ISSN 2277-2685
IJESR/Jan-Mar. 2025/ Vol-15/Issue-1s/56-67
Narri Manisha *et. al.*, / International Journal of Engineering & Science Research

Plant Disease Detection Using Image Processing

[1]N. Sony, [2]Narri Manisha, [3]Nagula Prasanna, [4]Kurra Prathyusha
[1] Assistant Professor, Electronics and Communication Engineering, BRECW
[2,3,4]B.Tech Students, Department of Electronics and Communication Engineering, BRECW

ABSTRACT:

Identification of the plant diseases is the key to preventing the losses in the yield and quantity of the agricultural product. The studies of the plant diseases mean the studies of visually observable patterns seen on the plant. Health monitoring and disease detection on plant is very critical for sustainable agriculture. It is very difficult to monitor the plant diseases manually. It requires tremendous amount of work, expertise in the plant diseases, and also require the excessive processing time. Hence, image processing is used for the detection of plant diseases. Disease detection involves the steps like image acquisition, image pre-processing, image segmentation, feature extraction and classification. This paper discussed the methods used for the detection of plant diseases using their leaves images. This paper also discussed some segmentation and feature extraction algorithm used in the plant disease detection.

1-INTRODUCTION

India is a cultivated country and about 70% of the population depends on agriculture. Farmers have large range of diversity for selecting various suitable crops and finding the suitable pesticides for plant. Disease on plant leads to the significant reduction in both the quality and quantity of agricultural products. The studies of plant disease refer to the studies of visually observable patterns on the plants. Monitoring of health and disease on plant plays an important role in successful cultivation of crops in the farm. In early days, the monitoring and analysis of plant diseases were done manually by the expertise person in that field. This requires tremendous amount of work and also requires excessive processing time. The image processing techniques can be used in the plant disease detection. In most of the cases disease symptoms are seen on the leaves, stem and fruit. The plant leaf for the detection of disease is considered which shows the disease symptoms. This paper gives the introduction to image processing technique used for plant.

India is eminent for Agriculture that means most of the people are engaged towards agriculture industry. The agriculture industry act as a significant role in the economic sectors. Most of the plants are infected by variant fungal and bacterial diseases. Due to the exponential inclination of population, the climatic conditions also cause the plant disease. The major challenges of sustainable development is to reduce the usage of pesticides, cost to save the environment and to increase the quality. Precise, accurate and early diagnosis may reduce the usage of pesticides. Data mining is termed as extracting the relevant information from large pool of resources. The advents of data mining technologies have been adopted in the prediction of plant diseases

The old and classical approach for detection and recognition of plant diseases is based on naked eye observation, which is very slow method also gives less accuracy. In some countries, consulting experts to find out plant disease is expensive and time consuming due to availability of expert. Irregular checkup of plant results in growing of various diseases on plant which requires more chemicals to cure it also these chemicals are toxic to other animals, insects and birds which are helpful for agriculture. Automatic detection of plant diseases is

essential to detect the symptoms of diseases in early stages when they appear on the growing leaf and fruit of plant. This paper introduces a MATLAB based system in which we focused on both leaf & fruit diseased area and used image processing technique for accurate detection and identification of plant diseases.

2-LITERATURE SURVEY

In this section, various method of image processing for plant disease detection is discussed. The vegetation indices from hyper spectral data have been shown for indirect monitoring of plant diseases. But they cannot distinguish different diseases on crop. Wenjiang Huanget al developed the new spectral indices for identifying.

They consider three different pests(Powdery mildew, yellow rust and aphids) in winter wheat for their study. The most and the least relevant wavelengths for different diseases were extracted using RELIEF-F algorithm.

The classification accuracies of these new indices for healthy and infected leaves with powdery mildew, yellow rust and aphids were 86.5%, 85.2%, 91.6% and 93.5% respectively. Enhanced images have high quality and clarity than the original image. Color images have primary colors red, green and blue. It is difficult to implement the applications using RGB because of their range i.e. 0 to 255. Hence they convert the RGB images into the grey images. Then the histogram equalization which distributes the intensities of the images is applied on the image to enhance the plant disease images. Monica Jhuria et al uses image processing for detection of disease and the fruit grading in . They have used artificial neural network for detection of disease. They have created two separate databases, one for the training of already stored disease images and other for the implementation of the query images. Back propagation is used for the weight adjustment of training databases. They consider three feature vectors, namely, color, textures and morphology . They have found that the morphological feature gives better result than the other two features. Zulkifli Bin Husin et al, in their paper, they captured the chilli plant leaf image and processed to determine the health status of the chilli plant. Their technique is ensuring that the chemicals should apply to the diseased chilli plant only.

They used the MATLAB for the feature extraction and image recognition. In this paper pre-processing is done using the Fourier filtering, edge detection and morphological operations. Computer vision extends the image processing paradigm for object classification. Here digital camera is used for the image capturing and LABVIEW software tool to build the GUI. The segmentation of leaf image is important while extracting the feature from that image. Mrunalini R. Badnakhe, PrashantR. Deshmukh compare the Otsu threshold and the k-means clustering algorithm used for infected leaf analysis in .They have concluded that the extracted values of the features are less for k-means clustering. The clarity of k-means clustering is more accurate than other method.

The RGB image is used for the identification of disease. After applying k-means clustering techniques, the green pixels is identified and then using otsu's method, varying threshold value is obtained. For the feature extraction, colour cooccurrence method is used. RGB image is converted into the2015 International Conference on Computing Communication Control and Automation b HSI translation. For the texture statistics computation the SGDM matrix is generated and using GLCM function the feature is calculated.

Santanu Phadikar and Jayafocused on Rice disease identification and considered the two diseases, namely Leaf Blast & Brown Spot. Boundary

detection & spot detection methods are used for feature extraction of the infected parts of plant's leaves. Authors introduced SOM (Self Organising Map) neural network in zooming algorithm for classification of rice diseased images. Method of making of input vector in SOM is padding of zeros & interpolation of missing points, zooming algorithm gives satisfactory result.

Dheeb Al Bashish, Malik Braik and Sulieman Bani-Ahmad considered five plant diseases namely Late scorch, Cottony mold, Early scorch, Ashen mold and Tiny whiteness from Jordan's Al-Ghor area for testing. K-Means clustering method is used for segmentation of leaf images and the CCM (Colour Co-occurrence Method) method is used for infected leaf texture analysis. For classification of plant diseases, back propagation algorithm in neural network is used.

Zulkifli Bin Husin, Abdul Hallis Bin Abdul Aziz, Ali Yeon Bin Md Shakaff and Rohani Binti S Mohamed Farook used LABVIEW vision & MATLAB for detection of chili plant disease. Leaf inspection in early stage is possible due to combined technique of two softwares. The LABVIEW is used for capturing images of leaf and MATLAB is used as image processing software. Edge detection, fourier filtering, morphological operations are done with help of image pre-processing and color clustering method is used for separating chili and non-chili leaves in

Sabah Bashir and Navdeep Sharma introduced technique for detection of Malus Domestica leaves disease. Grayscale images are obtained by histogram equalization and the texture analysis in image segmentation is done with help of co-occurrence matrix method algorithm also color analysis is obtained using K-means clustering algorithm. In threshold matching process, there is comparison between individual pixels value and threshold value. For detection of plant diseases, texture & color images are compared with previously obtained images of leaf.

Murali Krishnan and Dr.M.G.Sumithra described technique for detection of Bacterial leaf scorch infection in plant. In image segmentation, K-means clustering algorithm is applied for separating foreground and background images. Clustering in segmentation is based on subtracting the clustered leaf images and intensity mapping for highlighting leaf area. K-means is very effective and simple for detection of infected area.

Ms. Kiran R. Gavhale, Prof. Ujwalla Gawande and Mr. Kamal O. Hajari introduced technique of Citrus leaf disease detection and diseases are: Anthracnose, Citrus canker, Overwatering and Citrus greening. Image pre-processing involved color space conversion by applying YCbCr color system & L*a*b* color space also color image enhancement by applying discrete cosine transform. Gray-Level Cooccurrence Matrix is used for feature extraction to see various statistics such as energy, contrast, homogeneity and entropy. Lastly SVMRBF and SVMPOLY are used for citrus leaf diseases detection.

Wan Mohd Fadzil W.M.N, Shah Rizam M.S.B and R. Jailani, Nooritawati presented technique for detection of Sun scorch Orchid Black leaf & spot leaf disease. Preprocessing is obtained by histogram equalization, intensity adjustment and filtering for image enhancement. Segmentation involved thresholding process and three morphological processes which are applied for removing & preserving the small & large object respectively. Finally classification is done by calculation of white pixels in leaf image and diseases are recognised.

Usama Mokhtar, Mona A. S. Alit, Aboul Ella Hassenian, Hesham Hefny described technique of Tomato leaves diseases detection and diseases are: Powdery mildew & Early blight. Image pre-processing involved various techniques such as

smoothness, remove noise, image resizing, image isolation and background removing for image enhancement. Gabor wavelet transformation is applied in feature extraction for feature vectors also in classification. Cauchy Kernel, Laplacian Kernel and Invmult Kernel are applied in SVM for output decision & training for disease identification.

Sachin D. Khirade, A. B. Patil,authors described technique of Tomato leaves diseases detection and diseases are: Powdery mildew & Early blight. Image pre-processing involved various techniques such as smoothness, remove noise, image resizing, image isolation and background removing for image enhancement. Gabor wavelet transformation is applied in feature extraction for feature vectors also in classification. Cauchy Kernel, Laplacian Kernel and Invmult Kernel are applied in SVM for output decision & training for disease identification.

Ghulam Mustafa Choudhary and Vikrant Gulati authors presented technique in which pre-processing involved conversion RGB images to grey using the equation f(x)=0.2989*R+0.5870*G+0.114*B and removing objects and noise in image. Boundary & spot detection algorithms are configured in segmentation to find leaf infected part. After that H&B components and color cooccurrence methods are used to extract various features. Binary images are created from grey images by Otsu threshold algorithm and diseases are classified and identified using both artificial neural network and back propagation network along with K-means method.

Ramakrishnan. M and Sahaya, Anselin Nisha. Aauthors described technique to detect Spot & Scorch disease in which by creating color transformation structure, color values are converted to space value in image pre-processing. Masked cells inside the boundaries are removed by masking of green-pixels after applying K-means method. Color co-occurrence method extracts the features such as color, texture & edge and lastly neural network is used for recognition and disease classification.

Prakash M. Mainkar, Shreekant Ghorpade and Mayur Adawadkar authors introduced technique of Groundnut plant disease detection and diseases are: Late leaf spot and Early leaf spot disease. In pre-processing involved the conversion from RGB leaf image to HSV color image also used co-occurrence matrices to extract color features and statistical approach in texture feature extraction to analyze texture images. Back propagation algorithm is applied for disease recognition and classification.

Prajakta Mitkal, Priyanka Pawar, Mira Nagane, Priyanka Bhosale, Mira Padwal and Priti Nagane authors introduced technique in which after image acquisition, by creating color transformation structure, color values are converted to space value in image pre-processing also applied K-means method for segmentation. Leaf unnecessary area is removed by masking of green pixels and texture features are calculated for segmented object also masked cells are removed. Infected clusters are converted from RGB to HSI and after that SGDM matrix is generated for H & S. GLCM calculations are made for extraction of features which are then passed through the neural network for disease recognition and classifications.

Anand Singh Jalal, Shiv Ram Dubey described technique of Sugarcane leaf disease detection and diseases are: Brown Spot, Downy mildew, Sugarcane Mosaic, Downy Fungal, Red stripe and Red rot. Pre-processing involved conversion of RGB image to grayscale and unwanted parts are removed. Healthy area and potentially infected area are located by segmentation. Linear, Non linear and Multiclass SVM are applied for disease detection.

Sachin D. Khirade, A. B. Patil,authors described technique of Tomato leaves diseases detection and diseases are: Powdery mildew & Early blight. Image pre-processing involved various techniques such as

smoothness, remove noise, image resizing, image isolation and background removing for image enhancement.

3-SOFTWARE REQUIREMENTS

In this chapter we will discuss about the software required for Plant Disease Detection Using Image Processing. Plant diseases are a significant challenge in agriculture, affecting crop yields and food security. Early detection and diagnosis of plant diseases are critical for minimizing damage and ensuring timely interventions. One of the advanced methods for detecting plant diseases is using image processing techniques, particularly in MATLAB software.

Programming assignments in this course will almost exclusively be performed in MATLAB, a widely used environment for technical computing with a focus on matrix operations. The name MATLAB stands for “Matrix Laboratory” and was originally designed as a tool for doing numerical computations with matrices and vectors. It has since grown into a high-performance language for technical computing. MATLAB integrates computation, visualization, and programming in an easy-to-use environment, and allows easy matrix manipulation, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs in other languages. Typical areas of use include:

- Math and Computation
- Modelling and Simulation
- Data Analysis and Visualization
- Application Development
- Graphical User Interface Development 1.2 Getting Started Window Layout The first time you start MATLAB, the desktop appears with the default layout, as shown in Figure 1.

  The MATLAB desktop consists of the following parts:

- Command Window: Run MATLAB statements.
- Current Directory: To view, open, search for, and make changes to MATLAB related directories and files.
- Command History: Displays a log of the functions you have entered in the Command Window. You can copy them, execute them, and more.
- Workspace: Shows the name of each variable, its value, and the Min and Max entry if the variable is a matrix. In case that the desktop does not appear with the default layout, you can change it from the menu Desktop → Desktop Layout → Default. 1.3 Editor the MATLAB editor (Figure 2) can be used to create and edit M–files, in which you can write and save MATLAB programs. A file can take the form of a script file or a function. A script file contains a sequence of MATLAB statements; the statements contained in a script file can be run in the specified order, in the MATLAB command window simply by typing the name of the file at the command prompt. M–files are very useful when you use a sequence of commands over and over again, in many different MATLAB sessions and you do not want to manually type these commands at the command prompt every time you want to use them.

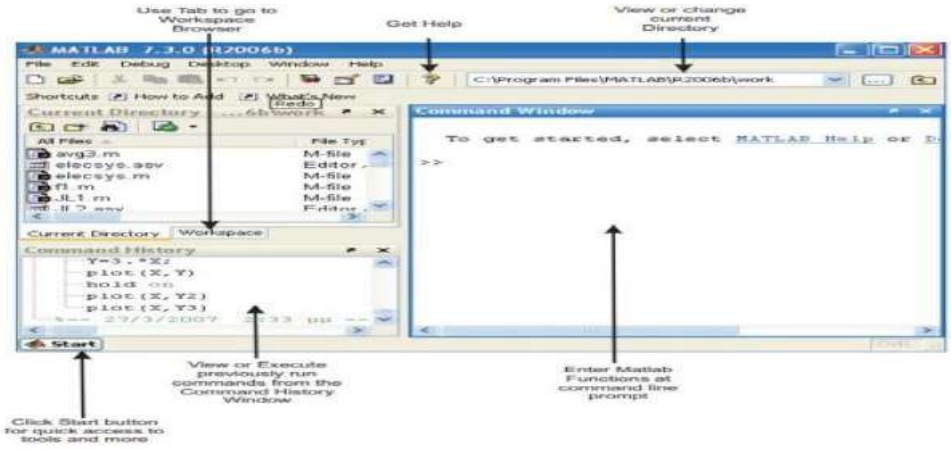

Figure 3.1: MATLAB Desktop (default layout)

4-PLANT DISEASE DETECTION USING IMAGE PROCESSING

In this chapter we will discuss about Existing/Proposed System, block diagram and methodology for Plant Disease Detection Using Image Processing. Plant disease detection using image processing automates the identification of diseases by analysing plant images based on features like colour, texture, and shape. This modern approach offers faster, more accurate detection compared to traditional manual methods, improving crop management and reducing losses.

Existing System

The most traditional methods of plant disease detection include naked-eye observation and consulting experts, both of which have been widely practiced in agriculture for centuries. These methods rely heavily on the experience and expertise of the farmer or agricultural specialist.

Naked-Eye Observation

One of the most traditional methods of plant disease detection is through naked-eye observation. Farmers or agricultural workers visually inspect plants for noticeable symptoms such as leaf spots, wilting, yellowing (chlorosis), mold, or mildew. These visible signs are often the first indication of a disease. For example, fungal infections may manifest as dark spots or powdery growth on leaves, while bacterial infections might cause leaf lesions or blight. Wilting or stunted growth could signal root diseases or vascular issues. This method is widely used because it is simple and cost-effective, requiring no specialized tools.

Fig 4.1: Observing the Leaf

However, naked-eye detection has significant limitations, particularly when it comes to early-stage disease detection. Many plant diseases, such as viral infections, may not produce obvious symptoms until the plant is severely compromised. By the time symptoms like yellowing or wilting appear, it may already be too late to save the plant or prevent the disease from spreading to neighbouring crops. Moreover, diseases often exhibit similar symptoms, leading to potential misdiagnoses. For example, nutrient deficiencies can cause yellowing that resembles viral infections, making it difficult for a farmer to determine the root cause without further analysis. In large farms, manual inspection of every plant is also labour-intensive and impractical.

Proposed System

Proposed system for plant disease detection using image processing, SVM for segmentation, and K-means clustering for classification is a robust approach. By employing image processing techniques to segment diseased areas, SVM for accurate identification, and K-means clustering for disease classification, this system can effectively detect and categorize plant diseases from images. The combination of these methods offers a comprehensive solution for automated plant disease diagnosis, aiding in timely intervention and management strategies for crop health.

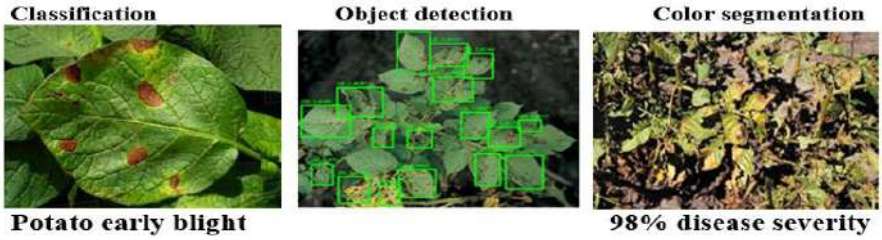

Fig 4.2: Segmentation and Classification

Support Vector Machine (SVM) Algorithm

SVM is a powerful supervised learning algorithm used for both classification and regression tasks. Its primary goal in plant disease detection is to classify plant images into two or more categories, such as healthy and diseased. The key concept behind SVM is finding the optimal hyperplane that best separates the different classes with the largest margin. This hyperplane is essentially a decision boundary that divides the feature space into regions corresponding to different classes.

In the context of plant disease detection, the features extracted from plant images—such as color values, texture patterns, or edge detection data—are used as inputs to the SVM. These features are mapped into a higher-dimensional space using a kernel function (like linear, polynomial, or radial basis function). This allows the SVM to handle complex, non-linearly separable data. The algorithm then identifies a hyperplane that maximizes the distance between the closest points (called support vectors) of different classes. Once trained, SVM can classify new plant images by determining on which side of the hyperplane the new image data falls. Because of its ability to handle high-dimensional and complex data, SVM is highly effective for identifying diseases based on subtle variations in image features, providing accurate and reliable results.

Both SVM and K-Means significantly improve upon traditional methods like naked-eye observation and consulting experts. Naked-eye observation is highly dependent on the experience of the observer, and visual inspection often misses early-stage diseases or subtle symptoms. Moreover, expert consultation

is time-consuming, expensive, and impractical for large-scale crop monitoring.

Flow Chart

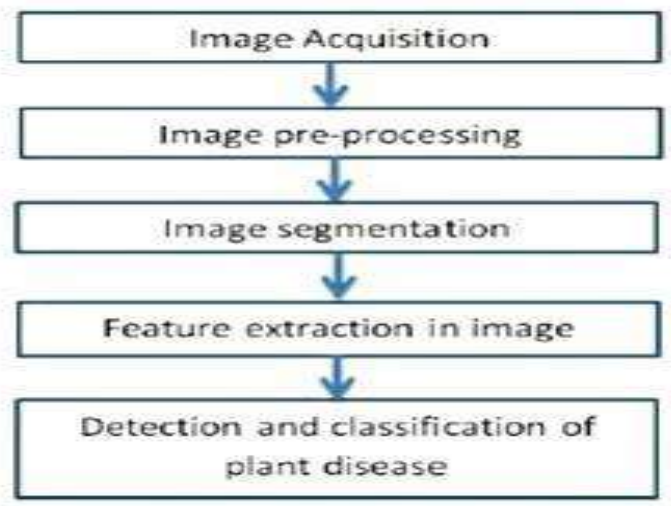

Figure 4.3: Flow Chart of Plant Disease Detection Using Image Processing

5-ADVANTAGES & DISADVANTAGES

Advantages

1. **Early Detection:** Image processing can identify disease symptoms at an early stage, allowing for timely intervention.
2. **Non-Invasive:** This method does not require physical sampling, preserving the integrity of the plant.
3. **High Accuracy:** Advanced algorithms can achieve high precision in identifying specific diseases based on visual symptoms.
4. **Automation:** Image processing can be integrated into automated systems, enabling large-scale monitoring without human intervention.
5. **Cost-Effective:** Reduces the need for expensive lab testing and can be deployed using affordable devices like smartphones.

Disadvantages

1. **Data Quality:** The accuracy of detection heavily relies on the quality of images captured, which can be affected by lighting, angle, and resolution.
2. **Complexity of Diseases:** Some plant diseases exhibit variable symptoms, making them difficult to classify accurately with image processing alone.
3. **Technical Expertise:** Requires a certain level of technical knowledge to operate and interpret results effectively, which may be a barrier for some farmers.
4. **Environmental Factors:** Variability in environmental conditions (e.g., weather, season) can affect image analysis and lead to inconsistent results.
5. **Dependence on Technology:** Reliance on technology may reduce traditional skills and knowledge among farmers regarding disease identification.

6- RESULTS

In this chapter, we will discuss about the results of the Plant Disease Detection Using Image

Processing. The results of plant disease detection using image processing highlight the effectiveness of automated systems in accurately identifying and classifying plant diseases. Techniques like colour conversion, pixel masking, and segmentation, along with machine learning algorithms like SVM and K-Means in MATLAB, enable precise detection of diseased areas. These results demonstrate improved accuracy, early detection, and effective classification compared to traditional methods, offering valuable insights for better crop management.

Working

Image Processing is a technique used to detect the disease of plants and this process will include the following steps in working:

Image Acquisition:

The images of the plant leaf are captured through the camera in a controlled background and are stored in the JPEG format. Infected leaf is located horizontal on a black background. The leaf is zoomed on so as to make sure that the picture taken contains only the leaf and black background. This image is in RGB (Red, Green and Blue) form. Colour transformation structure for the RGB leaf image is created, and then, a device-independent colour space transformation for the colour transformation structure is applied.

Image Pre-processing:

The images of the plant leaf are captured through the camera in a controlled background and are stored in the JPEG format. Infected leaf is located horizontal on a black background. The leaf is zoomed on so as to make sure that the picture taken contains only the leaf and black background. This image is in RGB (Red, Green and Blue) form. Colour transformation structure for the RGB leaf image is created, and then, a device-independent colour space transformation for the colour transformation structure is applied.

Gaussian Filter:

The Gaussian smoothing operator is a 2-D convolution operator that is used to smoothened images and remove detail (higher frequencies) and noise. However, it is similar to the mean filter, but it uses a different kernel that represents the shape of a Gaussian (`bell-shaped') hump.

Segmentation:

Segmentation means partitioning of image into various part ofsame features or having some similarity. The segmentationcan be done using various methods like otsu‟ method, k-means clustering, Boundary and spot detection algorithm,converting RGB image into HIS or HSV model. The RGB image is converted into the HSV model for segmenting using boundary detection and spot detection algorithm. Boundary etection and spot detection helps to find the infected part of the leaf. For boundary detection the connectivity of pixels is considered and boundary detection algorithm is applied.

Feature Extraction:

Feature extraction plays an important role for identification of an object. In many application of image processing, feature extraction is used. Colour, texture, morphology, edges are the features which can be used in plant disease detection.

Image Compression:

Computerized picture Compression plays out a recognized capacity in loads of photo handling applications. Yet, pressure a picture relies on numerous imperative components, for example, photograph power that is basically depends upon the splendor, assessment organizes so on. Particularly in bundles like steganography and watermarking in which the measurements is inserted or covered up on the photo. After effectively implanting the

measurements before transmission the particular picture need to pack for security issues. The weight of cutting edge photo may moreover likewise has a bent to free the assurances if well now not compacted and in two or three cases as a result of slanted encoding set of courses of action methodology the recuperation structure have ended up being extra difficult to recoup the records then it tends to confined the basic information. Weight frameworks makes them extraordinary procedures like DCT weight approach, JPEG weight, and so on.

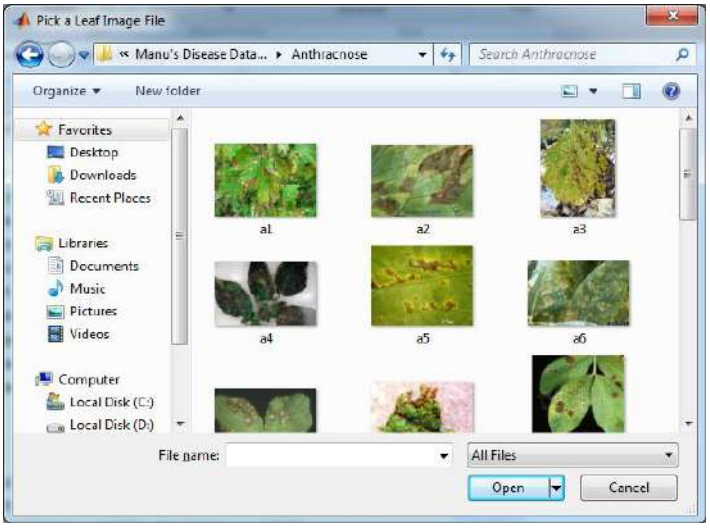

Figure 6.1: Selecting an input image

Here input image is selected from the available images and the choice of selection is given to the user for selection. User selected an input image which is used for further processing for detection and recognition.

Figure 6.2: Contrast enhancement as pre-processing

To apply a contrast filter, you determine if a pixel is lighter or darker than a threshold amount. If it's lighter, you scale the pixel's intensity up otherwise you scale it down. In code this is done by subtracting the threshold from a pixel, multiplying by the contrast factor and adding the threshold value back again. As with the brightness filter the resulting value needs to be clamped to ensure it remains in the range 0 - 255.

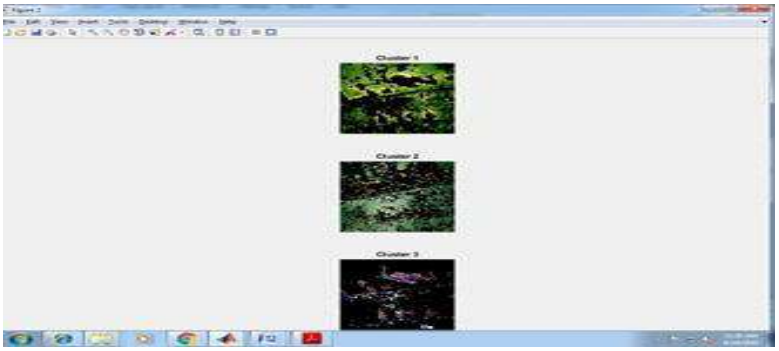

Figure 6.3: Selection of algorithm obtained from K-means Clustering algorithm

Figure 6.4: Disease cluster is selected from the user

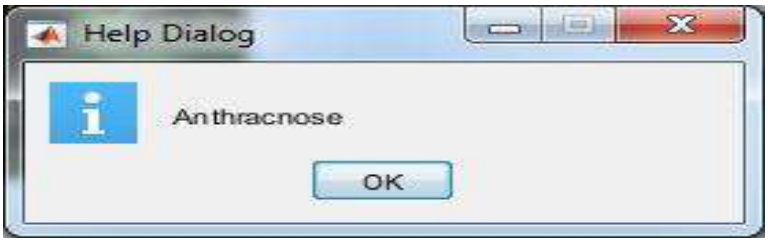

Figure 6.5: Output of the SVM Classifier

In the field of mathematical modeling, a radial basis function network is an artificial neural network that uses radial basis functions as activation functions. The output of the network is a linear combination of radial basis functions of the inputs and neuron parameters. Radial basis function networks have many uses, including function approximation, time series prediction, classification, and system control. They were first formulated in a 1988 paper by Broomhead and Lowe, both researchers at the Royal Signals and Radar Establishment.

7-CONCLUSION

This project gives the exact results on different diseases classification techniques that can be used for plant leaf diseases detection and an algorithm for image segmentation technique used for automatic detection as well as classification of plant leaf diseases has been described later. Therefore, related diseases for these plants were taken for identification. With very less This project gives the executed results on different diseases classification techniques that can be used for plant leaf diseases detection and an algorithm for image segmentation technique used for automatic detection as well as classification of plant leaf diseases has been described later. Therefore, related diseases for these plants were taken for identification. With very less computational efforts the optimum results were obtained which also shows the efficiency of the proposed algorithm in recognition and classification of the leaf diseases. Another advantage of using this

method is that the plant diseases can be identified at an early stage or the initial stage.

REFERENCES

[1] Too, E. C., Yujian, L., Njuki, S., & Yingchun, L. (2019). A comparative study of fine-tuning deep learning models for plant disease identification. Computers and Electronics in Agriculture,161,272279.[DOI:10.1016/j.compag.2018.03.032](https://doi.org/10.1016/j.compag.2018.03.032)

[2] Zhang, S., Huang, W., Zhang, C., & Li, P. (2019). Plant diseased leaf segmentation and recognition by fusion of superpixel, K-means and PHOG. Optik, 182, 10-20. [DOI: 10.1016/j.ijleo.2018.12.026](https://doi.org/10.1016/j.ijleo.2018.12.026)

[3] Huang, W., Liu, L., Wang, Q., & Wang, L. (2020). Plant disease recognition based on the fusion of ResNet and dense convolutional network. Computers and Electronics in Agriculture,167105844.[DOI:10.1016/j.compag.2019.105844](https://doi.org/10.1016/j.compag.2019.105844)

[4] Ferentinos, K. P. (2018). Deep learning models for plant disease detection and diagnosis. Computers and Electronics in Agriculture, 145, 311-318. [DOI: 10.1016/j.compag.2018.01.009](https://doi.org/10.1016/j.compag.2018.01.009)

[5] Al-Amin, M., Faisal, M. A., Uddin, M. S., Anower, M. S., & Rahman, M. M. (2021). Automatic recognition of plant diseases using CNN model. Procedia Computer Science, 192, 4940-4949.[DOI:10.1016/j.procs.2021.09.271](https://doi.org/10.1016/j.procs.2021.09.271)

[6] Sharma, P., & Singh, S. (2022). Image processing technique for identifying and classifying leaf diseases in tomato plant. Journal of Ambient Intelligence and Humanized Computing, 13(2), 1879-1890. [DOI: 10.1007/s12652-021-02957-2](https://doi.org/10.1007/s12652-021-02957-2)

[7] Hasan, M. J., Islam, M. M., & Hossain, E. (2021). Plant disease detection using image segmentation . Multimedia Tools and Applications, 80(2), 199-219. [DOI: 10.1007/s11042-020-09488-0](https://doi.org/10.1007/s11042-020-09488-0)

[8] Shrivastava, V. K., Pradhan, M. K., & Minz, S. (2022). Transfer learning-based model for disease identification in plant leaf images. Journal of Plant Pathology, 104(2), 521-532. [DOI: 10.1007/s42161-021-00956-4](https://doi.org/10.1007/s42161-021-00956-4)