Agricultural Plant Disease Detection with Image Processing and Machine Learning - An Analysis on Research Progress

Muhammed Ilyas H. and M. Sudheep Elayidom

Research Journal of Agricultural Sciences
An International Journal

P- ISSN: 0976-1675
E- ISSN: 2249-4538

Volume: 12
Issue: 03

Res Jr of Agril Sci (2021) 12: 843–847

CARAS

Res. Jr. of Agril. Sci. (May-Jun 2021) 12(3): 843–847
www.rjas.org

Full Length Research Article

Agricultural Plant Disease Detection with Image Processing and Machine Learning - An Analysis on Research Progress

Muhammed Ilyas H*[1] and M. Sudheep Elayidom[2]

Received: 24 Mar 2021 | Revised accepted: 12 May 2021 | Published online: 20 May 2021

A B S T R A C T

In Asian countries like India, there is a huge diversity of farming of different crops and this crop cultivation plays a major contribution in human civilization and the economy of the country. The plant/crop grown by our farmers gets destroyed due to various plant diseases which can mostly be viral, fungal, or bacterial infections, those that appear in the leaf of the plants which highly impact its further growth as well as the quality and quantity of the plants. Hence, early detection and prevention of plant diseases are obligatory to avoid the threat of infection to other plants which are not affected. Usually, by observing the shape and color of the plant leaf, farming people will recognize the disease with regular efforts and it is a time-consuming process for the crop in the larger farmlands. Therefore, various research works on plant disease detection based on machine learning and image processing were proposed by research scholars. In this paper, we provide a survey on various agricultural plant disease detection approaches by the research scholars, which are under consideration. And for this study, we have considered nearly thirty papers related to plant disease detection in order to analyze the disease and to compare various detection techniques.

***Key words*:** Plant disease detection, Agriculture, Image processing, Machine learning

In India agriculture plays a crucial role in the income of the people as well as in the Indian economy. The Punjab, Assam, Haryana, Bihar, Karnataka, Maharashtra, Kerala, and Tamil Nadu are some of the places in India, where agriculture is practiced most commonly by the farmers. Therefore, the disease on the plants pays major attention these days [1]. About 70% of our people count on farming and by visually monitoring the plants they used to identify the diseases based on their experience in farming, but it takes more time and labor [2]. The cultivated crops can be infected by bacteria, fungus, Virus and can be due to the change in weather conditions. The early detection of plant diseases helps in avoiding the practice of pests in the farmlands, which deliberately increases the quality and quantity of the production [3]. Image processing is an emerging technology in various fields and it paves a broad way to plant disease detection techniques with precise points to be followed [4]. The disease in plants which are visible to our eyes is yellow spots, brown spots, early and late scorch, whereas invisible diseases are mainly due to microorganisms [5]. These diseases can be predicted earlier based on symptoms by means of an Automatic plant disease detection approach by identifying the affected area and its color in image processing with less time consumption and less effort [6].

Hence, the trending machine learning strategy plays a major part in the recognition of plant diseases in the farmlands. It includes a personal computer that develops a technique to absorb the major parts of the leaf in order to detect the diseases [7]. While implementing this machine learning algorithm based on our concepts, we require a hardware or software interface system with the program inbuilt in it. At the initial stage of the detection process, the leaf images can be handled by various technical approaches [8]. The disease in the plant leaves can be varied, which makes the farmer worsen to find the apt solution for the diseases due to manual classification errors [9]. Nowadays, there are numerous approaches for classification and an emerging automatic plant disease detection strategy has a vital role in large hectares and it can monitor the symptoms as well as the side effects on the plants to onslaught [10]. Consequently, the disease detection strategy with the help of Machine learning techniques in image processing will be more precise and can monitor frequently based on its history of diseases [11]. Hence a majority of research scholars undergo their project design and develop an efficient plant disease detection strategy based on the machine learning approaches [12].

In this paper we intent to present a survey on agricultural plant disease detection strategy based on Machine learning approaches in image processing. It includes the techniques handled for image acquisition, preprocessing,

* Muhammed Ilyas H.
✉ ilyashm@gmail.com
[1-2] Division of Computer Science, School of Engineering, Cochin, University of Science and Technology, Kochi, Kerala, India

segmentation, feature extraction, and Classification, which were used by the research scholars in order to demonstrate its efficiency in disease detection and by providing the solution to recover. The rest of the paper is presented as stated: Section II presents the motivation behind this research works, Section III Presents the Mode of Plant Disease detection in Image processing and Section IV presents the comparative analysis and discussion regarding the survey, and finally, section V presents the conclusion of this work with its feature direction.

MATERIALS AND METHODS

The agricultural plant disease detection is a tough and huge process, in which if we made a wrong identification of disease and provide a wrong solution to the plants, then it will highly affect the production and the market value of the product. The plants which are being free from disease can be identified by the color and resemblance of spots in the leaf of the plant. A simple and affluent approach to identify the disease in plants is by means of an expert on agricultural plants, but it is a time-consuming process with the need of a lot of laborers. Therefore, as an alternative, the researchers concentrated on machine learning approaches to detect the disease in plants with less time and zero labors. A system with a detection strategy implemented on it will monitor, detect and classify the plant disease based on its pattern. This will be the key to the farmers to reduce their loss of production in a less time period. In image processing, there are different kinds of machine learning approaches with deliberately show their efficiency in plant disease detection automatically. The above criteria motivated us to do the survey a various machine learning approaches used in the identification of plant diseases.

Plant disease detection using image processing

Among the numerous varieties of plant diseases, most of them can be identified through its leaf's and in image processing, this infection can be identified through certain procedures. (Fig 1) shows the variety of diseases among our Indian agricultural crops. Various technical approaches of image processing are applied to them to analyze the features to identify the type of disease.

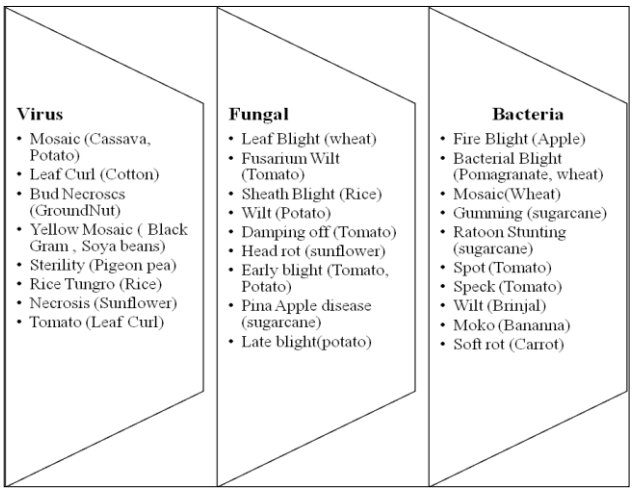

Fig 1 Plant diseases

Image acquisition

It is the initial step in plant disease detection in image processing, in which a camera is utilized to capture the leaf image of a plant in order to identify the type of disease the plant has been affected.

A plant disease detection approach using image processing, in which they make use of a digital camera to capture the image of the plant is stored in Red-Green-Blue color for the various implementation process [14].

To identify the plant disease and a resolution for the disease. In addition, they designed their approach with a voice navigation system, so that an illiterate person can also use this approach in a regular manner. Here in the image acquisition process, they collect the data through the public repository as an input to the detection approach and considered the image formats like.bmp, .jpg, .gif [15].

Preprocessing

In this step, the quality of the captured leaf image has been improved by removing the distortion using various filtering approaches introduced by the research scholars to get a perfect area to examine.

A computer solution has been introduced that automatically identifies and classifies plant disease. This involves four stages, the first stage acquisition of images, the second step is to preprocess the images, the third step is the segmentation of images, and the fourth step is to extract color, shape, and size. They used a classifier based on the Neural Network. Here they make use of 3×3 median filters for preprocessing in order to remove the unnecessary noise recorded while capturing the image [16].

An online platform created that helps the farmers to interrogate the agricultural expert about all kinds of plant diseases and can share their experience with them. This online platform ultimately helps them to collect the data to recognize the type of plant diseases and their required solutions. This approach is well suited for various agro-based companies and agricultural students to find new solutions for plant diseases. Here for preprocessing they make use of the raw data from the online portal and transfers the data to a useable format, in order to improve the quality and efficiency of the detection approach consequently [17].

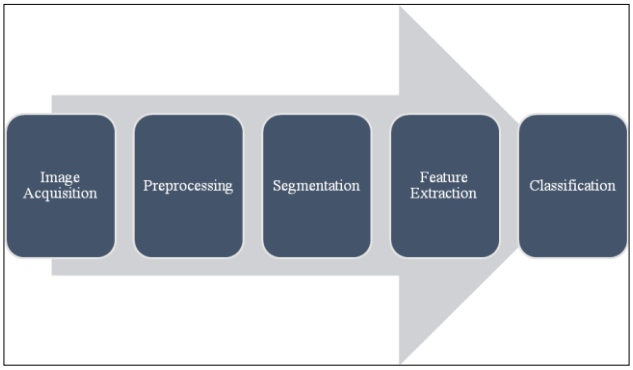

Fig 2 Disease detection strategy in image processing

Segmentation

In this stage, the original leaf image of the plant has been partitioned into multiple parts based on its features and similarities. This can be mostly carried out in image processing based on HIS, Clustering, and RGB image conversion process, to identify the infected area of the plants.

To detect plant disease using the leaf images. Here for the segmentation process, they make use of a KNN classifier to classify the image pixels to the number of regions based on their feature of similarity [18]. They have classified the clusters based on their centroid and the artifacts of the members; it highly helps in reducing the distance between the cluster points with an ease.

Feature extraction

Feature extraction plays an important role in the identification of an object. In many applications of image processing, feature extraction is used. Color, texture, morphology, edges, etc. are the features that can be used in plant disease detection.

A framework to detect and identify the rice diseases and their suggested device will provide the analytical results with its spot based on the mapping [19]. They introduced the device in IoT technology mainly to detect the disease in an earlier time period to avoid the loss of production in real-time. Here, they have categorized the feature extraction into two as color and shape due to its variations in various types of diseases and for that purpose, they make use of HSV color space using color angle for color characteristics and they calculate the diameter difference between the disease's major and minor axes for shape characteristics.

Classification

In this stage, the extracted color and shape feature of the leaf has been utilized to classify the type of disease the plant has been infected with. There is various type of classifiers such as BPNN, SVM, RBFN, KNN, etc., in which we must choose a proper classifier to identify the disease. The Classifier model's ability to respond accurately was thus assured by using the Mean Square Error (MSE) criterion to emphasize the model validity between the target and the output.

A study in previous plant disease detection strategies has formulated, in which they adopted the neural network to classify the diseases and backpropagation for the learning process and the classifier is trained based on the input data after the extraction process. Here the plant disease detection systems automatically detect the symptoms that occur on the leaves and stem of a plant with the aid of imaging technology and help to grow healthy plants in a field. Such systems control the plant, such as leaves and stems, and any deviations from its characteristics will be automatically detected and told to the consumer as well [20].

Plant disease detection approaches in image processing

This section provides a discussion on widely studied pathogens and study scenarios in various phases of a disease detection system. In addition, the State-of-the-art Machine Learning techniques performance that appears to work well across several crops or groups of crops has been reviewed here.

A plant-leaf disease detection model based on DCNN trained by 39 different classes of leaf images and 6 types of approaches to data augmentation. They found that the system's data augmentation could boost system performance by training it through different epochs [21]. Finally, their proposed approach is classifying the plant disease with an accuracy of about 96.46% by simulation.

A fast-reliable nondestructive approach based on deep learning to protect the tomato crops. Here they make use of 6 diseased and healthy tomato leaves for analyzing the proposed approach. Their proposed AlexNet and VGG16 Architecture has been analyzed based on the parameters such as size, weight, and learning rate of the suggested system model, which shows better accuracy and time of execution when comparing it to the existing approaches [22].

A 50-layer deep residual learning framework with five stages to classify the growing plants in the large agricultural sector. A recognition level of 93.09 % is reached by the model proposed as the reliability of research on the Leaf image dataset, demonstrating that deep learning is a very promising forest technology. For this study, they make use of Deep learning and convolutional neural network approach to extract the features of 185 leaf varieties [23].

A mechanical software system to detect and classify plant disease based on a random forest approach. The leaf image has been used for a forthcoming process like pre-processing, segmentation, extraction, and classification. For the ever-increasing population of Asian countries, agriculture is much more than just a means of feeding for a wide range of peoples. Their suggested approach paves a way to detect and classify plant diseases mechanically [24].

A real-time maize plant classifier based on a backpropagation neural network and single-lens vision technique. Their approach can even evaluate the object's different images and geometric patterns. Given the rapid development of agricultural robotics, the development of automated in-row weed control is one of the most expensive and complicated tasks in the agricultural industry. This study, therefore, proposes an effortless to implement and precise system capable of detecting maize plants in real-time, which is the key component of the whole weeding machine. Thus, the results obtained from BPNN were considered to be promising given that time-consuming differentiating the maize plant from other harmful herbs occurs manually [25].

Introduced a pomegranate plant disease detection approach by using their leaf images in order to prevent the loss of yield and the quality and quantity of the product. Farming is perhaps the mainstay of the overall GDP in countries like India. Agriculture is already one of the country's and even the farmers ' major sources of economy. Farmers will face a lot of losses due to the lack of early detection of the diseases. For various plant diseases such as Pomegranate, relying on pure naked-eye observation to detect and classify diseases can be expensive. This approach paves a way to detect the disease at a low cost [25].

A survey on various machine learning approaches in image processing and compares the various error measuring approaches in the literature. Rapid development in technology has led to an increase in the public domain of a large amount of data from different fields of agriculture. Therefore, a conceptual model results from studying and combining the available data with a method such as a plant enhancement, yield forecasting, crop disease analysis, water stress detection, and so on. Computing methods such as machine learning is a modern invention for understanding and addressing such complex problems [26].

A plant disease detection approach based on KNN as a classifier to classify diseases such as Alternaria alternate, anthracnose, bacterial blight, leaf spot, and canker of various plant species. Traditional agriculture is getting popular in many western countries. Because of various environmental factors, there are many problems in agriculture, and among these plant leaf diseases are considered to be the strongest factor that causes the agricultural product value deficit. Their main aim to use computer vision and machine learning techniques to mitigate this problem has a success rate of about 96.76% [27].

A disease detection approach in seasonal crops in the premature stage with the help of a deep convolutional neural network approach. They make use of a plant leaf database with 600 images of healthy and infected leaf samples. The proposed approach has been compared with the existing feature extraction and classification approaches. In the

proposed work, various convolution filters and pooling forms of various sizes are used. Max pooling of 32*32*3 filter length achieves 92% accuracy. Average pool size with a convolution filter size of 64*64*3 achieved a peak accuracy of 93.7% and obtained better results compared to other machine learning models and feature extraction models. This shows the ability of the suggested method in crop disease detection [28].

On the disease detection of grape plants, the process takes a single plant leaf as input and segmentation take place after elimination of the context. The segmented image of the leaf is then analyzed to detect the diseased part of the leaf by means of a high pass filter. Using the special fractal-based texture feature, the segmented leaf texture is recovered. Each individual disease's texture will be different. The texture pattern extracted is then graded using an SVM classifier. The focus of the research is on major diseases frequently seen in the Grapes crop that are downy mildew & black rot. The suggested solution easily provides farmers with 96.6% accuracy advice from agricultural experts [30].

An analysis of existing recorded techniques that are useful for detecting agricultural product diseases. In addition, a comparative study of various methods based on the type of agricultural product, methodology, and its effectiveness along with the advantages and disadvantages was also described. They also compare the number of systems based on different parameters, including the commodity and its disease, considered by researchers to test their process, database, methodology, findings of reliability including the study of gaps. Finally, they concluded that the SVM is a better option for disease detection from this study [31].

ANN machine learning algorithm in order to identify the rice plant disease symptoms. Here they have considered a dataset with 300 images for analysis. These images have undergone various simulation setups in image processing based on the suggested approach and then categorized as healthy and diseased leaf images. The accuracy of the testing phase was found to be 90 percent and 86 percent respectively for the infected and healthy photos. Thus, the proposed system detects the disease accurately for the rice plant based on the ANN machine learning algorithm [32].

RESULTS AND DISCUSSION

The prevention and detection of plant disease are one of the important jobs to be carried out while farming because it will have a greater impact on production. However, this is a challenging task to reduce the loss due to the infections in the plants. Whereas effort is carried out up to the time on disease detection but proper segmentation, extraction, and classification of the affected portion and disease respectively is still an open problem as a research area based on the type of plant family. (Table 1) summarizes some of the machine learning approaches in identifying plant disease is compared as a major research aspect.

Table 1 Comparative analysis of machine learning techniques adopted in image processing

Technique	Author and Year	Advantage	Disadvantage	Contribution
Deep Learning Approaches	Geetha Ramani G in 2019, Aravind Krishnaswamy Rangarajan in 2018, Vinit Bodhwani in 2019, Dhivya Elavarasan in 2018, Aditya Khampariaet in 2019	▪ High Accuracy	▪ Requires large data ▪ More time consumption during training Phase	Disease detection in crops using convolutional neural network, deep learning, and residual approach
Random Forest	Abirami Devaraj in 2019	▪ Quick prediction ▪ Can handle both numerical and categorical data	▪ Less effective in the linear combination of the features	Suggested a mechanical software system to detect and classify the plant disease based on a random forest approach
Back Propagation Neural Network:	Kamil Dimililer in 2017, Rashmi Pawar in 2017	▪ Good prediction ▪ Integrating the various combination of inputs	▪ Difficult to handle major problems ▪ Vulnerable to inappropriate features	proposed a real-time maize plant classifier based on backpropagation neural network and single-lens vision technique
K -Nearest Neighbor (KNN)	Eftekhar Hossainet in 2019	▪ Simplest Approach ▪ No need of training	▪ Sensitive to noise and inappropriate inputs	Diseases such Alternaria alternate, anthracnose, bacterial blight, leaf spot, and canker of various plant species are detected and classified
Support Vector Machine (SVM)	Harshal Waghmare in 2016, Mukesh Kumar Tripathi in 2016	▪ Robust ▪ Good prediction ▪ Easy to implement	▪ Sensitive to parameters ▪ Slow training ▪ Slower for the larger data set	Disease detection of grape plants and comparative analysis of existing approaches in comparison with SVM
Artificial Neural Network (ANN)	S. Ramesh in 2018	▪ Detect complex nonlinear relationships between the variables	▪ Computational complexity	Identification of the rice plant disease symptoms using ANN with a dataset of 300 images for analysis

CONCLUSION

This paper has made an attempt to study methods of machine learning that researchers used to identify diseases and classify plants in image processing. These methods of machine learning help farmers to diagnose disease in the crop earlier and based on the diagnosis the specialists would treat the diseased plant in a timely manner. This helps to increase crop yield. From the above analysis, we conclude that all the automated machine learning approaches have their own positives and negatives that this research on plant disease detection needs further advancements and it's still an open topic. Therefore, we suggest improving the algorithms of machine learning by optimizing its parameters for processing an infected and healthy leaf image that was acquired with different backgrounds in the future.

LITERATURE CITED

1. Halder, Monishanker. 2018. Plant disease detection by image processing: A literature review. *SDRP Journal of Food Science and Technology* 3(6): 534-538.
2. Khirade, Sachin D, Patil AB. 2016. Plant disease detection using image processing. 2015 International conference on computing communication control and automation. IEEE, 2016.
3. Saradhambal G. 2018. Plant disease detection and its solution using image classification. *International Journal of Pure and Applied Mathematics* 119(14): 879-884.
4. Sun G, Jia X, Geng T. 2018. Plant diseases recognition based on image processing technology. *Journal of Electrical and Computer Engineering*, 2018.
5. Astonkar, Shweta R, Shandilya VK. 2018. Detection and analysis of plant diseases using image processing technique. *International Research Journal of Engineering and Technology* 5(4): e395-0056.
6. Vijai S, Misra AK. 2017. Detection of plant leaf diseases using image segmentation and soft computing techniques. *Information Processing in Agriculture* 4(1): 41-49.
7. Francis J, Anoop BK. 2016. Identification of leaf diseases in pepper plants using soft computing techniques. In 2016 conference on emerging devices and smart systems (ICEDSS). pp 168-173. IEEE, 2016.
8. Goodridge W, Margaret B, René J, Reanne R. 2017. Intelligent diagnosis of diseases in plants using a hybrid Multi-Criteria decision-making technique. *Computers and Electronics in Agriculture* 133: 80-87.
9. Ray M, Ray A, Dash S, Mishra A, Achary KG, Nayak S, Singh S. 2017. Fungal disease detection in plants: Traditional assays, novel diagnostic techniques and biosensors. *Biosensors and Bioelectronics* 87: 708-723.
10. Jha K, Aalap D, Patel P, Shah M. 2019. A comprehensive review on automation in agriculture using artificial intelligence. *Artificial Intelligence in Agriculture* (2019).
11. Raghavendra BK. 2019. Diseases detection of various plant leaf using image processing techniques: A review. In 2019 5th International Conference on Advanced Computing and Communication Systems (ICACCS). IEEE, 2019. pp 313-316.
12. Sahu AK, Verma RK, Gaur RK, Mishra NS. 2018. Corrigendum to Complexity and recombination analysis of novel begomovirus associated with Spinach yellow vein disease in India. *Plant Gene* 13: 42-49.
13. Singh V. 2019. Sunflower leaf diseases detection using image segmentation based on particle swarm optimization. *Artificial Intelligence in Agriculture*, 2019.
14. Khirade SD, Patil AB. 2015. Plant disease detection using image processing. In 2015 International conference on computing communication control and automation. IEEE, 2015. pp 768-771.
15. Saradhambal G, Dhivya R, Latha S, Rajesh R. 2018. Plant disease detection and its solution using image classification. *International Journal of Pure and Applied Mathematics* 119(14): 879-884.
16. Gaikwad VP, Musande V. 2017. Wheat disease detection using image processing. In 2017 1st International Conference on Intelligent Systems and Information Management (ICISIM), IEEE, 2017. pp 110-112.
17. Bhaskar KS, Bhor S, Kotian S, Shetty A, Sawant P, Kotian SB, Bhor S, Kotian S, Shetty A, Sawant P. 2017. Developing an agricultural portal for crop disease prediction. *International Journal* 3: 144-147.
18. Astonkar, Shweta R, Shandilya VK. 2018. Detection and analysis of plant diseases using image processing technique. *International Research Journal of Engineering and Technology* (IRJET) e-ISSN: 2395-0056 5(4): 2018.
19. Nuttakarn K, Inoue M. 2018. Early rice disease detection and position mapping system using drone and IoT architecture. In 2018 12th South East Asian Technical University Consortium (SEATUC), IEEE, 2018. 1: 1-5.
20. Jobin F, Anoop BK. 2016. Identification of leaf diseases in pepper plants using soft computing techniques. In 2016 conference on emerging devices and smart systems (ICEDSS), IEEE, 2016. pp 168-173.
21. Geetharamani G, Pandian A. 2019. Identification of plant leaf diseases using a nine-layer deep convolutional neural network. *Computers and Electrical Engineering* 76: 323-338.
22. Rangarajan AK, Raja P, Ramesh A. 2018. Tomato crop disease classification using pre-trained deep learning algorithm. *Procedia Computer Science* 133: 1040-1047.
23. Bodhwani V, Acharjya DP, Bodhwani U. 2019. Deep residual networks for plant identification. *Procedia Computer Science* 152: 186-194.
24. Abirami D, Rathan K, Jaahnavi S, Indira K. 2019. Identification of plant disease using image processing technique. In 2019 International Conference on Communication and Signal Processing (ICCSP), IEEE, 2019. pp 0749-0753.
25. Kamil D, Kiani E. 2017. Application of back propagation neural networks on maize plant detection. *Procedia Computer Science* 120: 376-381.
26. Dhivya E, Vincent DR, Sharma V, Zomaya AY, Srinivasan K. 2018. Forecasting yield by integrating agrarian factors and machine learning models: A survey. *Computers and Electronics in Agriculture* 155: 257-282.
27. Hossain E, Hossain MF, Rahaman MA. 2019. A color and texture-based approach for the detection and classification of plant leaf disease using KNN classifier. International Conf. on Electrical, Computer & Communication Engineering. pp 1-6.
28. Aditya K, Singh A, Luhach AK, Pandey B, Pandey DK. 2019. Classification and identification of primitive kharif crops using supervised deep convolutional networks. *Sustainable Computing: Informatics and Systems* (2019).
29. Rashmi P, Jadhav A. 2017. Pomogranite disease detection and classification. In 2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI. IEEE, 2017. pp 2475-2479.
30. Harshal W, Kokare R, Dandawate Y. 2016. Detection and classification of diseases of grape plant using opposite colour local binary pattern feature and machine learning for automated decision support system. 3rd ICSPIN. pp 513-518.
31. Tripathi MK, Maktedar DD. 2016. Recent machine learning based approaches for disease detection and classification of agricultural products. In 2016 *International Conference on Computing Communication Control and Automation*. pp 1-6.
32. Ramesh S. 2018. Rice blast disease detection and classification using machine learning algorithm. In 2018 2nd International Conference on Micro-Electronics and Telecommunication Engineering (ICMETE). IEEE, 2018. pp 255-259.