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Development of Novel Neural Networks for the Identification of Types of Tulsi Leaves.

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ABSTRACT

Identification of different varieties of medicinal plants is quite important now days as it is helpful and more important in pharmaceutical applications. This paper describes about the methodology of the feature extraction of the different varieties of Tulsi and inputting these features to the neural network that has been trained by Levenberg Marquardt algorithm and the modified LM algorithm. The features like shape,color and texture are extracted from all the leaves and stored in the separate database for further analysis. The shape feature , color feature, texture feature and the combination of all these features will be given as input to the network trained by Levenberg Marquardt algorithm and to the Novel network that has been trained by the modified Levenberg Marquardt algorithm. The Damping parameter lamda plays an important role in the convergence of Levenberg Marquart algorithm. The Updation of the damping parameter in each iteration gets altered in the modified Levenberg Marquardt algorithm. Thus the validation performance and the efficiency obtained by both the neural networks are compared and to prove that the modified LM algorithm have better recognition accuracy. The software involved for this work is MATLAB- Image processing and Neural Network toolbox.

Keywords: Image processing, Neural Network, Feature Extraction, Levenberg Marquardt algorithm

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INTRODUCTION

Medicinal plants forms the major source for the herbal medicines and it is more beneficial and side effects are less when compared with the allopathy medicines.The Leaves of the medicinal plants plays a vital role in the preparation of the herbal medicines.Such plants are becoming extinct now a days. Hence proper authentication of the plants is very much important and the main application is in Pharmaceutical industries. There are many varieties of Tulsi and each variety has its unique medicinal value. Some of the varieties are Rama tulsi, Krishna Tulsi(purple leaved),Vana tulsi and Podhi (small leaved) Tulsi. Identifying such medicinal value plants becomes very tough and tedious process hence some automated tasks should be used for classifying and identification of such plant varieties. Image Processing is one of the rapidly emerging technologies to computerize and automate such tasks.

Literature Survey

Identification and authentication of such medicinal valued leaves involves microscopic and macroscopic observation. Microscopic observation involves chemical analysis, fingerprinting techniques etc. whereas the macroscopic observation involves observing the morphology of the leaf that is its size, shape, color and texture [14]. When compared with microscopic observation, macroscopic observations are quite easier and its external features can be extracted. By plucking the leaf samples from the plant and taking its digital images and it can be easily transferred to the Laptop. Thus by using the image processing tool its features can be extracted. The shape, size, color, veins are the characteristics that is used to differentiate or identify several varieties of medicinal leaves.

The plant identification system and classifying several varieties of leaves have been proposed by several researchers. According to [1], the classification of several medicinal plants is done by extracting its morphological features like shape, color and texture. In [2] has identified the verities of leaves by extracting only its Texture values with GLCM matrix concept for extraction and[3] has proposed many learning algorithms for training the neural network and to compare its performance. According to [5] have done work with the effect of the training algorithms for the performance of ANN for pattern recognition. Hence with the several algorithms neural networks can be trained and its performance and efficiency can be computed. Each and every application can work with the particular training algorithms. Levenberg Marquardt is found be the better pattern recognition algorithm.4 different varieties of Tulsi leaves are plucked and 15 images from each sample are taken and its features can be extracted. These features can be given as input to the neural network that has been trained with LM algorithm and modified LM algorithm. The plots like Confusion matrix, Performance plot are obtained and its recognition accuracy is compared.

MATERIALS AND METHODS

Preprocessing of images

The Digital Images that has been captured gets transferred to System and necessary preprocessing techniques are used to remove the background information, filling of holes and cropping of the images to the particular size. The preprocessing techniques involved are Median filtering, Gaussian filtering, Contrast Limited Adaptive Histogram Equalization.

Feature Extraction

The prominent geometric shape features namely Compactness (C), Eccentricity (Ecc), Aspect Ratio (AR) and Hu moments (HuM) are extracted initially. The mathematical expressions for the shape features are given in the following below Equations.

$$compactness = 4\pi * \frac{area}{perimeter^2}$$

$$Eccentricity = \sqrt{1 - (b/a)^2}$$

$$Aspectration = a/b$$

Where a where is the Major axis length and b is the Minor axis length.

Seven moments proposed by Hu [9] are used to capture the shape of a leaf. The moments are invariant to rotation, translation and scaling. The moment of the image is the sum of the moments of individual pixels. Here we used first four moments.

$$M(i,j) = \sum\sum (x^i)(y^j)I(x,y)$$

Where (x,y) refers to co-ordinate pixels of the leaf image and can be varied to get different moments. I(x,y) is the intensity level at the pixel of the image.

$$\mu 1 = M(2,0) + M(0,2)$$
$$\mu 2 = (M(2,0) - M(0,2))^2 + (2M(1,1))^2$$
$$\mu 3 = (M(3,0) - 3M(1,2))^2 + (M(3,0) - 3M(2,1))^2$$
$$\mu 4 = (M(3,0) + M(1,2))^2 + (M(3,0) + M(2,1))^2$$

The mean value of first four moments was taken as one of the shape parameter for analysis.

Color moments represent color features that can be used to characterize a color image. For RGB color space, the features can be extracted from each Red, Green and Blue plane. The color features of leaves such as mean, standard deviation, skewness, and kurtosis are calculated using the below equations. These operations are applied to the color image directly [10].

$$Mean(\mu) = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} P(i,j)$$

$$Standard\ deviation\ (\sigma) = \left[\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} P(i,j) - \mu\right]^{\frac{1}{2}}$$

$$skweness(\Theta) = \frac{1}{MN\sigma^3}\sum_{i=1}^{M}\sum_{j=1}^{N}[P(i,j) - \mu]^3$$

$$Kurtosis(\gamma) = \frac{1}{MN\sigma^4}\sum_{i=1}^{M}\sum_{j=1}^{N}[P(i,j) - \mu]^4$$

Where M and N are the dimensions of the image. P (i, j) are the values of the color on column and row.

Leaf image texture gives information regarding the spatial arrangement of color or intensity in a leaf image. A diversity of techniques is available for computing texture and we used the GLCM. A GLCM is a square matrix which consists of the same number of rows and columns as the number of gray levels in an image. Texture features like Sum variance (SV), Sum Entropy (SE), Entropy (En), Difference Variance (DV), Difference Entropy (DE) are calculated. The notations used while calculating texture features are given below:

$$P_x(i) = \sum_{j=0}^{G-1} P(i,j)$$

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$$P_Y(j) = \sum_{j=0}^{G-1} P(i,j)$$

$$P_{X+Y}(K) = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1} P(i,j)\,; \quad |i+j| = K$$

For $K = 0,1,\ldots 2(G-1)$

$$P_{X-Y}(K) = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1} P(i,j)\,; \quad |i-j| = K$$

The mathematical expressions for the calculation of texture features from GLCM matrix are given in the below equations

$$Entropy = -\sum_{i=0}^{G-1}\sum_{j=0}^{G-1} P(i,j)\log\big(P(i,j)\big)$$

$$Sum\ Entropy = -\sum_{i=n}^{2G} P_{X-Y}(i)\log\Big(P_{x+y}(i)\Big)$$

$$Difference\ variance = \sum_{i=n}^{G-1}\big(i-\mu_{x-y}\big)^2 P_{x-y}(i)$$

$$Variance = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}(i-\mu)^2 P(i,j)$$

Where μ_{x-y} is the mean value of $P_{x-y}(i)$.

Neural Network Classifier

Neural Networks are considered to be the efficient classifiers and it is mainly applicable in the pattern recognition problems. The main aim is to build the efficient classifier that is used for differentiating and identifying the varieties of Tulsi leaves as show in Figure 1.A 1- hidden layer feed forward network is used with number of hidden neurons and 'tansig' transfer function is used for the hidden layer neurons. The first step is to train the network with the 'trainlm' algorithm and to obtain the performance. The next step is to train the network with the modified LM algorithm and their validation performances are obtained. All the feature values that have been extracted are given as input to the Network that has been trained by LM and modified LM Algorithm.

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A Modified LM –ANN algorithm

The Modified LM basically in resolving $(H + \lambda I)\delta = g$ with various λ values is as follows

Step 1: Calculate the Jacobian (by utilizing finite various or the chain rule)

Step 2: Calculate the error gradient $J^t E$

$\nabla F(x) = 2J^T e(w)$

Step 3: Approximation of the Hessian utilizing the cross product Jacobian $H = J^t J$ and hessian matrix as

$G = H + \mu I$

Where $\mu = 0.01 e^T e$

Step 4: Solve $(H + \lambda I)\delta = g$ to find δ

Step 5: Update the network weights w utilizing δ

Step 6: Recalculation of the sum of squared errors on the utilization of updated weights

Step 7: If the sum of squared errors has not decreased, discard the new weights, increase λ and go to **step 4.**

Step 8: Else decrease λ to a larger factor and stop

Step 9: Forward propagate the input features to determine the ANN outputs.

Step 10: ANN error to generate Δwij for all weights wij.

Step 11: Update the weights based on the gathered values Δwij

Step 12: Until stopping measures reached.

(a) (b) (c) (d)

Figure 1: Sample Leaves for analysis (a) Krishna Tulsi (b)PodhiTulsi (c) Rama Tulsi (d) VanaTulsi

RESULTS AND DISCUSSION

The Leaf images are captured in the camera and the sample leaf images are shown in the above figure. 15 images from each variety of Tulsi leaves are taken. Image Processing Toolbox and Neural Network Toolbox in MATLAB tool is used to carry out the analysis.

The images are initially preprocessed and separate filtering techniques are applied to the images to fill the holes, resizing and to enhance the images. The features like shape, color and texture can be calculated for each images and stored in the separate database. For Texture feature calculation GLCM technique is used. Thus the features are given as input to the feedforward neural Network that has been trained by LM Algorithm and another Network that has been trained by modified LM Algorithm. Thus the efficiency or recognition accuracy of the network is separately calculated for each shape, color, texture and combination of all these features. Figure 2 shows shape feature accuracy level in (a) LM algorithm and (b) Modified LM algorithm.

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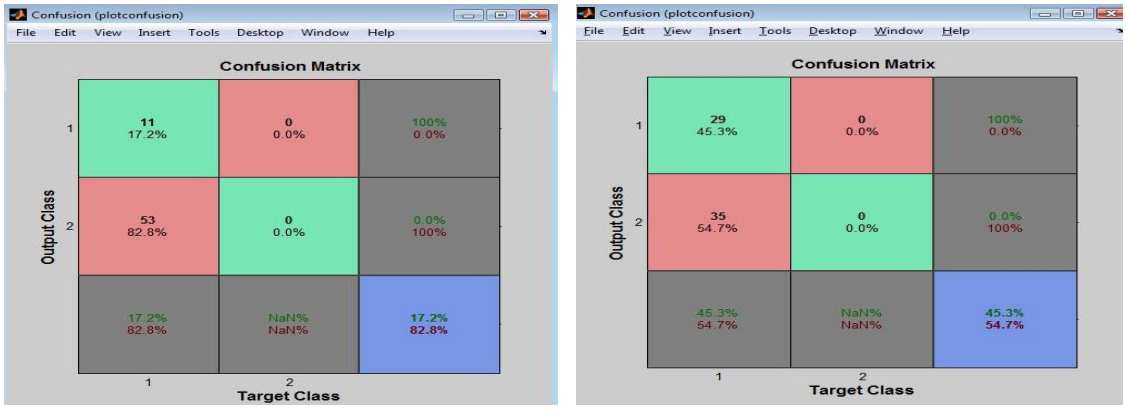


(a) (b)

Figure 2: Shape Feature

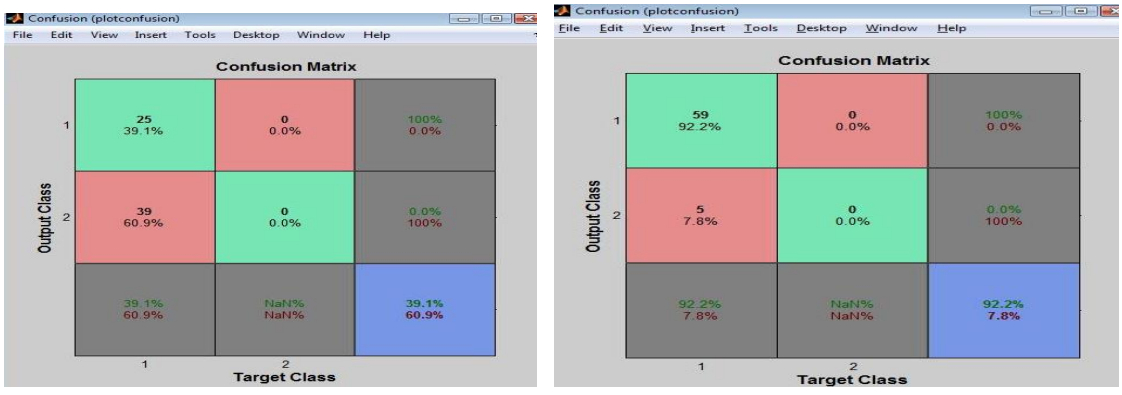
(a) LM: 17.2 %efficiency (b) Modified LM: efficiency 45.3%

(a) (b)

Figure 3 :Color feature

(a) LM: Efficiency 28% (b) Modified LM: Efficiency 92.2%

Figure 3 shows Color feature accuracy level in (a) LM algorithm and (b) Modified LM algorithm and Figure 4 shows texture feature accuracy level in (a) LM algorithm and (b) Modified LM algorithm. Combination of shape, color and texture accuracy level in (a) LM algorithm and (b) Modified LM algorithm as shown in figure 5.



(a) (b)

Figure 4 :Texture feature

(a) LM: efficiency 39.1% (b) Modified LM: efficiency 92.2%

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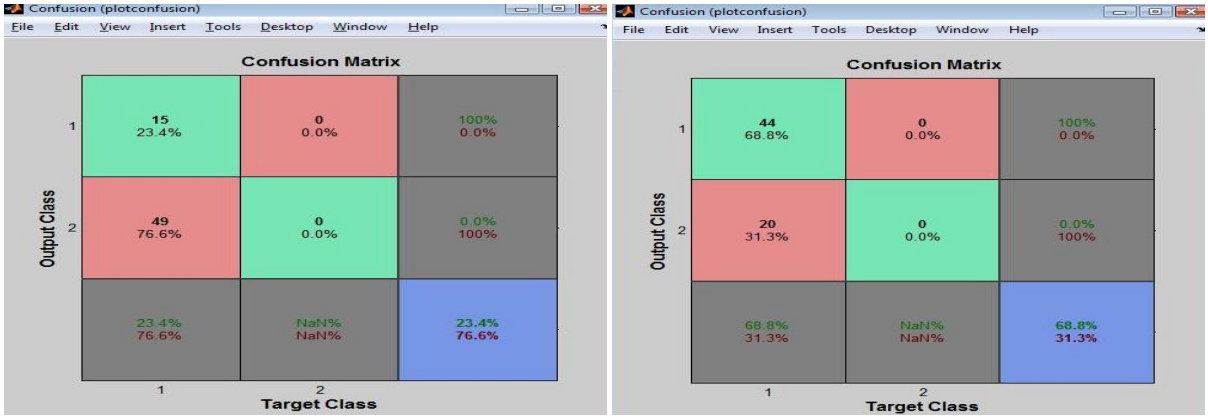

(a) (b)

Figure 5: Combination of shape, color and texture

(a) **LM: efficiency 23.4% (b) modified LM: efficiency 68.8%**

In LM algorithm lamda is the damping parameter that plays an important role in convergence and for computing the efficiency. Thus in the modified LM algorithm the steps involved are the network is trained and the update equation is performed. And if the error increases in the iteration then the step is rejected and then weights and biases are reset to the previous value and lamda is increased by constant factor. If the error gets reduced in the successive iteration then the step is accepted and weights values are updated. The lamda is reduced to larger constant factor. The updating of lamda gets changed in the modified LM method. In this manner its efficiency gets increased.

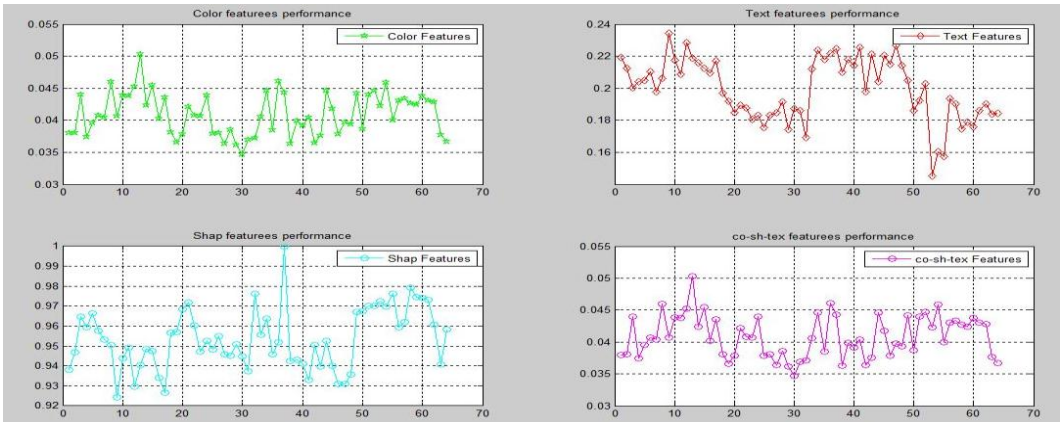

Figure 6: LM Algorithm

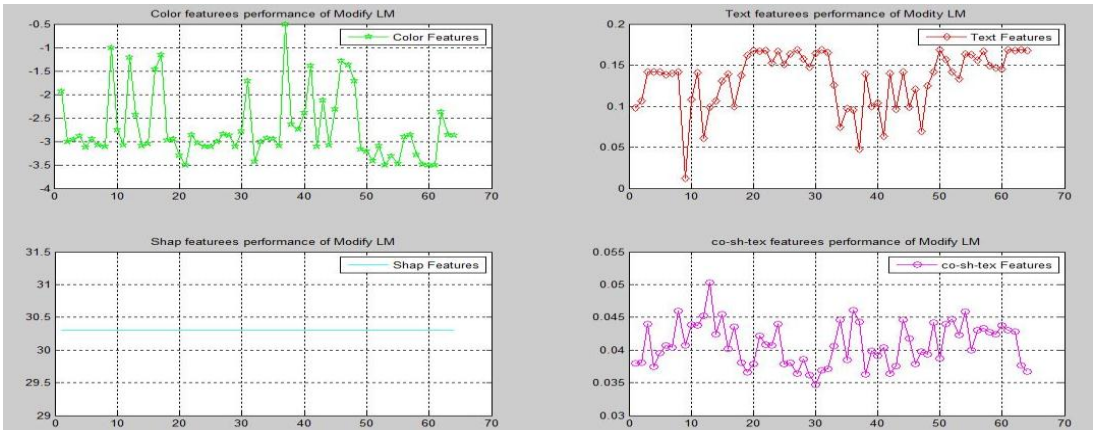

Figure 7: Modified LM Algorithm

LM algorithm and Modified LM algorithm Color, texture, shape and combination of these three features extraction experimental results are shown in Figure 6 and Figure 7. The Figure 7 results shows the promising results to compare with figure 6 results which mean Modified LM algorithms obtain the better results to combine with ANN classifier.

CONCLUSION

In this paper, we have proposed a Novel Neural Network to be more efficient. Thus, the LM algorithm is implemented for training the neural network, and then the modified Levenberg Marquart algorithm is to obtain the better recognition accuracy in the network. The efficiency and confusion matrix obtained by modified LM algorithm are proved to be better when compared with by implementing normal LM algorithm. This work can be extended to several varieties of Leaves and algorithm with better efficiency can also be obtained.

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