A NEW HYBRID BIO-INSPIRED OPTIMIZATION ALGORITHM FOR IDENTIFICATION OF DISEASES ON PLANTS

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ABSTRACT*:* Agriculture is the amplest monetary sector playing a paramount role in the socio-economic refinement of the provinces. Present agricultural realm thrashes the yield predominantly owed to pandemic plant diseases. Proposed exertion aims at detecting and clustering the diseases over black gram plant which is one of the highly prized pulses of India. Expounded work focuses on concert and scrutiny of special optimization on clustering using Particle Swam Optimization and its variants algorithm. The proposed work introduces a new hybrid algorithm to endorse convergence and stagnation drawback in using individual PSO algorithm on black gram diseased leaf. Current algorithm gives a superior optimized result on identifying the symptomatic and asymptomatic end members on the leaf image. The experimental evaluation of the projected new hybrid optimization algorithm is justified using Davis Bouldin indexing which shows the excellence of convergence with an eminent accuracy of 0.0029.

Key words: black gram diseased leaf, disease detection, particle swam optimization, hybrid algorithm, clustering

INTRODUCTION

The utilization of automated monitoring and administrative systems are advancing with increased demand in the hi-tech evolution in all applications. In such a way, image processing is an effective tool for analysis and development in the agricultural domain. The symptoms of plant diseases are evident in different parts of a plant, however, leaves are found to be the most commonly observed part for detecting infection at early stage (Sukhvir et al., 2018). Specifically, the detection of disease in black gram plant through the naked eye is adopted by experts only. But it is not possible on large farms to keep monitoring as it is time-consuming and expensive. Also, many agriculturists will be unaware of the non-native diseases, and they cannot get experts suggestions at all times. So the image processing technique using Particle Swarm Optimization (PSO) can be implemented to detect the healthiness of the plant for good yield reasons. PSO algorithm being versatile ad resolves many optimization problems have not been extensively used in the agricultural domain. By this proposed method, diseases can be identified at the initial stage and the pest control tools can be implemented instantly to reconcile the problems. The accurate quantification also helps to control the quantity of chemicals to be applied to plants.

The preprocessed images are clustered and tested using Particle Swarm Optimization (PSO), Chaotic Particle Swam Optimization (CPSO) and Inertia Weight Particle Swarm Optimization (WPSO) algorithms and segmented to obtain the accurate diseased area. Experimentally, this new proposed strategy converges faster than linear method during the early stage disease identification using MATLAB. There are several basic parameters of PSO used to control the velocity and for stable convergence. On the other hand, the conditions that are very difficult to optimize and cannot be solved using basic PSO are modified using variants of PSO. The observation and review are made to show the absolute function of PSO, advantages, disadvantages of PSO, modification of PSO and their applications in the complex environment. Pertinent data and graphs are deliberated to demonstrate the optimum results of the proposed new hybrid algorithm with high accuracy on clustering compared to the other PSO variants algorithms.

The work is further organized describing the related work, introducing the basic principles and procedures of classic optimization algorithms, the methodology of the proposed system along with the graphical illustrations of the results and concludes the paper with discussion and future scope.

The RGB image was processed for a color transformation structure using color co-occurrence method and a specific threshold value was used to remove the green pixels. This is followed by the segmentation process for getting useful segments and the texture statistics were computed. At last, SVM classifier was used for the features that are extracted to classify the diseases on plants (Arivazhagan et al., 2013).

A vision-based detection algorithm was used with masking of the green-pixels and color co-occurrence method for measuring the affected area of disease of the plants and to determine the difference in the color of the affected region (Dhaygude et al.,2013).

The features are extracted after segmentation and extended to disease classification using the Hybrid Feature Extraction (HFE) method. Three components namely color, texture and shape features were extracted using this method. The preprocessed image result is compared and the best result was taken for image segmentation using PSO. The gray level co-occurrence matrix is used to extract hybrid feature on different plant leaves exhibiting an effective experimental results (Muthukannan et al., 2015).

PSO clustering algorithm was used to minimize the quantization error and to maximize the intra-cluster and inter-cluster distances. Both the gbest PSO and GCPSO algorithm has been evaluated and further, the gbest PSO clustering algorithm was compared with K-means, FCM, KHM, H2 and GA. The PSO algorithm produced better results with reference to inter- cluster and intra-cluster distances and having less quantization errors compared with other methods (Omran et al., 2006).

An image processing clustering technique was implemented to aid color image segmentation on database images of apple and cucumber plants. A compact set of pixels were used which shared similar properties in color and texture called super-pixel clustering. It was well suited for spot representation in diseased leaf image grouped with local uniform color and texture super-pixels. In each super-pixel, the centroids are easily estimated and used for image segmentation (Radhakrishna et al., 2018).

The features of cotton leaf plants diseases were extracted using the skew divergence color variance method. The color histogram was calculated with a color descriptor. The skew divergence shape feature was calculated by the Sobel and Canny edge detection method and finally, texture is calculated by gober filter and texture descriptor. Then feature selection was done by PSO (Particle Swarm Optimization) technique to analyze the best matching image of the affected leaf. These features result in an optimal solution for disease detection. Then the classification was done using CIG-DFNN (Cross Information Gain - Deep Forward Neural Network) (Revathi et al., 2014).

The optimal spectral features were determined and a method for qualitative and quantitative detection of Apple Marssonina Blotch (AMB) disease in apple was developed and the features were clustered using PSO algorithm. These clustered features served as the input for Support Vector Machine (SVM) classifier (Shuaibu et al., 2017).

CLASSIC OPTIMIZATION ALGORITHMS

- Particle Swarm Optimization (PSO)
- Chaotic Particle Swarm Optimization (CPSO)
- Inertia Weighted Particle Swam Optimization (WPSO)

PARTICLE SWARM OPTIMIZATION (PSO)

Particle swarm optimization belongs to the class of swarm intelligence techniques that are used to solve optimization problems. The PSO was presented by Eberhart and Kennedy in 1995. PSO simulates the behaviors of bird flocking which means, a group of birds is randomly searching food in an area. PSO is an efficient, adaptive and robust search process performing a multi-dimensional search in order to provide near optimal solution. The main strength of PSO is its fast convergence. The prematurely convergence is the drawback of PSO. The global best PSO particles converge to a single point, which is on the line between the global best and the personal best positions is the principle behind prematurely convergence problem. This point is not guaranteed for a local optimum. The reason for local optimum problem is the fast rate of information flow between particles, resulting in the creation of similar particles with a loss in diversity which increases the possibility of being trapped in local optima.

CHAOTIC PARTICLE SWARM OPTIMIZATION (CPSO)

In Chaotic Particle Swarm Optimization algorithm the chaotic variables based on the chaos theory with a varied range of numbers instead of random numbers are used. Chaotic sequences have been used previously for parameters tuning in meta-heuristic optimization algorithms and to avoid being trapped in local optimums. They can generate random variables due to the erotic and dynamic properties of chaos variables. This system can be adopted as for the needed randomness by the evolutionary algorithms. However it is not ensured that CPSO can find out the exact best solution rapidly as it is highly sensitive to their initial conditions. The final solution searched by CPSO may be a random solution, which is close to the exact best gone. The main advantage of chaotic optimization is the maintenance of the population of diversity in the region of interest.

WEIGHTED PARTICLE SWARM OPTIMIZATION ALGORITHM (WPSO)

Inertia weight plays a key role which determines the contribution rate of a particle's previous velocity to its velocity at the current time step. The new parameter "inertia constant" (w) is introduced in PSO that controls global exploration and local exploitation in random search. It multiplies the velocity of the previous time step, V(t) resulting in the modified equation of the velocity of the particle in PSO. The inertia constant can be either implemented as a fixed value or can be dynamically changing and named as Weighted Particle Swarm Optimization Algorithm (WPSO).

MATERIALS AND METHODS

The proposed methodology is very beneficial to the concrete in agriculture domain on the black gram plant diseases such as Cercospora Leaf Spot (CLS), Bacterial Leaf Light (BLL), Powdery Mildew (PM), Root Rot (RR), Rust, Stem Canker (SC), Macrephomina Blight (MB), Yellow Mosaic Disease (YMD), Leaf Crinkle (LC). The preprocessing steps are as follows:

IMAGE PREPROCESSING

The aim of preprocessing is to amplify the quality of the image. The two typical techniques in preprocessing step are filtering and contrast enhancement. The acquired leaf image is preprocessed to obtain enhanced luminance image from the RGB image. The amount of noise appearing in the image is reduced using the median filter and the prominence features are used in image segmentation.

NOISE REMOVAL AND CONTRAST ENHANCEMENT

Images are often corrupted by noise during acquisition and transmission. It tends to degrade the resolution and contrast that lead to difficulties in disease identification on plants. For de-noising the image a linear smoothing median filter is used. It helps to preserve the edge information on the image to represent the affected region. Adaptive histogram equalization technique is used to improve contrast in the image by creating the difference in luminance reflected from two adjacent surfaces. It differs from ordinary histogram equalization by computing several histograms, each corresponding to the distinct section of the image. Thus, this step improves the local contrast and enhances the definition of edges in each region reflecting with good quality of resultant image.

HYBRID CPSO-WPSO CLUSTERING ALGORITHM

Clustering is the grouping of image information based only on data found in the image. Clustering is viewed as searching for an optimal number of clusters, and so implementing Particle Swam Optimization (PSO) to this problem seems to be an apt method. The iteration continues for 150 to 200 times to find the optimal solution. In this work, three classical optimization methods such as PSO, CPSO and WPSO are used. But the simulation results show that the proposed hybrid CPSO-WPSO algorithm has high accuracy and stability compared with the individual particle swarm optimization and its variant's algorithms. The maximum number of iterations, cycle index, and the running environment are the same. All three algorithms are iterated 200 times respectively. It can be seen from Figure 4 that the hybrid algorithm converges very quickly. The rate of convergence of PSO, CPSO, WPSO, and hybrid PSO-WPSO and hybrid CPSO-WPSO algorithms is minimum and best at 150th iteration. The convergence curve of hybrid CPSO-WPSO is best at 0.0029 DB index value. The goal of the compactness of the clusters is the separation between the abnormal from the normal occurrence in the analyzed group (Eberhart et al., 1998). The pixels within a group that are similar or related to one another and different or unrelated to the pixels are clustered into two different individual groups (Angeline 1998). Davies Bouldin Index is one of measure to compute the quality of clustering that has been performed. The Davies and Bouldin (DB) index take the pixel parameters to evaluate intra-cluster similarity and inter-cluster differences. The minimum cluster value gives the best clustered group as per DB index evaluation (Davies et al., 1979).

In the first phase, the parameter values of PSO control the velocity and they utilize the local search of WPSO to avoid being trapped in local optimums by embedding inertia weight. This point is not guaranteed for a local optimum in PSO. Another problem is the fast rate of information flow between particles, resulting in the creation of similar particles with a loss in diversity that increases the possibility of being trapped in local optima. So the velocity of PSO is tuned using WPSO for considerable impact on the convergence and optimization accuracy. Since PSO suffer from following two aspects I) It is easy to be trapped into local minima; II) it costs too much time to converge especially in a complex high dimensional space. In the worst case, when the best solution found by the group and the particles are all located at the same local minimum, it is almost impossible for particles to jump out and do further searching due to the velocity update equation.

In the second phase, the initial population of WPSO is assigned given by the solution of CPSO. The total numbers of iteration are equally shared by CPSO and WPSO. The first half of the iterations run by CPSO and the solutions are given as input for WPSO. Chaotic variable control the parameter values of WPSO and in the second phase, they utilize the local search of WPSO to avoid being trapped in local optimums by embedding chaotic variable. CPSO is able to escape from local minima. The velocity equation of the CPSO optimization algorithm is activated by the velocity equation of the WPSO algorithm. To overcome before mentioned problem, the proposed hybrid method that combines the CPSO with WPSO is performed. CPSO is a local optimization method, with high efficiency, possessing the ability to converge rapidly to local optimum nearby. So WPSO is introduced to help CPSO reaching the best solution efficiently. The hybrid algorithm combines both global search provided by PSO and local search provided by WPSO.

Pseudo code for HYBRID CPSO-WPSO Algorithm

Hybrid CPSO-WPSO algorithm

Step 1: Initialize the population randomly;

Step 2: Evaluate each particle's fitness function f;

Step 3 : Update the Chaotic r1 value with equation as follows,

$$r1(l) = k * r1(l-1) * (1 - r1(l-1))$$

Step 4: Update the velocity of the particle swarm with equation as given,

$$v\,(l) = v\,(l-1) + c1.* r1.* (pbest - 1) + c2.* (1 - r1).* (gbest - 1)$$

Step 5: For each particle, calculate velocity using the weighted PSO using given equation,

$$v1\,(l) = w.* v1 + (c1.* r1.* (pbest - m(1,1{:}4))) + (c2.* r2.* (gbest - m(1,1{:}4)))$$

Step 6: Update particle position according to position equation,

$$m(l) = m(l-1) + v1(l)$$

Step 7 :Repeat Step 2- Step 6 until the termination criterion was met.

Step 8 Output the result.

IMAGE SEGMENTATION

The segmentation procedure extracts the region of interest excluding the irrelevant components in the image. The segmented regions are selected as a number of individual components from the image which is defined as foreground and background. The region of interest is defined by the internal similarity of pixels with parameters such as texture, color, statistics, etc. Change of color of the infected region in comparison with the background is considered as one of the important features of disease segmentation. Performance of the disease identification depends on the result of segmentation as diseased and non-diseased regions on the plant images.

RESULTS AND DISCUSSIONS

Experimental results show that the executed method outperforms the high-tech clustering strategy over the individual PSO and its variant’s algorithms. This work exhibits that the median filter is better than the gaussian filter because the speckle suppression index and its mean preservation index values are lower for the median filter. The noise reduction is qualified using SSI and SMPI measurements and its comparison is shown in table1 and figure 3. In this work, three classical optimization algorithms such as PSO, CPSO and WPSO, are used. The iteration continues for 150 to 200 times to find the optimal solution. But the simulation results shows that proposed new hybrid CPSO-WPSO algorithm has high accuracy and stability compared with the individual and its variant's particle swarm optimization algorithms. The maximum number of iterations, cycle index, and the running environment are the same. The three algorithms will be iterated 200 times respectively and run 150 times independently. It can be seen from Figure 4 that the proposed new hybrid CPSO-WPSO algorithm converges very quickly. The rate of convergence of PSO, CPSO, WPSO, hybrid PSO-WPSO, and hybrid CPSO-WPSO algorithms is minimum and best at 150th iteration. The convergence curve of the proposed new hybrid CPSO-WPSO is best at 0.0029 DB index value. The images are collected from the plantvillage dataset for experiments. On comparing the other variants in optimization algorithm, the accuracy of the disease detection is improved with the average accuracy of 98.5% in this proposed CPSO-WPSO hybrid method. The validity of the proposed algorithm is proved using Davies-Bouldin Index computation which has the minimum index value of 0.0029. It is found to be better when compared to the previous method of using only PSO which had an average accuracy 95%. The results are encouraging and this effort includes the detection of diseases at an early stage. It is also noted that the proposed method finds the optimal number of clusters and also manages to find better clustering of the data points for the cluster validity indices used in the literature.

PERFORMANCE MEASURES

Performance of Filters

The performance of median and gaussian filters is measured using the following methods:

6.1.1 Speckle Suppression Index (SSI) and

6.1.2 Speckle Suppression and Mean Preservation Index (SMPI)

Speckle Suppression Index (SSI)

Speckle noise and salt and pepper noise can occur due to a random bit error in a communication channel. The ratio of coefficient of variance of a filtered image to the ratio of coefficient of variance of an input image is called as speckle suppression index. The ratio between standard deviation to mean of an image is called the coefficient of variation. This index is based on the equation as given below:

$$SSI = \frac{\sqrt{var\,(I_f)}}{mean\,(I_f)} * \frac{mean(I_o)}{\sqrt{var\,(I_o)}} \qquad (1)$$

Where, If = filtered image, Io = noisy image

This index tends to be less than 1 if the filter performance is efficient in reducing the speckle noise. The value lesser than unity and lowest indicates that the filtered image has minimum speckle noise with improved quality.

Speckle Suppression and Mean Preservation Index (SMPI)

SSI is not reliable when the filter overestimates the mean value. In such cases, an index called Speckle Suppression and Mean Preservation Index (SMPI) is a better indicator. The equation of this index is as follows:

$$SMPI = * \frac{\sqrt{var\,(I_f)}}{\sqrt{var\,(I_o)}} \qquad (2)$$

Q is calculated as follows:

$$Q = R + \left|mean(I_o) - meanI_f\right| \qquad (3)$$

Where,

$$R = \frac{Max(mean(I_f) - Min(mean(I_f)}{mean(I_o)} \qquad (4)$$

According to this index, lower values indicate better performance of the filter in terms of mean preservation and noise reduction. The value lesser than unity and lowest indicates that the filtered image has minimum speckle noise with improved quality.

Table 1. Comparative study of filters

TYPE OF FILTER	SSI	SMPI
Median Filter	0.12	4.29
Gaussian Filter	0.19	6.72

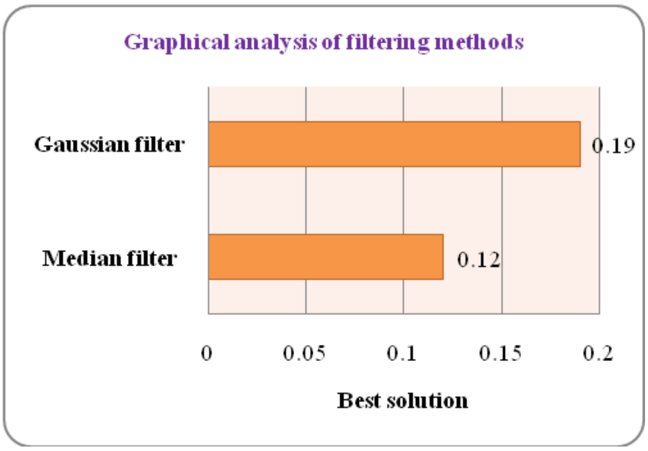

Figure 1: Graphical representation of filtering methods used

The graphical disparity of the SSI and SMPI is given in figure 1. From table 1 and figure 1, it is proved that the median filter has better performance over gaussian filter in removing the speckle noise. Median filter outperforms gaussian filter as per the rule with minimum SSI value and SMPI value less than 1.

PERFORMANCE EVALUATION OF CLUSTERING

Davies-Bouldin Cluster Validity Index

The quality of the proposed clustering algorithm is proved by Davies-Bouldin Index (DBI), an appropriate cluster validity index. DB index is based on the idea for fine clustering of inter cluster separation as well as intra cluster homogeneity and compactness. Davies-Bouldin index of the clustering is combined with the centroids diameters comparison between clusters. The centroids inter-cluster and intra-cluster measures are selected for compatibility with the Particle Swarm Optimization algorithm for each cluster in the image on features (this essentially computes centroids of cluster in each iteration). The comparative analysis of Davies-Bouldin Index is given in table 2, the graphical representation of DB index values on various iterations is shown in figure 2, and the sample clustered images of the proposed algorithms is exposed in figure 3.

Table 2. Comparative analysis of DB index's

OPTIMIZATION METHODS	DB INDEX VALUE FOR 150 AND 200 ITERATIONS RESPECTIVELY
PSO	0.1159,2.1566
CPSO	0.0921,1.3855
WPSO	0.0624,0.2222
Hybrid WPSO-PSO	0.0259,0.0272
Hybrid WPSO-CPSO	0.0029,0.0196

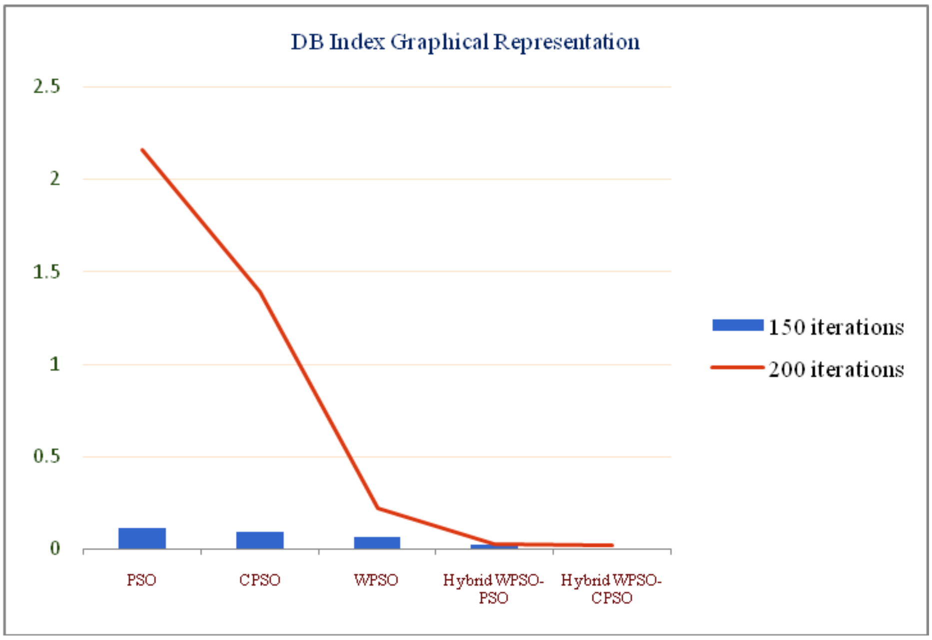

Figure 2: Graphical representation of DB index values on various iterations

SAMPLE CLUSTERED IMAGES OF IMPLEMENTED ALGORITHMS

Input image	Luminance image	Median filtered image	Enhanced image	PSO image	CPSO imaş	WPSO image	Hybrid WPSO-PSO image	HybridWPSO-CPSO image

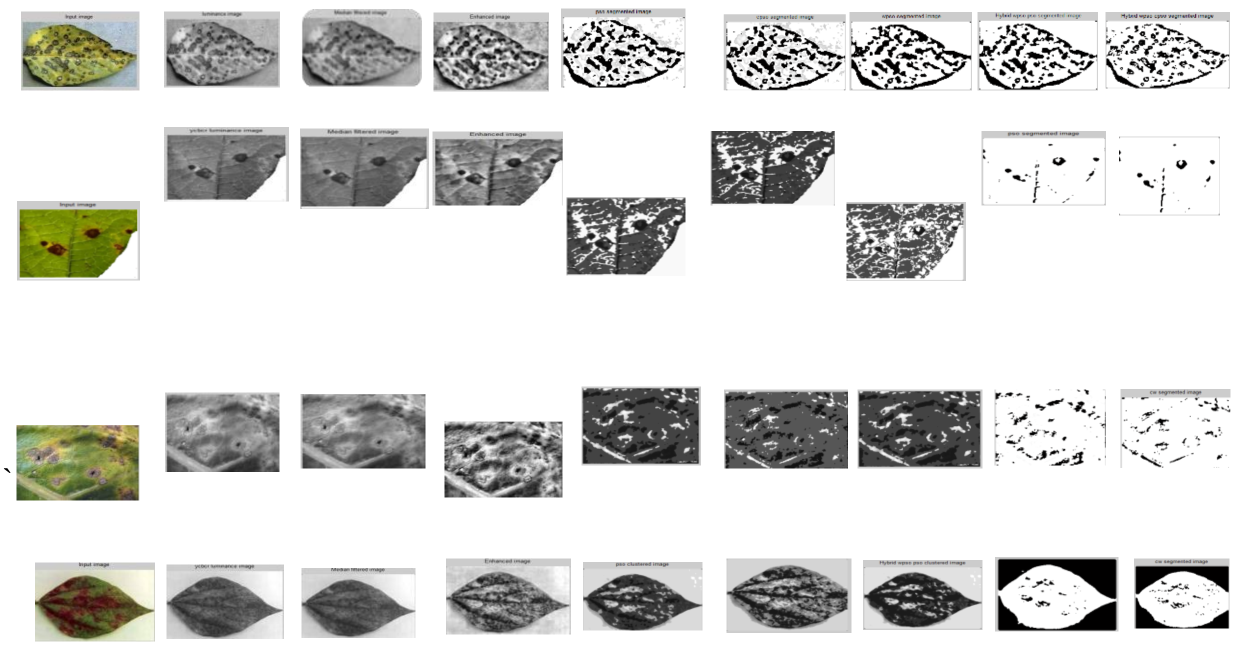

Figure 3: Clustered images

CONCLUSION

The numerical results of the proposed method furnish an evident proof that the median filter has lowest value of 0.1289 showing better performance in noise elimination. The contrast enhanced image is subject to classic optimization clustering algorithms but it is proved that the proposed new hybrid CPSO-WPSO method has Davis Bouldin index value of 0.0029. This is an inerrant and efficient evaluation on disease identification at early stage compared to the existing PSO and its variants algorithms. Thus it is concluded that, implementing the new HYBRID CPSO-WPSO optimization algorithm is a stunning success in the agricultural field with good significance. On considering the future scope of this opus, a strategy will be developed to dynamically determine the optimal number of clusters with more advanced features using other parameters to chance upon the least convergence on other types of agricultural plants.

REFERENCES

Angeline PJ (1998). Evolutionary optimization versus particle swarm optimization: philosophy and performance differences, Evolutionary Program 6,pp. 601–610.

Arivazhagan S, Newlin Shebiah R, Ananthi R, and Vishnu Varthini S(2013). Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture features. Agricultural Engineering International: CIGR Journal volume 15(1),pp.211-217.

Davies D and Bouldin D (1979). A Cluster Separation Measure, IEEE Transaction. Pattern Analysis 1(2),pp.224-7.

Dhaygude Sanjay B, Kumbhar Nitin P. Agricultural plant leaf disease detection using image processing (2013). International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering 2(1).pp.599-602.

Eberhart R C, Shi Y (1998). Evolving artificial neural networks, Proceedings of the 1998 International Conference on Neural Networks and Brain.pp.5–13.

Muthukannan K and Latha P (2015). A PSO Model For Disease Pattern Detection on Leaf Surfaces, Machine Intelligence 1(2),pp.224-227.

Omran M G, Engelbrecht A P, & Salman A (2006). Particle swarm optimization for pattern recognition and image processing, Swarm intelligence in data mining.pp, 125-151.

Radhakrishna A, Appu S, Kevin S (2018). SLIC super-pixels compared to state-of-the-art super-pixel methods, IEEE Transaction, Pattern Analysis and Machine Intelligence,pp.866–872.

Revathi P and Hemalatha M (2014). Identification of Cotton Diseases Based on Cross Information Gain_Deep Forward Neural Network Classifier with PSO Feature Selection, International Journal of Engineering and Technology 5(6),pp.4637-4642.

Shuaibu M , Lee W.S, Hong Y.K. and Kim S (2017). Detection of Apple Marssonina Blotch Disease Using Particle Swarm Optimization, Transactions of the ASABE (60),pp.303-312.

Sukhvir Kaur, Shreelekha Pandey, Shivani Goel (2018). Plants Disease Identification and Classification Through Leaf Images: A Survey, Archives of Computational Methods in Engineering.pp 1-24.

Zhang B, Sun X, Gao L, & Yang C (2011). End member extraction of hyperspectral remote sensing images based on the discrete particle swarm optimization algorithm. IEEE Transaction. Geoscience. Remote Sensing, 49(11),pp.4173-4176.