# Optimal Plant Leaf Disease Detection using SVM classifier with Fuzzy System

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**Abstract**

Agriculture is an important aspect of our lives. As a result, disease detection is critical in agriculture, and many plants become extinct as a result of diseases that go undiagnosed. For detection purpose, the leaf image is chosen since it is visible and available all the time. Leaves are the important for fast growing of plant and also to increase the production of crops. In the proposed system, able to detect the disease of the plant leaf by giving the leaf image as the source. To detect the disease of the leaf, the image acquisition is performed, then the pre-processing stage such as quality, smoothing and shape is done to detect the disease affected area. Genetic algorithm is performed to segment the components and SVM (Support Vector Machine) Classifier is used to classify the image. Once the leaf image is given, the proposed system is identify, detect and display the cause of the plant. Fuzzy system is applied to identify the healthy spot in the leaf and display the accuracy level.

**Keywords**

Agriculture, Leaf Detection, Disease Identification, Accuracy, Disease Name, Support Vector Machine.

## 1. Introduction

Agriculture plays a very important role in today's quick growing world and over that completely different diseases in agricultural crops and plants is increasing. Every year, plant diseases causes' vital loss of food crops around the world. Because the Food and Agriculture Organization of the globe organization (FAO) asserts [1], plant pests and diseases unit of measurement answerable for losses from two hundredth to four-hundredth of annual international food production. Hence because of this increasein plant diseases causes a severe impact in food security. The world organization declared the 2020 as International Year of Plant Health. It's estimated that food production will have to increase by 60% by 2050 to feed the estimated 10 billion people expected on Earth [2]. We hereby come with a replacement technique which helps us to notify about the diseased leaf and is incredibly simple and cheap. The development in computer vision helps us to solve many of the agricultural-related impacts. Likewise, with help of the plant leaf disease detection method, we can able to know about the disease caused to the leaf and be able to protect them with some basic pieces of knowledge shown in the output.

## 2. Literature Review

Various techniques are proposed by the researchers in the recent past. In this methods have own merits and demerits, which are discussed as follows. S. Ramesh et al. proposed system is used to detect the healthy and diseased leaf. The datasets is created and trained under the Random Forest to classify the healthy and diseased leaves. Once the image is inserted it undergoes several process and display the

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result. The final output shows both the healthy and diseased leaf of the particular image given. It displays the 70% accuracy level [3].

Arsenovic, Marko et al. execuetedin this system, a new dataset is created that containing 769,265 images was introduced with aim to craete one of the largest dataset containing the leaf images. The trained model gives the accuracy level 93.67 of the image compared with the the dataset created. Machine learning algorithms are used to provide various optimal decisions [4].

Ramcharan, Amanda, et al. presents the system detects the virus diseases of the cassava plant leaf. Image recognition gives both the cost effective and scalable technology for the disease detection. Thus it display the accuracy level for the leaflet of cassava dataset, then overall accuracy was higher and then ranged from 80%(20-70 split)KNN to 93.0%(80-10 split)SVM[5].

Kulkarni, Pranesh, et al. implemented system is a smart and efficient technique for the detection of the crop disease which uses the computer vision and machine learning algorithms. The proposed system can able to detect the 20 different diseases of the 5 common plants with the 93% accuracy. Thus the system can be used to detect the diseased plants in agricultural site as real time plant disease detection. It gives the average 93% accuracy and the 0.93 F1 score[6].

Chohan, Murk, et al. performed a system proposes a deep learning based model named the plant disease detector and able to detect the several diseases from the plants using the pictures of their leaves. PlantVillage is a dataset that is used to train the model. Thus 15% of the data from PlantVillage data is used for the testing purpose that contains the images of healthy as well as the diseased plants. The proposed system has achieved the 98.3% of testing accuracy[7].

Pantazi, Xanthoula Eirini, Dimitrios Moshou, and Alexandra A. Tamouridou. demonstrated an approach of an automated way of crop disease identification on the various leaf sample images. A success rate of 95% is achieved for total of the 46 plant-condition combinations tested. The implemented application is capable of identifying the healthy conditions in the plant species[8].

Kumar, P. Manoj, C. M. Surya, and Varun P. Gopi. executed a system that explores the feature vectors from both front and back side of the green leaf along with the morphological features to improve at a unique optimum combination that maximizes the identification rate.Using classifier or matching algorithm the performance analysis is executed and display the name of the medicinal plant with its accuracy[9].

De Luna, Robert G., et al. proposed a system that involves the image processing techniques to extract features related to leaf in coexistence with using the artificial neural network in order to identify and detect some of the Philippine herbal plants. The experimental results gives a 98.61% accuracy of the herbal plant identification. From the system, the results obtained from the 72 new leaf samples, complete system provides the herbal leaf identification of 98.61% accuracy[10].

Ibrahim, Zaidah, Nurbaity Sabri, and NN Abu Mangshor. executed system gives the application of texture features for the leaf recognition of herbal plant identification. Then pre-processing is done on image for resizing and converting the image into gray-scale image. The features are extracted and leaf recognition is executed. Finally, it displays the name of the herbal plant with its accuracy level[11].

Kumar, Santhosh S., and B. K. Raghavendra. describes that they have done survey on the different plants disease and the various advance techniques to detect the plant diseases. Disease in the plants that takes place when some of the virus, bacteria infects a plant and disturb its normal growth. Farmers need the fast and efficient techniques to detect all the types of diseases of the plants that can save time. These systems that can reduce the efforts and use of pesticides[12].

Oo, Yin Min, and Nay Chi Htun. proposed a methodology for the detection and analysis of the plant leaf diseases using the digital image processing techniques. The system works in the following

steps such as the image acquisition, preprocessing, segmentation, feature extraction using the GLCM, LBP method and then sample images are tested by the SVM classifier. The proposed system can successfully classify and classify the plant disease with the accuracy of 98.2%[13].

Pooja, V., Rahul Das, and V. Kanchana. executed system proposes a disease detection and the classification technique with the help of machine learning algorithms and image processing tools. Image Acquisition, Image Pre-Processing, Segmentation, Classification are the steps that are performed. It gives the accuracy level of 92.4% in the detection of the diseases[14].

Bhimte, Namrata R., and V. R. Thool. system proposed for the identification of the cotton diseases at early-stage diagnosis. The following steps are used for classification and image preprocessing of cotton leaf, 1) Acquisition of RGB Image 2) Preprocessing of acquired Image 3) Image Segmentation 4) Feature Extraction of Segmented Image 5) Classification. The composed classifier functions gives the accuracy of 98.46% [15].

Dhaware, Chaitali G., and K. H. Wanjale. executed system includes the techniques for the imagepre-processing, image segmentation algorithm used for the automatic recognition that may be used for the leaves disease classification. Plant leaf disease identification and detection includes the stages such as image acquisition, image pre-processing, image segmentation, feature extraction and classification. It displays the name of the disease affected by the leaf[16].

Barbedo, Jayme Garcia Arnal, et al. proposed system performs a deep-learning based approach to detect the tomato diseases and pests in the tomato plants using images captured in-place by using camera devices with various resolutions. Experimental results show that the proposed system can effectively recognize the nine different types of diseases and pests, with the ability to deal with the complex scenarios from a plant's surrounding area[17].

Devaraj, Abirami, et al. developed system gives a software system that mechanically find and classify disease. The steps like loading an image, preprocessing, Segmentation, extraction and classification that involves illness detection. The use of image process technique to find and classify thediseases in agricultural applications is useful[18].

Fan, Zhun, et al. proposed system states a new algorithm based on the deep neural networks is proposed to detect the tobacco plants in images captured by the unmanned aerial vehicles (UAVs) calledUAV images. The experimental results shows that the proposed algorithm performs well on the detection of the tobacco plants in UAV images. The proposed system performs the detection of the tobacco plants and achieves an accuracy (Pacc and Error) of 0.9370, 0.9126, and 3.94%, respectively[19].

Kaur, Prabhjot, et al. executed system is to detect the leaf disease in grapevines. Leaf blight, stable Black rot, and Black measles are the four types of diseases found in the grapevines plants. Also for the detection and the classification of grapevine leaf disease using "Deep Transfer Learning" a proposed approach is used. Finally, the traits are identified with the highest accuracy of 98.7% using the state-of-the-art classifiers[20].

Shao, Feifei, et al. created system is used for detecting multiple and single instances with in bounding boxes in an image using image-level labels. As firstly describe the setting and formulation of the Weakly-Supervised Object Detection (WSOD), including the background, challenges and the basic framework. It detects and display the name and accuracy of the image so that we can identify the comparison of the given image with the image trained in the dataset[21].

Based on the above study, the following challenges are identified:

- There is no separate system for classification and disease detection for herbs.
- The existing method for plant disease detection is simple naked eye observation by

specialists, which allows professionals to identify and detect plant illnesses. To do so, a huge team of experts as well as continual plant monitoring are necessary, both of which are quite expensive and only possible with large farms.

## 3. Key takeaways in the proposed scheme

Primarily, in the proposed methodology, the above-said issues are sufficiently addressed. This proposed methodology helps user to easily identify the disease causes and name of the disease and also gives the solution to the disease by downloading the document.

Secondly, the proposed system adapting the genetic algorithm it is easy to understand the disease of the plant and name of the plant.

Thirdly, the accuracy of the disease finding is high in the proposed model, which is evaluated by fuzzy inference system. The outcome of the proposed technique was tested using MATLAB, thus the proposed work efficiently detecting the disease of the herbs.

## 4. Proposed Methodology

The proposed methodology Optimal Plant Leaf Disease Detection using SVM classifier with Fuzzy system is used to find the affected area in the leafs as well as disease caused in the plant .A Convolutional Neural Network(CNN) is a type of artificial neural network that is used in image recognition and processing that is designed to process the pixel data, Optimal Mobile Network-Based Convolutional Neural Network(OMNCNN) model is an automated model for classification and detecting the plant leaf diseases[22]. The OMNCNN model operates on the different stages namely preprocessing, segmentation, feature extraction, and the classification. First it trains the given input images and preprocessing is done using Bilateral Filtering. Image segmentation process is performed using threshold selection technique. Various processing are involved in the disease identification and detection, which are discussed as follows.

### 4.1. Detecting the healthiness of the leaf

In the Artificial Neural Network, the first step is preparing the data for execution after that the training set will be created for the images to execute pre-possessing the data into a form that can be used with neutral network. Once the image is given then it will visit all the pixels by POS then uses Nested loops it will Traverse one copied image to another location or else filtered cluster. After this the given image is divided into 4 different type 1. Original image, 2. Filtered Image 3. Image with spots will be displayed, 4. Binary image all the images are grouped into cluster formation. Each steps the image will be more clear and accurate so that the identification of the diseases will be much easier. The filtered image will add the more extraction to the image so image will be more brighten than the original image.

The next will be the image with spots. In this process the brighten image will be identified the spots thatis being damaged or affected, the Binary image will mask the images with the pixels value 0 and 1. Thehealthy part of the image that is Green colored images are masked by White color with the value of 0 and those are eliminated or masked from the image by using artificial neural network.

The Emperor Penguin Optimizer (EPO) algorithm and Extreme Learning Machine (ELM) is used for the feature extraction process and for classification purpose. In OMNCNN model classification is performed using the Neural Network Classifier. Neural Networks helps to classify and cluster. The affected area will be masked with Value 1 then it will colored by Black color based on this Black sports and pixel value 0 the affected area is calculated Once the cluster is divided into different parts then user will be asked to give the cluster value to identify the diseased part and affected area of the

particular cluster after gibing the cluster value it will calculate the healthiness of the lead by using % metrics that is calculated by Fuzzy Rule Based System. It is mainly used for the clustering and classification layer on the top of the data to store and manage it. It also helps to group the unlabeled data according to the similarities among them in the inputs, and they classify the data when it have a labeled dataset to train it on.

## 4.2. Disease Caused

The flow diagram of the proposed system Optimal Plant Leaf Disease Detection using SVM classifier with Fuzzy is shown in Figure 1. The previous Module filtered image will be used as input for this process, The neural network classifier consist of units arranged in layers which convert an imagevector into some desired output. Each unit takes an image and applies a function to perform and then passes the output on to the next layer. The Deep Learning algorithm studies the different dataset images and classifies into one of the 5 categories 1.Bacteria 2.Fungi 3. Nematode 4. Virus and 5.Normal leaf (i.e) Not affected by any disease these are the basic causes for the leaf to affected by diseases. The basicdisease will be identified based on two value that is filter value and H value of the image The filtered image is taken as input for this process when image is filter value is greater than 0.17 and filter value is less than 0.65 ((filter>0.17) &(filter<0.65) then the leaf will be affected by Bacteria. If the filter value is greater than 0.15 and filter value is and less than 0.5 ((filter>0.15) &(filter<0.5) then the leaf will be affected by Fungi. If the filter value is greater than 0.08 and filter value is less than 0.5 ((filter>0.08) &(filter<0.5) then the leaf will be affected by Nematode. Filter value is greater than 0.08 and filter value is less than 0.3 ((filter>0.08) &(filter<0.3) then the leaf will be affected by Virus. filter value is greater than 0.1and filter value is less than 0.5 ((filter>0.1) &(filter<0.5) then the leaf is in Normal condition it is not affected by any diseases these are briefly plotted in the following graph Figure 2.

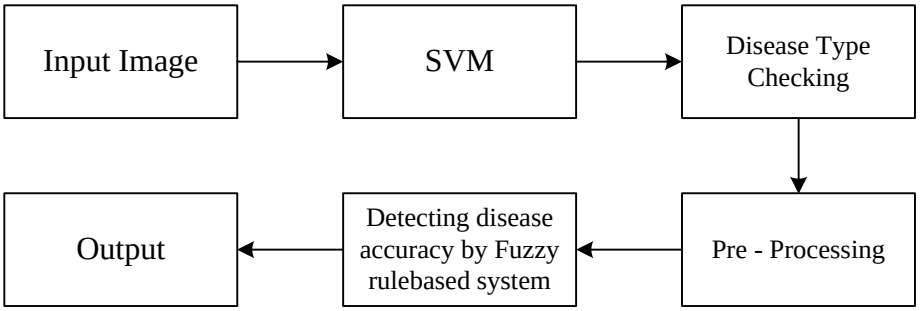


**Figure 1:** Flow diagram for identifying the disease caused

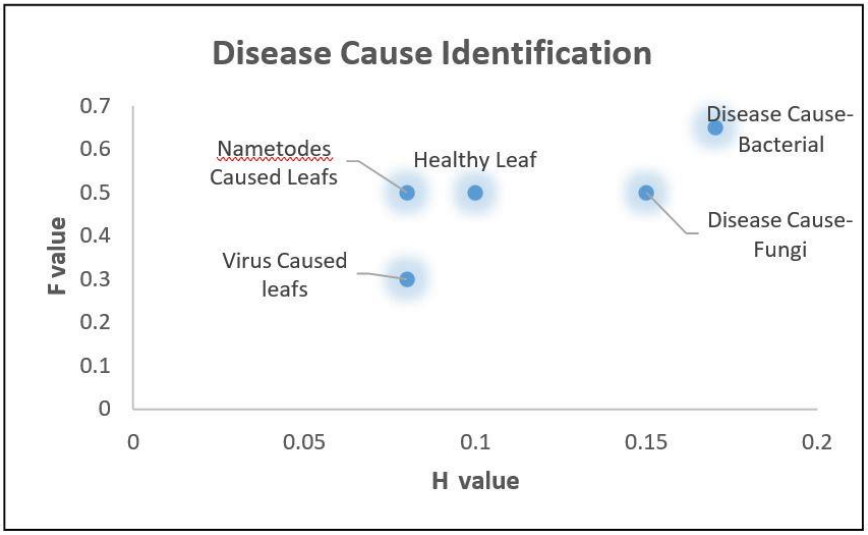


**Figure 2:** Disease Cause identification

## 4.3. Image Acquisition

Image acquisition is the first step which requires the capturing of an image with the help of a camera or pick a leaf from local storage.

## 4.4. Image Preprocessing

Preprocessing of the input image to improve the quality of the image and to remove undesired distortion of the image. The main objective of the technique of image processing is to extract the infected area of the leaf and isolating the background and the green part of the leaf. This would allow us to focus on the affected area alone. Clipping the leaf image is performed to get the image smoothing using the smoothing filter and to increase the contrast image enhancement. The dataset sample has been shown in Figure 3.

## 4.5. Feature Extraction

In this stage, the green colored pixels are masked. So, the computed threshold value is used for these pixels. In the following steps mostly green pixels are masked:, if the pixel intensity of green component is less than the pre computed threshold value, then the zero value is assigned to red, green and blue(RGB) components of the this pixel. In infected clusters, the masked cells are removed that are inside the boundaries. After classifying feature extraction of the infected leaf has been done using Digital Image segmentation technique.

**Figure 3:** Dataset of the plant leaves

## 4.6. Image Segmentation

Classify the leaf diseases to obtain the useful segments. Segmentation of the components are executed using genetic algorithm. It is used to identify the disease of the leaf.

## 4.7. Classification

Support Vector Machine (SVM) is supervised machine learning algorithm that can be used for either the classification or the regression of challenges. It is mostly used in the classification problems. In this algorithm, we plot each of the data item as a point in the n-dimensional space where n is the number of features. Using the SVM classifier is used for the classification purpose. It classify the image and display the accuracy level.

**Disease Type:**

- **Alternaria Alternata –** It is a fungus which causes a black spot in leaf of fruits and vegetables.It main occurs in the crops such as cabbage, cauliflower, broccoli, etc.
- **Anthracnose –** It is a group of fungal diseases which affect a wide variety of humid areas andplants in warm. It found in oak, ash, maple.
- **Bacterial Blight –** A widespread disease which is most common during wet, cool weather that occurs mainly in soyabean.
- **Cercospora Leaf Spot –** It is an infectious disease which affects the oak leaf, panicle and hydrangea big leaves.

# 5. Methods used to detect the disease and its accuracy

In the proposed system Optimal Plant Leaf Disease Detection using SVM classifier with Fuzzy system adapts the various techniques for achieving higher level accuracy in the classification and detection process, which are briefed as follows.

## 5.1. Genetic algorithm to identify the plant leaf disease

This proposed system uses the genetic algorithm for the segmentation and Clustering. Genetic algorithm is an unbiased optimization technique [23]. It is useful in the image enhancement and the segmentation. GA was the most powerful optimization technique in the large solution space. This describes the increasing popularity of genetic algorithm applications in the image processing and other fields. The genetic algorithmic program repeatedly modifies the population of the individual solutions. It also selects the individuals from the current population to be parents and uses them to produce the children for the next generation. The genetic algorithm evaluates the problems of the mixed integer programming where some of them are restricted to be an integer-valued. The genetic algorithms uses the evolutionary generational cycle to produce a high-quality solutions. They may use various operations that increase or replace the population that provide an improved fit solution.

Genetic Algorithm are based on the behavior of the chromosomes and their genetic structure. All chromosomes play an important role of providing a possible solution. Also the fitness function helps in providing the characteristics of all the individuals within the given population.

## 5.2. RGB to HSV color space

The proposed system performs the conversion of RGB to HSV values, because RGB defines the color in terms of the combination of primary colors, where HSV describes the color using familiar comparisons such as color, vibrancy and brightness. **HSV = rgb2hsv(RGB)** is used to converts the red,green, and blue values of an RGB image into hue, saturation, and value(HSV) values of an HSV image[24]. **hsvmap = rgb2hsv(rgbmap)** is used to convert an RGB colormap into an HSV colormap. RGB is corelated to the color luminance (loosely call intensity), where we cannot separate the color image from the luminance. HSV value is performed to separate the image luminance from the color image.

## 5.3. Fuzzy rule-based system

In this system, the fuzzy rule-based system used to identify the healthy spots in the leaf and display the percentage of the healthiness of the leaf [26]. Fuzzy rules are used within the fuzzy logic systems to infer an output based on the input variables. Fuzzy rule-based systems are one of the most important application of the fuzzy sets and fuzzy logic. It allows the capturing and handling the potential of uncertainty of the represented knowledge.

## 5.4. K-means Clustering

K-Means clustering algorithm is used to classify the given input data points into a many number of classes based on the clusters inherent distances. This algorithm assigns the data features to create a vector spacing for clustering.

Steps to be followed:

- Computing the histogram on the basis of intensities.
- Initializing the centroids with the k random intensity.
- Execute the steps until the Cluster labels of the input images reaches it constant.
- Clustering is done based on the distance from the intensities of centroids to the cluster intensities.
- New centroid of each of the cluster is computed.

K-Means clustering is performed to split the given image into normal image, filtered image and binary image. The normal image is the image which is given as input. The filtered image is the image which add a filter to the image and binary image is the image which identify the healthy and diseased spots in the leaf image[27].

## 5.5. SVM Classification Algorithm

Support Vector Machine (SVM) is a supervised machine learning algorithm which can be used for both classification and regression challenges. However, it is mostly used in classification problems. In this algorithm, we plot each data item as a point in ndimensional space where n is number of features you have with the value of each feature being the value of a particular coordinate. Then, we perform classification by finding the hyper-plane that differentiate the two classes very well.

# 6. Results and Discussions

All the experiments are performed in MATLAB. For input disease leaf data, samples of plant leaves like cabbage, cauliflower with alternaria alternata disease, oak, ash with anthracnose disease, soya bean with bacterial blight disease, oak and hydrangea with cercospora leaf spot disease are considered. The first image is original images which are followed by the contrast image. The enhanced contrast image which adds extra filter, brighten and gives the clear structure of the image. Followed by the diseased image chooses for the classification stage. The co-occurrence of the features are calculated after the mapping of the R, G, B components of input image to the threshold images. Then the co- occurrence of the features for the leaves are compared and extracted with the corresponding feature values which are stored in the feature library.

The classification first performed using the K-Mean Clustering and it shows the efficiency with the accuracy of 86.54%. Detection accuracy is improved to 93.63% by proposed algorithm. The second stage classification is performed using the SVM classifier and it shows the efficiency with the accuracy level of 95.71%. Now the detection of the accuracy is improved to 95.71% by SVM with proposed algorithm. Then the training and testing sets for each of the type of plant leaf along with the

detection accuracy. From the results it can be seen that the detection accuracy is enhanced by the SVM with proposed algorithm compared to the other approaches reported. The number of plant leaf disease samples that are classified into the five classes of plant leaf diseases using in the proposed algorithm. In Figure 4, shows the segmented ROI of the respected leaf image and as result the disease name, accuracy and identified region. Figure 5 shows the number of clusters with healthiness of the leaf and name of the disease depending on the cluster number.

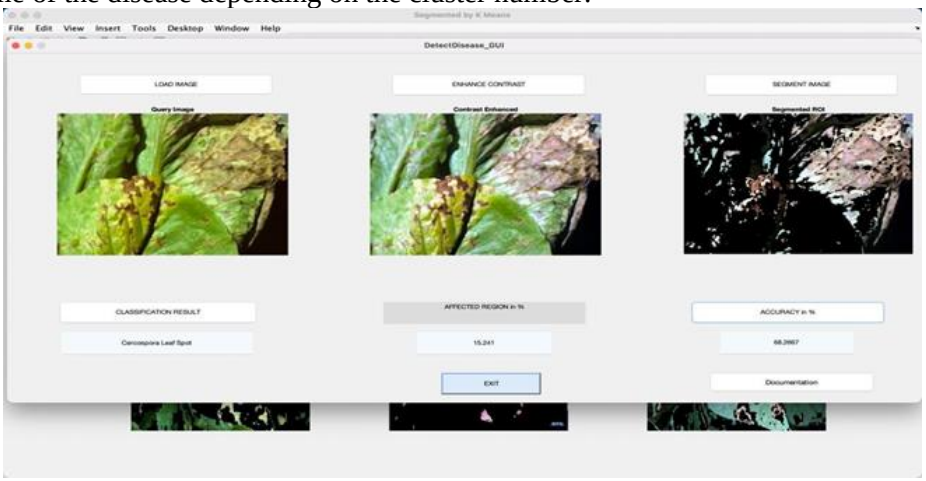


**Figure 4 -** Segmented ROI of the respected leaf image

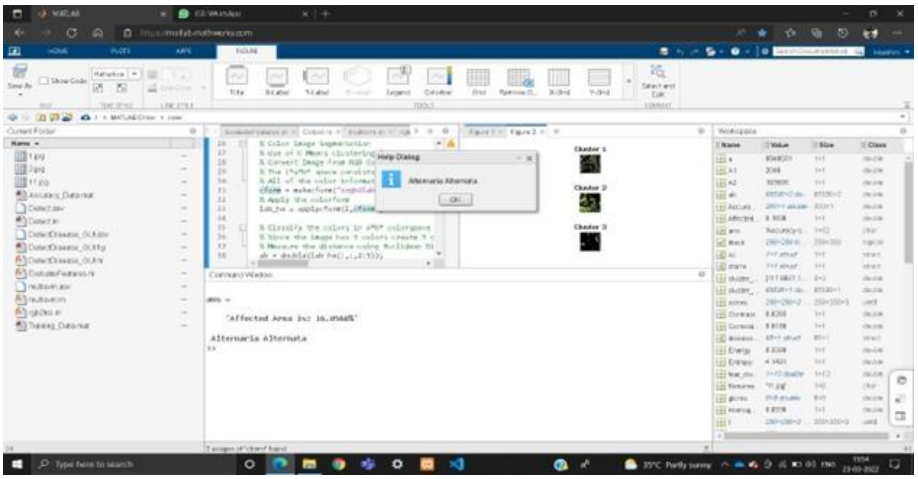

**Figure 5 -** Number of clusters with healthiness of the leaf and name of the disease

## 6.1. Result comparison with existing techniques:

To evaluate the performance of the proposed technique, the accuracy was compared with the existing methods which are shown in Figure 6. It is evident that the proposed model is found to be appropriate for the classification and detection of diseases in the plant leaf in real time environment.

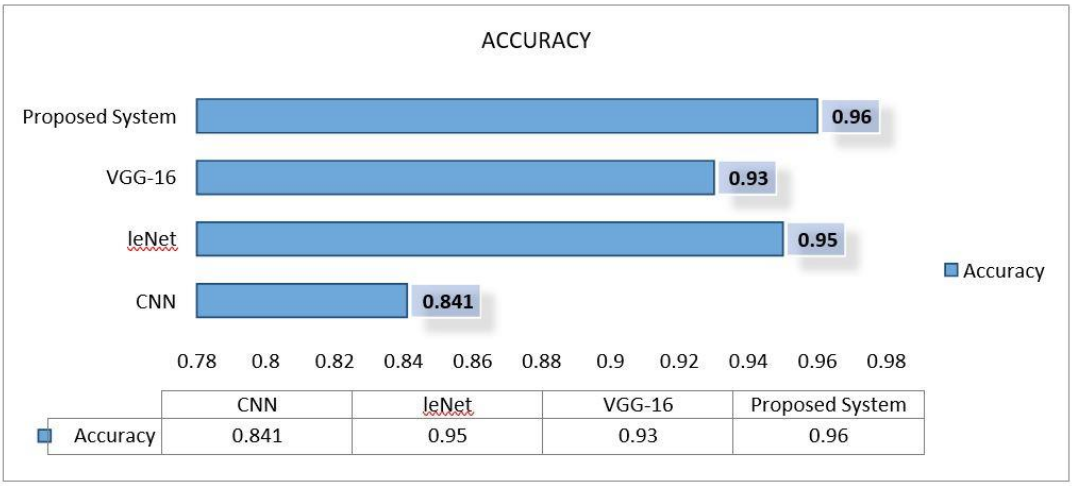


**Figure 6 –** Accuracy of proposed with existing techniques

## 7. Conclusion

The proposed method, Optimal Plant Leaf Disease Detection Using SVM Classifiers and Fuzzy Systems, was created to detect plant diseases at an early stage. This system saves the farmer time and money by detecting sickness and recommending fertilizers for the plant. Using various methodologies and algorithms, the damaged region, healthy part of the leaf, and disease affected area will be recognized in a segmented image with a varying number of clusters. The proposed system uses image processing techniques and a fuzzy inference system to allow the user to identify a disease caused by a specific microorganism infested on a plant leaf, as well as present the predicted health severity of the leaf basedon how much of the leaf is infected.

The future works are, the disease identification will be done in real time utilizing a live camera,and it will also assist the Agriculture Officer in checking the quality of a crop without the need for manual monitoring. The suggested system's applicability is that data gathered from farmers would assist the government in identifying the disease that has been developed in a specific region and taking appropriate measures to prevent or manage it.

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## 9. References

[1] S. Ashwinkumar a, S. Rajagopal a, V. Manimaran a, B. Jegajothi, “Automated plant leaf disease detection and classification using optimal MobileNet based convolutional neural networks”, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2021.05.584, May 2021.

[2] Olmos, A., et al. "High-throughput sequencing the technologies for plant pest diagnosis: opportunities and the challenges." in EPPO Bulletin 48.2 (2018): 219-224.

[3] Ristaino, Jean B., et al. "The persistent threat of emerging plant disease pandemics to global food security." Proceedings of the National Academy of Sciences 118.23 (2021).

[4] S. Ramesh et al., "Plant Disease Detection Using Machine Learning," 2018 International Conference on Design Innovations for 3Cs Compute Communicate Control (ICDI3C), 2018, pp. 41-45, doi: 10.1109/ICDI3C.2018.00017.

[5] Arsenovic, Marko, et al. "Solving current limitations of deep learning based approaches for plant disease detection." Symmetry 11.7 (2019): 939.

[6] Ramcharan, Amanda, et al. "Deep learning for image-based cassava disease detection." Frontiers in plant science 8 (2017): 1852.
[7] Kulkarni, Pranesh, et al. "Plant Disease Detection Using Image Processing and Machine Learning." arXiv preprint arXiv:2106.10698 (2021).
[8] Chohan, Murk, et al. "Plant disease detection using deep learning." International Journal of Recent Technology and Engineering 9.1 (2020): 909-914.
[9] Pantazi, Xanthoula Eirini, Dimitrios Moshou, and Alexandra A. Tamouridou. "Automated leaf disease detection in different crop species through image features analysis and One Class Classifiers." Computers and electronics in agriculture 156 (2019): 96-104.
[10] Kumar, P. Manoj, C. M. Surya, and Varun P. Gopi. "Identification of ayurvedic medicinal plants by image processing of leaf samples." 2017 Third International Conference on Research in Computational Intelligence and Communication Networks (ICRCICN). IEEE, 2017.
[11] De Luna, Robert G., et al. "Identification of philippine herbal medicine plant leaf using artificial neural network." 2017IEEE 9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM). IEEE, 2017.
[12] Ibrahim, Zaidah, Nurbaity Sabri, and NN Abu Mangshor. "Leaf recognition using texture features for herbal plant identification." Indonesian Journal of Electrical Engineering and Computer Science 9.1 (2018): 152-156.
[13] Kumar, Santhosh S., and B. K. Raghavendra. "Diseases detection of various plant leaf usingimage processing techniques: A review." 2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS). IEEE, 2019.
[14] Oo, Yin Min, and Nay Chi Htun. "Plant leaf disease detection and classification using image processing." International Journal of Research and Engineering 5.9 (2018): 516-523.
[15] Pooja, V., Rahul Das, and V. Kanchana. "Identification of plant leaf diseases using image processing techniques." 2017 IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR). IEEE, 2017.
[16] Bhimte, Namrata R., and V. R. Thool. "Diseases detection of cotton leaf spot using image processing and SVM classifier." 2018 Second International Conference on Intelligent Computing and Control Systems (ICICCS). IEEE, 2018.
[17] Dhaware, Chaitali G., and K. H. Wanjale. "A modern approach for plant leaf disease classification which depends on leaf image processing01." 2017 International Conference on Computer Communication and Informatics (ICCCI). IEEE, 27.
[18] Barbedo, Jayme Garcia Arnal, et al. "Annotated plant pathology databases for image-based detection and recognition of diseases." IEEE Latin America Transactions 16.6 (2018): 1749-1757.
[19] Devaraj, Abirami, et al. "Identification of plant disease using image processing technique." 2019 International Conference on Communication and Signal Processing (ICCSP). IEEE, 2019.
[20] Fan, Zhun, et al. "Automatic tobacco plant detection in UAV images via deep neural networks." IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 11.3 (2018): 876-887.
[21] Kaur, Prabhjot, et al. "Recognition of Leaf Disease Using Hybrid Convolutional Neural Network by Applying Feature Reduction." Sensors 22.2 (2022): 575.
[22] Shao, Feifei, et al. "Deep Learning for Weakly-Supervised Object Detection and Object Localization: A Survey." arXiv preprint arXiv:2105.12694 (2021).
[23] Singh, Vijai, and Ak K. Misra. "Detection of plant leaf diseases using image segmentation and soft computing techniques." Information processing in Agriculture 4.1 (2017): 41-49.
[24] Elias, Israel, et al. "Genetic algorithm with radial basis mapping network for the electricity consumption modeling." Applied Sciences 10.12 (2020): 4239.
[25] Patil, Rupali, et al. "Grape leaf disease detection using k-means clustering algorithm." International Research Journal of Engineering and Technology (IRJET) 3.4 (2016): 2330-2333.
[26] Cherkassky, Vladimir. "Fuzzy inference systems: a critical review." Computational intelligence: soft computing and fuzzy-neuro integration with applications (1998): 177-197.
[27] Michael, A., and Hideyuki Takagi. "Dynamic control of genetic algorithms using fuzzy logic techniques." Proceedings of the Fifth International Conference on Genetic Algorithms. Morgan

Kaufmann, 1993.
[28] Devi, T. Gayathri, P. Neelamegam, and A. Srinivasan. "Plant leaf disease detection using K means segmentation." Int. J. Pure Appl. Math 119.15 (2018): 3477-3483.