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PLANT DISEASE RECOGNITION USING OPTIMIZED IMAGE SEGMENTATION TECHNIQUE

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Abstract- The economy of any country is highly dependent on agricultural yield. In India, agriculturalists have a great variety of crops. Necessary attention and appropriate care are essential; failing to do this will cause harmful effects on plants and subsequently affect the quality and quantity of the production. Discovering the infections in the plant is the first step to prevent such harmful effects. By taking the images of plants, extraction of disease parts and their identification can be done with the help of automated methods. In the pre-processing stage, Convolution Neural Network (CNN) denoise method is used. CNN is preferable to pre-process the images compared to the other filters such as Median and Discrete Wavelet Transform (DWT) filter. The Image Segmentation technique extracts healthy and unhealthy parts of the plant leaf to recognize the disease present in the image. In this work, Duck Search Optimization-based Image Segmentation (DSOIS) is proposed to segment the healthy and unhealthy parts of the images. Experimental results show that the proposed scheme attains 97% accuracy, which is far better than all other techniques. The proposed technique has a significant performance advantage over other state-of-the-art methodologies, according to the empirical findings. According to the study, such disorders cannot be identified and detected manually. This work discusses about image segmentation methods and several pre-processing techniques. In terms of plant disease identification, the proposed method shows tremendous potential and offers a fresh perspective on quickly identifying photos of plant illness.

Keywords: Image Segmentation, Particle Swarm Optimization Based Segmentation, Convolution Neural Network, Duck Search Optimization Based Image Segmentation.

1. INTRODUCTION

India is a highly cultured country where farming is the primary source of income for almost 70% of the population. Choosing appropriate crops for their soil and identifying the suitable pesticides for their crops are challenging for farmers. Infections in crops will reduce productivity.

Computer Vision Systems (CVS) is established for discovering weeds, categorizing fruits, ordering grains, identifying foodstuff, therapeutic herb recognition, etc. All of these apps use digital cameras to capture images, which are then processed to extract significant information for future analysis [1]. Identification of plant diseases is quite exciting and at the same time, more knowledge is needed in this process. Its symptoms could notify most plant diseases. The indicative procedure (i.e., identification of symptoms and signs) is fundamentally visual and necessitates intuitive decision-making and scientific approaches [2].

Experts use naked eye inspection to detect plant diseases, which has long been the standard method of doing so. Huge farms require a large team of experts and constant monitoring of plants, which costs a lot of money. Farmers in certain countries lack the resources or even the knowledge to consult specialists, which drives up the cost and length of time associated with doing so [3]. Large fields of crops can be monitored effectively with the technique described here. It's quicker and less expensive if illnesses can be detected automatically by looking for symptoms on plant leaves. Automated process control and inspection as well as robot navigation can all be achieved using machine vision.

The images of symptoms and signs of herb infections are used comprehensively to develop depiction of plant infections are precious in research, teaching, diagnostics, etc. Plant pathologists combine digital images [5] using familiar tools to analyze plant sicknesses. So far, the occurrences of diseases in the pants are carried out manually. However, it is a costly approach for an agriculturalist to access a professional in this domain, hence it is vital to find the symptoms of diseases in the plant without human intervention as soon as they look in plants. The massive loss could be prevented if such detection is done in the initial phase. Agriculture will become smarter when it functions with the support of technology [6].

The most concern of researchers is an analysis of plant infections without any level of human involvement. Many scientists establish numerous significant technologies combining ideas from image processing and artificial intelligence earlier to handle this scenario.

On the other hand, hardware procedures like intelligent robots are used to examine the infections in plants. The main task of a smart robot [7] is to capture pictures of leaves with the help of a web camera. Based on the images captured, the smart robot will construct a model to identify the disorders in plants. There are some disadvantages in this approach too. If the picture is not clear and precise, it will harm its results. So, it is evident to propose a software-based approach [8] and [9] to detect diseases.

2. BACKGROUND STUDY

In our nation, a standard 70-30 policy exists. That is 70 percent of people are in the farming division and the other 30 percent are attached to this division in other ways. Agriculture [10] is mostly affected by two reasons. The primary factor is a natural disaster and the other one is an organism that causes diseases in plants. So, there is an urgent requirement to discover such organisms which cause infections. Conventional methods are not much effective. Experts of this field have suggested various image processing [11] for finding the ailments in plants. Some irregular patches or spots indicate the diseases in plants.

Betel vine leaf rot infection detection is expected to be aided by an image processing algorithm [12]. One of the most important aspects of plant science research and application is the study of herb characteristics. Leaf rot illness detection for betel vine leaves has been done using a variety of methods (Piper BetelL.). Time complexity is greater with conventional methods than with newer methods. Plant exterior diseases are expected to be detected using vision-based approaches [13]. The hue of the degraded leaf region is used to indicate the presence of leaf rot infection. Once the degraded patch was isolated, experimental plant characteristic data was used to infer a portion of the decayed leaf. Agriculturalists and scientists are looking for a system that is both efficient and cost-effective.

Plant disease is a major challenge to maximizing productivity and food value. Insecticides are used excessively due to incorrect plant infection analysis. An algorithm is suggested to discover Soybean infection and its rigorousness [14]. A clear focus is given on the categorization and septic part approximation of various soybean diseases. An attempt has been made to apply the Image augmentation technique for improving the quality image. Then k-means separation procedure is applied to isolate the diseased group from the leaf. Also, using NN has helped the experts achieve 93.3% of accuracy [15].

Diverse classifiers are proposed to categorize such as SVM, KNN, ANN, etc. Various image processing methods are described to know about the primary discovery of infections in plants. The chief motivation of this attempt was the serious investigation of various plant ailment separation methods [9]. In the upcoming years, the pros and cons of all these methods were briefly discussed and concluded with the finest procedures to overcome the errors of different techniques.

Undoubtedly, farming is the strongest pillar of our nation's economy. Most of the rural region people are being employed because of agriculture. It also pays a significant portion of GDP. The scattering of infections can be controlled if it could be identified at the very first stage. Leaf inspection is considered a unique method in plant infection analysis. Computer vision and ML [16] are budding areas that make computers identify and comprehend information from digital descriptions. A forecast model is projected for plant sickness discovery and categorization. The unstructured image of a leaf is pre-processed, classified, and analysed. The input images are classified using ML classifiers [4]. Compared to existing classifiers, the proposed prediction model uses a random forest.

Syndrome discovery in the arena of farming is significant. There is a possibility of getting multiple infections in the plant; this makes agriculturists struggle a lot to get rid of this. Leaf spot is the chief ailment in the crop. Using image processing procedures will help to point the spotted areas in the plant. Infection discovery [17] can be completed in four phases, image acquirement, image dissection, attribute mining, and categorization. K-means is utilized to segment the input images. Certain attributes such as dissimilarity, homogeneousness, texture, shape is mined. These mined attributes are considered to be input elements for classifiers. NN classifier [18] is used to identify the infection in cotton and tomato leaves and achieved better results.

A sickness in plants depreciates production and causes financial harm. In recent years, the field of plant disease identification has become more and more popular as a means of keeping control on the vast expanse of agricultural land. Agriculturalists used to go through boundless problems in transferring from one infection control strategy to another. Physical observation [19] of specialists is the outdated method implemented in practice to discover and identify plant ailments. A simple analysis about plant leaves infection identification is carried out, which would ease improvements in farming. Prompt information on crop conditions and illness discovery can enable infection control mechanisms. Considering this procedure will increase the yield of crops.

A brief study was conducted in which digital image processing is being used to find, measure, and categories plant deficiencies. While infection symptoms might appear in any plant, only methods that detect signs in leaves are studied. There are two main reasons [20] behind this, most of the infections in plants occur in leaves; image processing techniques are quite efficient in dealing with images of leaves.

Finding out the deficiency in crops is the crucial task to precluding the damages in the income and capacity of the agronomic product. Investigations of plant infections point to the analysis of visually noticeable spots on the plants. Essential to the viability of farming is keeping an eye on the health and detection of disease in herbs. In order to physically monitor plant infections, it is extremely difficult. It necessitates a significant amount of work, the expertise of plant disease specialists, as well as the intricacy of time management.

For the time being, image processing is employed to identify plant diseases [21]. The use of pictures of leaves as a deficit detection tool is described in detail. Microbes, such as germs, fungi, and other microorganisms [22], can cause a variety of harm to plants. In terms of agricultural losses, this is an enormous problem. This urgent problem necessitates the use of a proper approach.

3. PLANT LEAVES DISEASE DETECTION FRAMEWORK

The design of a plant disease detection framework is a three-step process. It comprises Image Acquisition, Pre-Processing, and Segmentation. The suggested framework is depicted in Figure 1.

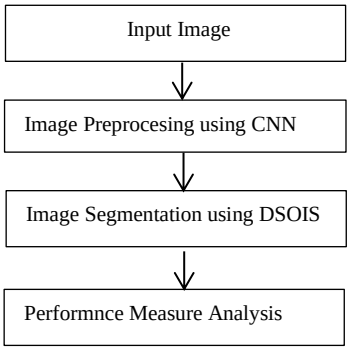

Figure 1. Plant disease detection phases

3.1. Procedure for Proposed Work Flow

1. Acquire Plant leaf image taken by Digital Camera.
2. Pre-process the Image using CNN to remove noise from the Image
3. Apply Duck Search optimization-based Image segmentation Algorithm on Plant leaf images to segment the ROI.
4. Post-Processing to enhance the segmentation result.
5. Recognize the leaf has disease or not

3.2. Image Processing

Before extracting the relevant features from an image, it is evident to pre-process it. The phases in image pre-processing are cropping an image, image transforming, and image enrichment. The image cropping process focuses just on the affected part of the leaf, ignoring the rest of the image. Once the infected area is pointed, it could be transformed to grey levels. In this procedure, the outliers are eradicated from the taken image to improve the quality. In this work, three different filtering approaches have been used to accomplish the goal. There are three of them: the Median filter, the DWT filter, and the CNN denoise.

3.2.1. Median Filter

It is one of the simplest approaches in linear filtering scheme. Also, it is very easy to use the method of levelling images, which means minimizing the amount of intensity difference between one pixel and the next [23].

$$x[a,b]=\frac{1}{R}\sum_{(c,d)\in N}^{n} f[c,d] \quad (1)$$

The R denotes entire quantity of pixels in the neighborhood N. For example, considering a 3×3 neighborhood about [a, b] produces [23]:

$$x[a,b]=\frac{1}{9}\sum_{c=a-1}^{a+1}\sum_{d=b-1}^{b+1} f[c,d] \quad (2)$$

Now if x [a, b] = 1/9 for every [a, b] in the convolution mask, the convolution process decreases to the local averaging execution. This effect indicates that a median filter can be employed as a convolution procedure with identical loads in the convolution mask.

3.2.2. DWT Filter

The Discrete Wavelet Transform is a multipurpose signal handling tool for multi-resolution illustration of signals based on wavelet disintegration. A digital image is decomposed into 2 stages in DWT. It has a dual set of tasks. Scaling activities are taken care by low pass and wavelet tasks are accomplished by high pass filters respectively. The below steps are utilized to apply wavelet transform:

1. Acquire the gray scale digital image of 256×256-pixel rate.
2. Make use of appropriate MATLAB code for DWT.
3. Design stems function for the input and DWT images.
4. Relate various wavelet transforms for the original input image.

3.2.3. CNN Based Denoising

Convolutional Neural Networks (CNN) signifies a remarkable technique for adaptive image handling. In image handling, filtering outliers to restructure a great quality image is a significant effort for additional image handling mechanisms such as dissection, discovery, analysis and monitoring, etc. Convolutional layers of the CNN model help to carry out the filtering process of input images. The benefits of considering the CNN model are that it always augments loads of convolution core throughout network preparation. After network preparation, two models can be obtained that are related to screen Gaussian outliers and salt-and-pepper outliers. The denoising through the CNN model attains greater results from the efficiency of filtering tasks.

The convolutional filters are fixed at 3×3 and the pooling covers are removed. So, the reachable area of CNN at r must be (2r+1) (2r+1).

A CNN's accessible area dimension is fixed to 35×35 with a noise level of 17, Gaussian denoising is used.

The residual learning formulation is: $x = y$-R(y). So, we learn R(y).

To be specific, there are three types of layers.

(i) Conv+ReLU: For the first layer, 64 filters of size 3X3Xc are employed to construct 64 feature maps, with each filter having a size of 3. Image with grayscale is equal to one, whereas image with colour is equal to three.

(ii) Conv+BN+ReLU: A total of 64 filters of size 3×3×6×64 is applied for layers 2 to (D-1), and batch normalization is applied between convolution and ReLU layers.

(iii) Conv: For the final layer, 3×3×64 c filters are used to re-create the output.

Before convolution, a basic zero-padding method is utilised to ensure that no boundary artefacts are generated.

With convolution and the use of ReLU, CNN is able to gradually isolate visual structure from noise. The CNN team is trained from beginning to end. Both Residual Learning (RL) and Batch Normalization (BN) are capable of achieving the maximum PSNR.

The median, DWT, and CNN denoising filters' performances are measured using PSNR, RMS, and Time Period, among other characteristics. Compared to the other two denoising methods, CNN is the most effective.

3.3. Image Segmentation

It is the process of dividing a digital image into a number of smaller pieces or blocks. The basic goal of segmentation is to develop and adjust the illustration of a picture as much as possible into something more important and less challenging to scrutinize.

- Threshold Based Segmentation (TBS)

It is a familiar type of image thresholding technique. Image thresholding is the simplest variety of image segmentation since it divides the image into two sets of pixels, white for foreground and dark for background

Image thresholding can be categorized as the local and global techniques. Global technique, the solo threshold is utilized globally, for the entire image. Local technique certain features of images may be considered to pick a dissimilar threshold for various image regions. OTSU comes under the category of global image thresholding procedure. The steps in the OTSU approach are given below:

1. Progress the input image
2. Acquire image histogram (scattering of pixels)
3. Calculate the threshold value TH
4. If saturation value is more than threshold value TH, update the image pixels into white, if not black.
5. Conversely, the chief drawback of this approach is difficulty in computation and it takes more time to process the image.

3.3.1. Region-Based Segmentation (RBS)

This method generates segments by distributing the image into several parts with related features. This method primarily examines the input image's minor or significantly more significant portions for specific seed points. Subsequently, definite methods are implemented to enhance more pixels or diminish them. Henceforth, there are 2 simple procedures based on this technique.

3.3.2. Region Growing

In this technique, the process starts with a smaller group of pixels and accumulates or repeatedly combines them based on some similarity measure. So, it is claimed to be a bottom-up approach. Region growth technique initiates with randomly chosen seed pixel in the input image and execution continues by comparing it with nearest pixels.

If similarity exists during this comparison, it is attached to the seed pixel thus, the dimension of the selected region grows tremendously. Once the threshold value is reached, there will not a scope for growing further. At this point, the algorithm selects alternate seed pixels and the process continues again. Region growing procedures are desirable for images with more outliers, but the detection of edges is cumbersome.

3.3.3. Region Splitting and Merging

It is splitting deals with repeatedly dividing an image into several sub-sections that do not possess identical features. Merging denotes joining the nearby areas that are slightly identical to each other. Unlike region growth, this considers the whole image for processing. This is quite similar to the divide and conquer strategy.

As of now, only the splitting process is over. To get a complete result, merging has to be performed. At the end of the splitting phase, several identically noticeable regions dispersed in the images. Now, merge process comes into the picture. After every split, the comparison process will happen by considering the nearby regions. If necessary, based on the identical features, merge operations take place. Over segmentation is the major problem of this approach. If the image has more outliers or the intensity deviation is present, it is difficult to differentiate the shielding of the real images, thus consuming more time and power.

3.3.4. Edge Based Image Segmentation (EBS)

Image intensity discontinuities are critical for edge-based segmentation algorithms. Identifying the boundary between these two regions is the primary goal of the method. Several edge detection techniques are studied in the literature that may be used to identify the borders of a region. Noise Environment and Edge Structure are three factors to consider while deciding on an edge detector. Most often used edge detection techniques are LoG segmentation and Canny segmentation, Sobel segmentation and Kirsh-Prewitt segmentation Roberts's segmentation, Robinson segmentation, Marr-Hildreth segmentation, based on discontinuity. First-order derivative operators, such as the Sobel, Prewitt, and Using a two dimensional different geometric, Robert's operators can identify areas of high spatial frequency in an image, which correlate to the image's edges. Using the mask, the Laplacian of Gaussian (LoG) Operator implements the Laplacian function. Canny Operator: It finds the edges from the noisy image without loss of information present in the image.

3.3.5. Particle Swarm Optimization Based Segmentation

This algorithm initiates by employing a 3×3 low pass filter to eradicate outliers from a required image. Every element in the swarm is arbitrarily set to have k saturation points. Then, the required image is thresholded and separated into sections using the saturation points of every elementary particle distinctly.

3.3.6. Duck Search Optimization Based Image Segmentation (DSOIS)

The proposed technique is a meta investigative enrichment method to find the ideal solution for a problem. This is an alternate approach to handle specific areas of the input image. The pre-processed image is utilized for segmentation. The pre-processed picture is applied as input to Duck Search optimization-based Image segmentation.

Let first review the interpretations from ducks' searching behavior.

Task 1: A duck population is a group of ducks. Each group's ducks optimize food seek movement.

Task 2: Height is an important factor in determining hunting spots.

Task 3: Ducks normally follow their local guide.

Task 4: Several jobs later, ducks arrive to share with their local associate's exploitation, places, and lots of food foundations.

Task 5: If the food supply is insufficient for the ducks to survive, they will move.

Task 6: Produce the optimal solution based on the end criteria.

It operates on a five-stage system.

Phase 1: Initialization of the populace

Phase 2: The second stage is characterized by growth and reproduction.

Phase 3: Exclusion from a competitive environment

Phase 4: Calculation of robustness in the fourth stage

Phase 5: Identifying the most optimal option D_{gr} denotes the greatest duck;

D_{t1} and D_{t2} are two transitory ducks in duck group i.

Random() is a function to initialize the parameters randomly.

Greatest() is a function to find the optimum value.

Ducks' fitness is calculated using the Robustness() function.

The competitive system is implemented using the functions Remunerate() and Reprimand().

There are n ducks in this group, thus n_i is the number of ducks, and Pi is the survival rate of the ith duck.

```
Initialize Dgr= Dt1= Dt2= Φ;
Dgr=Dt1;
Do {
Dt1= random();
Dt2= random();
remunerate (Dgt);
If robustness (Dt1)<=robustness (Dt2)
{
Dgr= Dt2;
remunerate (Dgt);
}
rebuke(Dgt)
 }while end condition is satisfied;
Return Dgt
```

4. RESULTS AND DISCUSSION

Finding out the deficiency in crops is the crucial task to precluding the damages in the income and capacity of the agronomic product. Investigations of plant infections point to the analysis of visually noticeable spots that appear on the plants. Herb health monitoring and infection detection are critical for profitable farming. Physically screening plant diseases is extremely difficult.

It necessitates a significant amount of labour, professionals in plant ailments, and time intricacy. The experiments are carried out using MATLAB. Plant samples with bacterial infection are used as input data for illness. The original leaf image is pre-processed. Then the healthy and unhealthy part is extracted using Duck Search optimization-based Image segmentation. This study compares the accuracy of segmentation results with TBS, RBS, EBS, and PSOS methods.

Figure 2 depicts a leaf that has been affected by Bacterial Blight disease taken as input for Experimental purposes. This image is also corrupted by noise. Figure 3 depicts the Grey Scale Image of the Input Image.

Figure 2. Input image infected by Blight Bacterial

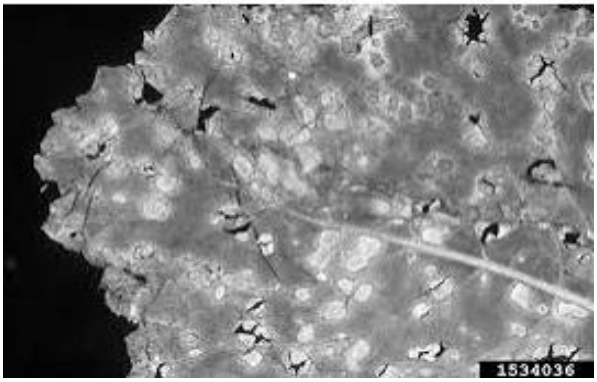

Figure 3. RGB image to Grayscale

Figures 4, 5 and 6 show the output images after applying the Median, DWT, and CNN filters to remove noise.

Figures 7, 8, 9 and 10 displays the afflicted part's segmentation of the Input Leaf for TBS, RBS, PSOS, DSSIS Segmentation, respectively.

Table 1 provides the efficiency comparison in the preprocessing stage. Figures 11 and 12 show that CNN offers 45% and 20.8% better Peak Signal to Noise Ratio (PSNR) than Median and Discrete Wavelet Transform, (DWT), respectively, and 45% and 27% better Root Mean Square (RMS) compared to Median and DWT.

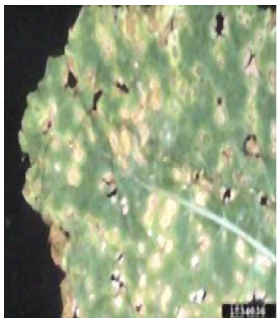

Figure 4. Output image median filter

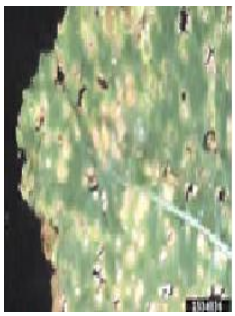

Figure 5. Output image DWT

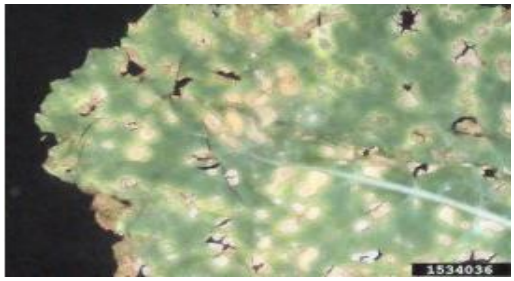

Figure 6. CNN output image

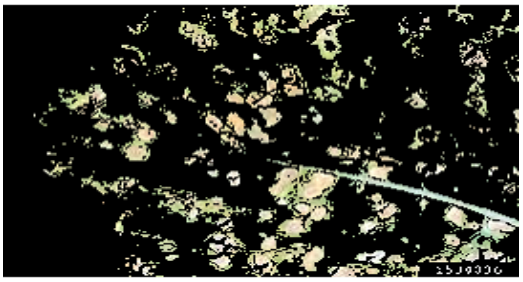

Figure 7. TBS segmentation

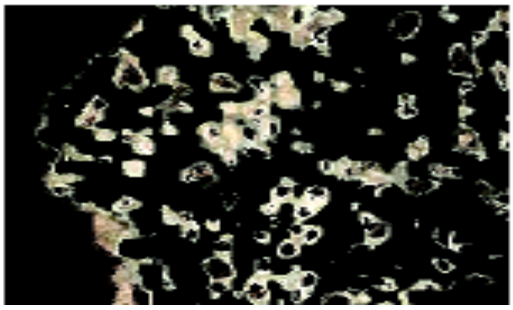

Figure 8. RBS segmentation

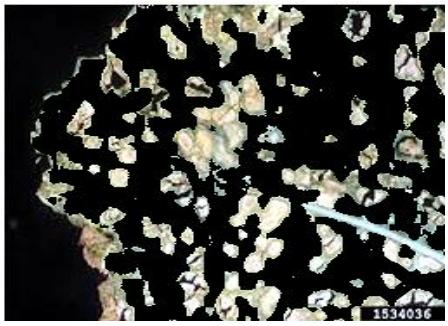

Figure 9. PSOS segmentation

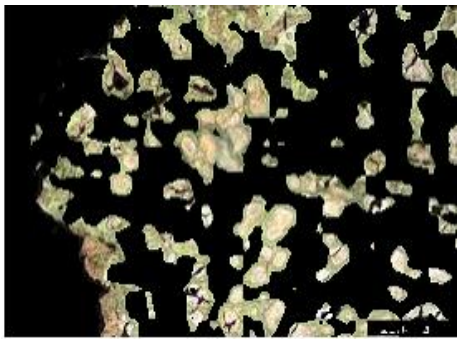

Figure 10. DSOIS segmentation

Table 1. Performance comparison in pre-processing stage

Image Quality Metrics	MEDIAN	DWT	CNN
PSNR	20dB	24dB	29dB
RMS	0.32	0.28	0.22

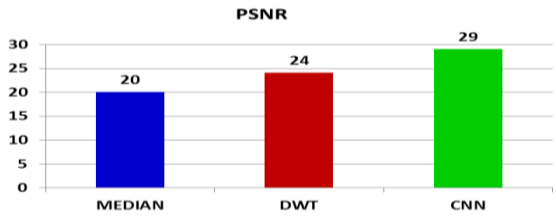

Figure 11. PSNR pre-processing

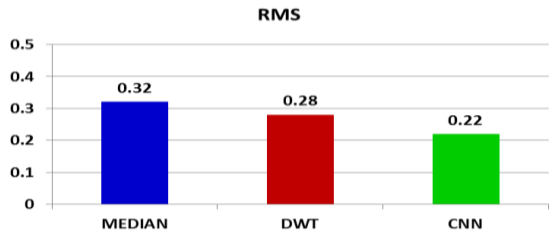

Figure 12. RMS pre-processing

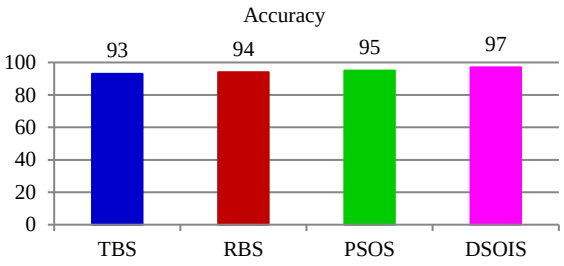

Figure 13. Accuracy for segmentation

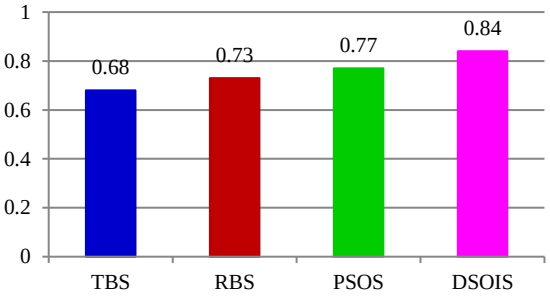

Figure 14. DSC for segmentation

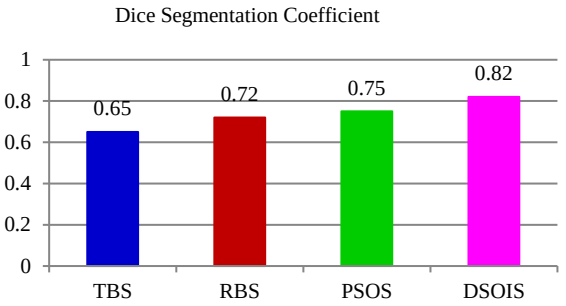

Figure 15. DSC for segmentation

Figures 13, 14 and 15 shows the Performance of Segmentation results with respect to Accuracy, Dice Coefficient for segmentation (DSC) and Jaccard Similarity Coefficient (JSC). Table 2, presents the performance comparison in the segmentation stage.

Table 2. Performance comparison in segmentation stage

	TBS	RBS	PSOS	DSOIS
ACCURACY	93	94	95	97
DSC	0.65	0.72	0.75	0.82
JSC	0.68	0.73	0.77	0.84

The experimental results suggest that the combination of segmentation and arrangement algorithms may be achieved efficiently for the purpose of plant leaves disease detection and identification. The diseased areas are efficiently taken from the plant leaf pictures using the augmented ANN segmentation technique, which results in a well-defined classification and resilience for the disease spot regions extracted. More importantly, CNN has a greater accuracy when compared with traditional approach, because the sickness characteristics are well recovered after segmentation, which reduces the complexity of feature extraction and prevents the influence of difficult contexts. Convolutional layers of the CNN model help to carry out the filtering process of input images. The benefits of considering the CNN model are that it always augments loads of convolution core throughout network preparation. In general, the suggested approach demonstrates great capability in recognizing and detecting plant diseases, and it introduces a novel concept for the fast identification of plant leaves disease data. The goal is to include it in a system that can detect a wide range of plant diseases automatically in the future.

5. CONCLUSION

The problem of plant disease identification is addressed in this paper, which is a major concern of farmers. Identification and classification of crop diseases using digital images are extremely important for improving the quality of plant production and reducing costs. In many fields, image segmentation technology is used to distinguish important targets from a complicated background. Image segmentation technology is used to extract useful targets from a complex background. The studies show that the detection of such diseases cannot be handled manually. So, various pre-processing techniques and image segmentation algorithms are discussed in this regard.

Experimental results have shown that the CNN denoising for pre-processing images produces promising results compared to other methods. In Image Segmentation, Duck Search Optimization-based Segmentation is proposed in this paper. Various evaluation parameters are utilized to check the performance of image segmentation algorithms. The proposed DSOIS approach for image segmentation yields better accuracy of 97%, which is better when compared to other existing techniques.

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