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Leaf disease identification and classification using optimized deep learning

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ABSTRACT

Diseases that affect plant leaves stop the growth of their individual species. Early and accurate diagnosis of plant diseases may reduce the likelihood that the plant will suffer further harm. The intriguing approach needed more time, exclusivity, and skill. Images of leaves are used to identify plant leaf diseases. Research on deep learning (DL) appears to have a lot of potential for improved accuracy. The substantial advancements and expansions in deep learning have created the opportunity to improve the coordination and accuracy of the system for identifying and appreciating plant leaf diseases. This study presents an innovative deep learning technique for disease detection and classification named Ant Colony Optimization with Convolution Neural Network (ACO-CNN).The effectiveness of disease diagnosis in plant leaves was investigated using ant colony optimization (ACO). Geometries of colour, texture, and plant leaf arrangement are subtracted from the provided images using the CNN classifier. A few of the effectiveness metrics used for analysis and proposing a suggested method prove that the proposed approach performs better than existing techniques with an accuracy rate concert measures are utilized for the execution of these approaches. These steps are used in the phases of disease detection: picture acquisition, image separation, nose removal, and classification.

1. Introduction

In India agriculture is the backbone of the country. Plants are the most important source for human survival thus it's crucial to take care of them. Analyzing healthy and unhealthy plants is an important process for successful agriculture development. Identification of the infected plants is an important process to protect the uninfected plants from infected plants [1]. The leaves of plants are the main source for detecting leaf infection because most of the signs of the diseases may visible on the leaves [2]. Leaf disease detection is the most recommended process to detect plant infection by recognizing different symptoms of different infections. Some of the mutualsigns of disease in plants leaf disease are Chlorosis (yellowing of leaves), Damping off of seedlings (phytophthora), Stem rust (wheat stem rust), Powdery mildew, Leaf rust (common leaf rust in corn) Sclerotinia(white mold), Leaf spot (septoria brown spot), Birds-eye spot on berries (anthracnose) [3] (see Table 1).

Convolutional Neural Network (CNN) is the often used classifier for image processing, and it has shown accurate image filtering and grouping [4]. CNN is one of the artificial neural networks which is widely used for image identification. The Image processing methods are used for disease detection in leaves [5]. CNN is categorized by some fully connected layers in the consequent phase and all adaptable factors of the leaf image portions are optimized by dropping the error over the training set [6].The Deep learning method is a bundle of machine learning methods. By using deep learning that no characteristics arrangement is needed, not like other machine learning methods. Other plant disease methods have archived good results but they consume more time and lack mouldability [7].

An Ant Colony algorithm has been implemented for the identification of leaf disease. An ant colony optimization is a session of optimization algorithms on the actions of an ant colony [8]. An ant colony optimization algorithm uses an artificial ant that uses simple computational of an agent which looks for a better solution for the problem [9]. An ant colony algorithm controls the maximum and minimum

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Table 1
Comparison of performance matrix.

Method	Accuracy	Precision	Recall	F1-score
C-GAN	99.6%	97%	97%	97%
CNN	99.97%	99.3%	99.4%	99.98%
SGD	85%	86%	85%	86%
ACO-CNN	**99.98%**	**99.6%**	**99.6%**	**99.99%**

pheromone amount on each trail. Therefore, on the shortest paths pheromone departure is less than on the longest paths in which a small number of ants travel [10]. The more pheromone is gathered in the shortest paths. This means that since more pheromone restores more number of ants,so that all the ants can eventually find the shortest path. In this algorithm, the given problem desires to be converted into the problem of finding the optimized route for the complex problem. In the first step of duplication, each ant finds a solution. By using the ant colony algorithm the unhealthy or infected area of the plants may be detected.

The rest of the segments are organized as follows: the second section discusses the related work. The proposed ACO-CNN algorithm for leaf disease detection is described in section 4. The proposed method was tested for efficiency and performance in section 5, and the result was presented in tables and graphs. The Conclusion is summarised in the final section.

2. Related works

The deep learning method is often utilized to diagnose the disease in plants by using computer vision. The visualization of the plot train and test are analyzed in the paper [11].It uses 35000 images of healthy and diseased plants. This method gives an accuracy of 96.5% but the proposed method has been able to attain a 100% exactness rate and it includes various plant leaf diseases for the detection of the infected leaf. It recovered 31 different plant variations and plant diseases using a convolution neural network. This method needs a large amount of data for accurate recognition. The deep learning method has been applied to detect plant leaf diseases as it analyzed the images from different phases, and classified them into one of the predefined sets of classes.

The documentation of the Tomato Plant leaf infection by image processing method is proposed in the paper [12],which includes clustering, an open-source algorithm, and Image segmentation. Here CNN algorithm is used for the extraction of hierarchical features, which maps input image pixel concentrations and compares with the training set of images. It utilizes fuzzy logic, hybrid algorithms, and an Artificial Neural Network could also be organized. GLCM (Gray Level Co-occurrence Matrix) has been implemented to categorize and segregate the leaf image depending on various phases. Real-time submission centered on disease identification will be the main factor in the selection of techniques. However, the method consumes more time during the training process.

The leaf may classify into multiple levels to eliminate the possibilities in each level to provide better accuracy during predictions explained In the paper [13].Here a YOLOv3 object identification is used to abstract a plant leaf from the input images. The execution of more accurate deep learning systems may help to identify the diseases. This level of detail cannot be recognized by using naked eyes [14].The ant colony optimization is used to examine classified the feature examinationinterplanetary to find the best discriminate structurefor the identification of separate classes. To find a feature examinationplanetary, a set of available individualities suchasfigure, morphology, colour, and texture are removed from the leaf images.

An impending of techniques of plant leaves disease identification is proposed in the paper [15]. It includes various stages such as image segmentation, image acquisition, classification, and feature extraction. Here are SVM (Support vector machine algorithm), BPNN (Back Propagation Neural Network), SGDM (Stochastic Gradient Descent) techniques, Otsu's algorithm, K-means clustering, and CCM (Cluster based Classification Model) have been used for disease detection. It consumes more time for leaf disease detection.Numerous tasks arise in this process which includes the automation of the identification system using composite images taken in outdoor lighting and penetrating environmental conditions.

The paper [16]has some classification methods which depend upon the input data. k-mean clustering and Support Vector Machine are the classification methods used in the paper [16]. Method selection is always a difficult part because the quality of the result can vary for each input data. Detection of diseases identified with proper segmentation of affected part based on the type of plant family.coffee leaf diseases havebeen detected using Convolution Neural Network (CNN) used to identify the coffee leaf diseases in paper [17]. Convolutional Neural Network has verified its effectiveness and correctness in the image classification andpattern recognition phase. The main purpose of this method of a neural network is for the detection of coffee leaf disease with a high level of accuracy. This method more time compared to other methods.

3. Problem statement

The existing methods for plant leaf disease identification have not given anaccurate output. These methods consume more time, a lake of flexibility, some environmental conditions, thedetonation of the image may not appear properly, took more process for the accurate output.here the Ant Colony Optimization (ACO) with Convolution Neural Network (CNN) has been proposed. The proposed method has overcome all of the above drawbacks and achievedthe predictable result for plant leaf disease identification.

4. Proposed methodology

Plant leaf disease detection involves a collection of copy datasets, pre-processing, feature extraction, segmentation, and classification the last three processesare enhanced by the ACO-CNN method. The proposed ACO-CNN process for disease detection is shown in Fig. 1.

4.1. Data collection

The collected dataset is invented of healthy and infected leaves with the following sets; greening, Canker, melanosis, and blackspots [18]. The proposed modelwas used to classify the infected leaves from the healthy leaves. The proposed method has Ant Colony Optimization with Convolution Neural Network. The classification model includes two-parts such as the training method. In the training portion, the dataset is trained with the Deep Learning method to give an exact result. Then, the testing portion is used to calculate the model's exhibition using some enactment metrics. The testing portion only has attentions on how fast it will take to give the exact result.

4.2. Data pre-processing

After the image is selected the initial step forleaf disease detection is pre-processing. Fornoise reduction and removalof other objects,the median filter has been applied to enhance the leaf images. The median filter is a non-linear well-organized digital filtering technique that is usually used to reduce noise in an image. The Median filter equation has given

$$\widehat{g}(a,b) = median_{(x,y)\in T_{ab}}\{f(x,y)\} \tag{1}$$

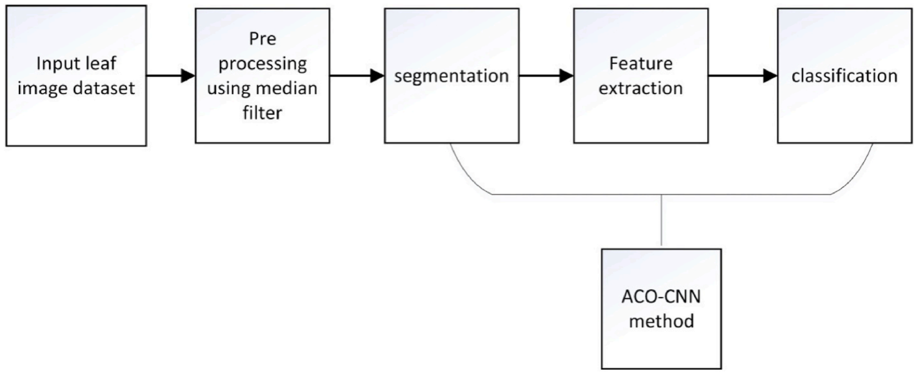

Fig. 1. Steps for the plant leaf disease identification.

43. *Segmentation*

Segmentation is the progression of classifying the plant leaf images into a smaller section of the surface, which is related to characteristics. The proposed method is used for the separation process to determine the edge of the plant leaf and make it into pieces. There are two properties of pixel concentration resemblance and variation used to stop the process of segmentation. For the similarities, color-based thresholding has been used. An Equation has been given for the segmentation.

$$|h(r,q)| = \begin{cases} 0, g(r,q) < r \\ 1, g(r,q) \geq r \end{cases} \tag{2}$$

44. *Feature extraction and classification using ACO-CNN*

The most important phase in image identification is feature extraction. The feature extraction is done by using ACOand classification is done with CNN. Which is used to identify the shortest path for the infected region identification by the ant's specific behavior of communication and classify the infected plant leaf for the protection of future prevention.

4.4.1. *Ant colony optimization (ACO)*

In recent days Ant Colony Optimization technique is used forapproximate optimization. Ant's seeking behavior is the reason behind the Ant Colony Optimization. The essentialbehavior of the ant is indirect communication, which provisions them to find the shortest footpathfor theirfoodstuff. This individual characteristic of ant is used inAnt Colony Optimization (ACO). Here the ACO is used to identify the infected pant leaf from the healthy leaf.One of the important parameters that should be modified first in the database is the pheromone rate. All pheromone material of the feature examine in the matrix(h) with a dimension of G*G such that G as rows and columns denote the complete number of a novel feature vectors. Ant colony optimization parameters are modified and the main calculation such as the experimental function F is calculated.Iidentify the confined best subset and assets, for the next repetition.

To implement the Ant Colony Optimization algorithm, the firstand most important step involves the initialization of its factors. It includesmany applicant ants.ACO algorithm has strong toughness as well as an isolated calculative mechanism.ACO can be shared with other methods easily; it displays well performance in determining the complex optimization problem.ACO performs by the updated pheromone and ants are moving in the search space according to mathematical formulae.ACO is based on local search and global search.

4.4.1.1. Transition probability of region (m). The equation for the transition probability of region which is used to find the diasesed portion of the leaf.

$$Q_m(s) = \frac{s_m(s)}{\sum_{i=1}^{d} s_i(s)} \tag{3}$$

Here $s_m(s)$ represents the total pheromone at region m and d is the number of global ants.

4.4.1.2. The equation for pheromone update. The equation for the pheromone update which is used for the ant"scommunication.

$$n_j(n+1) = (1-s)n_j(n) \tag{4}$$

Here "s' denotes pheromone evaporation rate.

4.4.2. *Convolution neural network (CNN)*

The classifiers of Convolution Neural Network (CNN) are used to identify each leaf disease. It efficiently evaluates graphicalpictures and removes the needed features through its multi-layered construction. CNN classifier containsfour layers: image input, convolutional layer, Max pooling layer, fully connected layer, and output. The range of image pixelintensity values of plant leaf in the dataset before training convolution neural network model. During the training phase CNN is the fastest model.The images which are given as input should have the same size.formula or the normalization of each image in the training set:

$$p(a,b) = \frac{O(a,b) - \mu}{\sigma} \tag{5}$$

a) Convolution layer

The convolution layer collects some images as input and analyses the complication of each of them with the help of each layer.It relates exactly to the features we want to find in the given images.

$$f_i^m = x\left(\sum_{j \in N_i} f_j^{m-1} * p_{ji}^m + a_i^m\right) \tag{6}$$

N_i–it representsaninput selection.An additive bias b has given as a output. The kernel applied to map i ,that if the map j an dmap k both sum over map i.

b) Max pooling layer

This layer is used to decrease fitting and lower the neuron size which is used in the downsamplinglayer. The Pooling layer reduces the parameter number, computation rate, feature map size, training time, and controls overfitting. Overfitting is defined by50% on test data-and100% on the training dataset.

$$x_{mab} = max_{(s,t)\in} f_{mst} \tag{7}$$

Map, f_{mst} is the element at (s, t) within the pooling region p_{ab} which represents a local neighborhood around the place (a, b).

c) Fully connected layer

For the context of image classificationFully Connected Layer has used.The FC layers are placed after all the Convolution layers. The FC layer helps to map the illustration between the input and the output. Fully connected layers form the last layers in the network. The output of the max pooling layer is the input of the fully connected layer.

d) Softmax layer

The Softmax layer is used to convert the scores to a normalized probability distribution. the classifier gets the output as an input. Softmax classifier is the familiar contribution classifier and organization of plant leaf diseases is applied in the softmax layer.

$$\sigma\left(\vec{X}\right)_n = \frac{e^{x_n}}{\sum_{i=1}^{m} e^{x_i}} \tag{8}$$

Algorithm. ACO-CNN mechanism

Algorithm: ACO-CNN mechanism	
Input: *leaf images*	
Output: *classification of healthy and unhealthy leaves*	
Load input image data	
$I = \{I_1, I_2, I_3 \ldots\}$	*// data acquisition*
Pre-processing of images	*//median filter*
I_p=*I-n*	
Feature extraction	*// Ant Colony Optimization*
Initialize the starting pointof the infected portion	
if (ant reaches the next position)	
Gather the subset	
Identify the infected region of the leaf using eqn. (1)	
Else	
Find out the next component using eqn. (2)	*//update pheromone*
Repeat until stopping criterion is met	
end if	
Return	
Classification of healthy and unhealthy leaf	*//CNN Classifier*

The complete flow diagram is shown in Fig. 2. The flow chart begins by importing images. Pre-processing is done by the median filter. The features are removed and it is classified using ACO-CNN to identify the infected leaf and the healthy leaf (see Fig. 3).

5. Result and discussion

The proposed method has beentested using the collected plant leaf images.The proposed method used Ant colony optimization with Convolution neural network (ACO-CNN)was used to identify the infected leaf from the uninfected leaf. The four standard evaluation measures are evaluated in the study, such as classificationRecall, precision, accuracy,and F1-score which are defined below.

Accuracy provides appropriate results from the available leaf images. Accuracy is represented in eqn. (9)

$$Accuracy = \frac{TN + TP}{FN + FP + TP + TN} \tag{9}$$

Precision evaluates the performance of a classifier in detail. If the plant leaf has low positives, then the precision will be high andif the plant leaf has high positives then the precision will be low. Precision is represented in eqn. (10)

$$precision = \frac{TP}{FP + TP} \tag{10}$$

Recall measures the fullness of the classifier. The higher the recall, the more positive samples are detected. The formula for the recall is represented in the eqn. (11)

$$Recall = \frac{TP}{FN + TP} \tag{11}$$

Recall and precision has been measured by the F1 –score.The F1-score measure is calculated from the precision and recall. F1 measure is represented in eqn. (12)

$$F1 - score = \frac{2 \times Precision \times Recall}{Precision + Recall} \tag{12}$$

Where TN= True Negative, FN= False Negative, TP= True Positive, FP= False Positive.

Here the ACO-CNN model has given betteraccuracy, precision, recall,and F1-score compared with C-GAN, CNN, and SGD models. In C-GAN,CNN,and SGD's accuracy rates are 99.6%, 99.97%, and 85% respectively. In the ACO-CNN model, the accuracy rate has 99.98% hence the precision, recall, and F1-score have the better rate in the ACO-CNNN method compared with other models, and the F1-score has achieved the highest rate compared to other models. Which is shown in Fig. 2.

5.1. Discussion

Many different plant leaves were used with different leaf shapes, clustering behavior, and sizes. The proposed method would also be subject to different performance. The classification of the method has been achieved over all other traditional methods. It classifies whether

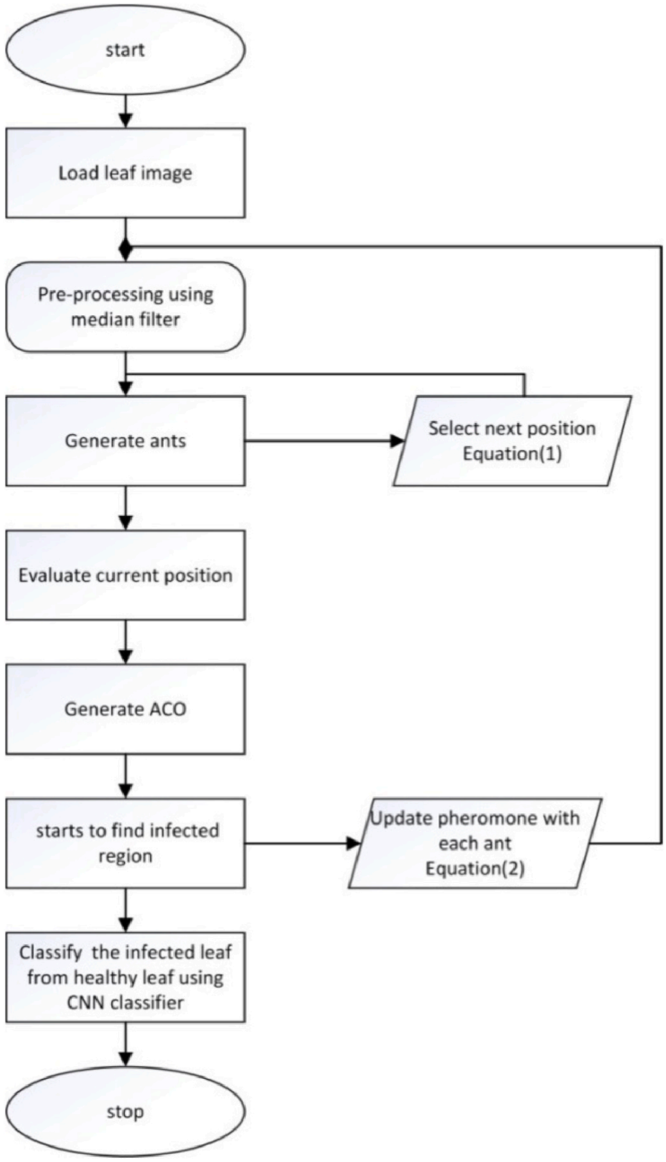

Fig. 2. Complete flow diagram of the proposed method.

the plant leaves are diseased or healthy so that the farmers can take the right action on particular diseases in their early stages. To make decision for the collection of optimal features an Ant Colony Optimization has been used.Ant Colony Optimization with Convolutional Neural Network (ACO-CNN) provided a review of the most interesting research direction. This can be useful specifically when large difficult problem instances are considered.

6. Conclusion

Crop protection in organic farming is not an easy chore.This needs thorough knowledge about weeds, pathogens, possible pests, and the crop being grown. Early identification of leaf diseases is essential to the agricultural industry. Here is the basic concept of plant leafinfection identification and plant leaf infection symptoms.For test real-time images for leaf disease identification the traditional method has been used. The proposed method can provideprovision for farmerstodetect and recognize plant leaf diseases.Here theACO-CNN optimization approach is proposed for leaf disease detection.ACOwas used for the feature

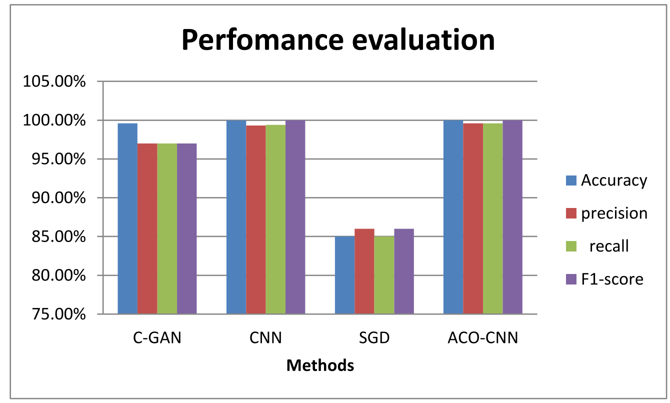

Fig. 3. Performance metrics.

extraction and CNN classifier hasused for the organization.The proposed method is used to detect the infected leaf from the healthy leaf.

CRediT authorship contribution statement

Yousef Methkal Abd Algani: Conceptualization. **Liz Maribel Robladillo Bravo:** Formal analysis, Validation. **Chamandeep Kaur:** Implementation and validation. **Mohammed Saleh Al Ansari:** Validation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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