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Early Detection of Disease in Commonly Used Spinach Leaves Using Machine Learning

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***Abstract**:* Leaf diseases, such as Anthracnose caused by the fungus Colletotrichum spinaciae, result in small, dark olive-colored water-soaked spots on spinach leaves. These diseases thrive in cool, moist conditions, reducing both the yield and quality of spinach crops. They also pose a threat to global food security and impact small-scale farmers who rely on safe cultivation practices. Detecting leaf diseases early is crucial, as various environmental factors like fungi, water storage, insects, and weeds can affect plant health. Farmers must take preventive measures to enhance productivity. To address this issue, we propose developing a system that can easily identify common diseases in spinach leaves. By utilizing image processing and Machine Learning Algorithms, we aim to classify diseases accurately and provide farmers with a tool to diagnose plant issues simply by taking a picture of affected leaves. This system not only helps in preserving crops but also aids in cost-saving by ensuring the correct use of pesticides.

Keyword: Machine learning, Feature Extraction, Image Processing, Support Vector Machine

I. INTRODUCTION

Agriculture is the key development for the source of Indian economy. It is the cultivation of land to provide food, medicines and other products to sustain the life. In the past decades, Agriculture, has been associated with theproduction of basic food crops. Now a days, agriculture andfarming are not commercialized. But as the process of economic development, many more other occupations allied to farming came to be recofarminggnized as a part of agriculture. In day to day life agricultural products has been accepted as a part of modern agriculture. By controlling thedisease that affect the plants will make reliable production of food. The proper maintenance of farm also leads to good cultivation.

The pesticide which is heavily affected in the productis spinach. In 2016, world production of spinach was 26.7 million tones. Mostly it was affected in the broader leaves and in the seeds.

The spinach leaves disease is classified as follows they areexplained below

1.1 Anthracnose

The spinach leaves caused by the fungus Colletotrichum spinaciae is anthracnose. Symptoms of Anthracnose are characterized as small, dark olive-coloredwater-soaked spots. As with most anthracnose, cool (79- 86F), conditions with lots of moisture are perfect for this pathogen. The fungus reduces both spinach yield and quality. It also eliminates the volunteer spinach.

1.2 Leaf miner

Leaf miner, or Liriomyza chenopodii, is the cause of spinach leaves. Serpentine mines investigate the illness. Thirteen
In extreme situations, photosynthetic activity decreases. In extreme situations, there is a reduction in photosynthetic activity, which results in leaf death. The climate is favorable for multiplication when it is warm.

I.3. Cladosporium Leafspot

Cladoporium Leafspot of spinach is caused by Fungus Cladosporium variable. The fungus affects the leaf spots upto 0.25 cm in the range of diameter. Fungus can grow undera wide range of temperatures, ranging from 410 to 860F.

I.4 Downy Mildew

Peronospora farinose spinaciae is the cause of downy mildew on spinach leaves. When it is severely impacted, high tunnels will correspond with it. Similar to other downy mildews, this disease thrives in chilly, humid environments (59–700F). The upper leaf surfaces exhibit uneven yellow patches as a symptom. Eventually, lesions may get brown and dry out. There will be purplish-grey sporulation on the undersides of the leaves.
Sporangia are formed in the morning and spread throughout the day by wind currents. Until the circumstances are right for the development of the disease, an infection may remain latent for a long period. Sometimes symptoms and indicators emerge after harvest. In high tunnels, improve air circulation and lower humidity. If you can, use drip watering.

1.5 White Rust Disease

The water mold Albugo occidentalis is the source of white rust on spinach leaves. The spinach plant's afflicted leaves are promptly removed in order to prevent a further infection.

The multifractal downscaling model [1] was adjusted to mimic and attenuate natural phenomena. Enhancing the influence of soil moisture requires the application of statistical measurements. The Otsu method for segmenting the leaf region is described in [2]. The operator determines the quotient values of the affected regions and is used to detect the disease-spotted areas. The K-means technique requires pre-processing steps in order to apply clustering. The CNN tool is employed in the validation and training phases. The smartphone app [3] is the one that is used to turn on the device. Using an implanted camera, the chambers that served as a waterproof are observed. Rechargeable batteries are used to power the sensor and charge it utilizing that chamber. In order to identify unhealthy roots, stems, and leaves and stop the illness from spreading, image processing is utilized in smart farming [5]. HSV space is employed to keep light from reaching the impacted area. Leaf wetness sensors and soil moisture sensors are the parameters [6] that are employed. These sensors are compared to crop and soil-specific threshold values. Maintaining soil fertility requires the wireless sensor network [9], which is used to sense parameters including temperature, humidity, and air. The main problem that is seen is power. In order to identify the type of fungal infection mostly affecting leaves and fruits, a novel approach is presented [10]. The method of naked eye observation is outdated and yields lower accuracy. In order to address the shortcomings of the conventional eye-observing method, the classifier [11] employed a rapid, accurate digital detection technology called Support Vector Machine.

The evolutionary algorithm is used [14] to generate solutions for optimization problems. A method, New Spectral Indices (NSIs) is used in [15] for identifying different varieties of diseases that occurs on the crops. The NSIs are computed by using weighted algorithm and normalized wavelength.

II. PROPOSED METHODOLOGY

Now a day's agriculture and farming were not commercialized. But as the process of economic development, many more other occupations allied to farming came to be recognized as a part of agriculture. The Indian economy is mainly depends on the productivity of agriculture. Hence it plays a crucial role in the field of agriculture. There are both bacterial and fungal diseases forplants which can destroy the whole crop like Anthracnose, mosaic, leaf spot and downy mildew and many more diseases. In traditional method plant disease is identified by using naked eye. Even-though the farmers detect disease by naked eye, it is difficult to distinguish it and it leads to reduction and loss of huge quality and quality of production. So segmentation method is used in disease detection.

In this paper, detection of spinach leaves disease is done by using neural network classifier. Figure 1 shows the proposed diagram of disease detection. First, the image is captured, followed by pre-processing to

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improve the intensity of image, then the required region is being generated using initial active location. Further, it is being segmented using Active Contour Location. Histogram image feature Oriented Gradient (HOG) is used for extraction. Neural Network classifier is used to classify the image as disease or non-disease.

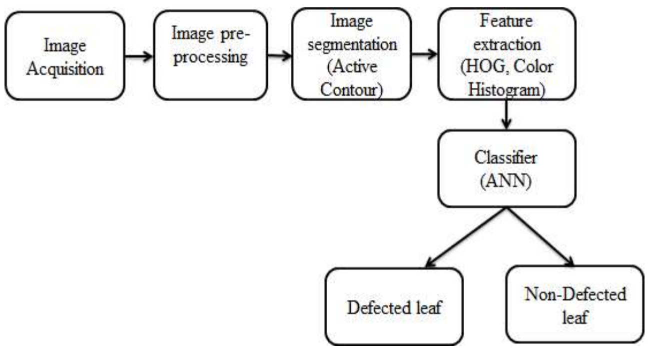

Fig 1. Block diagram of disease detection

2.1 Image Acquisition

The first step is image acquisition stage. Spinach leaves images are captured using the camera. . The captured images are in digital form. After capturing the image, different methods of processing is done in orderto avoid errors.

2.2 Pre-Processing

The Pre-processing is done by histogram equalization technique. For segmentation process the image is needed toimprove the image intensity so that the image is clearer thannormally appear. This process is done by using contrast enhancement. The color conversion is given by,

$$f(x)=0.2989*R+0.5870*G+0.114.*B \qquad (1)$$

This technique is used to spread image intensities on the collected image in order to intensify the detection of spinach illness. This method is also used in this instance to extend the range of intensity and enhance the contrast of the image that was obtained. This technique also draws attention to the background and foreground images. The process of histogram equalization is simple to use.

The technique used for adjusting image intensities is nothing but histogram equalization technique which is given by,

$$P_n = \frac{\text{number of pixels with intensity } n}{\text{total number of pixels}} \qquad (2)$$

Where, P denotes the normalized histogram with possible intensity

The equalized image g is defined using

$$g(i, j) = floor(L-1) \sum_{n=0}^{f(i,j)} P_n \qquad (3)$$

Where, floor () rounds down to the nearest integer

f= image represented as a m_r by m_c matrix of integer

Consider the given image as 'x'. The probability of a pixel level 'i' in the image is given by equation (4),

$$P(i) = \frac{ni}{n} \; 0 \le i < L \qquad (4)$$

Where 'L' represents the total number of grey levels in the image;

'n' represents the number of pixels that occurred in the image. Then the cumulative distribution function of P(i) isgiven by using equation(5).

$$cdf(v) = \sum_{i=0} P(j) \qquad (5)$$

Then calculate the intensity values by using equation(6).

$$h(v) = round\left(\frac{cdf(v) - cdf\ min}{(M*N) - cdf\ min} * (L-1)\right) \qquad (6)$$

Where cdf(v) be the cumulative distribution function; cdf min represents non-zero minimum value. By using this image gets enhanced.

2.3 .Active Contour Segmentation

Active contour segmentation is used after pre-processing segmentation. Floyd and Steinberg apply a filter to the image before beginning the segmentation process in order to enhance the overall perception of the image. By allowing itself to settle in an object border, the Active contour, also known as snakes, segments an object under the guidance of constraint forces. Energy minimization is the predetermined requirement. Additionally, it may divide a picture into its background and foreground curves. The snake's movement represents the process of minimizing energy. In active contour segmentation, two different types of energies are involved: internal and external. In order to characterize the outline shape and all elements of its own positioning of contour on the gradient image taken into account of its lines, both are computed for internal and exterior snake points energies. In order to advance the model toward the object boundary, the external energy is defined. The energy regulates the curve's movement to comprehend the region. Masking image is the first step in active contour segmentation. The initial contour location is represented by the color white, which is a binary. The segmentation results obtained are more precise and faster when the starting contour position is used.

Active Contour segmentation is defined in equation (7), The energy minimizing function is defined in equation (8) respectively.

$$v(s) = [x(s), y(s)], \quad s \in [0,1] \qquad (7)$$

where,

v(s) - energy minimization function

x(s),y(s)- time derivatives

The internal energy is both smoothness continuity of the contour

$$E_{internal} = E_{cont} + E_{curv} \qquad (8)$$

Where, E_{cont}- Energy that forces the contour to be continuous.

E_{curv}- Energy that forces the contour to be smooth.

Morphology is a powerful set of tools for extracting features in an image. We implement algorithms like Thinning thickening skeletons etc. The morphological operation which is sensitive to certain shapes can be constructed easily. Morphological operations mainly involve two processes such as dilation and erosion. Morphological opening examined as erosion followed by dilation and closing is examined as dilation followed by erosion. The operations are well suited to process the binary image and gray scale images. Region props are used to measurHOGe properties of image regions. It returns the measurements for the set of properties specified by the properties for the each connected components Stats is Structured array containing a structure for each object in the image.

2.4 HOG feature Extraction

For object detection Histogram Oriented Gradient (HOG) is one of the methods of feature extraction is used. This feature extraction counts the number of cells occurred in each image. Then compute HOG features for the selected ROIs and compare horizontal and vertical of the image.

$$\text{Gradient}, A_f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} \qquad (9)$$

Where, G_x computes x-gradient matrix using convolving with mask

G_y computes y-gradient matrix usingconvolving with mask

The magnitude and orientation is given by

$$\text{Magnitude}, \square_f = \sqrt{(G_x^2 + G_y^2)} \qquad (10)$$

$$\text{Orientation}, \ \alpha(x,y) = tan^{-1}\frac{G_y}{G_x} \qquad (11)$$

Then the image is split into equal cells of 8×8 pixels and block size 16×16. Enumerate a nine bin histogram for eachcell and normalize the histograms with block of 2×2 cells.

$$f = \frac{v}{\sqrt{(||v^2||) + 0.01}} \qquad (12)$$

Where, v is the non-normalized vector containing all the histogram in a given block.

Then gather all the normalized histograms into an individual vector

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2.5 Color Histogram

After HOG feature extraction, color histogram is used which is a portrayal of dispersal of color in an image. Herefirst convert the captured image into HSV image. Then quantize the HSV image into give formula,

$$H=\begin{cases} 0 & h\in[316,360] \\ 1 & h\in[1,25] \\ 2 & h\in[26,40] \\ 3 & h\in[41,120] \\ 4 & h\in[121,190] \\ 5 & h\in[191,270] \\ 6 & h\in[271,295] \\ 7 & h\in[295,315] \end{cases} \quad (13)$$

$$S=\begin{cases} 0 & s\in[0,0.2) \\ 1 & s\in[0.2,0.7) \\ 2 & s\in[0.7,1] \end{cases} \quad (14)$$

$$V=\begin{cases} 0 & v\in[0,0.2) \\ 1 & v\in[0.2,0.7) \\ 2 & v\in[0.7,1] \end{cases} \quad (15)$$

Where, H-Hue represents the appearance of color
S=Saturation represents the dominance of that color
V=Value dimension represents the brightness

2.6 Neural network classifier

Then classify the selected ROIs as defected and non- defected leaf using neural network classifier because it gives a solution for complex problems. The method used to train the artificial neural network is back propagation algorithm.

III. RESULTS AND DISCUSSION

Diseases are detected using the process of morphological opening and closing operations followed by region propping. The images are read and are subjected to segmentation. The preliminary step is image acquisition in which the images are captured.

Fig 2:. Input image

To improve the image for segmentation, preprocessing is applied. In most image processing applications, pre-processing is done, notably prior to segmentation. This phase involves applying contrast enhancement to the input to make the image appear sharper than it usually does.

The histogram equalization technique is used to enhance contrast. Here The process of histogram equalization is utilized to enhance the contrast of illness images by extending their intensity range. The intensities are spread by this adjustment.

Fig 3:.Contrast Enhancement

Here, the images are segmented using active contour segmentation. The maximum n iterations is segmented in an image.

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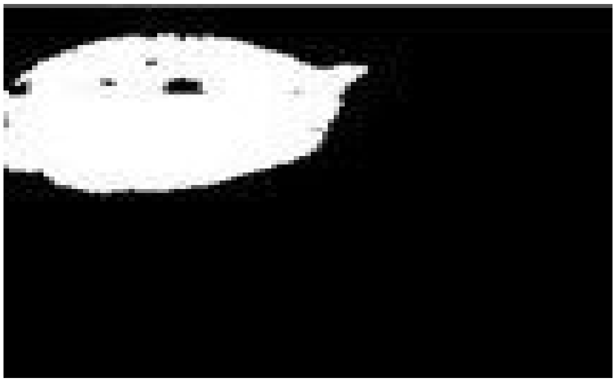

Fig 4: Active Contour Segmentation

Morphological operation is used to eliminate unwantednoise such as fog, mist and much more. In this image both morphological closing and morphological opening is done.In figure 5 it performs morphological closing on the segmented image. When it removes all connected all connected components fewer than p pixels. This is known as area opening. The connectivity for this image is 50.

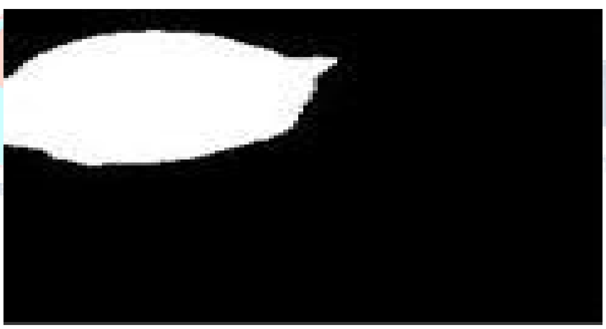

Fig5: Morphological closing

HOG feature extraction is performed on detected leaf todecompose the image into small squared cells and computes HOG on each cell.

Fig 6:.HOG Visualization

The segmented image is converted to HSV image and then quantised.

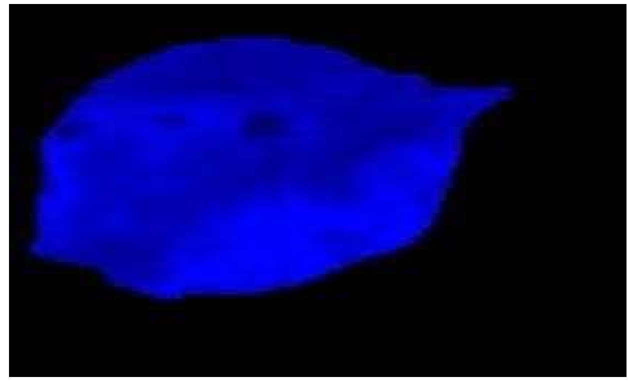

Fig7:. HSV image

In this step the properties strings are given as ‘all’, hence area, centroid, bounding box, eccentricity etc. are computed which is shown in figure 8. The structured array used here is ‘STATS’. The field of structured array denotes the different measurements of region. In this figure 8 the actualnumber of pixels in the region is taken as true positive value.

stats

1x1 struct with 23 fields

Field	Value
Area	3707
Centroid	[44.3653,43.2236]
BoundingBox	[7.5000,11.5000,79,64]
SubarrayIdx	1x2 cell
MajorAxisLength	77.8384
MinorAxisLength	61.1919
Eccentricity	0.6180
Orientation	21.1976
ConvexHull	63x2 double
ConvexImage	64x79 logical
ConvexArea	3839
Image	64x79 logical
FilledImage	64x79 logical
FilledArea	3707
EulerNumber	1
Extrema	8x2 double
EquivDiameter	68.7015
Solidity	0.9656
Extent	0.7332
PixelIdxList	3707x1 double
PixelList	3707x2 double
Perimeter	227.1820
PerimeterOld	239.2376

Fig 8: Computed property strings values

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IV. PERFORMANCE ANALYSIS

The performance of the disease detection is analyzed and the information regarding the performance of individual, group etc., are collected. The images chosen for performance analysis are shown below. Eight images areused as test images. The images are of size MxN where the M and N can vary. The performance does not change even if the size of the images varies. The images used as test images are shown in Figure 9

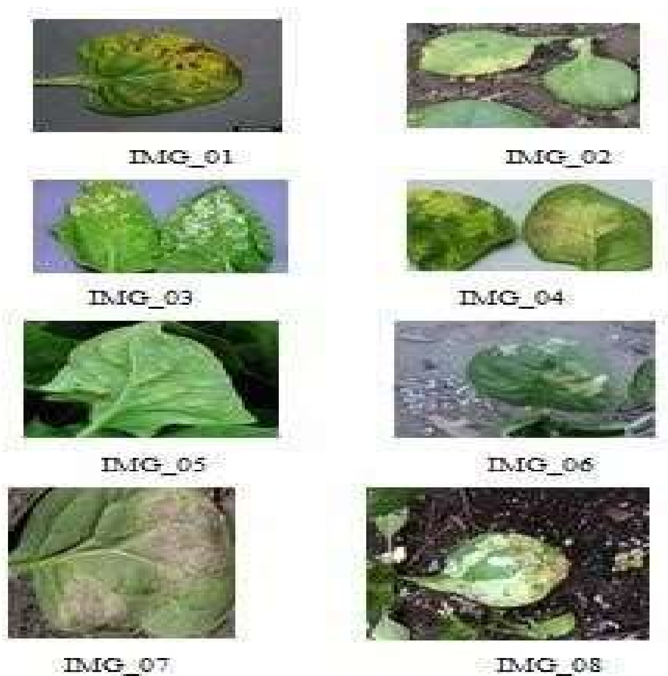

Fig 9: Test images

Accuracy measures the proportion of excellent and poor leaves those are selected correctly to the total number of excellent and poor leaves.

$$ACC = \frac{(TP + TN)}{(TP + FP + FN + TN)}$$

Where,

TP represents the number of True Positive value

TN represents the number of True Negative value

FP represents the number of False Positive value

FN represents the number of False Negative value

Table 1 shows accuracy values using artificial neuralnetwork

Images	No of True positive(TP)	No of True Negative(TN)	No of False Positive(FP)	No of False Negative(FN)	Accuracy (ACC)
IMG_01	6965	10	300	5	95.8%
IMG_02	3635	25	100	50	96.06%
IMG_03	5781	250	125	75	96.7%
IMG_04	4192	0	75	25	97.6%
IMG_05	12425	75	35	28	99.4%
IMG_06	4057	25	25	5	99.2%
IMG_07	31922	15	50	25	99.7%
IMG_08	7964	0	25	5	99.6%
			Average		98.7%

From the above table, it can be proved that the artificial neural network gives fine result with the accuracy of 98.7%. Hence this method can used to detect the spinach leaves disease and can be used in many image segmentationapplications.

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V. CONCLUSION

The Early Detection of Diseases in Commonly Used Spinach Leaves Techniques, specifically for detecting diseased spinach leaves ,Demonstrate promising potential.CNNs which are a Type of Deep Learning algorithm is specifically designed for image analysis,Through use of large datasets for labelled images ,CNNs can learn to recongonise the pattern and features indicative for different diseases , enable them to make accurate predictions. The project mostly extracting the features like shape and colour using CNN.Diseased Detection with the proposed features will be obtaining the Diseased and Non-Diseased Spinach Leaves using the CNN algorithm.

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