Fungal infection in plant leaves-A Review

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Abstract: The primary resource of a country is agriculture and crop production. The economic development of the country also resides on the agricultural products which ultimately determines the growth of the citizen. The major crisis in food production is the influence of diseases in plants. This ultimately abolish the economy of the country, as major portion of progress of the nation is dependent on agriculture and its products. The challenges faced by the farmers are the unawareness of the various diseases that affects different parts of the plants. They should be able to identify the early infection caused in plants by different pathogens like bacteria, fungi, virus etc., Main disease-causing agent is found to be the fungus which was the vital factor that produce serious loss in the agriculture. Again, the pesticides and fertilizers used by the agriculturist changes to be hazardous for human beings and wild life species. This problem should be considered as a chief calamity and an alternate measure must be found to support the cultivators. An innovative step adopted by the researchers are prompt detection of the diseases using machine learning and deep learning algorithms. These algorithms use different image processing techniques and computer vision process to classify the disease in plant parts at an earlier stage. This paper provides a detailed review on the fungal infection caused in plant leaves and its identification using deep learning methodology.

Keywords: Plant diseases, Fungal infection, Machine learning, Deep learning and Computer vision process.

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I. Introduction

Around 85% of plant diseases are found to be caused by fungi, which comprise the largest number of plant pathogens. Serious plant diseases are caused by fungi. World wide analysis shows that about 19,000 fungi are known to produce diseases in plants [1]. These pathogens initiate damages in plants by triggering stress in the plants are by meagerly killing its cells. The basis source of the fungal defects are diseases weeds, soil, seed, nearby crops and crop debris. These pathogens move into the plants via stomata, wounds created by pruning, during harvesting, mechanical injury and through insects. The fungal spread is also caused by animals, workers, machinery tools used for cropping, seedlings, wind and water plop, contaminated soil and through different plant material. Certain fungi cause foliar diseases such as Powdery mildews, White blister and Downy mildews, some initiate clubroot diseases like Rhizoctonia species, Pythium species, Fusarium species, while soilborne diseases are produced by Sclerotinia and Sclerotium species. Such damages to the crop area chaotic problem for the farmer as well as for the economic development of the nation.

One can easily determine the consequence of disease on the plant by seeing the symptoms present in it. The indications of the fungi infected area show a detectable change in shape, color, size or the function of the plant which has responded to the pathogen. Few examples are fungal plant pathogens caused by the Verticilliumalbo-atrumand V. dahlia are leaf wilting, brown or necrotic lesions enclosed by a bright yellow halo at the leaf margin on bean plant is due to bacterial blight etc. Here it not the pathogen but the symptom caused by the different microorganisms on the plant parts are recognized. The productivity in agriculture depends largely on the production of crop.

Even though the technological advancement has provided modernized equipment's, pesticides, fungicides etc., still diseases in plants decline the yield in crop production. Now a days even soils, seeds are completely analyzed to increase the nutrient and harvest of the crop. Present agriculture is involved in the efficient usages of scientific devices and methods for rising the yield of the crop. But still agriculture faces an evident challenge of plant diseases caused by different pathogens. To overcome this difficulty, one has to adopt many timely activities such as instant watching the plants for infection, choosing proper remedies like insecticides, pesticides etc., which actually downgrade the crop to unfavorable stuff. This encompasses uncovering instant cure for the challenges faced in day to day crop production. So, the diseases actually disturb the complete functional capacity of the plant resulting in leaf fall, abridged growth, fewer fruit production and so on. In the early days, farmers detected the diseases in the crops using their bare eyes and using their practical experience and understanding. Finding a skillful person in the identifying of disease is really a wearying and time-consuming process which also seems to be a lengthy and exclusive method. These whole procedures always take much time that will still be a tedious time taking process for eliminating the disease when land extends over a large area [2,3]. Recent technological advancement like deep learning algorithm has shown the path way for detection and identification of plant disease at an earlier stage and found to be time saving than ancient methods utilized [4-8]. Not only early recognition, but also these methods

has created a new footpath for progressing the quality of the crops by inducing a vital cure for the plant disease [9]. In plants, leaves play a chief role in indicating the initial infection of diseases. Owing to the high degree of complications in spotting out the diseases at a primary stage, many agriculturists was led to incorrect identification and treatments. Hence Image processing methods acts an emerging technique in classification of diseases and its early diagnosing. Apart from this various imaging technique also performs as a non-destructive testing in the detection of diseases infected by various pathogens. These methodologies will help the agricultures to prevent the diseases and increase this crop yield. This paper deals with various image examination techniques, detection of plant diseases at early stage and its rectification process.

II. Literature survey

JatinArora et al. [10],applied deep forest algorithm for classification and identification of leaf diseases in maize plant leaf. It was suggested that the Deep forest technique are important step-up compared to the manual classification and found to be a automated innovative approach for accurate cataloguing. This planned method hasoutstripped Deep Neural models and other old-style machine learning algorithms in terms of precision. It validates its truncateddependence on extensive Hyper-parameter tuning andthe size of the dataset in contradiction of other Deep Learning Models based on neural networks.

Konstantinos P. Ferentinos et al. [11], proposed a convolutional neural network pattern for analysis of leave images both healthy and diseased plant. This model found to be précises for the detection of diseased plant by means of deep learning methodologies. They considered 25 different plant models with more than 87,000 images using open database. This suggested architecture has gained them an accuracy of 99.53% in identifying the plant diseases. This considerable achievement rate has made this approach a suitable tool and method for disease recognition in plants to improve the farming condition.

Aravind Krishnaswamy Rangarajan et al. [12],projected that deep learning in one of the dynamic parts of research for sorting the diseases in the crop. They studied a vital crop namely eggplant which is liable to solemn diseases that delays its production. Unexpectedly, the availability of dataset for this plant disease is so rare. Hence a Visual Geometry Group 16 (VGG16) design was created considering field conditions for five major diseases. The images in this architecture was transformed to color spaces namely Hue Saturation Value (HSV), YCbCr and grayscale for assessment. The outcome display that the dataset generated with RGB and YCbCr images in the domain condition was capable with a cataloguing accuracy of 99.4%. Furthermore, has been utilized as a feature extractor from 8^{th} convolution layer and these topographies have been treated for categorizing diseases employing Multi-Class Support Vector Machine (MSVM).

Krishnaswamy Rangarajan Aravind et al. [13], has revealed imageries got from the smartphone and transferred them to computer through wireless network connection. They used these ideas to classify ten different diseases in four major farming crops which are minimum explored. Six different Convolutional Neural Network techniques AlexNet, Visual Geometry Group16 (VGG16), VGG19, GoogLeNet, ResNet101 and DenseNet201 were employed and its corresponding

output were analyzed. Among which GoogLeNetgave rise to in the finest authentication accuracy of 97.3%.

MostafaMehdipour Ghazi et al. [14], employed deep convolutional neural network to recognize the plant species taken in a photograph and estimated various factors distressing the functioning of these systems. Three prevailing and current deep learning architectures, namely GoogLeNet, AlexNet, and VGGNet, are utilized for this intent. The plant task datasets of LifeCLEF 2015 was cast-off to modify the pre-trained models. To avoid overfitting, image transforms like reflection, translation, scaling and rotation are done using data augmentation techniques. Additionally, in the dataset unlike classifiers are merged and the networks' parameters are attuned to progress overall performance. They succeeded with an accuracy of 80% using the above training process. They have also made a comparison on the outcome of their result with the results of the LifeCLEF 2015 plant identification campaign and achieved an improvement by 15% points and its complete inverse rank score on the test set by 0.1 while outstripping the top three competition participants in all categories. Their system also gained a very close second place in the PlantCLEF 2016.

Table 1. Reported work on plant-disease detection.

Authors	Techniques	Accuracy	References
JatinArora et al.	Deep forest algorithm	96.25%	[10]
Konstantinos P. Ferentinos et al.	Convolutional Neural network	99.53%	[11]
Aravind Krishnaswamy Rangarajan et al.	Visual Geometry Group 16 (VGG16)	99.4%	[12]
Krishnaswamy Rangarajan Aravind et al.	GoogLeNet	97.3%	[13]
MostafaMehdipour Ghazi et al.	Deep convolutional neural networks	80%	[14]

III. Common non-destructive imaging techniques for plant leaves disease detection

In general, many imaging techniques for identifying the plant leaves infection is available. Among which few are discussed below.

(i). Photo acoustic imaging

Photoacoustic imaging allows the transfer of light energy that is absorbed by the plant tissues causing a thermoelastic expansion. This enlargement then produces ultrasound waves that are sensed by the transducer and generate images of optical absorption distinction within plant tissues. Using the above effect, it is easier to develop sound wave followed by the light absorption in the plant sample taken. Hence this effect is also called as optoacoustic effect.The Photoacoustic imaging (PAI) has arisen as a nondestructive and nonionizing within the living medium, and has greatly been utilized now in biomedical imaging with comparatively deep tissue imaging capability.

(ii). Spectroscopic and imaging technologies

Spectral imaging discusses the fit in conventional imaging and spectroscopy approaches to attain both spatial and spectral data of an object. So, it is also called as imaging spectroscopy. This methodology trusts on using personalized mathematical algorithms in directive to employ and improve data processing through images captured from the spectral imaging system. The meek handling embraces noise reduction, changing image contrast, color correction and retouching which would really aid the identification of plant diseases in a better way without damaging the original property of the plant leaves.

(iii). Thermography

Thermography can aid the protection of power plants, industrial plants refineries, steel industry and apparatus with its speedy and profitable application. This non-contact method is now a days used in the early detection of plant diseases also due to its compatibility, safety, non-destructive property and accuracy. This helps in the enhancement of the productivity of the crops and its yield. The basic principle behind this method is release of thermal energy invisible to human eye and the temperature difference between the normal and damaged leave provides us the map of infection level. The thermal image is captured through an infrared camera which actually measures the heat flow to, from and through a sample (plant leaf). The as observed temperature differences a spot out the extent of the plants infected by diseases. Thermography is a system of acquiring an image of the temperature distribution over the surface of abody. The normaltechnique is theusageof a special television camera with an infrared sensitive detector and a lens which broadcasts infrared radiation.Temperature disparities in the focusof the sample are then shown as shades of grey and then be transformed into pseudo-colour image. Temperature differences as small as 0.1°C can be sensed.

Hyperspectral imaging

Hyperspectral Imaging is a new diagnosticmethodology based on spectroscopy. In this type of imaging technique more that hundred images for different wavelengths are analyzed for the same It collects hundreds of images at different wavelengths for the same three-dimensional area. This method detects the continuous spectrum of the light for each pixel with definite wavelength resolution from the visible to near infrared region. This technique helps us to see the real world as a multispectral image which is equivalent tot eh remote sensing data gathered from satellites. The specialty of this imaging is that focus on a single hyper pixel assist us to have a continuous spectrum data for the same. Its application includes the field of medical, texture , industry and agriculture to explore the visualizing information invisible to human eyes.

IV. Classification of Images based on disease detection

Image recognition technology based on deep learning

Image recognition technology is the ability of the software to identify object, places, people, certain actions etc. There are many methods available for image recognition, in which deep learning has many advantages like iterative learning, capacity to achieve worldwide and appropriate features of images, has durability, sturdiness and sophisticated detection precision.

Deep learning theory

The idea behind Deep Learning (DL) is its extreme focus on video, audio identification, automatic driving, image detection, robotic, etc [15]. In 1986, RinaDechter presented the word deep learning with main idea of introducing intelligent machine that imitate the human brain. After such an inspiration this field got much stimulus from the academicians and researchers. Similar to brain, this method is designed in such a way to make decision on its own, store datas on its memory and solve more complex problems on its experience.

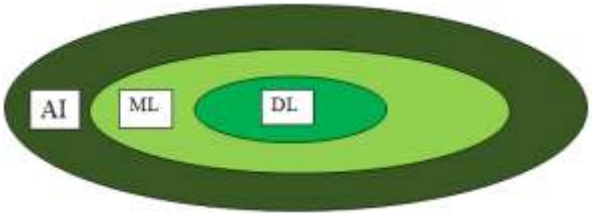

Figure 1. Indicates Deep Learning (DL) as a subset of Machine Learning (ML) and Artificial Intelligence (AI)

Deep learning is one of the most pioneeringmodels that is much helpful in many fields including agriculture. The word deep in deep learning, indicates the number of layers throughwhich data are renewed from input to the preferred output. Basically, a new researcher finds hard to differentiate artificial intelligence (AI), machine learning (ML) or deep learning (DL) as all the concept overlap each other in its way [16]. It is very clearly depicted in the above Fig. 1, that; DL is the subset of ML and AI. Machine learning is a kind of simple computer program which could be learned by our own. It is categorized into two namely supervised and unsupervised learning. Supervised learning consists of completely categorized data which the machine acquires the data first and then forecast the unpredicted data, so it is a lengthy process that utilizes more time and it is essential to have a well experienced person in data science. Unsupervised learning does not require any typical protocol and it gathers models on its own with novel data and determines the info inside the data. It is quite complex and mainly used in defining the unidentified patterns and to discover various features.

The concept of deep learning deals with the set of algorithms which progress a enormous set of data and emulates the discerning process. The actual development of this process is started from 1943 by Warren MCCulloch and Walter Pitts developed a computer model based on neural network. These networks are based on the model of human brain, Alan Turing, father of AI resolved that machines will start thinking of their own sooner which is nothing but the development and applications of deep learning. The history of deep learning is given below [17]:

- 1957–1962 : Frank Rosenblatt presented single and multi-layer artificial neural network
- 1967 : Alexey Icakhnenko introduced the first deep feedforward general purpose learning algorithm multilayer perceptron’s

- 1971 : deep network with eight layers trained by the group method of data handlingalgorithm was proposed
- 1970–1986 : The idea of backpropagation, Recurrent Neural Network (RNN), and restricted Boltzmann machine (RBM) was presented
- 1979-1998 : Convolution Neural Network (CNN), Bidirectional RNN, and long short-term memory (LSTM) was introduced
- 2006 : Geoff Hinton initiated deep belief network (DBN)
- 2009 : data sets called ImageNet and AlexNet that was formed
- 2014 : Ian Goodfellow and his colleagues designed Generative Adversarial Network (GAN)
- 2016-2017 : AlfaGo and AlfaZero are computer programs established by artificial intelligence research company called DeepMind
- 2017-2019 : a deep learning model used specially used for Natural language Processing (NLP) was invented

The above history of deep learning clearly predicts its growth year wise and its contribution to the nation.

V. Fungal infection in plant leaves:

In general, there are more than 19000 fungi known to infect the plants in the world wide survey. Fungi are found to endure inactive but still alive on living and dead plant tissues. The fungal spores can be easily transmitted by insects, soil, water, wind, etc., and they afflict all the crop plants [18]. Again, in some circumstances, few fungi are much helpful to the host in the progress and development like mycorrhizae that develops a mutualistic relationship with the host plant root systems. But pathogenic fungi, initiates diseases in plant such as leaf spot, rust, wilt, blight, canker, damping-off, root rot, mildew, etc which are the key reason for loss in the crop yield [19]. The speedy recognition of fungal disease and constant monitoring of their symptoms will be is a real supervision practice and will definitely aid control and avert their spread and growth. Leaves with fungal lesions are snapped and related with images in databases uploaded on the internet. There is rising sign that these variations play main roles in defining the formation of microbial pathogens in plants [20].

In this respect, investigations on the prevalence of fungal leaf diseases and its implications arein progress. More information is required regarding the leaf diseases caused by fungi to overcome the difficulties faced by the farmers. Hence the progress of accurate models and simulations to incorporate the characteristics of the fungal pathogen are still in improvement. Table 2 shows the different plant and the different diseases caused in them along with their symptoms. Henceforth, deep learning and the practical model developed in them helps the agriculturist in the detection of fungal diseases at the early stage.

Table2 Different plants and the diseases that infects them

Year	Plant	Disease	Symptoms	Reference
2004	Maize	Downy mildew	pale yellow to whitish discolorations on the leaf blade. Tassels may be deformed, and	21

			ears maybe aborted.	
2005	Pear	Fire blight	first leaves turn yellow-brown and after that all are dying	22
2007	Carrot cultivars	Leaf blight	Brownish spotting on leaf	23
2008	Celery	Early blight	Light-brown spots somewhat circular or slightly bony. Spots might be oily look with or with no nearby yellow coronas.	24
2009	Coronus Florida	Leaf blight	Dead and brown blotches on leaves.	25
2010	Potato	Late blight	Pale green spots	26
2011	Pea and apple	Fire blight	Red-brown to black streaking may be apparent in wood just under the bark	27

Downy mildew in Maize [28]

Fire blight in Pear [29]

Early blight in Celery [31]

Leaf flight in Carrot cultivars [30]

Leaf blight in Coronus Florida [32]

Late blight in Potato [33]

Late blight in Potato [33]

V. Conclusion

Fungal infections in plant play a vital role in the crop yield which in turn affects the economy of the nation. Hence detection of the plant disease caused by the fungal pathogen with good accuracy is needed for the growth of crops. Particularly fungal leaf diseases are the major reason for the losses in commercial yield of certain plants. So, it is quite necessary to develop an efficient tool to identify the diseases at an early stage, so that rectifying the diseases will be possible for the agriculturist. This review paper deals with the survey of various fungal infections caused by the pathogen and a fruitful approach namely the deep learning algorithm, that acts as a better tool to identify the infection.

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