IDENTIFICAION OF LEAF DISEASE USING MACHINE LEARNING ALGORITHM FOR IMPROVING THE AGRICULTURAL SYSTEM

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Abstract
The diagnosis of plant disease is the foundation for effective and accurate plant disease prevention in a complicated environment. Smart farming is one of the fast growing processes in agricultural system with identification of disease in plants being major one to help farmers. The processed data is saved in database and is been used in making decisions in advance support, analysis of plants and helps in crop planning. Plants are one of the most important resources for avoiding global warming. However, diseases such as blast, canker, black spot, brown spot, and bacterial leaf damage the plants. In this paper, an integration of image processing is developed in identifying the type of disease and help in automatic process of inspection of all the leaf batches by storing the processed data. In some places, farmers were unaware of the experts, and they do not have proper facilities. In such conditions, one technique can be beneficial in keeping track and monitoring of more number of crops. This technique makes it much easier and cheaper to detect disease. Machine learning can provide a method and algorithm to detect the disease. There should be the training of images of all types of leaves that include the ones that are healthy and disease leaf images. Five stage detection processes is done in this paper. The stages are preprocessing, segmentation using k-Mean, feature extraction, features optimization using firefly optimization algorithm (FA) and finally classified using support vector machine (SVM). The rate of accuracy achieved using proposed technique i.e. GA-SVM is 91.3%, sensitivity is 90.72%, specificity 91.88 and precision is 92%. The results are evaluated using matlab software tool.

Keywords:
Leaf Diseases, k-Mean, Firefly optimization algorithm, support vector machine

1. Introduction

Many crops get destroyed because of the lack of use of technology. One of the important sources of income for people in India is agriculture. A variety of crops are grown by farmers, but one reason for the destruction of crops diseases. Plant disease is the primary cause of crop damage in India. Different plants suffer from different diseases. The central part is the leaf of a plant to examine the disease with the help of agriculture experts who knew plant disease used to detect diseases in plants. However, this kind of detection of diseases in plants was costly and time-consuming. Hence, a better method was required to detect diseases in the leaf. Computer and software play an important role in the identification and classification of leaf diseases. For leaf disease detection, there are lots of image processing and pattern recognition techniques that can be used. The key to preventing agricultural loss is leaf disease detection.

Plant illness can straightforwardly prompt hindered development causing terrible impacts on yields [1]. A financial loss of up to $20 billion every year is assessed all around the world [2]. Various conditions are the most troublesome test for specialists because of the geographic contrasts that might prevent the exact distinguishing proof [3]. Also, customary strategies chiefly depend on subject matter experts, experience, and manuals [4], yet most of them are costly, time consuming, and work concentrated with trouble identifying exactly [5]. Consequently, a fast and exact way to deal with recognizes plant infections appear to be so pressing to assist business and nature to agribusiness. In rural harvests, leaves assume a crucial part to give data about the sum and nature of agricultural yield. A few elements influence food creation, for example, environmental change, presence of weed, and infertility of soil. Aside from that, plant or leaf sickness is a worldwide danger to the development of a few horticultural items and a wellspring of monetary misfortunes [6]. The inability to analyze contaminations/microscopic organisms/infection in plants drives consequently to inadequate pesticide/fungicide use. Consequently, plant sicknesses have been generally thought to be in mainstream researchers, with an attention on the organic provisions of illnesses. Exactness cultivating utilizes the most trend setting innovation for the improvement of making decisions. The visual examinations by specialists and organic audit are normally brought out through diagnosis of plants when required. This strategy, be that as it may, time consuming and cost ineffectual. To resolve these issues, it is important to recognize plant infections by the techniques which are advanced and intelligent.

To play out the activities of agriculture, regular machine learning (ML) calculations have been applied in many investigations [7]. Nonetheless, as of late, deep learning (DL) as a sub-set of ML, has been strikingly successful for genuine identification of object and for the purpose of classification [8]. Thus, research in farming has been moving towards the DL-based arrangements. The DL procedures have been cultivated best in class results to play out the rural tasks including crop/weed segregation [9], organic product gathering [10], and plant acknowledgment [11]. Essentially, late examinations have additionally centered around one more significant agriculture issue of plant disease recognizable proof [12]. Several state of art DL approaches have been used to conduct plant infection grouping by utilizing notable DL structures. In addition, a few specialists presented adjusted adaptations of DL calculations to work on the presentation of the order of illness in a few plant animal varieties. A couple of the unmistakable/ongoing examinations are featured in this part. For instance, a new article introduced a near investigation of different Convolutional Neural Networks (CNN) and DL optimizers to accomplish better consequences of plant infection characterization [13].

One directional pixel difference histogram (PDH) analysis detects Wu and Tsai's one directional PVD and Khodaei and Faez's two directional PVD [16]. As a real-world case study, the GOA-DE algorithm solves visual tracking issues. Visual tracking of several items in a video stream with complex backdrops and objects is useful in next-generation computer vision architecture [17]. The suggested CNN (convolutional neural networks)–GB (Gradient Boosting) and adaptive median filter (AMF) mechanisms increase disease detection performance [18]. Attacks caused by malicious node activity are identified utilising the Hybrid Reactive Search and Bat (HRSB) method, which prevents hostile nodes from entering the network behind false information [19].

To validate the own user, the Gait pattern authentication mechanism is introduced. To recognise the owner, the current study offers a running Gaussian grey wolf boosting (RGGWB) model [20]. A mixed machine learning system is excellent in predicting heart attacks and arterial stiffness. Initially, we used a hybrid fish bee optimization (HFBO) method to do feature selection [21]. Jaya Method-based Multi-Verse Optimization algorithm is used to optimise the weight function by combining two meta-heuristic algorithms (JA-MVO). The best features are exposed to hybrid deep learning algorithms such as “Deep Belief Network (DBN) and Recurrent Neural Network (RNN)” [22]. The characteristics of KNN combined with ACO to provide improved Drug Consumption Similarities [23]. In this paper optimization technique is introduced along with machine learning algorithm. The optimization when combined with support vector machine classifier given accurate results in identification of leaf disease. Here in this paper firefly optimization technique is used. The optimization technique helps in obtaining the best features to identify the disease. The discussion of proposed method is studied in upcoming section.

2. Material and Methods

The leaf disease identification model framework based on machine learning technique is shown in Figure 1, including four steps, the preprocessing and segmentation of plant leaves, the feature extraction of images, the feature optimization of images, and the identification of disease using classification technique. The model employed in this study is described, and the experimental findings are assessed.

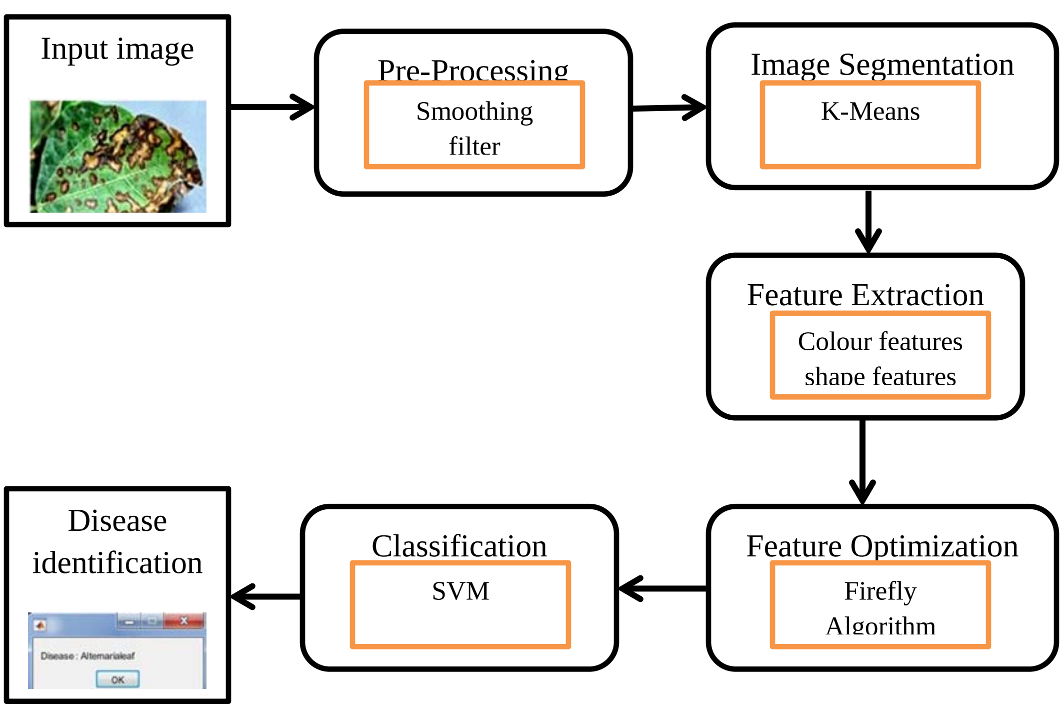

Fig1. Proposed Process flow

A. Data Acquisition

The RGB Color pictures of the leaf are shot with smart phones or digital cameras with pixel sizes of 768*1024 for a clean image. Each of the digitized pictures is 225KB in size. These pictures have been cropped into smaller ones of 109*310 pixel size. Using the matlab image analysis library, images are saved in PNG format. Figure 2 depicts several sorts of diseased leaves for processing.

Fig2. Different type of leaf images

B. Image Preprocessing

The work of image preprocessing entails noise removal and image enhancement. A leaf picture with a resolution of 109*310 pixels is utilised. The RGB pictures are transformed into grey scale images to ensure great accuracy. The image's noise is filtered before it is processed further. In this case, a smoothing filter is applied. To improve contrast, use contrast enhancement techniques such as histogram equalisation and contrast modification. The probability distribution is used to build the occurrence matrix from the input pictures.

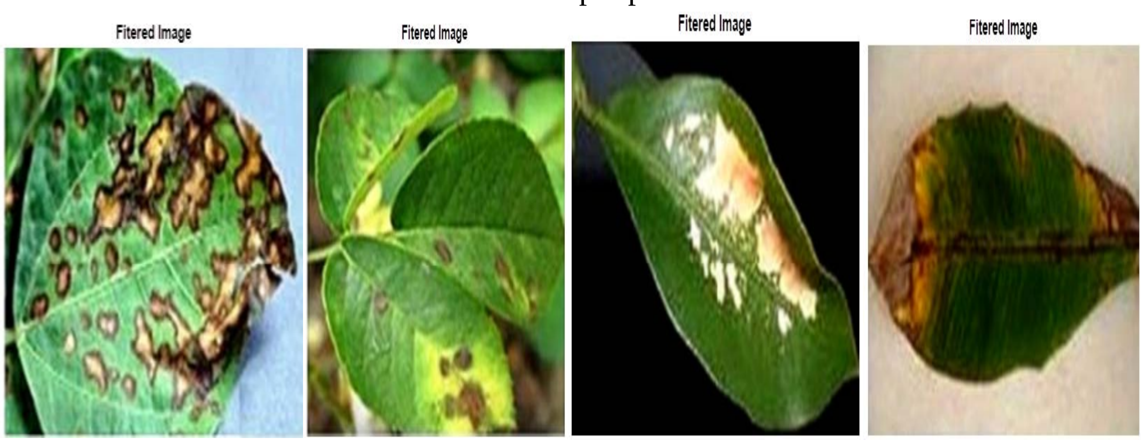

Fig3. Preprocessing of different leaf images

C. Image segmentation

Image noises that degrade image quality are identified during image segmentation. The K algorithm is used to eliminate noise and unwanted spots. The binary picture with noise is transformed to a noise-free image. The filtered pictures are the noise-free images. The filtered picture is then improved using the K means method, which produces a high-quality image for identifying leaf disease.

D. Feature extraction

As the diseases in leaf is composed of various forms of disease blast, brown spot, and narrow brown spot, each with a unique lesion shape and colour.

a. Shape feature extraction

One of the image's most essential parameters is its shape. The image's breadth and length are important characteristics for describing the type of image. A straightforward method for determining the image's width and height is to count the object pixels.

b. Color feature extraction

Color is very essential in image processing. Digital image processing generates quantitative colour measurements, which are important for the job of investigating the lesion for early diagnosis. Pixels in colour pictures are frequently represented in RGB format, where RGB stands for RED, GREEN, and BLUE values from the colour image recording equipment.

E. Feature Optimization

The features are optimized based of firefly optimization. The process of optimization is discussed below. Firefly Algorithm (FA) was first developed by Xin-She Yang in late 2007 and 2008 at Cambridge University [13-14], which was based on the flashing patterns and behaviour of fireflies. Evolution of firefly algorithm in recent years became more significant and many research works are been performed based on Firefly Algorithm.

Fireflies are unisex with the goal that each individual firefly will be pulled into different fireflies paying little mind to their opposite sex. The attractiveness and brightness are directly proportional to each other, and they both lessening as their separation increments. Along these lines for any two blazing fireflies, the less splendid one will attract the more brilliant one. On the off chance that there is no more brilliant one than a specific firefly, it will move randomly. The brightness of a firefly is controlled by the scene of the goal work [14].

As a firefly's attractiveness is proportional to the light intensity seen by adjacent fireflies, can now define the variation of attractiveness β with the distance r by

$$\beta = \beta_0 e^{-\gamma r^2} \tag{1}$$

Where β_0 is attractiveness at r=0

The firefly i is attracted to another more brighter firefly j and move towards j and the sane is determined by

$$x_i^{t+1} = x_i^t + \beta_o e^{-\gamma r_{ij}^2}\left(x_j^t - x_i^t\right) + \alpha_t \epsilon_i^t \tag{2}$$

Where the second term $\boldsymbol{\beta_o e^{-\gamma r_{ij}^2}\left(x_j^t - x_i^t\right)}$ is concern based on the attraction. The third term i.e $\boldsymbol{\alpha_t \epsilon_i^t}$ is randomization with $\boldsymbol{\alpha_t}$ being the randomization parameter, and $\boldsymbol{\epsilon_i^t}$ is a vector of random numbers drawn from a Gaussian distribution or uniform distribution at time t.

If $\boldsymbol{\beta_0}$ = 0, it becomes a regular pattern for determining the optimised value. On the other hand, if γ = 0, FA in generally termed to be particle swarm optimization [13].

The complexity of firefly algorithm has inner loop and outer loop and the complexity of FA algorithm is given as *O(nt* log*(n))*. This is obtained based on inner loop population size n and number of iteration t [15]. If the value of n is more the ranking of fireflies which are brighter will be obtained more easily.

The progression of firefly close to the ideal arrangement ought to be set little. Also, the progression of firefly far from the ideal arrangement ought to be set substantial. Fireflies between the over two are utilized to adjust the worldwide inquiry and neighborhood look. Accordingly, the progression of firefly ought to likewise be worried about its authentic data and current circumstance. Based on the comments mentioned above and many experiments, the step of each firefly is calculated by (3) and (4), respectively

$$h_i(t) = \frac{1}{\sqrt{\left(f_{pi}(t-1)-f_{pi}(t-2)\right)^2+1}} \tag{3}$$

$$\propto_i (t+1) = 1 - \frac{1}{\sqrt{\left(f_{best}(t)-f_i(t)\right)^2+h_i(t)^2+1}} \tag{4}$$

Algorithm for firefly optimized features

The firefly algorithm is implemented in this paper and the process is stated below:

Step1. Initialization of extracted features from image

Step2. The population of features is gives as, $\{x_1, x_2, \dots \dots, x_n\}$.

Step3. Calculating the brightness value using cost function based on firefly for the assigned images

Step4. Fireflies' intensity is given as $\{I_1, I_2, \dots \dots, I_n\}$.

Step5. Update the step of each feature

Step6. Ranking of features and finding current best

Step7. Moving of each firefly *i* towards other brighter fireflies (for obtaining optimized features)

Step8. Update the solution set.

Step9. Stop when result obtained; otherwise go to Step 2.

Finally the optimized features are fed to support vector machine learning algorithm for identification of disease.

F. SVM Classification

SVM is a parallel classifier dependent on supervised learning which gives better execution over different classifiers. SVM characterizes between two classes by building a hyperplane in high-dimensional element space which can be utilized for arrangement. Hyperplane can be addressed by the following condition

$$w.x + b = 0 \tag{5}$$

w is weight vector and normal to hyperplane. b is bias or threshold.

In this work, a 10-fold cross-approval is utilized as grouping calculation for anticipating the test errors for given datasets. It randomly divides the training set into 10 disjoint subsets. Each subset has the roughly equal size and roughly the same class proportions as in the training set. A SVM model is trained on a large dataset of leaf images to classify different types of diseases in plants when it is provided with a new leaf image. It is based on leaf feature extraction and optimization; the leaf features are orthogonalized into different variables and passed as an input vector to the SVM.

3. Results and Discussion

All of the experiments are carried out in MATLAB. For disease input data, plant leaf samples such as bacterial disease in rose leaves, bacterial disease in bean leaf, Sun burn disease in lemon leaf, early scorch disease in banana leaf, and beans leaf with fungal disease, among others, are taken into account. The entire process is generated using graphical user interface. Each stage is processed and the output results are obtained.

Case1. Input is paddy leaf

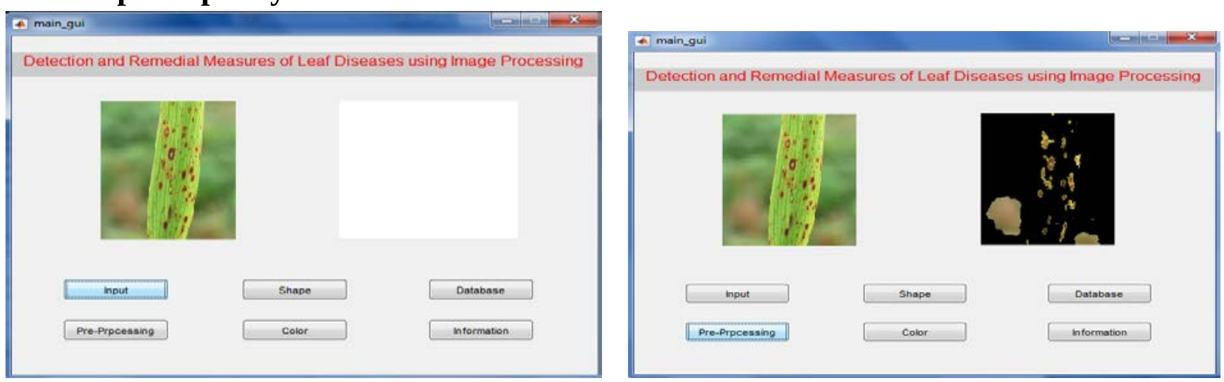

Fig4. Main GUI block and Preprocessed Image

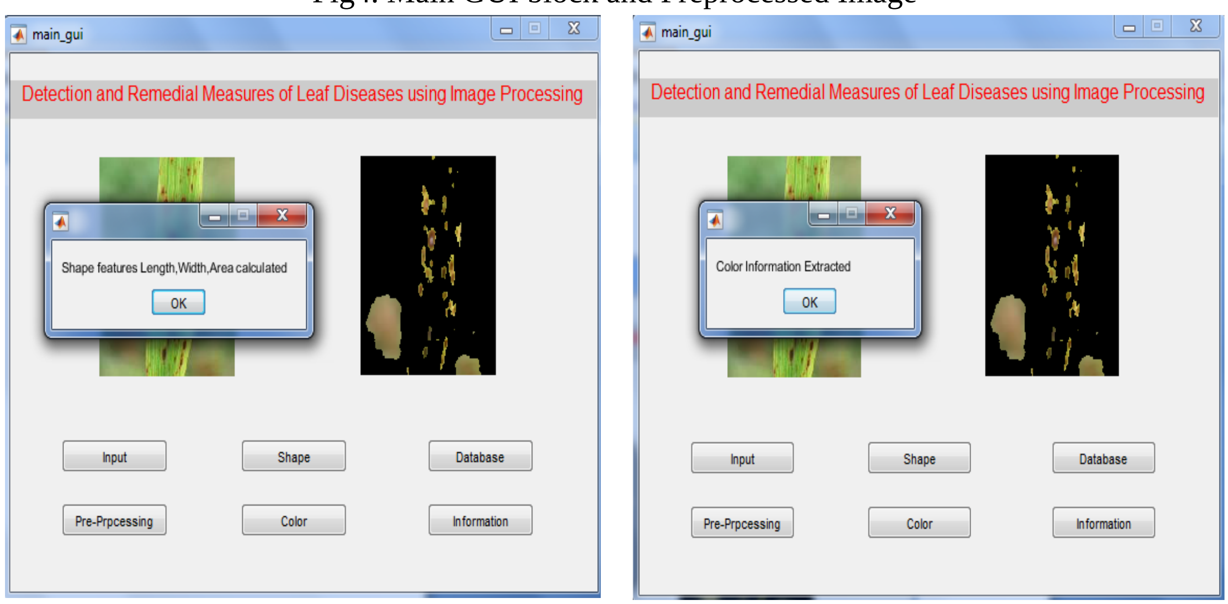

Fig5. Shape and colour features extraction block

After all the stages of implementation, the disease is spotted and identified. The remedy for the disease is shown and the information is saved in the database for further processing for the famers. For achieving this support vector machine algorithm plays a key role. For analysis of proposed system the parameters are evaluated.

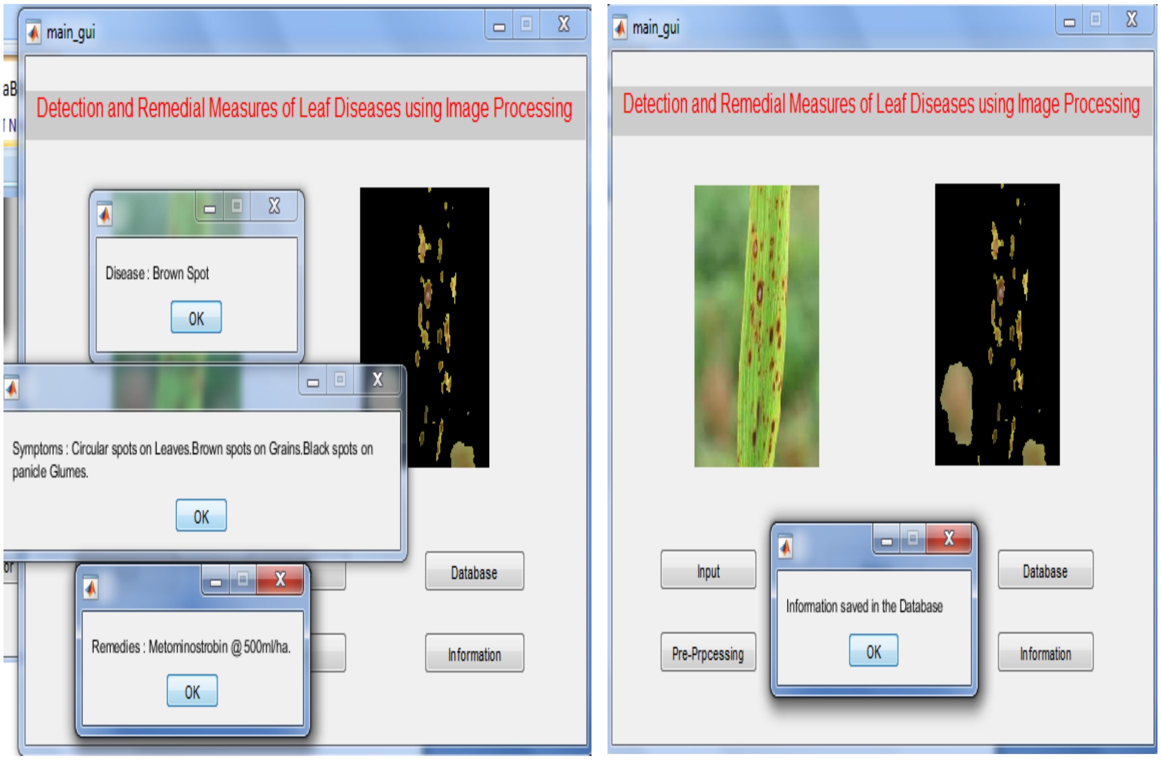

Fig6. Identification of disease and display of remedy

Some of the disease names, scientific names, symptoms along with the remedies for different leafs are shown in table1.

Table1. Various disease name and remedies

Disease Name	**Scientific Name**	**Symptoms**	**Remedies**
Bacterial Leaf Blight	Xanthomonas Oryzae	* Seedling wilt or kresek. * Water soaked to yellowish strips on leaf blades. * Appearance of Bacterial ooze that look like milky or opaque.	* Spray fresh cowdung extract 20% twice. * Neem oil 60 EC 3% or NSKE 5% is recommended.
Rice tungro	**Rice tungro** bacilliform virus RTBV	* Stunning and Reduced Tillering. * Leaves become yellow or orange . * Delayed flowering. * Partially filled grains.	* Thiamethoxam 25 WDG 100g/ha. * Imidacloprid 17.8 SL 100ml/ha.
Sheath Blight	Rhizoctonia Solani	* Rust coloured spots * Discoloration from leaf tip to lower portion. * Panicles Sterile	* Carbendazim 50 WP @ 500g/ha. * Azoxystrobin @ 500ml/ha. Hexaconazole 75% WG @ 100mg/lit

Sheath Rot	SarocladiumOryzae	* Irregular spots or lesions with dark reddish brown margins. * Whitish powdery growth. * Unemerged panicles rot.	* Gypsum @ 500kg/ha. * Neem oil 3%. * Metominostrobin @ 500ml/ha.
Brown Spot	HelminthosporiumOryzae	* Circular spots on Leaves. * Brown spots on Grains. * Black spots on panicle Glumes.	* Metominostrobin @ 500ml/ha.
False Smut	UstilaginoideaVirens	* Growth of velvety spares. * Rice grains transformed into yellow bodies. * Growth of spores result to broken membrane.	* Propiconazole 25 EC @ 500ml/ha. * copper hydroxide 77 wp @ 1.25 kg/ha.
Leaf Streak	Xanthomonas Oryzaepv.Oryzicola	* Initially small,dark green water soaked. * Lesions turn Brown. * Bacteria ooze out under humid weather.	* Spray fresh cowdung water extract 20%. * Copper hydroxide 77 WP @1.25 kg/ha.

Parametric Values

For evaluating the below shown parameters, 15 types of leaves are considered and the parameters are evaluated. Table2 shows the calculated values of different images.

Area

Area is a shape related parameter for an image and is calculated. This parameter is for estimating the objects area in binary image BW. Total is a scalar whose value corresponds roughly to the total pixels count in the image, but might not be exactly the same because different patterns of pixels are weighted differently.

Perimeter

It is also a shape related parameter in an image. It produces a binary image containing just the perimeter pixels of the objects in the input image BW. A pixel is part of the perimeter if it is nonzero and it is connected to at least one zero-valued pixel.

Entropy:

Entropy is a quantitative metric used to assess picture quality. Entropy is a statistical metric that is used to describe the texture of an input picture. Entropy measures the amount of information in a picture that is required for image improvement. Entropy quantifies the loss of information or message in a sent signal containing picture data. The entropy is said to be zero if all of the pixels have the same value.

$$E = -\sum_{i=0}^{L-1} p_i . log_2 p_i \qquad [6]$$

Table2. Parameters of different leafs

Parameter	Area (A)	Entropy (En)	Perimeter (P)
Image1	79321	0.9635	2603
Image2	89515	0.8924	2239
Image3	83121	0.9415	3418
Image4	85489	0.9252	2556
Image5	45678	0.9362	4461
Image6	101262	0.7577	6733
Image7	58519	0.9932	6777
Image8	52068	0.9720	7594
Image9	57677	0.9913	6741
Image10	52494	0.9738	6134
Image11	83751	0.9374	4330
Image12	56666	0.9886	4313
Image13	59844	0.9958	8402
Image14	101749	0.7507	2947
Image15	60340	0.9966	3856

Sensitivity

Sensitivity (also called the true positive rate, the recall, or probability of detection in some fields) determines the percentage of true positives that are accurately detected.

$$Se = \frac{Truly\ Positive}{Truly\ Poitive + Falsy\ Neagative} \qquad [7]$$

Specificity

Specificity (also called the true negative rate) measures the proportion of actual negatives that are correctly identified as such (e.g., the percentage of non-diseased leafs which are correctly identified as not having the disease).

$$Sp = \frac{Truly\ Neagtive}{Truly\ Negative + Falsy\ Positive} \qquad [8]$$

Accuracy

The accuracy is given as,

$$Ac = \frac{Truly\ Positive + Truly\ Negative}{Truly\ Positive + Truly\ Negative + Falsy\ Positive + Falsy\ Neagative} \qquad [9]$$

Precision

Precision is a description of random errors, a measure of statistical variability and is valuated using the formula given below,

$$P_r = \frac{True\ Positive}{True\ Positive + False\ Positive} \qquad [10]$$

The results obtained using optimization technique and without optimization technique are compared and shown in table3.

Table3. Overall rate of Parameters

Technique/Parameter	SVM	FA-SVM
Accuracy	90	91.30
Sensitivity	89.21	90.73
Specificity	90.81	91.88
Precision	91	92

From table3 it is clear that using optimization technique the rate of accuracy is improved by 1.3%. The changes obtained in overall rate of accuracy, sensitivity, specificity and precision for the entire dataset used for processing is shown in fig7.

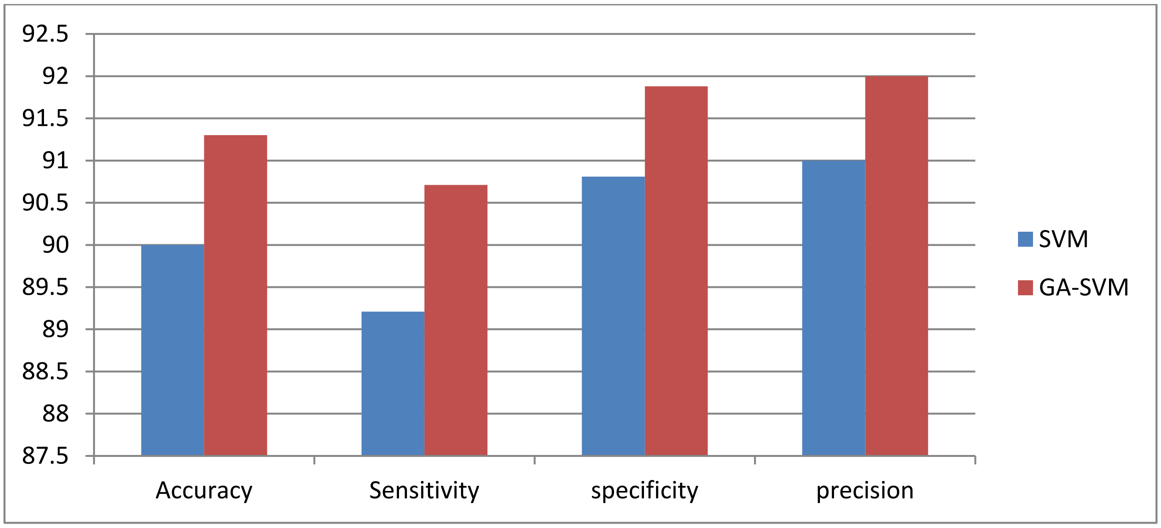

Fig7. Changes obtained in parameters

4. Conclusion

The main goal of this paper was to perform the complex task of plant disease classification and identification in a single framework. A graphical user interface is developed for purpose of identification and giving remedy for the identified diseased. The proposed System shows usefulness of integration of optimization and machine learning algorithms for obtaining an expert system model. To utilize the proposed model the entire system need to be trained with set of diseased images. In order to diagnose a disorder from leaf image four image processing phases have to be applied: Image preprocessing, Image segmentation, Feature extraction, & classification. Due to integration of optimization and machine learning technique the rate of accuracy in identifying the disease will be increased. The results obtained using optimization and without using optimization technique are compared and the results shows that using optimization technique along with machine learning technique gives more accurate results in identification of diseases. The rate of accuracy using SVM is 90% and using firefly algorithm along with SVM is 91.3%.

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