International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 03 Issue: 07 July 2025
Page No: 3051 - 3055
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2025.0449

The Detection and Grading of Grape Leaf Disease Using Fuzzy Logic and Artificial Neural Network

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Abstract
Research in agriculture focusing on the automatic detection of grape leaf diseases is crucial, as it can aid in overseeing extensive grape fields and promptly identifying disease symptoms on leaves. In the agricultural industry, crops often suffer damage due to diseases. Early diagnosis of these diseases allows for the protection of crops through various treatments. The cultivation of grape plants has rapidly advanced in both quality and quantity, yet pests and diseases, particularly on leaves, have impeded the quality of agricultural products. Suppose pest infestations on grape crops and leaves are not well monitored and addressed on time. In that case, the quality and yield of grape farming will decline, leading to increased poverty, food insecurity, and mortality rates. This significant impact can disrupt the economy of any nation, especially those where about 75% of the population relies on agricultural products for their livelihood and survival. A primary challenge for farmers is reducing or eliminating pest growth that affects crop yields. Pests are organisms that spread disease, cause damage, or are bothersome. Pests that frequently harm plants include aphids, fungi, beetles, thrips, flies, snails, slugs, caterpillars, and mites. These pests can cause fitful disease dawn, resulting in famine and food shortages.

Keywords: *Grape leaf disease, detection, grading, pests, economy.*

1. Introduction
In many nations, farmers rely on manual pest detection by visually inspecting crops, which demands constant vigilance of plant stems and leaves. This process is challenging, labour-intensive, prone to errors, and costly, especially for large-scale farms. Moreover, identifying plant diseases early is crucial, as even a few infected leaves can lead to widespread contamination, impacting the storage and sale of agricultural goods. [1] The consequences of plant diseases are devastating, often discouraging farmers to the extent that some choose to cease farming altogether. Therefore, it is critical to identify these illnesses early or late and suggest ways to reduce harm and increase crop yield. Remote sensing, medical imaging, agricultural processing and industrial inspection are just a few of the fields that have made use of digital image processing technology. These methods have worked well in agriculture for tasks like identifying plants, calculating agricultural yields, and evaluating the condition of the soil. Given the vast diversity of plant species and their applications across different sectors, the quality of agricultural goods has become a critical concern. Machine vision systems and other image processing methods have proven to be successful automated solutions. Artificially intelligent computer vision techniques based on image processing are becoming useful tools that can drastically cut down on calculation time, allowing for considerably quicker automated leaf disease diagnosis. Understanding some basic ideas, such as machine vision technologies, neuro-fuzzy computing techniques, precision agriculture, and the need for an automated model for grape leaf disease detection, is

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crucial to better understanding future research in this field. [2]

2. Detection of Grape Leaf Disease and Grading System

The suggested approach is displayed in Figure 1. Two phases have been identified for the planned system. First phase of training of the system comprises Image procurement, image pre-processing, feature extraction, and artificial neural network training. Second phase of testing of the system comprises the following: Feature extraction, classification, K-means segmentation, percentage infection calculation, test image acquisition, test image pre-processing, and fuzzy logic disease grading. (Figure 1)

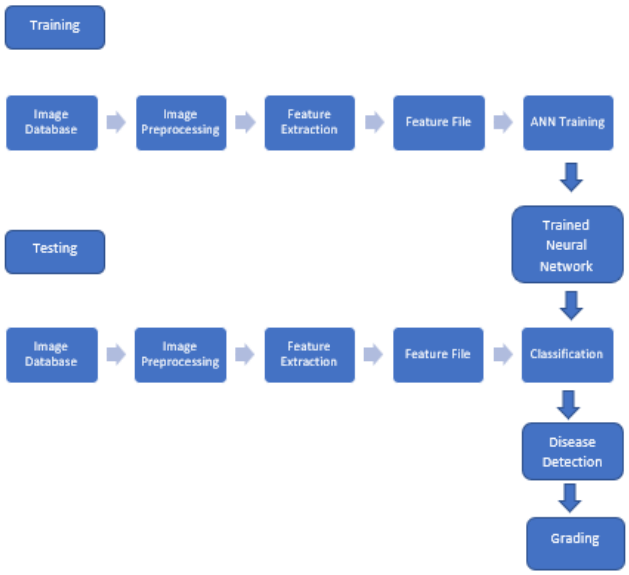

Figure 1 Methodology of Leaf Disease Detection & Grading System

2.1.Image Procurement

Image procurement is the process of taking a picture of any real-world scene using a camera. Digital camera photography is a widely used technique for this in the modern world. However, alternative approaches are also possible. In this project, the photos will be retrieved and the algorithm will be trained and evaluated using a predefined directory.

2.2.Image Pre-Processing

Image Pre-processing is the process of transforming images into a format that is appropriate for training and testing the blueprint. To enable efficient testing, the taken photos will be cropped and scaled during this stage of our cycle [4]. Digital image processing is the process of processing digital images using a computer blueprint. There are numerous steps involved in pre-processing, including:

- Resize Image
- Filter Image

2.3.Feature Extraction

In image processing, the process of extracting an image's features involves identifying the key attributes that require analysis. Several characteristics have been taken from the leaves in order to identify the illness to which the leaf belongs; some of these leaves will be used to test the system and some will be used to teach it. However, certain of the GLCM matrix's characteristics, such as contrast, homogeneity, and correlation, have been computed to identify the kind of disease in plant leaves and grade them further. Consequently, the creation of a feature file is being given to the ANN toolbox for training.

2.4.Artificial Neural Network-Based Training

Composite nonlinear systems that are difficult to model with a closed-form equation can be designed with the help of artificial neural networks [1]. Neural networks can be used to train the system after the feature file has been constructed and the output values of the images have been determined.

2.5.Testing Phase and Classification

Test photos that have been pre-processed and have had their features retrieved as being comparable to the training image are taken during the testing phase. Additionally, the Trained Neural Network's input is used to perform the categorization. [3]

2.6.Calculation of Total Leaf Area (TLA) and Diseased Area (DA)

K-means segmentation is used to group picture elements in a picture that are comparable. This is a quick and simple approach. The input pictures are used to determine the number of arrays in k-means. RGB space is redesigned into l*a*b space, where a*b is the color space and l is luminosity. A binary image is created from the initial input image, which was scaled during pre-processing. The total number of picture elements in this image is taken into account

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when determining the total leaf area (AT). Additionally, the clusters created following the color picture segmentation that contain the diseased spots are taken into consideration when computing the diseased area (DA).

2.7.Infection Rate (I) Calculation

Equation I = (DA / TLA) *100 is used to determine the Infection rate (I) following the computation of the total leaf area (TLA) and diseased area (DA). [4]

2.8.Use of the Fuzzy Logic Toolbox for Grading

Following the computation of the diseased leaf's infection percentage, the outcome will be categorized using the fuzzy logic toolbox according to the following categories:

Table 1 Diseased Grape Leaf Grading System

Grade	Hazard	Infection Rate
I	Extremely Low	Between 1% to 10%
II	Low	Between 10% to 20%
III	Medium	Between 20% to 30%
IV	High	Between 30% to 50%
V	Very High	Between 50% to 100%

Based on Table 1, the fuzzy model has been developed to classify the grape leaf disease davnya into five distinct groups; the input variable in this fuzzy system is the infection rate, and the output variable is Grade; the variables are set using triangular membership functions, and five fuzzy principles are established for the aids of grading. [5]

3. Results and Discussion

The goal of identifying and grading Grape leaf disease using an ANN and Fuzzy logic system is to make it simple for farmers to spot and grade the disease davanya. act appropriately. The outcomes for the same are listed below.The goal of identifying and grading Grape leaf disease using an ANN and Fuzzy logic system is to make it simple for farmers to spot and grade the disease davanya. act appropriately. The outcomes for the same are listed below. [6-8]

3.1.Original Leaf Image

The execution of this code will lead to the appearance of the following graphical user interface window as shown in Figure 2

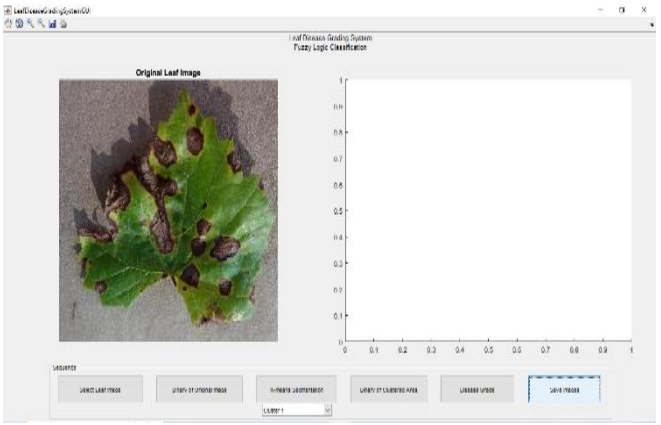

Figure 2 Original Leaf Image

3.2.Binary of Original Image

Click on load button to load image.

To begin the process, locate and click on the "Load Image" button within the application interface. This action will prompt a file browser window to open, allowing you to navigate through your computer's directories. Select the desired image file from your system that you wish to analyze or process. Once the appropriate image is selected, click "Open" to upload it into the system. The image will then be loaded into the workspace, making it ready for further processing or analysis steps, as shown in fig 3.

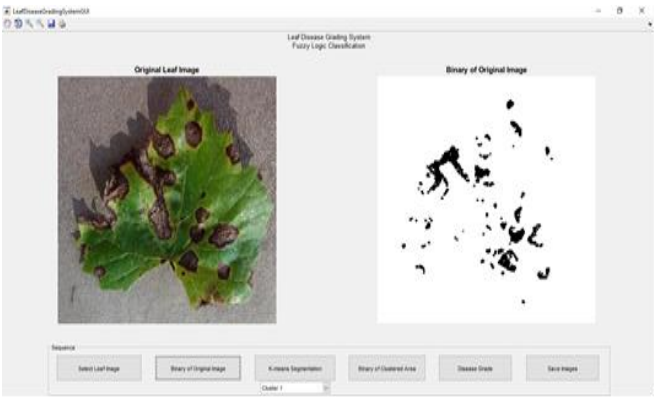

Figure 3 Binary of Original Image

3.3.Segmentation of Image

Click on the Binary of the Original button to get the binary of the original image.

To get the binary of the original grape leaf image,

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click on the button Binary of Original Image. After clicking on the binary of the original image, the binary image is displayed in the GUI window, as shown in Figure 4.

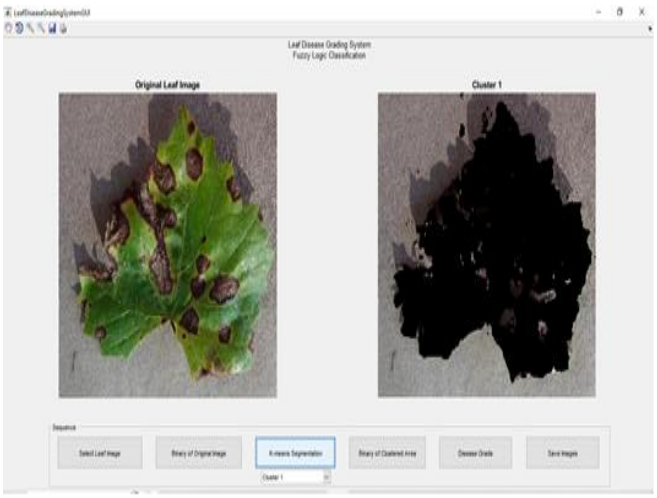

Figure 4 Segmentation of Image

3.4.Binary of Segmented Image

Click on the K-means Segmentation button to get the segmentation of the image.

To obtain the segmented image of the diseased image, click on the K-means segmentation button. The segmented image of the diseased leaf will be displayed in the GUI window, as shown in Figure 5.

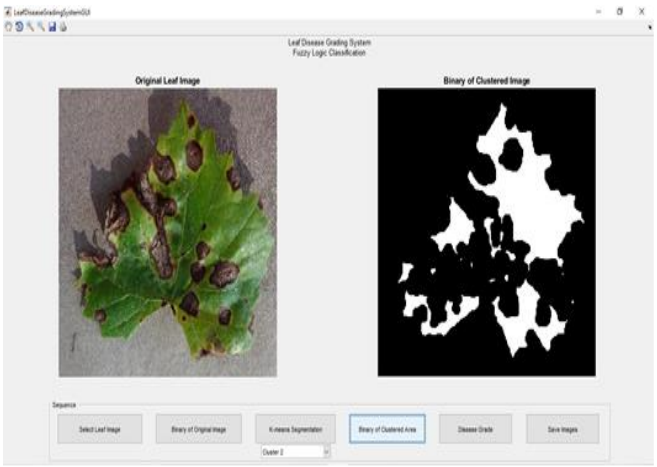

Figure 5 Binary of Segmented Image

Grading of Diseased Image

Click on the Binary of Clustered Area button to get the binary image of the segmented image. The binary of the segmented image will be displayed in the GUI window as shown in Figure 6. [9]

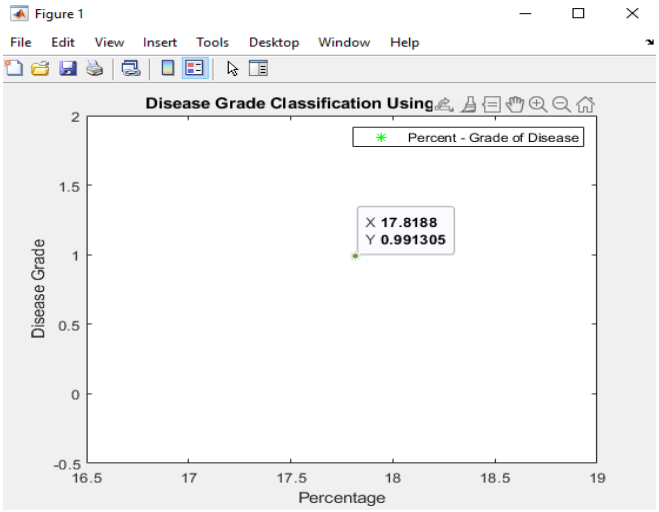

Figure 6 Grading of Diseased Image

Conclusion

We developed a system that identifies disease on grape leaves, specifically "DAVANYA". The classification of the disease is carried out using ANN technique, which also assesses the extent of the affected area. The system categorizes the severity of the disease into five distinct grades based on the percentage of the leaf area affected as shown in figure 3.5 and listed below- [10]

- **Extremely Low Risk:** 1% to 10% infected area
- **Low Risk:** 10% to 20% infected area
- **Medium Risk:** 20% to 30% infected area
- **High Risk:** 30% to 50% infected area
- **Very High Risk:** Above 50% infected area

In the current agriculture landscape, it is essential to have an automated system for detecting and grading disease on grape leaves. A system that incorporates ANN and Fuzzy logic is particularly advantageous for the automatic detection and assessment of grape leaf disease. The system offers greater efficiency compared to the traditional manual method, making it highly beneficial for agricultural practitioners. The grape leaf detection and grading system utilizes the K- Means segmentation technique for Image Segmentation. This approach enables the system to distinguish between the grape leaf area, the diseased

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area, and the background in the input images, facilitating the calculation of the infection percentage and the subsequent grading of the disease.

Acknowledgements

The completion of this research paper would not have been possible without the support and guidance of Prof. Kiran D. Salunkhe and Prof Shubhangi C. Deshmukh, Sanjay Ghodawat University. Their dedication and overwhelming attitude towards helping his/her students is solely responsible for completing my research paper. The encouragement and insightful feedback were instrumental in accomplishing this task. I also thankful to our HoD, Dr. Swapnil M. Hirikude and all the staff of the Electronics and Communication Engineering department, Sanjay Ghodawat University for their cooperation and kind support throughout my research period.

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