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A Deep Learning Approach Based Plant Leaf Disease Detection Using Soft Computing Techniques

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ABSTRACT: Plant diseases are most important factors as they result in serious diminution in quantity and quality of farming products. The financial system of India is highly depends upon the farming productivity. Therefore, it becomes compulsory to identify the plant disease at initial stage using their parts like roots, leafs, branches etc. If there is no appropriate care in this area, it can cause serious damage to plants and affects the quality, quantity and productivity of the relevant product in the farming section. For illustration, a disease called small leaf disease is a dangerous disease found in apple trees in India. In this research work, an automatic plant leaf disease system is developed by using deep learning approach along with the soft computing techniques. The procedure of detecting leaf disease in this work goes through various steps such as pre-processing, image segmentation, feature extraction, feature optimization and classification. The main problem in the plant leaf detection system is to extract a set of best and appropriate feature sets from leaf images. So in this work, these types of problem are overcome by using SURF (Speed up robust feature) descriptor and SURF returns the key points from the leaf images. But uniqueness of feature is less then; the extracted features are optimized by using soft computing technique such as GA (Genetic Algorithm), PSO (Particle Swarm Optimization) and SA (Simulated Annealing) to create a set of unique feature. By using appropriate fitness function with soft computing techniques, the unwanted features are removed and appropriate feature set of the leaf images are selected. On the basis of optimized feature sets of different types of images, CNN (Convolution Neural Network) is trained to classify the disease. In this paper, CNN architecture is used which is only applicable for CPU based system. At last of paper, the performance parameters of the system are determined followed by the comparison between existing soft computing techniques such as PSO and SA with proposed work (GA). It is observed that the accuracy of the proposed research is increased by 10.44% from PSO and by 24.69% from SA technique.

KEYWORDS: Image Processing, Plant, Leaf, SURF, GA, CNN, PSO, SA.

I.INTRODUCTION

In the recent world, plant diseases are foremost sources of food crisis and food uncertainty. The status of any country depends on its financial system, and most countries' economies depend on agricultural production. Production is affected by crop diseases. Plant diseases are a major obstacle to the loss of modern agricultural production [1]. Plant disease severity is an essential parameter for measuring disease levels and can therefore it become essential to detect disease at the initial stage. Plant disease detection become a vital area of research as because the production quality as well as the quantity. India ranks second in fruit production [2]. Agriculture is an important sector of the Indian economy because it accounts for 17% of GDP and provide employment opportunities for more than 60% of the population. Consistently, a large number of apples are shipped to all parts of the world. In India, agriculture is the main profession of mankind [3]. But because of the unconditional weather, plants often suffer from many bacterial, fungal and viral diseases. In order to control these diseases, an initial remedy must be taken. This test can help farmers to control agricultural as well as economic losses [4]. Plant disease symptoms can be analysed by several methods such as

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Vol. 6, Issue 2, February 2019

visible spectrum, light reflection, remote sensing, thermal imaging, and laser sensing. To offer great Product quality, it is important to find infected fruit [5].

In this research, an automatic apple leaf disease detection system based on feature extraction technique is proposed. To detect and classify the leaf disease, image processing is used that consists of several steps such as pre-processing, image segmentation, feature extraction, feature optimization and classification [6]. The main problem observed after studying various research papers regarding detection and classification of plant leaf is that the existing "plant disease detection system" are not used an appropriate feature sets from the leaf. To minimize this problem, SURF descriptor is used to extract the key points from the plant leaf [7]. There are another problems in the plant diseases detection system, that is, if the feature sets are not optimized then the possibility of error rate is more, so, to overcome the error rate optimization is a need with a novel objective function. To optimize the extracted feature sets, soft computing techniques [8] such as genetic algorithm, PSO [9] and SA techniques are used and the unwanted feature sets are eliminated, so that the accuracy of proposed work will increase. Thus for the extraction of features and to optimize the feature set algorithms such as SURF [10] and GA [11], PSO, SA respectively are used. Also, to classify the leaf disease, CNN is used as a classifier. On the basis of optimized feature set, CNN [12] trained the system and the architecture of CNN model for plant leaf disease detection system is given in figure 1. At last, the performance parameters are measured to verify the efficiency of proposed work.

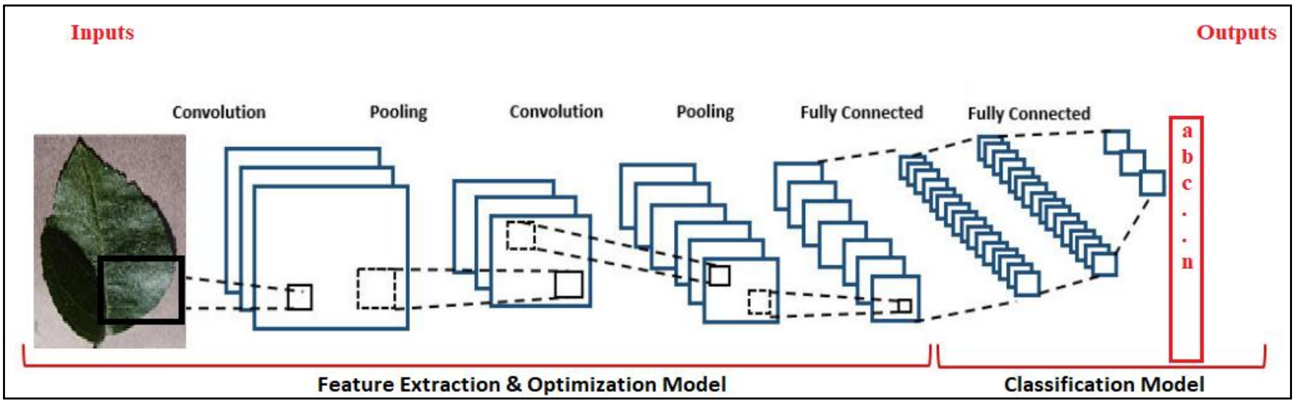

Figure 1: CNN model of Plant Leaf Disease Detection System

Above figure represents the CPU based CNN model for proposed work with different layers. The layers of CNN are given as:

CONVOLUTION MAP*:* In CNN, the convolution layer is a basic element and the objective of convolution is to extract features from the input image but in CPU based it is used for filtering the extracted feature by SURF descriptor. It consists of a group of learnable square filters which helps to find out the appropriate feature sets. Each filter is applied to the raw pixel values of the leaf image.

MAX-POOLING MAP*:* In the CNN architecture of proposed model, convolution layers are followed by sub-sampling layers and act as an optimization. Each sub-sampling layer act as a dimension reduction method which helps to reduces the size of the convolution maps, and introduces unique feature sets. A layer of max-pooling is an alternative of optimization but in this work we used optimization techniques separately to increase the chances of feature uniqueness. The output of max-pooling layer is passes to the classification model which is used as a maximum activation value and creates a structure of model.

CLASSIFICATION MODEL*:* In the CNN, within the classification step we use fully connected layers where each neuron provides a full connection to all learned optimized feature maps issued from the previous CNN layer. These connected layers are based on the activation function in order to compute the class's scores. The input of the classifier is a vector of optimized features resulting from the soft computing technique using fitness function and the output is a probability that an image belongs to a given class. CNN contains multiple neurons arranged in different layers. The neurons in the adjacent layers are connected to each other and help to carried out the data from one layer to another layer. These neurons learn how to convert inputs into corresponding output.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 6, Issue 2, February 2019

II. SIGNIFICANCE OF THE SYSTEM

The paper mainly focuses on how soft computing techniques in artificial intelligence can be applied to detect the diseases from plant leaf. The revision of literature assessment is covered in section III, and materials and methods with result is explained in section IV and section V discusses the Conclusion of this research with future trends.

III. LITERATURE SURVEY

Since the application of computer-based image processing technology to agricultural research has been started in the late 1970s, researchers have publicized that image processing technology can be successfully used as a disease detection system by [13] and [14]. Arivazhagan et al. [15, 2013] proposed a plant leaf detection system using SVM as a classification technique with an accuracy of 94 %. The experiment has been carried out on 500 leaves collected from 30 different plants in Tamil Nadu, India. Meunkaewjinda et al. [16, 2008] presented a grapes lead disease detection system using BPNN (Back propagation neural network) as a classification algorithm. The experiment has been performed on two kinds of leaf diseases namely scab, rust and normal leaf with 97.85 % of detection rate. Mokhtar et al. [17, 2015] presented tomato leaf disease detection system with the help of SVM as a classifier. SVM trained the system by using 200 infected tomato leaves and the disease is detected with accuracy of 92 %. Kamal et al. [18, 2015] proposed a palm oil leaf disease detection system that works in four different phases like image acquisition, enhancement of image, image clustering and classification using SVM approach. The system works to identify two most commonly palm leaf disease namely Chimarea an Anthracnose with accuracy rate of 97% and 95% respectively. Mengistu et al. [19, 2018] presented Coffee plat disease detection system by using BPNN along with decision tree. The experiment has been performed on total 9100 coffee leaf images. The accuracy rate up to 94% has been obtained when BPNN and decision tree techniques are used in hybridization. Kaur et al. [20, 2018] presented a rule based technique along with K-mean clustering approach to differentiate between healthy and diseased leaves.

IV. MATERIALS AND METHODS

This section describes the used algorithms for diseases detection from the plant leaf images. To detect and classify the "Apple Leaf Diseases", initially data is collected from the dataset named as *"Plant Village Dataset Master".* In the test dataset we are considering four diseases from which apple leaves are suffered namely Apple scab, Black rot, Cedar apple rust and healthy leaves.

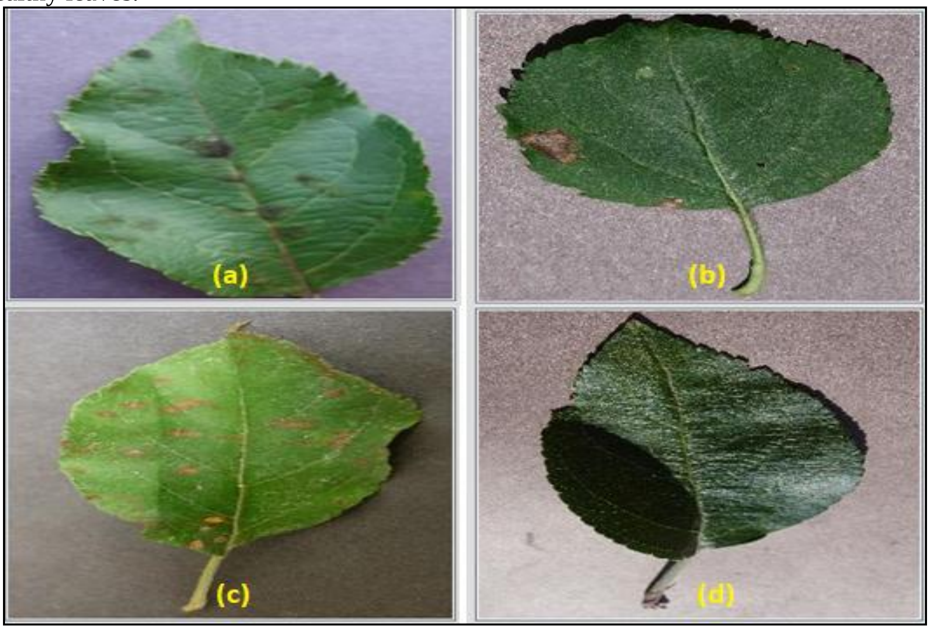

Figure 2: (a) Apple scab (b) Apple Black rot (c) Apple Cedar (d) Apple Healthy

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 6, Issue 2, February 2019

Above figure represents the different types of diseases which are applicable for apple. The stages that are followed to design an accurate apple leaf diseases classification system are explained below:

Data Acquisition: Initially, the apple leaf from the dataset has been selected and loaded.

Figure 3: Test apple leaf image

PRE-PROCESSING*:* This is the initial stage in which image enhancement is applied. Image enhancement is used to split the background and foreground of the test image.

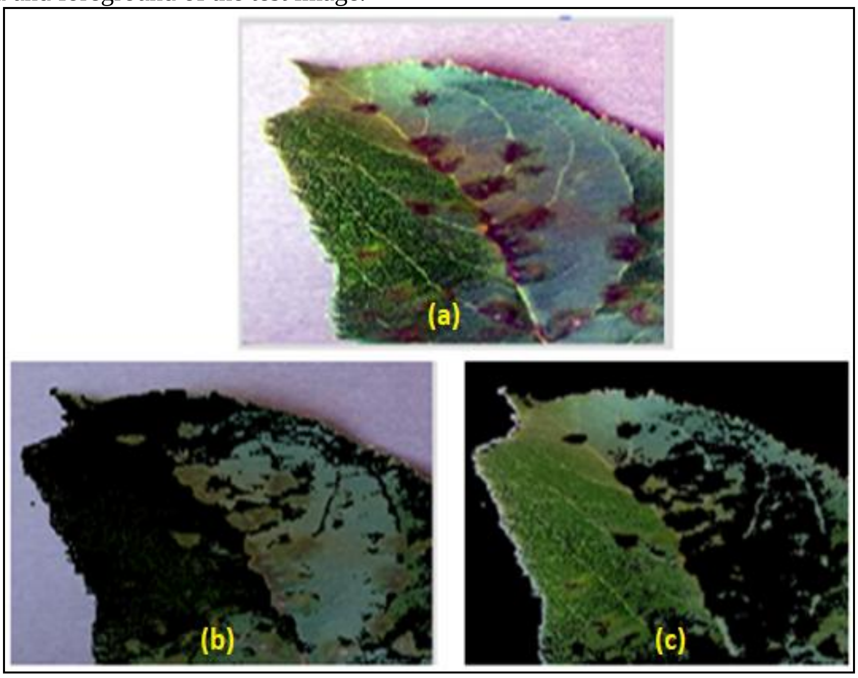

Figure 4: (a) Enhanced image (b) Background image (c) Foreground image

In pre-processing, leaf image to be enhanced using image enhancement process. For leaf image enhancement the algorithm used is written below:

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 6, Issue 2, February 2019

Algorithm: Image Enhancement Algorithm

Input: Original Leaf Image (I) of apple
Output: Enhanced Leaf Image
Calculate the dimension (D) of I
If D==3
I_Red=Red Part of I
I_Green= Green Part of I
I_Blue= Blue Part of I
Using equation (1)
for Clip Limit 1 → all
Red Enhanced=H_E (I_Red, P_{CL})
Green Enhanced = H_E (I_Green, P_{CL})
Blue Enhanced = H_E (I_Blue, P_{CL})
end
Enhanced Image=cat (3, Red Enhanced, Green Enhanced, Blue Enhanced)
else
for Clip Limit 1 to all
Enhanced Image= H_E (I, P_{CL})
end
end
Return: Enhanced Image
end

$$P_{CL} = P_{Clip} - P_{average} \quad \ldots\ldots\ldots \ldots\ldots (1)$$

Where P_{CL} is the pixels clip limit which is used to set the contrast limitation of an image

Segmentation Process: In this process K-mean algorithm is applied. K-mean technique is used to differentiate foreground image and background image. As the required image is foreground image therefore, by applying K-mean algorithm foreground image has been extracted.

Figure 5: Segmented image

The algorithm is defined below:

Algorithm: K-means segmentation algorithm

Input: Leaf Image and Estimated group
Output: Segmented Image
Initialize an estimated group
Calculate size of dataset [Row, Col]

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 6, Issue 2, February 2019

3 for i→1 to all Row
4 for j→1 to all Col
5if leaf image pixel distance (i,j)==Background
6 Cluster1=Background (i,j)
7 else
8 Cluster2=Foreground (i,j)
9 end
10 end
11 end
12 Returns: Clusters as Segmented Image
13 end

FEATURE EXTRACTION: To achieve only the desired features from the whole leaf image we are applying SURF as a feature extraction technique. This technique extracts only those parts of the leaf which is affected by disease. While feature extraction technique is applied on the segmented image that is on the foreground image, the disease's part of the leaf is highlighted as shown in figure below:

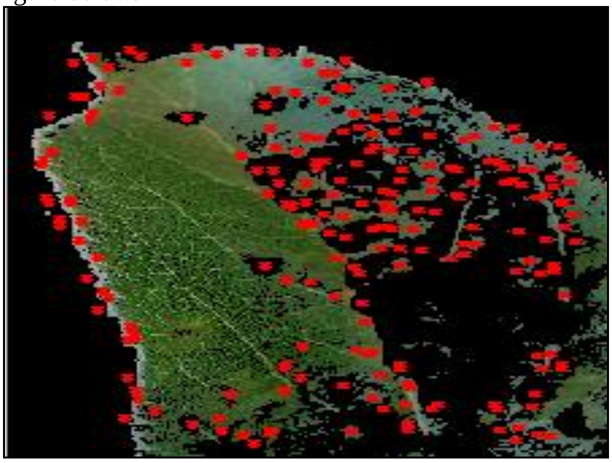

Figure 6: SURF applied on leaf image

The algorithm used to extract features is written below:

Algorithm: SURF
Input: Segmented foreground of plant leaf image
Output: SURF Key points as a feature vector
1Calculate size of dataset [Row, Col]
2 for i→1 to all Row
3 for j→1 to all Col
4Scale image=scaling (foreground (i.j), scale size)
5 Loc_Keypoints=Localization (scale image (i, j))
6 O_Keypoints=Orientation (Loc_ Keypoint (i, j), Angle)
7 SURF_Keypoints=Filtering (O_Keypoint (i.j), Square Filter)
8 end
9 end
10Return: Feature vector = SURF_Keypoints
11 end

FEATURE OPTIMIZATION*:* Genetic Algorithm is used to optimize SURF featuresand remove the unwanted feature sets by using the novel objective function of GA. The algorithms used soft computing techniques such as GA, PSO and SA algorithms are described below:

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 6, Issue 2, February 2019

Algorithm: GA

Input: key-points of leaf segmented foreground
Output: Optimized feature set
1 Initialize the GA with their function
{
2Initialize populations;
3Calculate fitness function;
4While (fitness value! = termination criteria)
5Selections;
6Crossovers;
7Mutations;
8Calculate fitness function;

$$Fit_{function} = \begin{matrix} True; & if \quad f_s > f_t \\ False; & otherwise \end{matrix}$$

9 end

Algorithm: PSO

Input: key-points of leaf segmented foreground
Output: Optimized feature set
1Initialize the PSOalgorithm with their operating functions –Swarm Size
2Define fitness function of PSO
3Fit_function_PSO = True; if $f_s > f_t$
False; otherwise
3Calculate sizes of key-points (R, C)
4 For i→1 to R
5 For j→1 to C
6Fs=Key-points (i, j)
7Ft=Threshold (i, j)
8Fit_fun_PSO =Call Fit_function_PSO (Fs, Ft)
9No. of Variable=1
10 Fitdata=PSO (Fit_function_PSO, No. of Variable, PSO functions)
11end
12 end
13Returns: Fit data as an optimized feature set
14 end

Algorithm: SA

Input: key-points of leaf segmented foreground
Output: Optimized feature set
1 Initialize the SA with their operating functions – Initial Temperatures
2Define fitness function of SA
3Fit_function_SA = True; if $f_s > f_t$
False; otherwise
4Calculate sizes of key-points (R, C)
5 For i→1 to R
6 For j→1 to C
7 Fs=Key-points (i, j)
8 Ft=Threshold (i, j)
9Fit_function_SA =Call Fit_function_SA (Fs, Ft)
10 No. of Variable=1
11Fitdata=SA (Fit_function_SA, No. of Variable, SA functions)
12end
13 end
14Returns: Fit data as an optimized feature set
15 end

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 6, Issue 2, February 2019

CLASSIFICATION: In the classification process, the apple leaf disease has been classified by using CNN as a classifier.

Figure 7: Detected plant leaf disease

Algorithm: CPU based CNN Algorithm

Input: Optimized properties as a Training Data (T), Target (G) and Neurons (N)
Output: Classify leaf disease

1 Initialize CNN with parameters
→ Epochs (E)
→ Neurons (N)
→ Performance parameters: Cross Entropy, Gradient, Mutation and Validation
→Training Techniques: Scaled Conjugate Gradient (Trainscg)
→Data Division: Random
2 for each set of T
3 if Training Data ε Category 1st
$Group(1) = Categories\ of\ Trainingdata$
4 else if Training Data ε Category 2nd
$Group(2) = Categories\ of\ Trainingdata$
5 else if Training Data ε Category 3rd
$Group(3) = Categories\ of\ Trainingdata$
6 else if Training Data ε Category 4th
$Group(4) = Categories\ of\ Trainingdata$
7 end
8 Initialized the CNN using Training data and Group
9Net = patternnet (N)
10Set the training parameters according to the requirements and train the system
11 Net = Train ($Net, Training\ data\ , Group$)
12Classification Results = simulate (Net, leaf disease properties)
13 If Classification Results = True
14Show classified results in terms of the leaf disease
Calculate the performance parameters
15 end
15 Returns: Classified Results
17 end

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 6, Issue 2, February 2019

V. EXPERIMENTAL RESULTS

The results of detecting leaf disease such as precision, recall, F-measure, accuracy and error obtained for three different soft computing schemes are demonstrated in the graphical form;

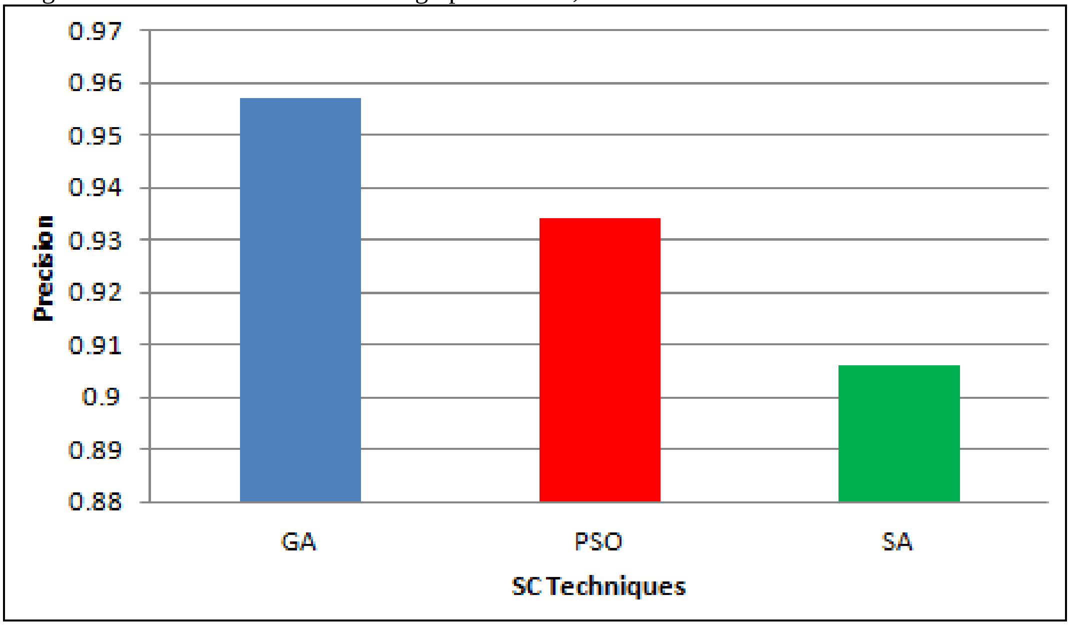

Figure 8: Comparison of Precision

Figure 8 signify the average values of precision obtained for the proposed three soft computing techniques namely GA, PSO and SA respectively. From the above graph it has been concluded that the average value of precision obtained for the proposed work are 0.9578, 0.934 and 0.906 respectively.

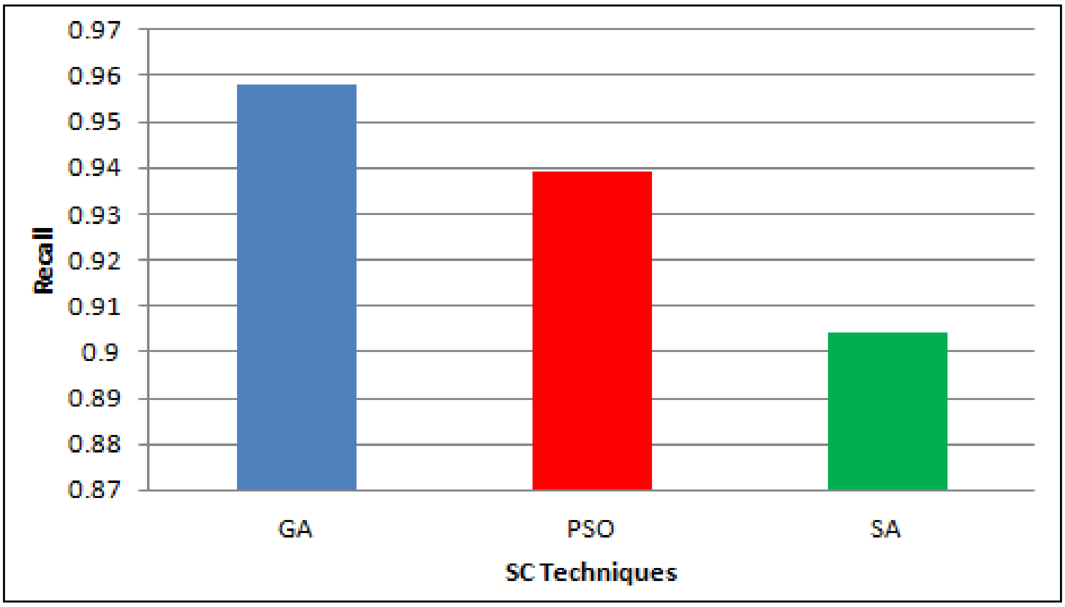

Figure 9: Comparison of Recall

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 6, Issue 2, February 2019

The average value of recall obtained for the proposed work with three SC techniques in the form of graph is shown in figure 9. The average value of recall obtained for GA, PSO and SA techniques are 0.9582, 0.939 and, 0.904 respectively.

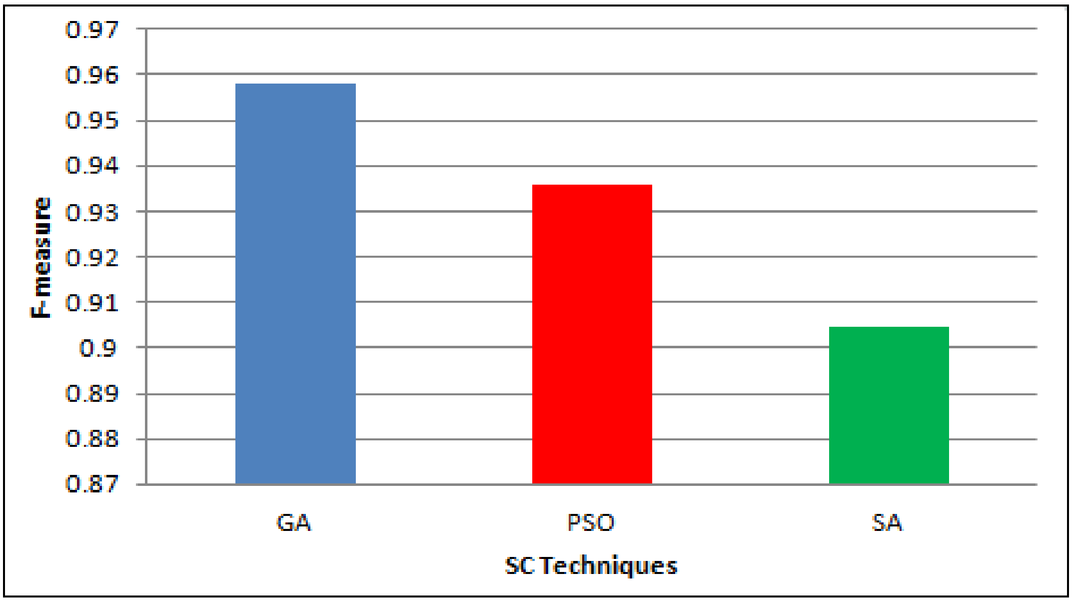

Figure 10: Comparison of F-measure

The graph obtained for the average value of F-measure for detecting the apple leaf disease using GA, PSO and SA techniques are 0.958, 0.936 and 0.9045 respectively.

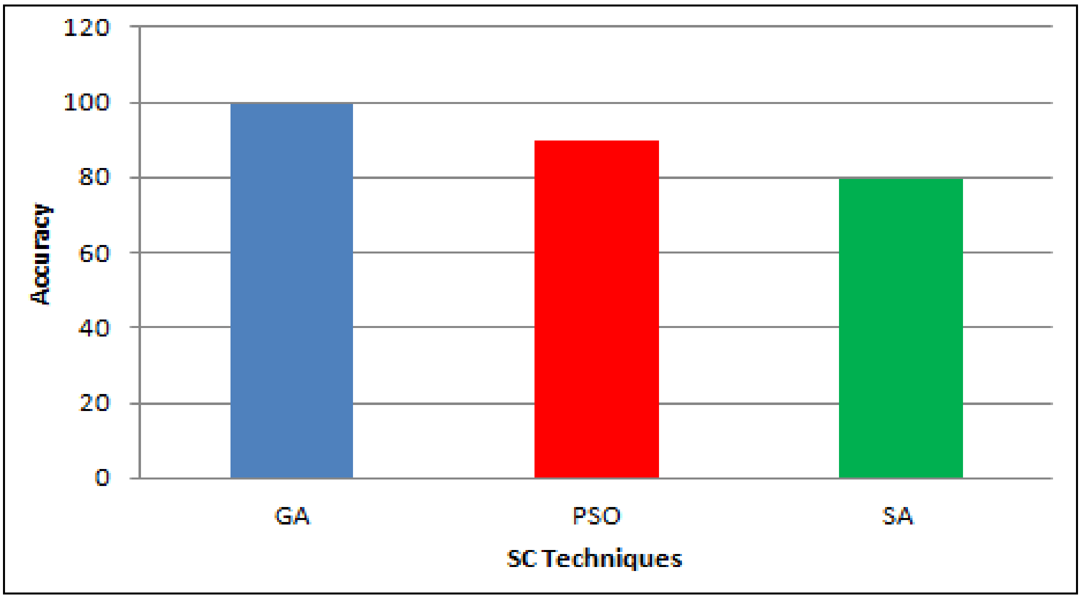

Figure 11: Comparison of Accuracy

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 6, Issue 2, February 2019

In the research work, we are mainly using three SC techniques namely; GA, PSO and SA. The average value of accuracy obtained for GA, PSO and SA techniques are 99.44, 90.04 and 79.75 respectively. It has been clear that GA algorithm perform better than other two SC techniques.

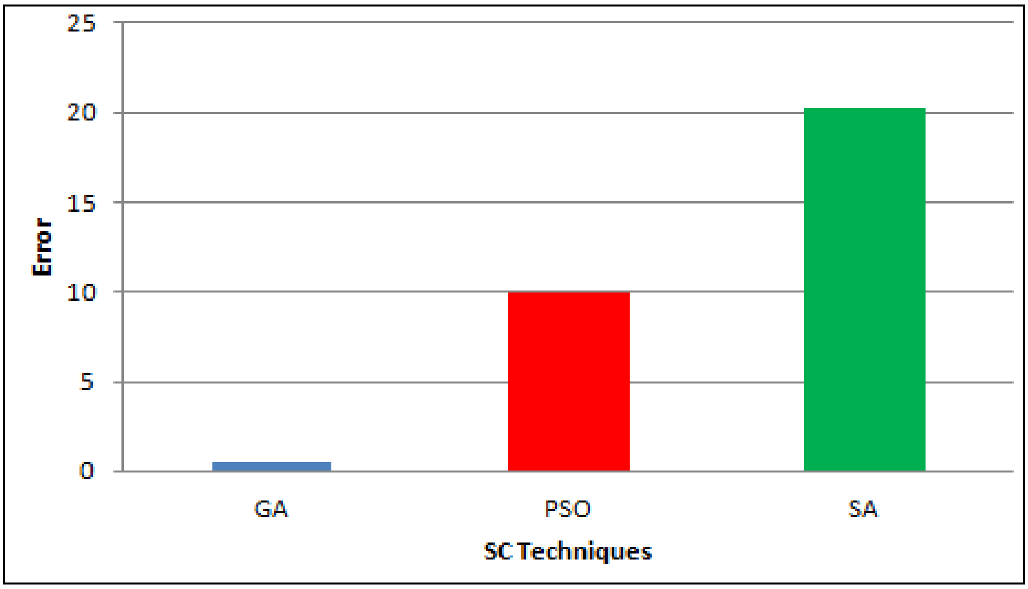

Figure 12: Comparison of Error

Figure 12 defines the average error rate obtained for the three different algorithms. Blue, red and green colour represents the average value of error obtained for the GA, PSO and SA schemes respectively. It is clear from the graph that GA algorithm test image with less error as compared to other two existing techniques.

VI.CONCLUSION AND FUTURE WORK

In the world, agriculture suffers from a brutal trouble which is known asplant diseases and due to this problem the productionand quality of farming is poor. In addition, the deficiency of appropriate diagnostics tools in undersized countries has a demoralizing impact on their progress and superiority of life. Hence, there is animperativerequire to identify the diseases of plant at the initialphase with reasonable and effortless solutions.In this research work, we developed an artificial intelligent concept based technique to detect apple plant diseases using their leaf properties. For the simulation of model, dataset has been taken from "plant village dataset master" that comprises of several apple leaf images affected by various diseases. In this research, we have considered four categories of apple leaf diseases named as apple scab, black rot; cedar apple rust and healthy leaves on the basis of which CNN has been trained. The proposed plant disease detection system has been carried out in different steps such as (i) image enhancement (ii) segmentation (iii) feature extraction (iv) feature optimization and (v) classification. By using all these processes the accuracy of the proposed apple leaf disease detection system has been improved. From the experiments, it has been concluded that the accuracy of the proposed GA technique has been increased by 10.44% from PSO technique and 24.69% from SA technique.

In future, we intend to design and test more plants diseases with our proposed artificial intelligence based model. Besides, we will intention the automatic harshness estimation of the detected disease since it is a significanttrouble that can help the farmers in deciding how to intervene to stop the disease.

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