decade to remove polluted or exposedplants. Figure 3 shows examples of canker infected leaves.

Figure 3. Citrus canker

Figures 4 show that the disease not only affects the colour of the leaf, but also changes its morphs/stripes (e.g. shape). Diseases are often referred to as characteristics. The amount of green leaf content decreases because it includes diseases. It interferes with plant photosynthesis, lowering the process of forming plant food and, as a result, overall performance. The late blight disease on potato leaves demonstrates how leaf characteristics such as shape and edges have changed. In comparison to a healthy leaf, the diseased leaf has a strongly rolling surface. Another example of the effect of viral disease on a soybean leaf is seen in Figure 4 (b), which shows teeth of the margin on one side.

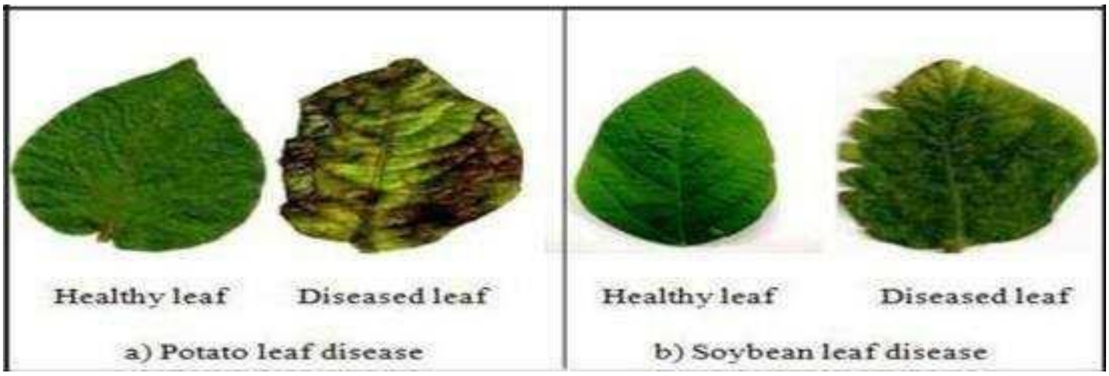

Figure 4. Effect of disease on leaf traits like shape and margin

1.3. Disease Diagnosis

Plant diseases spread through the air, water, and insects. Disease incidence and distribution are often influenced by environmental factors. Although humans have little power over climate change, growing crops in greenhouses may provide some control. Both growers, however, would be unable to cultivate in a greenhouse. Greenhouse maintenance and expenses are prohibitively expensive for large farms. It is only necessary for farmers to keep a close eye on their crops in order to manage diseases and pests, including early detection and treatment of plant diseases. An ICR survey found that 93 percent of Indian farmers only use pesticides to control crop diseases and pests.A crop is given between 1 and 15 pesticide sprays after harvest, according to the survey. Crop losses for farmers range from 11 to 40%.Overuse of pesticides has a negative impact on the food chain, can result in secondary pests, is hazardous to human health, and can cause acute and chronic illnesses. The ability to diagnose a disease early allows for timely treatment. It also aids in the surveillance of disease transmission, which increases over time and spreads through wind, water, birds, and insects. Once the disease has been detected, a variety of disease-control strategies may be used. Pesticide use, biological control organisms, and Integrated Pest Management (IPM) are examples of these strategies. The diagnosis method necessitates the presence of a particular individual in order to diagnose the disease and explain its treatment and protection. Recognizing a disease is a daunting task. It needs not only plant and disease awareness, but also experience. If the disease signs are correct, disease recognition is correct. As a result, farmers need a competent and expert system. This system is designated as an Expert System. An expert system could be:

- An expert farmer.
- Agricultural advisor.
- Electronic or Computerized expert system.

A professional farmer can understand the changes in the crops by regularly observing the growing crops.According to the most recent update, they deal with cultivation. Farmers have the ability to gain insight into subtle changes in crops through observation and long cultivation experience. This knowledge is difficult to hand on to future generations. If farmers decide to seek advice from an agricultural expert on how to handle plant diseases in order to boost productivity, the following will occur. Farmers must occasionally travel long distances to visit experts. Experts will not be accessible if the farmer travels such a long way. The expert will not always be able to provide factual advice to the farmers. Seeking expert advice in such a situation is both costly and time consuming. Disease diagnosis may be done using imaging or computer vision techniques based on the results of a visual inspection. Expert systems for electronics are the name given to the devices created using these techniques.

In this research we offer a literature overview of some of the work done in this field, along with the introduction of deep learning and the workings of CNN, followed by the conclusion.

2. LITERATURE SURVEY

Many methods were used to correctly diagnose the disease in the plants in the photographs. The majority of them are concerned with image processing in general, SVM classification, K-mean, genetics, and so on. We couldn't have asked for a more positive outlook. Some researchers have recently used neural network-based methods in this area. When opposed to traditional image processing methods, deep neural networks are effective at detecting image disease. India is particularly important in today's fast-growing world. The prevalence and simplicity of certain major diseases pose major challenges in the management and control of these conditions. As a result, the most recent study is crucial. Disease is a major impediment to fruit development, resulting in both qualitative and quantitative losses. It is important to understand the origin, persistence, and spread of the pathogens that cause disease in order to enforce management measures quickly. The various causes of the epidemic must also be recognized, and these diseases must signal the appearance of preventive or treatment chemicals, as well as their timely implementation.

[Xinda Liu et al. 2021] discuss the systemic problem of disease recognition in plants in the diagnosis of disease. Compared to other types of photographs, plant photographs usually show divided lesions, different symptoms and complex backgrounds, so it is difficult to obtain discriminatory information. To promote research on the identification of plant diseases, they have compiled a database of major diseases, which includes 271 disease categories and 220,592 images. Based on these data, they solve the problem of plant disease identification by reevaluating the visible area and the loss to highlight the diseased part. They first calculated the value of the blocks with each section per image according tothe cluster distribution of blocks to indicate the level of discrimination per block. Then, during a weak control exercise, they weighed the losses for each pair of patch marks to determine the study distinguishing the part of the disease. They extract the patch features from the network that has undergone weight loss training, and use the LSTM network to patch the sequence of the heavy-duty pipelines into a complete feature set. Excessive evaluation of this information fund and other public funds proves the benefits of the proposed method. They hope that this research will further advance the program for the detection of diseases in plants in the field of image processing[1]. The study by [Xulang Guan et al. 2021] created a new technique for illness identification whilst also integrating four CNN models. The experiment employed an open source collection of 362,258 pictures split into 10 kinds of plants and 61 species of healthy and ill plants. Four CNN models were transmitted and the outcomes of all the models have been set. Inception, Resnet, Inception Resnet and Densenet. Using the modified approach, the accuracy reaches 87 percent, a substantial increase from the findings of the CNN model. This high precision ratio shows that the integration with both the implant technique of the CNN model may have been a feasible method that may also be expanded as an early warning instrument to true cultivation[2]. Plant diseases are a factor of low yields and reduced incomes for farmers. Currently, researchers are doing their best to find mechanics to automatically diagnose plant diseases. Accurately diagnosing plant diseases can help with treatment as quickly as possible to control the loss. This article attempts to create a new way to predict plant diseases through the use of machine learning technology. Experimental results show that plant diseases can be successfully detected[3]. [Bincy Chellapandi et al. 2021] employed a detailed research and migration study model in the article to identify pictures of sick plant leaves in 38 plant species based on data flaws. Eight models, including VGG16, VGG19, ResNet50, InceptionV3, InceptionResnetV2 and MobileNet V2, DenseNet, are used in research. They found that DenseNet achieved the best results with the test data, with a 99%accuracy rate[4]. [PE Rubini et.al 2021] In additionto assigning disease types, an in-depth study model was also proposed, which can accurately classify whether the diseased leaves have images. Images of tomato plants were taken from the Plant Village data, and trained models such as VGG16 and Dense Net were used for training through migration studies, and compared. Therefore, the proposed system, in addition to the interpretation and measurement of the dimensions, can help the farmer in the pre-identification of diseased leaves[5]. An extensive study model for the classification of different plant diseases was applied in the [Akshai KP et.al (2021)] project. Dueto its great efficacy in image classification, the convolution neural model (CNN) is utilized. The in-depth research methodology could give faster and more precise predictions when compared to studying plant leaves. This study has been conducted using the data for CNN models and trained models such as VGG, ResNet and DenseNet models. The DenseNet model was found to be the most precise amongst them[6]. The goal is to offer solutions to monitor plants and identify plant-borne diseases. [N. Radha et al. 2021] Automatic plant detection technology helps to relieve the symptoms of the disease in large farms. The data used for this work includes images of various plants with diseased and healthy leaves. Convolutional Neural Networks (CNN) are used to train models for the diagnosis of neurological dis-eases. The plants considered include corn, strawberries, grapes, tomatoes and potatoes. The model predicts the status of most plants with an optimal predictive ability of 85%, and the losses observed during the training data arenegligible by 0.25[7]. [Satoi Kanno et al. 2021] research offers a method of high-quality plant imaging to educate the diagnostic system, which is called reproductive & pathogenic imaging (PPIG). There are two phases of PPIG: mass manufacturing and the pathogenic process. During the initial phase of the production of the pictures, a number of healthy leaf photos were prepared. Therefore, the symptoms of both the leaf sections of the healthy image will be applied in the second stage. In this work, they carried out an experiment to assess PPIG with test pictures collected from various training regions, on the assumption that cucumber leaves are six kinds of illness. The proposed PPIG can create images that appear natural, healthy and patient, and the use of these images to improve the data improves the robustness of the diagnostic system. Examination of 8,834 images taken from 53,045 training images in different domains shows that our proposal improves the diagnostic efficiency of F1 model yellow eyes by 9.4%. In addition, it is 4.5% higher than the previous data improvement method[8]. [Majji V Applalanaidu et.al 2021] checked the latest progress in the development of medical systems and classification systems according to machine learning (ML) and deep learning (DL) models. In this study, they collected more than 45 papers that were published between 2017 and 2020. These papers were from journals reviewed by colleagues in various databases, such as the use of machine learning to detect, diagnose and classify plant diseases and other keywords. The structured methods of the various disease classification models are presented in a well-organized table. In this article, the much more sophisticated ML and DL techniques, including the SVM, the Fuel Network, the closest K nearest neighbours (KNN), and Bayes net (NB), have been systematically reviewed. There are so many more prominent ML and AlexNet methods, such as GoogLeNet, VGGNet, and a number of other famous DL techniques. Each dedicated algorithm passed a corresponding processing method (e.g. image sharing, feature extraction) and experimental parameters (e.g. total training/testing data used, number of diseases considered, type of classification used, and the accuracy of the classification). This work by the author is a useful source of information for researchers to identify which specific plant species by means of data retrieval methods[9]. [Bari et al. 2021] utilized an r-CNN method with a modified rpn architecture in the article to address the position extremely precisely, and the robustness is increased by publicly accessible and real-world rice leaf datasets. Models were used to identify diseases such as blast, brown spot, and hispa, with accuracy rates of 98.09 percent, 98.85 percent, and 99.17 percent, respectively. Healthy leaves have a detection accuracy of around 99.25 percent[10]. The [Saradhambal G et al. 2018] study introduces a spectrometric technique for diagnosing cassava disease in the field. A comparison of spectral data and picture data, the de-facto auto[9]ted diagnostic approach, has been conducted by the authors. Spectral data has been shown to improve illness prediction accuracy in experiments. It was shown in this study that spectral data from different regions of the leaf may be collected with a high degree of consistency. In particular, the gathering of spectral data from the leaf's good portion is of importance, since it might be used to detect illness in plants before symptoms appear[11]. According to a [Bansal et al. 2021] study, apple tree leaves may be classified into four groups based on their appearance: healthy, apple scab-infected, apple cedar rust-infected, and many diseases. The model employs a variety of image enhancement techniques to achieve 96.25 percent accuracy on the validation datasets. Among the apple leaves in the dataset are 3642 that are classified as having apple scab, cedar rust on apple leaves, different diseases, and healthy apple leaves. The final model is a clear winner, with 96.25 percent accuracy on the validation dataset. A numberof state-of-the art models were evaluated to see how well they performed[12]. [Faizan Akhtar et al. 2021] developed and modified in-depth measurements which are used in terms of multiple vision techniques to detect and differentiate the symptoms of plant diseases. In addition, many degrees work on examining these systems and methods. This review provides a complete summary of the in-depth study models used to characterize three diseased eyes. In addition, some analytical gaps are known, although their symptoms are not yet obvious, the measurements determine their specific characteristics of the identified diseases in the plant[13].

3. DEEP LEARNING

Deep learning is a field of machine learning, it is an AI function that models the workings of the human brain in processing data for use in object classification, speech recognition, text analysis, and decision making. AI is capable of learning without human supervision, using both unstructured and unlabelled data. Deep learning, a subset of machine learning, should be used to aid in the investigation of fraud and money laundering, among other matters. A broad number of fields make use of CNN. The first layer is the convolution layer. The convolutional layer is CNN's fundamental building piece. It takes the highlevel features of the incoming signal from it. The pooling layer is then applied once the convolution layer has been completed. Applications are used to decide how pooling events may be established. Maximal, minimal and average pooling are three different types of procedures that may be performed on data. To decrease the number of dimensions and to choose the most essential characteristic, the pooling process is utilized a lot. These features are transferred to the completely connected layer, which has an activation function. Multiple-filter convolution can be used to extract features (feature map) from the data collection, preserving their spatial information. In the convolution procedure, the feature maps are reduced in dimensionality using the pooling method, also known as subsampling. CNN's most popular pooling procedures are maximum and average.

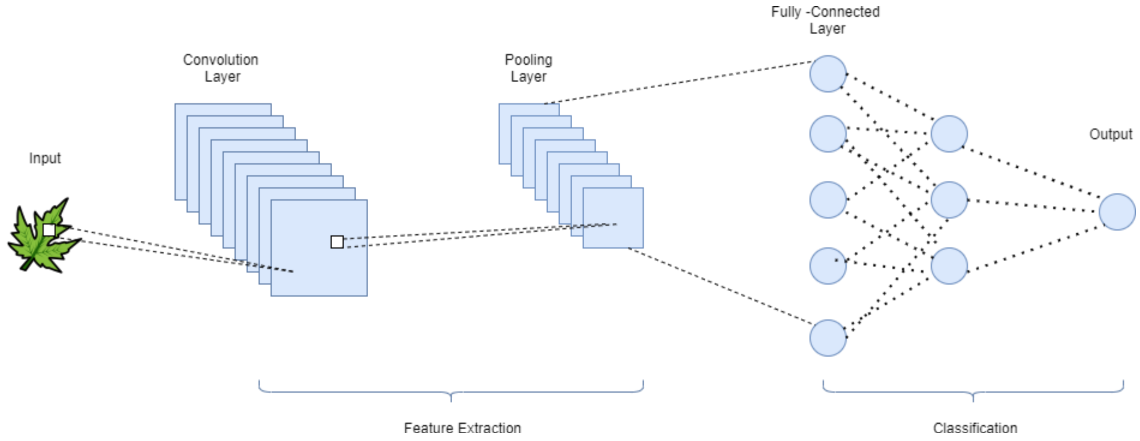

Figure 5. CNN architecture

3.1. Convolutional Layer

Each neuron acts as a convolution kernel in the convolutional layer. The image is divided into smaller parts, called receptive fields, using the convolution kernel. When divided into tiny parts, the feature patterns of a picture may conveniently be retrieved. By multiplying the parts by the relevant elements of the receptive field using a certain number of weights, the kernel convolves with the pictures.

3.2. Pooling Layer

After a convolution layer it is usual to use a pooling layer. The major objective of this layer is to minimize the size of the feature map in order to reduce computation expenses. Reduce linkages between layers and work on each map independently to attain this aim, various methods permit various sorts of pooling activities. The largest element of Max Pooling comes from the characteristic map. The average pooling is used to average the components in the predefined image segment. The pooling method is used to sum up the designated section.

3.3. Fully Connected Layer

Simply put, the fully linked layer is formed by forward neural networks. The final few layers of the network are fully linked. The final output for pooling or convolution layer is flattened and transmitted as an input into the fully linked layer. A completely connected (FC), which connects neurons between layers, consists of both weights and biases and neurons. The last layers of the CNN architecture are usually positioned before the output layer. The images from the previous levels will be flattered in this phase and transferred to the FC-layer.

3.4. Types of convolutional neural network

- LeNet
- AlexNet
- ZFNet
- GoogLeNet
- VGG Net
- ResNet

3.4.1. GoogLeNet.

The GoogLeNet architecture contains 27 pooling layers at a depth of 22 layers. A total of 9 starting modules stay in the linear. Both sides of the starting module are connected to the global average pooling layer. There are 4 million parameters across GoogLeNet.

3.4.2. AlexNet

AlexNet is comprised of five convolution layers, three maxpooling layers, and two regularisation layers, and two fully connected layers, along with a softmax layer. A convolution filter and just a nonlinear activation function ReLU make up every convolution layer. Max pooling was implemented via the pooling layer. Since fully con-nected layers exist, the input size is fixed. The AlexNet has 60 million parameters over-all.

4. CONCLUSION

The research described in this review paper shows that various techniques of disease detection have already shown efficiency and precision, so that they too are able to operate, as well as have certain limitations, in the system created to detect leaf diseases. Therefore, more may yet be done to improve existing activities in this area. The study concludes that the means of detecting plant diseases is the identification of diseased parts of the leaf. The detection of plant disease consists of two phases, the first of which involves segmenting the picture, and the second step is the extraction and classification approach, which classifies the disease and the normal section of the image. This study reviews and discusses several approaches for detecting plant disease according to different criteria.

REFERENCES

[1] X. Liu, W. Min, S. Mei, L. Wang, and S. Jiang, “Plant Disease Recognition: A Large-Scale Benchmark Dataset and a Visual Region and Loss Reweighting Approach,” IEEE Trans. Image Process., vol. 30, pp. 2003–2015, 2021, doi: 10.1109/TIP.2021.3049334.

[2] X. Guan, “A Novel Method of Plant Leaf Disease Detection Based on Deep Learning and Convolutional Neural Network,” 2021 IEEE 6th Int. Conf. Intell. Comput. Signal Process. ICSP2021, no. Icsp, pp. 816–819, 2021, doi: 10.1109/ICSP51882.2021.9408806.

[3] Deepa, N. Rashmi, and C. Shetty, “A Machine Learning Technique for Identification of PlantDiseases in Leaves,” Proc. 6th Int. Conf. Inven. Comput. Technol. ICICT 2021, pp. 481–484, 2021, doi: 10.1109/ICICT50816.2021.9358797.

[4] B. Chellapandi, M. Vijayalakshmi, and S. Chopra, “Comparison of pre-trained models using transfer learning for detecting plant disease,” Proc. - IEEE 2021 Int. Conf. Comput. Commun. Intell. Syst. ICCCIS 2021, pp. 383–387, 2021, doi: 10.1109/ICCCIS51004.2021.9397098.

[5] P. E. Rubini and P. Kavitha, “Deep learning model for early prediction of plant disease,” Proc.3rd Int. Conf. Intell. Commun. Technol. Virtual Mob. Networks, ICICV 2021, no. Icicv, pp. 1104–1107, 2021, doi: 10.1109/ICICV50876.2021.9388538.

[6] K. P. Akshai and J. Anitha, “Plant disease classification using deep learning,” 2021 3rd Int. Conf. Signal Process. Commun. ICPSC 2021, no. May, pp. 407–411, 2021, doi: 10.1109/ICSPC51351.2021.9451696.

[7] N. Radha and R. Swathika, “A Polyhouse: Plant Monitoring and Diseases Detection using CNN,” Proc. - Int. Conf. Artif. Intell. Smart Syst. ICAIS 2021, pp. 966–971, 2021, doi: 10.1109/ICAIS50930.2021.9395847.

[8] S. Kanno et al., “PPIG: Productive and Pathogenic Image Generation for Plant Disease Diagnosis,” Proc. - 2020 IEEE EMBS Conf. Biomed. Eng. Sci. IECBES 2020, pp. 554–559, 2021, doi: 10.1109/IECBES48179.2021.9398772.

[9] M. V. Appalanaidu and G. Kumaravelan, “Plant leaf disease detection and classification using machine learning approaches: A review,” Lect. Notes Networks Syst., vol. 171, no. Icicv, pp. 515–525, 2021, doi: 10.1007/978-981-33-4543-0_55.

[10] B. S. Bari et al., “A real-time approach of diagnosing rice leaf disease using deep learning-basedfaster R-CNN framework,” PeerJ Comput. Sci., vol. 7, p. e432, Apr. 2021, doi: 10.7717/peerj- cs.432.

[11] Saradhambal G, Dhivya R, Latha S, and R. Rajesh, “PLANT DISEASE DETECTION AND ITS SOLUTION USING IMAGE CLASSIFICATION.” [Online]. Available: http://www.ijpam.eu.

[12] P. Bansal, R. Kumar, and S. Kumar, “Disease detection in apple leaves using deep convolutional neural network,” Agric., vol. 11, no. 7, 2021, doi: 10.3390/agriculture11070617.

[13] Faizan Akhtar, N. Partheeban, A. Daniel, Srinivasan Sriramulu, Saloni Mehra, Nishant Gupta: Plant Disease Detection based on Deep Learning Approach. 2021 International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE), 2021, pp. 74-77.

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