Research Article

Research Review on Plant Leaf Disease Detection utilizing Swarm Intelligence

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Abstract: Plants are both a source of food and resource for mankind. In country like India, plants have a wide application keeping in mind the agricultural and medicine research area. Out of several thousands of classes of medicinal plants, few may get vanished soon due to global warming, lack of knowledge of different species and several other diseases. Plants assume a significant job in human life being one of the critical variables of natural way of life; on the other hand couples of them are toxic and harmful to mankind as well. Thus, protecting the plants with medicinal and food values, as well as identifying the unknown species of the plants is the need of an hour. The study of plants classification with the help of different features of the leaf can be done in order to build an ideal database for the farmers and professional botanist. This could also serve for the automatic plant leaf disease detection system. The loss of crops as well as plants with medicinal values due to diseases is of the core concern to plant security. It is utmost important to design the essential infrastructure for the detection of the diseases that are observed in plant leaves. An optimal system for plant leaf detection can further guide for remedial solution. This work reviews different methodologies for plant leaf detection, its classification and detection of plant leaves diseases. Swarm Intelligence based techniques impressively address the real time optimization problems which motivates the further research work.

Keywords: plant leaf disease detection, optimization, feature extraction, image segmentation, swarm intelligence, machine learning

1. Introduction

It is reported in the literature that earth is occupied with immense number of living green growth, creatures, plants and people. Out of these, plant is the main species that spread more than 30 percent of earth land and fundamental for human life cycle. A general meaning of a plant is any life form that contains chlorophyll (a green shade contained in a specific cell called a chloroplast) and can produce its own nourishment; the made nourishment is the oxygen [1,17]. Plants keep up the parity of O_2 and CO_2 in earth's environment and subsequently are perceived as crucial living entity that exist on the earth [2,3,13]. Plants can be found in human environment or in the place where there is no people existence.

A large number of plants convey noteworthy data, for example, social worth, monetary worth, home grown worth and natural incentive for the human culture advancement [4,5]. A lot of medications and nourishment bases are the endowment of plants to people. World Health Organization (WHO) assesses that sufficiently large number of Asian and African people (approximately 80%) rely upon home developed meds because of how they are getting unmistakable quality around the globe as they are secured to human prosperity and moderate as stated in [6]. Several of them pass on vital information for the progression of human culture. Consequently, having precise distinctive confirmation of the variety of plant is a suitable idea to treat any long-suffering human entity. In view of notable troublesome scenarios namely an earth-wide temperature boost and illiteracy in terms of plants, the categorization of plants are getting uncommon which may invites termination of noteworthy herbal species too soon. There is a critical requirement for perceiving and ordering these valuable species of plants in categorized database that can be a remarkable assistance to people working in this field [6,15].

Perceiving the advanced knowledge about the plants is impossible if we fail to get acquainted with its name and type. Generally, perception of plants is done by observation, a thorough contact, additionally it's smell and taste [11,18,26]. An essential part of this customary acknowledgment is based on the perception of outer morphological structure of the plant, moreover exactness of the acknowledgment relies to a great extent upon proficient information and experience. If we can achieve teaching any computing model to segregate the plants according to its name and type then it can assume a significant job is done for particularly with individuals (understudies and analysts in botany field) who manage plants legitimately in logical way [8]. Programmed plant distinguishing proof framework can likewise be valuable for everyday citizens who don't think about a specific plant and to foresee the plant's wellbeing just as gauge the yields [1,4,5,7]. With the improvement of current gadgets, PCs and as the presentation of image processing tool turns out to be better, picture based investigations of recognition, grouping and recovery of plants have extraordinary scholastic worth and application criticalness. Plant leaf disease discovery is one of those significant applications that instruct the botanist, analysts and ranchers about the presence of disease in the plant leaf. Be that as it may, recognizing plant species and identifying the awfulness of plant leaf is difficult job thinking about the enormous number of existing species. Likewise, it is troublesome and tedious because of species similarity and inconstancy, number of obscure maladies and absence of proper database of the plant diseases [4,8]. Consequently, to make an effective database of plant leaves and its illnesses, the initial step to be cultivated is the plant leaf identification and classification framework [16,24].

Plants can be grouped by the shapes, color, texture pattern and structures of their leaf, stem, blossom, seedling and transform. One or a few highlights of a plant ought to be utilized as the proof to perceive and order the plant. As a rule, leaf being the most significant organ of the plant is frequently taken as the article to particularly perceive a plant since this entity has notable and stable two dimensional structure along with long living span of life [16,19,22,27]. The greater part of the plant recognition framework depends on leaf identification, since its contributes significant job in preservation of plants and furthermore gives effectiveness to access, convey and process [1,2,3]. In any case, a noteworthy obstacle in growing fine plant distinguishing proof framework exist in separating the essential highlights out of the leaves; which in turn can act as a tool with great capacity to order the various species of herb, vegetables, weeds and flowers. A leaf has a few highlights, outstandingly; shading, vein, shape and surface and each component has its very own one of a kind significance in plant leaf distinguishing proof. Diverse programmed plant leaf identification frameworks examined in the state-of-the-art utilizes various combinations of leaf morphological features [4,8,23].

Plant leaf detection and classification procedure involves several steps which are depicted in Fig. 1. The general approach rightly classifies the leaves to respective classes of plants [43]. Keeping in view to attain a utmost performance accuracy of any plant segregation framework; there cannot be any escape from using proper dissolution of a plant image that will not only highlight the feature statistics from images of leaves but also act as an accurate function choice resulting in most fulfilling category [24,28,38,41]. Thus, the optimal choice of the image bifurcation and feature selection approach could be challenging one. Swarms Intelligence (SI) has witnessed its applications in diverse disciplines, optimization area could be one of those notable provinces. Particle swarm optimization (PSO) turned out to be an exceptional tool to deal with optimization problems. PSO has proved its importance and effectiveness in both image segmentation and feature selection/type several times within the literature [7,30].

The remaining sections of this paper are assembled as follows. Literature review of the said topic is discussed in section II. Opportunities for further research work with reference to diagnosis of herb leaf are extended in section III. Section IV is reserved for the conclusion of this research work with the proposal of further work that can be done.

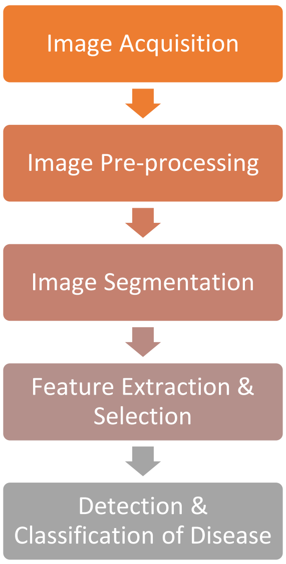

Fig. 1. General Process of Plant Leaf Desease Detection

2. Literature Review

Several researchers came up with different findings in the said area of deciding, clustering or segregating the plant leaves. The study and analysis of recognizing the plant leaves along with the grouping scenario will be helpful for understanding the concept of recognizing the diseased plant leaves and further in its classification, which are discussed in this section one by one. Table 1 represents the comparative analysis of notable methodologies mentioned in the literature survey.

A framework for detecting and grouping different kinds of Tulsi plant leaves through images considering color and surface structure morphological features is proposed in Kavya B. et al.(2018) [2]. Firstly, a leave's image dataset is formed and then noteworthy highlights of the leave's image are taken into consideration to educate the system which is often termed as training the system. While testing, the hue along with the appearance of the leaf are separated from the test scanned input image. K-Nearest Neighborhood (K-NN) algorithm is utilized for the purpose of matching the retrieved features with the available information to present the type of the leaf. Gray Level Co-occurrence Matrix (GLCM) was meant to capture texture features whereas color features are obtained from color moments. White background while scanning has helped to avoid the need of pre-processing the image. Total 60 images consisting of three types of Tulsi plants were used and the proposed system has given 95% of accuracy in classification. T. Vijayashree et al., (2015) [3] has identified Tulsi leaves under various classes based on its texture characteristics. This paper has stated that detecting the leaf based on its texture is a challenging task. The samples are collected and the features are acquired using GLCM technique.

Wei Lie et al., (2017) [4] have processed the digital images before the extraction with respect to design and shape related information from the leaves. Support Vector Machine (SVM) is put in front working on extracted features for classification purpose. Once SVM classification is done, the SVM generated variables were enhanced with the help of PSO algorithm to optimize the design and classification accuracy. Matlab simulation results proved the improved accuracy. Magadi Rashad et al., (2011) [5] have put in front the methodology that categorize the plant considering the surface information. They used the LVQ based combined classifier for the classification purpose. Aarbitrarily selected texture based guiding set and evaluation set (30 blocks of each) were utilized. The approach employed provided a high performance as compared to existing methods with average correct recognition rate of 98.7%.

Heba F. Eid, (2016) [7] has considered a novel approach for separating each type of plant leaf. PSO algorithm was utilized for breaking the images of leaves into meaningful information. Then, information gain and discritization process was employed to select notable highlights from the retrieved information in the previous stage. The said framework was tested on freely available Flavia dataset and several exceptional classification systems were used for experimental analysis to show an improvement in the detection accuracy.

TABLE I. Comparative analysis of state of the art methodologies

S. N.	**Year of Pub.- [Citation]**	**Comparison Parameters**					
		Features extracted	***Feature extraction***	***Feature Selection***	***Classification***	***Data set***	***Accuracy***
1.	(2018)-[2]	2 Color features (Mean, Std. Deviation. 6 Texture features (Contrast, Correlation, Energy, Homogeneity entropy PSNR)	Color moments and Gray Level Co-occurrence matrix (GLCM)	--	K-NN	Real Data set with 60 images of 3 types of Tulsi Leaves (Krishna, Rama and ordinary)	95%
2.	(2015)-[3]	11 Texture features (Entropy, contrast homogeneity, eccentricity, SIDM, IDM, sum entropy, sum variance, energy correlation, mean)	Gray Level Co-occurrence matrix (GLCM)	--	Bsed on Dissimilarity	Real Data set of 50 images of Three types of Tulsi leaves of (Karun, Krishna, Rama)	--
3.	(2017)-[4]	Shape	Hu's moment of invariants	--	SVM	Real Data set of 424 leaf images of 5 plant species from Hainan Medical University	--
4.	(2011)-[5]	Texture	--	--	LVQ + RBF	--	98.7%
5.	(2016)-[7]	HOG Features from digital image of leaf	Histogram of Oriented Gradients (HOG)	IG followed by IEMD	J48, Naive Bayes (NB) and SVM	Flavia Data set with 50 images with 23 species	90.38% (NB) 98.7% (SVM)
6.	(2019)-[9]	Color, Size, Shape, Texture	Histogram of oriented gradients (HOG)	--	SVM & ANN	Data set of 200 images of tomato and maize crops (healthy and with Bacterial spot, Tomato Mosaic virus, Northern blight, Rust diseases)	Tomato: 60-70% (SVM), 80-85% (ANN) Corn/Maize : 70-75% (SVM), 55-65% (ANN)

7.	(2016)-[10]	Texture Features (Mean, Energy, Standard Deviation, Skewness, Contrast, Kurtosis)	Gabor Filter	PSO-CFS	KNN, J48, CART, RF	Real Data set with 500 Images (250 Dorsal side and 250 Ventral side images) of 10 plant species	89.82% (PDFS) 92.09% (PVFS)
8.	(2018)-[12]	Shape features (roundness, slimness, solidity, diameter, area) Texture features (256 bin LBP vectors) Color (mean, standard deviation, skewness, kurtosis)	PSO followed by Binarization, Color moments, LBP-GWO	Normalization, GWO for texture fature selection	Dual Coordinate Descent L2-SVM	Swedish Data set of 15 plant species with 75 images per species. Flavia Data set of 32 plant species with 40-70 images per species.	98.9% (Flavia) 93.3% (Swedish)
9.	(2016)-[14]	Texture (13 Haralick features with 24 Gabor features), Shape (9 features), Color (6 features)	Gabor-based Haralick Texture Feature, Color feature, Shape feature	Kernal-based PSO	Fuzzy-Relevance Vector Machine (FRVM)	ICL Leaf Dataset with leaf images of 60 plant species	correctness (99.87%), vulnerability (99.5%) and distinction (99.9%)
10.	(2018)-[20]	Shape (area, color axis length, eccentricity, solidity, perimeter) Texture (contrast, correlation, energy, homogeneity and mean)	Otsu model	--	Neural Network based classifier	Data set of Alternaria Alternata, Anthracnose, Bacterial Blight, Cercospora leaf spot,Healthy Leaves	--
11.	(2019)-[21]	--	--	--	New DL based PlantDissease Net architecture	New largest PlantDisease Data set with 79265 images PlantVillage Data Set of 54,323 images with 38 classes of diseased and healthy plants based on 14 d crop specie	93.67%
12.	(2017)-[25]	Texture (Local homogeneity, contrast, cluster shade, Energy, and cluster prominence), Color	Color co-occurrence method (RGB to HIS)	--	SVM	Real Data set of related diseases (Rose and Beans leaf with bacterial disease, Lemon leaf with Sun burn disease, Banana leaf with early scorch disease and Fungal disease in beans leaf)	95.71%
13.	(2019)-[31]	Texture feature (contrast, correlation, homogeniety, mean, standard deviation, entropy, RMS, variance, smoothness, kurtosis, skewness)	Gray Level Co-occurrence matrix	PSO	Multi-Class SVM	Data set of Rice leaf disease images (Brown Spot, Bacterial Blight, Leaf Blast and Leaf Scald)	97.91%
14.	(2017)-[35]	Texture features (Skewness, Std. Deviation, Homogeneity, Contrast, Smoothness, Correlation, Kurtosis, Energy, Entropy, Mean, Variance, RMS, and IDM)	GLCM, SVM	PSO	PSO	Data set of images of four types of diseases (Cercospora leaf spot, bacterial blight, anthracnose, Alternaria alternate)	95.16-98.38%
15.	(2019)-[39]	Texture features (Local homogeneity, contrast, energy and entropy)	Color Co-occurrence method		Minimum Distance classifier	Collected Data set of Sunflower disease images (White rust, Bacterial leaf spot, Downy mildew, Powdery mildew, Septoria leaf blight, Sun rust)	98.0 %
16.	(2019)-[40]	Texture, Color, Shape features (Contrast, Correlation, Entropy, Energy, and Homogeneity)	GLCM	--	Back-propagation to train Feed Forward Network and NN connection weights are classified by	Data set of images of leaf diseases (bacterial and fungal, Alternaria Alternata, Anthracnose, Bacterial Blight and Cercospora Leaf Spot	96.2%

					PSO		
17.	(2015)-[42]	Texture features (contrast, correlation, energy, and homogeneity)	Hybrid Feature Extraction (HFE), GLCM	--	Evolutionary classifier	Data set of images of diseases (late blight, septoria leaf spot, down mildew, blast and rust teak.)	--

N. Kanaka Durga et al., (2019) [9] used Histogram of Oriented Gradient (HOG) operation and predicted the information that is useful for grouping purpose. Leaves were examined and noted for the sickness and transferred that information to farmer via message. Leaves of the tomato and maize crops were picked with the aid of using Support Vector Machine along with ANN algorithms in contemplation of the productivity as well as reliability of the results obtained.

PSO optimized feature selection and use of front sides of leaves for classification of plant leaf is done by Arun Kumar et al., (2016) [10]. Texture surface related information were grabbed by using Gabor based technique and then applied to PSO-CFC based searching methodology for optimal selection of features. These optimized features then classified by four classification algorithms namely; Classification and Regression Trees (CART), J48, k-NN and Random Forest (RF). This system has used two sides of the leaf (front and back) for the division purpose and accuracy is compared.

A hybrid feature selection approach is proposed considering leaf surface, design and hue parameters utilizing novel Grey Wolf Optimizer (GWO) and promising PSO by Heba F EId et al., (2018) [12]. GWO has reduced the overload of leaf surface describing proportions. Lastly, the twofold coordinate subsiding L2-SVM classifier is utilized for classification. During experimental analysis, the introduced idea has improved the rate of accuracy of classification up to 98.9% for Flavia dataset and 93.3% not only for Flavia but also for Swedish dataset.

Balasubramanian V. et al. (2016) [14] have developed a detection system that automatically labels the plant leaf under specified category using the parameters namely surface, design, and hue. The noise effect was reduced to marginal level using Cellular Automata (CA) filter. To enhance the image caliber, equalization through histogram and Segmentation based on ROI concept were employed. GLCM and LBP algorithms were introduced for extractions of important highlights namely; haralick texture feature, gabor feature, design and hue features. Optimal feature set were retrieved with the help of kernel-PSO. FRVM was employed for classification purpose and the system is tested based on three parameters such as correctness (99.87%), vulnerability (99.5%) and distinction (99.9%) and provided appreciating results.

Saradhambal.G et al., (2018) [20] have proposed an idea to diagnose the disease within the plant leaf before the time. An improvised version of the clustering was used to foresee the contaminated area. A bifurcation framework based on hue/color parameter was introduced to separate the contaminated leaves from healthy leaves. This model has also provided the solutions to recover from the diseases.

Marko Arsenovic et al., (2019) [21] have presented the drawbacks of state of the art plant illness identification frameworks. Furthermore, a new so called largest dataset till date countably 79,265 images was put forward. Images were captured in different climate scenarios, clicked in different orientations, and utilizing sunlight with not consistent backdrop realizing the real time situations. Two approaches namely; conventional augmentation systems justifying generative adversarial networks were used to augment the number of images in the dataset. Lastly, neural network built framework was proposed for segregating different diseases that occur in plant. After training the said framework, it has attained recision of 93.67%.

Vijai Singh et al., (2016) [25] have presented an image division algorithm which can be utilized for mechanical observation and for labeling the plant leaf with its identified diseases. This work also presented a literature survey on existing labeling aapproaches specifically in the taken research area. Genetic Algorithm (GA) is used for image segmentation. The provided algorithm was tested on some of the fruit species and proved as an efficient algorithm in identifying and labeling the fruits under specific diseased category.

Prabira K. S. et al., (2019) [31] have reported a new approach focusing on diseases those are usually found in rice leaf by to utilize the benefits of K-means, multi class SVM and PSO algorithms. Feature extraction was acquired by GLCM. The SVM classifier was used for labeling the disease and the identification accuracy was improved with the application PSO algorithm. The achieved accuracy was 97.91%.

Kaur et al., (2017) [35] presented a combinational advancement in terms of PSO algorithm along with SVM algorithm for recognizing and categorizing the infected plant. The dataset of four diseases cercospora leaf spot, bacterial blight, anthracnose, and alternaria alternate was constructed and used in the proposed system. They determined the proportion of infection from the plant leaf during the labeling procedure. Vijai Singh, (2019) [39] presented a system focusing on the disease identification and grouping of sunflower leaf through digital images. This work presented a survey on various disease labeling approaches which were based on sunflower crop images. Using PSO, image bifurcation work was done and minimum distance classifier was applied for classification. The approximate correctness of labeling process of said methodology was 98%. Moumita chanda et al., (2019) [40] proposed a classification of plant leaf where the back-propagation algorithm evaluated the values of weights that are assigned to links of neural network and then the optimization was done on these weights using PSO to overcome the well-known limitation of getting trapped in local optima and misclassification which are usually observed in neural networks. The images of contaminated leaves due to diseases caused by fungi and bacteria were used in the experimental work to achieve 96.2% accuracy.

The main objective of the work given by Kanthan M. et al., (2015) [42] was to make division of the contaminated part of the plant leaf and capturing the blended useful information for better grouping of non-related infected patterns. Segmentation was done using PSO. The Hybrid Feature Extraction (HFE), which uses hue, surface and design related parameter values were extracted using GLCM.

3. Research Opportunities

Plant disorder recognition often accomplished via specialists making use of the naked eye belief method that encourages distinguishing evidence and plant sickness identification. An organization of professionals persistently observes the crops, flowers and plants, and this strategy can be very exorbitant for farms those are of quite large area. On the contrary, farmers want fundamental farming centres or way to reach to professionals. Also, farmers are not willing to spend money for consulting the experts since sometimes it proved to be a tedious process. Since, visible detection of infectious plants is the labour- exhaustive, unreliable, time-ingesting method and is limited to constrained regions, an automated plant leaf disease detection technique, in contrast, a good way to be less time-ingesting and requires much less effort despite the fact that provides higher accuracy is the requirement of an hour [32,34].

Considering market growth scenario and to guard the plants, healthiness detection of plants is a crucial task. Diagnosis of exact disorder of plant leaf could be a vital and difficult piece of work [33]. Vast range of leaf generated disorders are exist. Hence, the diagnosis of the disorder of specific crop, flower or plant with some preventive plan of action is extremely imperative. Therefore, knowing about the disorder, the amount of contamination, symptoms of infection, precautions to be taken, remedial actions etc are utmost important in order to grow healthy plants. This defines the scope of research to be done to propose an advance, efficient and flawless leaf disorder detection approach that will diagnose the disorders within the leaf by using various infected images of leaf spots, fungi, bacteria and viruses. To diagnose the illness of plant's leaf (i.e., uncommon growth or dysfunction), several researchers are using image transformation tools and techniques to achieve better result with ease [36]. Diseases within the plant leaf can be identified through below mentioned approaches:

- Distinguishing the infected object or part of the object.
- Feature extraction from the infected object.
- Recognizing the presence of the diseases and its classification.

Although, several image processing approaches are explored in the review of literature done on both plant leaf detection and its classification along with plant leaf disease detection and classification areas, there are several limitations associated with it which motivates for further research are listed down next:

- Accuracy of detection and classification is still not up to the mark. Optimization technique should be applied to attain better accuracy.
- The correctness of the detection and its classification depends on the availability of the database. The strong database with maximum images of healthy plant leaves along with their diseases is the need of an hour. The availability of such database is missing. Few works done in the literature were based on two well-know databases i.e. Flavia and PlantVillage which are freely available over the internet and other works were based on the real collected images datasets which are holding very few images to compete on detection decision making accuracy [37]. Hence, constructing a huge database of leaf images can let us reach ahead in terms of accuracy of classification.
- Very few leaf disorders were addressed in the literature and therefore the further work is expected to be done to cover other diseases.

4. Conclusion

Image processing has been considered as one of the efficient approaches to deal with plant leaf disease detection. Although, several methodologies are defined in the literature, the accuracy of the detection of the plant disease is still required to be optimized. The limitation of the existing systems invites the better approach for plant leaf disease detection which reduces the computations and optimizes the detection results. Plant leaf detection can be considered as a complex computational problem, an evolutionary optimization approach can be a better solution. Swarm Intelligence based paradigm called PSO based algorithm can be utilized to address the several limitations of the state-of-the-art techniques. Advanced version of PSO can be employed for accurate leaf image segmentation, parameter selection or for optimization of the classification results. An optimization methodology using SI can be built-in for smartphone for accurate plant leaf disease detection which can be helpful for farmers, researchers, and botanist. Diagnosis of the plant leaf disorder at the early stage can guide for further remedial actions.

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