Swarm Intelligence Based Detection of Citrus Plant Diseases and Their Severity Level

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Abstract: The quality of food production is reduced directly through plant diseases. The citrus plants are widely grown fruits worldwide. Each year, a large amount of waste is produced by citrus manufacturers, who annually destroy 50 percent of the citrus peel due to various plant diseases. The discovery of citrus plant diseases and their severity level will improve the quality of agricultural production. Image processing techniques are widely for detection of citrus plant disease. In this paper, evolutionary algorithms are introduced to detect citrus plant diseases and their severity level. The leaf images of citrus plants are collected and those images are pre-processed by removing noise using filtering technique. Then, the diseased portion in the leaf image is extracted by partitioning the image into multiple segments. From the segmented images, the features such as contrast, color, energy, local homogeneity, cluster shade and prominence are extracted using co-occurrence method and these features are processed in GA and PSO to detect the citrus plant diseases and their severity level. In GA, each gene randomly selects the features and classification rule is formed by chromosome. In PSO, each particle randomly selects the features and classification rule is generated. The best classification rule is selected based on the classification accuracy of selected classification rule. After the selection of best classification rule, it is applied to the testing data to detect citrus plant diseases and their severity level.

Keywords: Citrus plant disease detection, Genetic Algorithm, image processing, Particle Swarm Optimization, Plant disease, severity level detection.

I. INTRODUCTION

Fruit plants constitute a significant aspect of any agribusiness. Plant diseases that cause global economic losses are one of the reasons for declining productivity. Citrus is the main contributing source of nutrients including vitamin C, while citrus diseases are severely impacted the production and quality of citrus fruit. In agriculture, one of the factors for production declines has been diseases that cause global economic losses. Citrus plants such as grapefruit, lemons, oranges and limes affect with citrus lesions including scab, anthracnose, black spot, greening and etc. Citrus canker, leprosis, lime anthracnose, and Huanglongbing (HLB) are different types of citrus plant diseases.

The micro-organism pathogens can easily spread from one leaf to another that causes citrus canker [1]. The cause of the leprosis [2] has always been considered to be a virus transmitted by mite species. The leprosis disease is the reason for severe defoliation of twig, leaf and fruit lesions, death of twigs, premature fruit drop, girdled limbs and reduction in both yield and fruit quality. Lime anthracnose [3] is caused by fungus and that affects fruits, flowers and young leaves, and lesions ranges from small spots that can expand to cover large areas. HLB [4] is also known as citrus greening disease which is caused by the bacterial disease candidatus liberibacter asiaticus that spread through the tree canopy, causing decline and death of the tree.

The early detection of citrus plant disease [5] is necessary for disease control. So far various technologies such as molecular biology, plant physiology, biochemistry and serological techniques have been used to identify citrus plant disease. These techniques must be performed in the laboratory and pathologists visually monitor every suspect tree, based on the assumption that citrus canker is primarily a leaf spotting disorder. Moreover, plant disease severity [6] is a significant parameter to measure the disease level and thus can be used to predict yield and recommend treatment. The exact and fast diagnosis of the severity of citrus plant diseases could help to reduce losses in yield. Image analysis technology [7, 8] has recently been used for the detection of citrus plant disease and their seriousness.

In this paper, citrus plant disease and their severity level is predicted by using evolutionary algorithms. Initially, leaf images of citrus plants are collected using a digital camera and these images are pre-processed to get an enhanced image. Then, the pre-processed images are segmented into multiple segments and the features in each segment are extracted. Finally, the extracted features are processed by GA and PSO to detect citrus plant diseases and their severity level. In GA, each gene assigned feature and generates a classification rule based on crossover and mutation operator. In PSO, each particle assigned features and generates classification rule based on light intensity of particles. The classification rule is used to detect the citrus plant diseases and their severity level.

II. LITERATURE SURVEY

An adaptive approach [9] was proposed for identification of fruit disease. In the adaptive approach, K-means clustering and Multi-class Support Vector Machine (MSVM) was used for defect segmentation and image classification respectively. However, classification accuracy is influenced by k value of K-means clustering.

A software solution [10] was proposed to detect and classify plant leaf diseases automatically. First, a color transformation structure for the image was created, and then the pixels were masked, deleted using a certain threshold value. The input images were then partitioned into several segments, and texture statistics of useful segments were measured and the extracted features were then processed by the Support Vector Machine (SVM) classification for plant disease detection. The threshold value, however, affects the accuracy of the plant detection.

A new technique [11] was proposed for citrus canker detection. This exploited the fluorescence imaging spectroscopy with SVM for the detection of citrus canker. SVM created an optimal hyperplane between citrus canker leaf image and normal image by increasing the space between the nearest data points and boundary. However, the efficiency of this technique is low.

A hybrid method [12] was proposed to detect and classify the citrus canker disease. The citrus lesion spots were taken out from the input images through an optimized weighted segmentation method and those features were combined with codebook. The most significant features were chosen by using a hybrid feature selection method and the selected features were used in Multi-class SVM (M-SVM) for citrus canker disease classification. A deep model would be constructed for citrus disease detection.

III. PROPOSED METHODOLOGY

In this section, citrus plant diseases detection and their severity level detection based on evolutionary algorithms are described in detail. Initially, citrus plants leaf images are collected from citrus diseases image database. Then, the noise in the images is removed by using a filtering technique which enhanced the quality of image. The pre-processed image is segmented using clustering method to extract the diseased portion of the leaves. From the segmented image, texture features like contrast, color, energy, local homogeneity, cluster shade and prominence are computed using co-occurrence method. The extracted features are processed by GA and PSO algorithm to detect the citrus plant diseases and their severity level.

A. GA based citrus plant disease and their severity level detection

Genetic Algorithm (GA) [13] is an evolutionary algorithm which encodes which encodes the citrus plant disease detection in a simple chromosome-like data structure. To preserve critical information, this algorithm applies recombination operators. The fitness value of individuals of any population tends to reproduce and survive to the next generation, thus improving the fitness value of successive generations. The GA training process is started with the initialization of population size. Each gene in the chromosome represents the features. Each gene in the population randomly selects the features and forms a classification rule by chromosome as,

If feature1=value1 and feature2=value2 and … then class= presence of disease

If feature1=value1 and feature2=value2 and … then class=absence of disease

Then calculate the fitness (classification accuracy) of each

chromosome based on the following cost functions. The chromosomes which have high classification accuracy are chosen as parent chromosomes. Then crossover process is carried out by creating a new population from two existing chromosomes. The mutation process occurs occasionally which allows the specific child to obtain the features that are not possessed by either parent. The replacement process of GA is used to decide which features stay or get replaced in a population. This process is repeated until the maximum number of generations. After the detection of citrus plant disease, the features of diseased citrus plant leaf such as Hue histograms, Histograms of Oriented Gradient (HOG), Scale Invariant Feature Transforms (SIFT) and Speeded Up Robust Features (SURF) features are extracted and those are processed by GA to detect the severity level (early stage, middle stage and severe stage) of citrus plant disease.

Genetic Algorithm for citrus plant diseases and their severity level detection

Input: Population of n chromosomes, features, maximum number of iteration

Output: Detection of citrus plant diseases and their severity level

1. Each gene randomly selects the features and forms a classification rule by chromosomes.
2. Evaluate the fitness of each chromosome in the population.
3. Select some parent chromosome in the population according to the fitness values.
4. Perform crossover and mutation process to create a new population.
5. Replace the old population of chromosomes with the new population.
6. If the maximum number of generation is reached, then stop and return the best classification rule.
7. Else, Go to step 2.
8. Apply best classification rule in the testing data to detect citrus plant disease and their severity level.

B. PSO based citrus plant disease and their severity level detection

Particle Swarm Optimization (PSO) [16] algorithm is a stochastic, population-based optimization technique which is derived from the behavioral research on bird predation. Initially, the number of particles is initialized and each particle in D-dimensional space is denoted as $P_i = (p_{i1}, p_{i2}, \dots p_{id})$, where $i = 1,2, \dots d$ is the particle number and d denotes the dimension number of parameters defining the solutions. The particles fly over search space with adjusted velocities. Each particle of PSO keeps two values in their memory are $pbest$, i.e., its own best experience and $gbest$, i.e., the experience of the whole particles. After the initialization, each particle randomly selects the features. Then, classification rules are generated based on the extracted features and its values.

The classification accuracy of each particle is calculated and based on its value $pbest$ and $gbest$ of each particle are selected. At each iteration in PSO, a new velocity for each particle is calculated. The velocity for each dimension is denoted as $V_i = (v_{i1}, v_{i2}, \dots, v_{id})$.

The new velocity is used to calculate the next position of the particle in the search space. This process is continued until a user-specified maximum iteration is achieved. It returns the best classification rule. The best classification rule is used in the testing data to detect the citrus plant diseases. After the detection of citrus plant diseases, the features such as of diseased leaves Hue histograms, HOG, SIFT and SURF features are extracted and those features are processed by PSO to detect their severity level as early stage, middle stage and severe stage of citrus plant disease.

PSO Algorithm for citrus plant disease and their severity level detection

Input: num_p, features, $gbest$=0, $pbest = 0$, $maxiter$, c_1, c_2, r_1, r_2

Output: optimal selection of migration VMs and optimal selection of destination PMs

1. Each particle randomly chooses the features and forms a classification rule
2. do
3. for $i = 1$ to num_p
4. Evaluate the fitness (classification accuracy) value of each particle
5. if the current fitness value is better than $pbest$
6. Set current value as the new $pbest$
7. End if
8. End for
9. Choose the particle which has best fitness value as $gbest$
10. For $i = 1$ to num_p
11. Calculate the velocity of particle using

$$v_i^{t+1} = v_i^t + c_1 r_1 (pbest_i^t - x_i^t) + c_2 r_2 (gbest_i^t - x_i^t) \quad (1)$$

12. Update the position of particle using

$$x_i^{t+1} = x_i^t + v_i^{t+1} \qquad (2)$$

13. End for
14. while ($maxiter$)
15. End while
16. Apply best classification rule in the testing data to detect citrus plant diseases and their severity level.

In the PSO algorithm, $gbest$ denotes the global best, $pbest$ denotes the particle best, $maxiter$ denotes the maximum iteration, c_1 and c_2 are the learning factor, r_1 and r_2 are the random number between 0 to 1, num_p is the number of particles in population, v_i^t is the i-th particle velocity at t-th iteration and the position of i-th particle velocity at t-th iteration is denoted as x_i^t.

The above GA and PSO algorithms are used detect the citrus plant diseases and their severity level effectively.

IV. RESULT AND DISCUSSION

In this section, the performance of GA and PSO based citrus plant diseases and their severity level detections are evaluated in terms of accuracy, precision, recall and f-measure. For the experimental purpose, citrus disease image gallery dataset is used that contains 1000 images of several citrus diseases includes citrus canker, leprosis, lime anthracnose, HLB, scab and few more. The images in the dataset consist of both leaf and fruits with image dimension of 100×150 with resolution 96 dpi. From the citrus disease image dataset, 48 images of citrus canker, leprosis, lime anthracnose and HLB are used in this experiment. Table I shows the sample images and segmented images of the selected disease.

Table- I: Sample and Segmented images of the selected citrus diseases

Citrus diseases	Sample image	Segmented Image
Citrus Canker		
Leprosis		

| Lime Anthracnose | | |
| HLB | | |
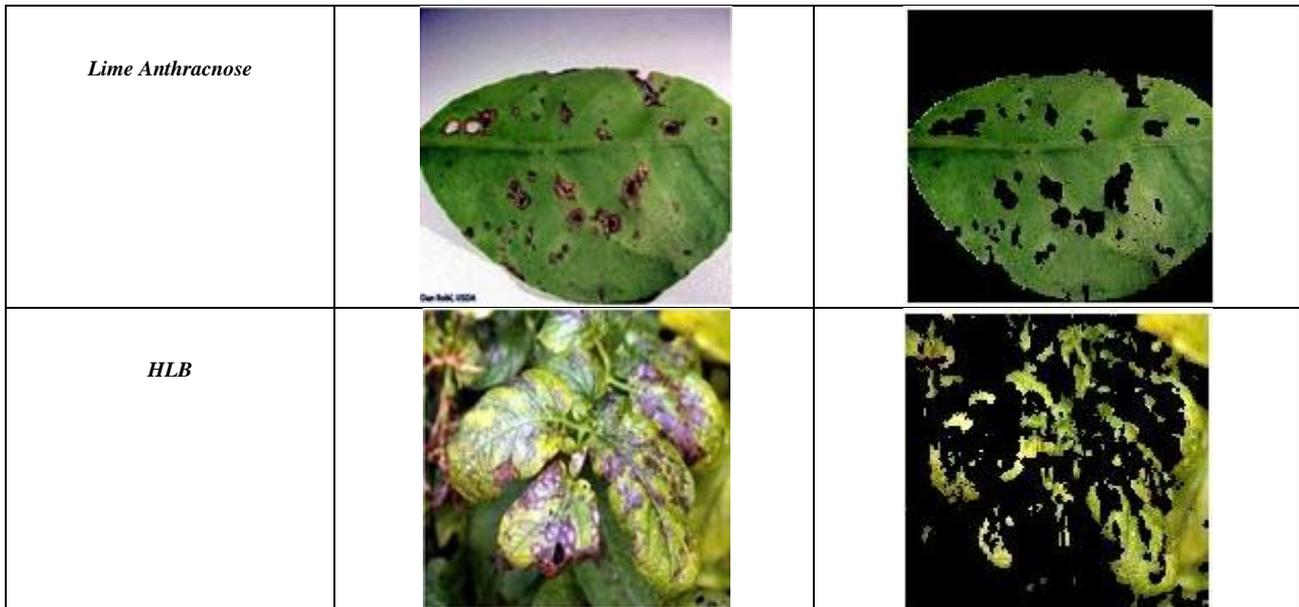
A. Accuracy

Accuracy measures the ratio of correct citrus disease and their severity level detections over the total number of images evaluated. It can be evaluated as,

$$Accuracy = \frac{True\ Positive\ (TP) + True\ Negative\ (TN)}{TP + False\ Positive\ (FP) + TN + False\ Negative(FN)} \quad (3)$$
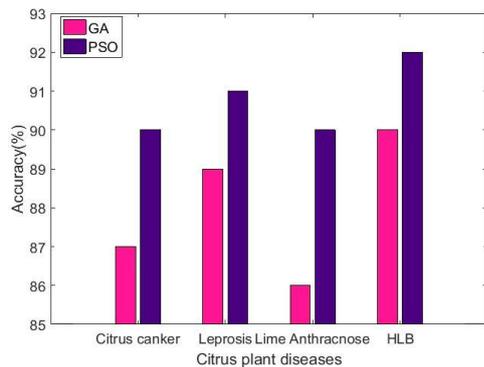

Fig. 1. Comparison of Accuracy

Fig.1 shows the accuracy of GA-based citrus diseases and their severity level detection and PSO-based citrus diseases and their severity level detection for different citrus plant diseases. The accuracy of PSO method for detection of HLB and its severity level is 2.2% greater than GA based HLB and its severity level detection. From Fig.1, it is proved that the PSO based citrus plant diseases and their severity level detection method has high accuracy than GA based method.

B. Precision

Precision is used to measure the positive classes (presence of citrus disease) that are correctly detected from the total predicted patterns in a positive class. It can be calculated as,

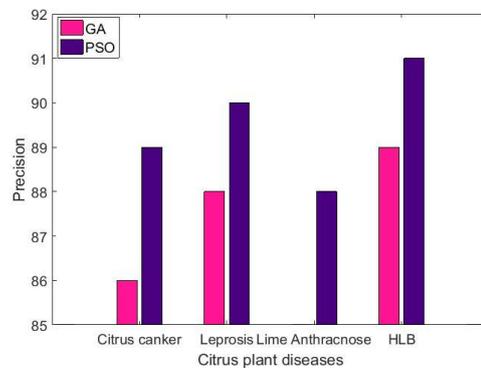$$Precision = \frac{TP}{TP + FP} \quad (4)$$

Fig. 2. Comparison of Precision

Fig.2 shows the precision of GA-based citrus diseases and their severity level detection and PSO-based citrus diseases and their severity level detection for different citrus plant diseases. The precision of PSO method for detection of HLB and its severity level is 2.25% greater than GA based HLB and its severity level detection. From Fig.2, it is proved that the PSO based citrus plant diseases and their severity level detection method has high precision than GA based method.

C. Recall

Recall is used to measure the fraction of positive patterns that are correctly detected. It can be calculated as,

$$Recall = \frac{TP}{TP + TN} \quad (5)$$

Fig.3 shows the recall of GA-based citrus diseases and their severity level detection and PSO-based citrus diseases and their severity level detection for different citrus plant diseases. The recall of PSO method for detection of HLB and its severity level is 3.64% greater than GA based HLB and its severity level detection. From Fig.3, it is proved that the PSO based citrus plant diseases and their severity level detection method has high recall than GA based method.
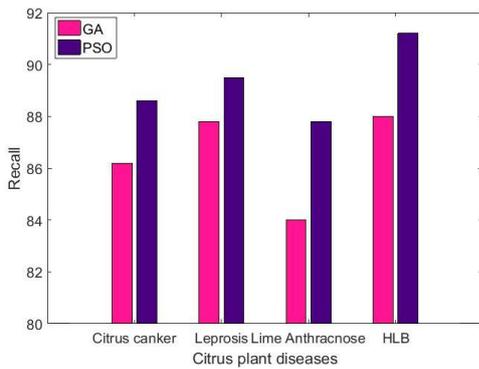
Fig. 3.Comparison of Recall

D. F-measure

F-measure is the harmonic mean of precision and recall. It can be calculated as,

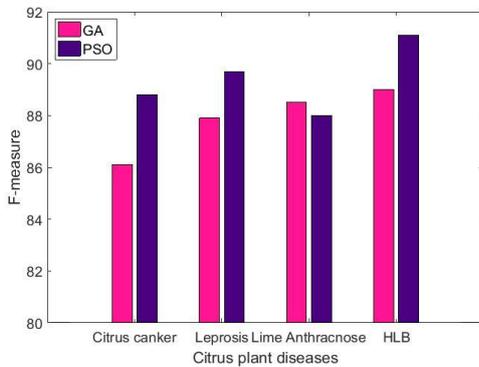$$F - measure = \frac{2 \times Precision \times Recall}{Precision + Recall} \qquad (6)$$

Fig. 4.Comparison of F-measure

Fig.4 shows the f-measure of GA-based citrus diseases and their severity level detection and PSO-based citrus diseases and their severity level detection for different citrus plant diseases. The f-measure of PSO method for detection of HLB and its severity level is 2.36% greater than GA based HLB and its severity level detection. From Fig.4, it is proved that the PSO based citrus plant diseases and their severity level detection method has high f-measure than GA based method.

V. CONCLUSION

In this paper, GA and PSO are introduced for citrus plant diseases and their severity level detection. The citrus plant diseases and their severity level detection consists of pre-processing, image segmentation, feature extraction and classification processes. In the pre-processing phase, the noise in the collected images is removed. In the image segmentation phase, the images are segmented into multiple segments and the features in the segmented images are extracted. Finally, GA and PSO are used to detect the citrus plant diseases and their severity level. By detecting severity level, proper treatment for plants would be given which helpful to increase the agriculture production. The experimental results prove that the PSO has better accuracy, precision, recall and f-measure than GA for citrus plant

diseases and their severity level detection.

REFERENCES

1. R. Gavhale, and U. Gawande, "An overview of the research on plant leaves disease detection using image processing techniques," IOSR J. Comput. Eng. (IOSR-JCE), vol. 16, no. 1, pp. 10-16, 2014.
2. J.S. Hartung, A. Roy, S. Fu, J. Shao, W.L. Schneider, and R.H. Brlansky, "History and diversity of citrus leprosis virus recorded in herbarium specimens," Phytopathol., vol. 105, no. 9, pp. 1277-1284, 2015.
3. I. Talaat, and R. Lobna, "Anthracnose disease (Colletotrichum sp.) affecting olive fruit quality and its control in Egypt," J. Agric. Technol., vol. 10, no. 5, pp. 1289-1306, 2014.
4. http://www.agriculture.gov.au/pests-diseases-eeds/plant/huanglongbing
5. M. Zhang, and Q. Meng, "Citrus canker detection based on leaf images analysis," 2nd IEEE Int. conf. inf. sci. eng., pp. 3584-3587, 2010.
6. C.H. Bock, G.H. Poole, P.E. Parker, and T.R. Gottwald, "Plant disease severity estimated visually, by digital photography and image analysis, and by hyperspectral imaging," Crit. Rev. Plant Sci., vol. 29, no. 2, pp. 59-107, 2010.
7. Z. Iqbal, M.A. Khan, M. Sharif, J.H. Shah, M.H. ur Rehman, and K. Javed, "An automated detection and classification of citrus plant diseases using image processing techniques: A review," Comput. electron. agric., vol. 153, pp. 12-32, 2018.
8. S. Sunny, and R. Peter, "Detection of canker disease on citrus leaves using image processing," Int. J. Comput. Eng. Appl., vol. 10, no. 3, pp. 129-134, 2016.
9. S.R. Dubey, and A.S. Jalal, "Adapted approach for fruit disease identification using images," Int. J. comput. vis. image process. (IJCVIP), vol. 2, no. 3, pp. 44-58, 2012.
10. S. Arivazhagan, R.N. Shebiah, S. Ananthi, and S.V. Varthini, "Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture features," Agric. Eng. Int. CIGR J., vol. 15, no. 1, pp. 211-217, 2013.
11. C.B. Wetterich, R. F. de Oliveira Neves, J. Belasque, and L.G. Marcassa, "Detection of citrus canker and Huanglongbing using fluorescence imaging spectroscopy and support vector machine technique," Appl. opt., vol. 55, no. 2, pp. 400-407, 2016.
12. M. Sharif, M.A. Khan, Z. Iqbal, M.F. Azam, M.I.U. Lali, and M.Y. Javed, "Detection and classification of citrus diseases in agriculture based on optimized weighted segmentation and feature selection," Comput. electron. agric., vol. 150, pp. 220-234, 2018.
13. M. Vengateshwaran, and E.V.R.M. Kalaimani, "Deep learner based earlier plant leaf disease prediction and classification using machine learning algorithm," IOSR J. Eng. (IOSRJEN), pp. 45-51, 2018.
14. S. Sengupta, and A.K. Das, "Particle Swarm Optimization based incremental classifier design for rice disease prediction," Comput. Electron. Agric., vol. 140, pp. 443-451, 2017.

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