EXTRACTION AND OPTIMIZATION OF LEAVES IMAGES OF MANGO TREES AND CLASSIFICATION USING ANN

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Abstract: In this paper a novel method is developed to identify the variety of a mango tree from the geometrical and morphological characteristics of its leaves. The different features of the sample of leaves are extracted by the digital image processing technique to form a leaves wise database. Finally an Artificial Neural Network is used to classify a test leaves from this database.

Index Terms-Morphological Feature, Artificial Neural Network, Confusion Matrix, Performance Plot, Lavenberg-Markquared Algorithm.

I. INTRODUCTION

India is an agriculture based country. Its economy is solely dependent on agriculture. The food inflation is a national challenge. Scientists, agriculturists work day and night to promote the yield of food grains. It is very difficult to infer the varieties of a plant species by simple visual observation. It is very time consuming and can be accomplished by the trained botanists.

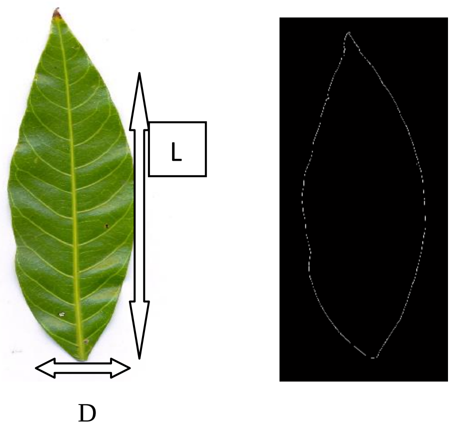
The classification of plant leaves is a crucial process in botany and in tea, cotton and other industries. It is therefore a major concern to detect and classify the different types of plant. There are several approaches proposed for the automatic leaf extraction from images by using the image processing and machine learning techniques in the literature [1-5].

In our work we have tried to identify the varieties of mango plant. Mango (Mangifera indica L.) is considered as the king of fruits due to its nutritional value and tast. Mango trees have a large no. of varieties ranging from Alphonso to Amrapali. Four different varieties of mango plant have been taken as our frame of reference and investigation.

II. LEAVE FEATURES

Plants are basically identified according to their morphological and geometrical features of their leaves [7-10] .These features of leaves are captured with the data acquisition system e.g. digital scanner or a digital camera. The acquired image is processed by digital image processing technique explained in Section III. Brief accounts of the two significant leaf features are detailed below.

Geometrical and Morphological Features: The geometrical features are associated with the shape of the leaves such as length, width, aspect ratio and so on.



(a) (b)

Fig.1. (a) Colored Image of “Amrapali” mango leaves,

(b) Edge detected output of the “Amrapali” mango leaves

- Leaf length: In the Fig.1 (a), the length, L of the leaf is the distance between the points A and B.
- Leaf width: The maximum horizontal distance between the two points C and D laying on the edge of the leaf is considered as the width ,W of the leaf.
- Aspect ratio: It is defined as the ratio of length, L to the width, W of the leaf. Thus L/W is the aspect ratio.

- Area: The area of the leaf is calculated by counting the no of pixels of binary value 1 on smoothed leave image and it is denoted by A.[11]
- Perimeter: The leaf perimeter, P is calculated by evaluating the total no. of pixels present on the leaf margin as shown in the Fig.1(b)
- Form factor: This feature is used to describe the difference between a leaf and a circle. It is defined as $FF = 4\pi A/P^2$, where A is the area of the leaf with P being its perimeter.[11]

A. Statistical Features:

1. Entropy: If an image has G gray levels and probability of gray level k is P(k) then the entropy H, not considering correlation of gray levels is defined as[15]

$$H = -\sum_{k=0}^{G-1} P(k)\log[P(k)] \qquad (1)$$

2. Constant: A measure of the intensity contrast between a pixel and its neighbor over whole image. Contrast is zero for a constant image.

$$\mathbf{C} = \sum_{\mathbf{i,j}} |\mathbf{i}-\mathbf{j}|^{2}\mathbf{P}(\mathbf{i},\mathbf{j}) \qquad (2)$$

3. Homogeneity: In [12], a measure of local homogeneity has been used in one-dimensional histogram thresholding. The homogeneity consists of two parts: the standard deviation and the discontinuity of the intensities at each pixel of the image. The standard derivation S_{ij} at pixel P_{ij} can be written as:

$$\mathbf{S_{ij}} = \sqrt{\frac{\mathbf{1}}{\mathbf{n_w}}\sum_{\mathbf{I_w w_d P(ij)}}\left(\mathbf{I_w}-\mathbf{m_{ij}}\right)^{\mathbf{2}}} \qquad (\mathbf{3})$$

Where m_{ij} is the mean of n_w intensities within the window$w_d P(ij)$, which has a size of d by d and is centered at P(ij).

A measure of the discontinuity D_{ij} at pixel P_{ij} can be written as:

$$\mathbf{D_{ij}} = \sqrt{\left(\mathbf{G_x^2}+\mathbf{G_y^2}\right)} \qquad (4)$$

Where, Gx and G_y are the gradients at pixel P(ij) in the x and y direction.

Thus, the homogeneity H_{ij} at P_{ij} can be written as:

$$\mathbf{H_{ij}} = \mathbf{1} - \left(\frac{\mathbf{S_{ij}}}{\mathbf{S_{max}}}\right)\times\left(\frac{\mathbf{D_{ij}}}{\mathbf{D_{max}}}\right) \qquad (5)$$

From the equation (5), we can see that H value ranges from 0 to 1.

4. Correlation: for a digital image the Pearson correlation coefficient is defined as

$$\mathbf{r} = \frac{\sum_{\mathbf{i}}(\mathbf{x_i}-\mathbf{x_m})(\mathbf{y_i}-\mathbf{y_m})}{\sqrt{\sum_{\mathbf{i}}(\mathbf{x_i}-\mathbf{x_m})^{\mathbf{2}}}\sqrt{\sum_{\mathbf{i}}(\mathbf{y_i}-\mathbf{y_m})^{\mathbf{2}}}} \qquad (6)$$

Where the x_i is the intensity of the ith pixel in image 1, y_i is the intensity of the ith pixel in image 2, x_m is the mean intensity of image 1 and y_m is the mean intensity of the image 2.

III. ARTIFICIAL NEURAL NETWORK

Artificial Neural Network (ANN) is a powerful general purpose software tool used for a number of data analysis such as prediction, classification and clustering and so on. An ANN consists of a set of processing elements, also known as neurons or nodes, which are interconnected. It can be described as a directed graph in which each node k performs a function f_k of the form [13]

$$y_k = f_k\left(\sum_{j=1}^{p} w_{kj}x_j - \theta_k\right) \qquad (7)$$

Where y_k is the output of the node k, x_j is the jth input to the node and w_{kj} is the connection weight between nodes k and j. θ_k is the threshold (or bias) of the node. Usually f_k is nonlinear, such as a Heaviside, sigmoid, or Gaussian function.

The basic mathematical model of ANN is shown in the Fig.2.

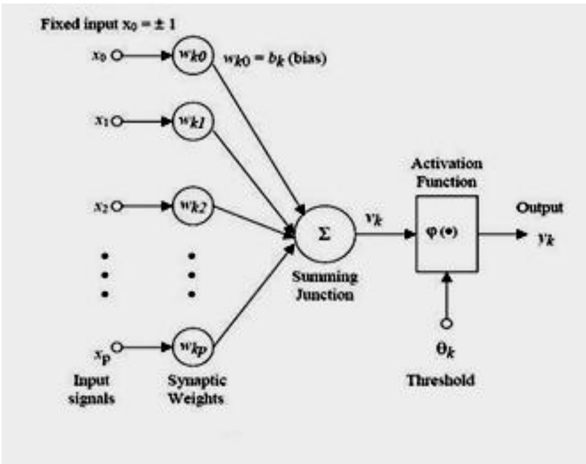


Fig.2. Generic model of Artificial Neural Network

In equation (7), each term in summation only involves one input x_j. Higher-order ANN's are those that contain higher-order nodes, i.e., nodes in which more that one input are involved in some of the terms of the summation. For example, a second-order node can be described as

$$y_k = f_k\left(\sum_{j,i=1}^{p} w_{kji} x_j x_i - \theta_k\right) \qquad (8)$$

Where, all the symbols have similar definitions as on equation no (7).

IV. OUR WORK

Image Recording: Digital scanner was use to taken the leaves images. The image is in colored form and stored as a JPJE format. The sizes of image are 1700 row and 2300 Column of pixels.

Images Analysis: As images are taken by digital scanner so it is clear that to analysis this images different pre- processing technique had been done by the simple operation in MATLAB-7.01[17]

RGB to grayscale conversion is the first part of preprocessing. Then, median filter is applied for smoothing the image. Median filter is a high efficiency, low memory consumption of the non-linear filtering technique first introduced by the Tukey. Generally we use an odd number of points of a sliding window. In the window; the gray value of the specified point is replaced with the median gray value. Median filter is mainly used to impulse noise. It is able to completely filter out noise interference caused by sharp wave, while protecting the edge of the target image. Black leaf image on a white background is obtained by converting to binary form. Leaf shape is segmented from the background and by the way interested part of leaf image is acquired.

Four different varieties of mango leaves are taken. The **edge detection** technique of the sample mango leaf can be briefly explained by the following algorithm and example as shown in the Fig.3 and Fig.4 respectively.

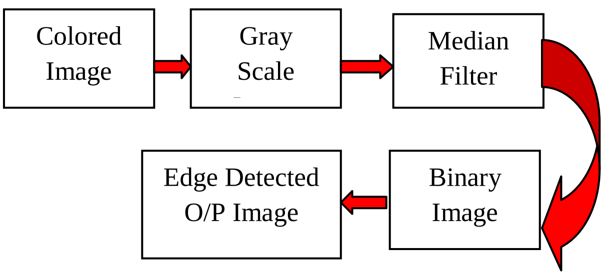


Fig.3. Block diagram representation of image pre-processing technique

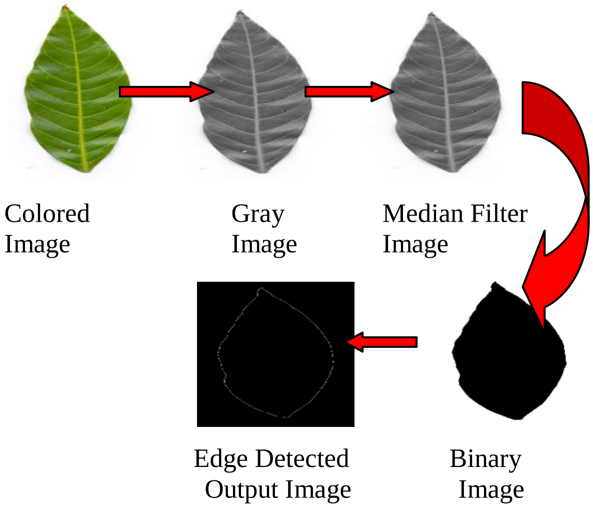


Fig. 4. Image pre-processing algorithm using a suitable "Amrapali" leave

The same process is carried for other varieties of mango leaves too. The perimeter so extracted would be utilized for the calculation of various geometrical features e.g area, length, width as shown in the Table-I. As accuracy is the major concern of every experiment, we take hare 20 random sample images for every variety of leaves. The geometrical and morphological features of the twenty sample leaf images for "*Amrapali*" leaves are evaluated and stored in the Table-I and Table-II respectively.

TABLE I

GEOMETRICAL FEATURE OF "AMRAPALI" LEAVES

Sample No.	Area (A)	Length (L)	Width (W)	Perimeter (P)	Aspect Ratio (L/W)	From Factor (A/P^2)
1	255991	1242	301	2535	4.126	0.039
2	268446	1275	327	2600	3.899	0.039
3	292134	1366	310	2781	4.406	0.037
4	231547	1228	269	2505	4.565	0.036
5	327224	1482	323	3019	4.588	0.035
6	189289	1121	254	2329	4.413	0.034
7	179051	1121	233	2288	4.811	0.034
8	344317	1439	356	2932	4.042	0.040
9	394091	1457	423	3002	3.444	0.043
10	345137	1496	350	3044	4.274	0.037
11	291344	1357	325	2895	4.175	0.034
12	188380	1120	350	2319	4.480	0.035
13	345027	1492	350	3050	4.262	0.037
14	394090	1437	356	2330	4.036	0.037
15	327054	1479	340	3020	4.350	0.035
16	327524	1472	320	3020	4.600	0.035
17	327440	1470	318	3021	4.620	0.035
18	189301	1120	253	2330	4.420	0.034
19	188903	1118	251	2331	4.540	0.034
20	187906	1121	252	2327	4.440	0.034
Mean					**4.3196**	**0.0362**
Variance					**0.1456**	**6.0632e-006**

TABLE II
STATISTICAL FEATURE OF "AMRAPALI" LEAVES

Sample No.	Entropy	Contrast	Homogeneity	Energy	Concentration
1	3.0651	0.0433	0.9799	0.5088	0.9939
2	3.7254	0.0497	0.9779	0.4336	0.9938
3	3.8750	0.0696	0.9679	0.3842	0.9921
4	3.7071	0.0584	0.9730	0.4303	0.9926
5	4.4775	0.0967	0.9555	0.3474	0.9896
6	3.2292	0.0504	0.9763	0.4530	0.9925
7	3.8494	0.0508	0.9767	0.4291	0.9934
8	3.8123	0.0759	0.9649	0.3778	0.9923
9	3.2518	0.0291	0.9865	0.4995	0.9959
10	3.8664	0.0693	0.9672	0.3916	0.9924
11	3.8331	0.0565	0.9741	0.3966	0.9935
12	3.4289	0.0332	0.9850	0.4538	0.9954
13	3.4737	0.0304	0.9520	0.4310	0.9932
14	3.8301	0.0521	0.9812	0.3422	0.9901
15	3.2780	0.0313	0.9701	0.5078	0.9922
16	3.2100	0.0484	0.9531	0.3178	0.9937
17	3.1250	0.0522	0.9751	0.4201	0.9945
18	3.5411	0.0631	0.9623	0.4532	0.9921
19	3.3450	0.0301	0.9473	0.3978	0.9935
20	3.4290	0.0712	0.9357	0.3472	0.9954
Mean	**3.5677**	**0.0531**	**0.9681**	**0.4161**	**0.9931**
Variance	**0.1214**	**3.1886e-004**	**1.8186e-004**	**0.0030**	**2.5310e-006**

This process of feature extraction is similarly executed for other three varieties of mango leaves also. Thus the complete database comprising of the geometrical and morphological features of 20 sample images for every variety of mango leaves are created.

This section of our work basically deals with the identification of a test leaf from the created database with the help of artificial neuron network. The first step is the creation of the network by the ANN Toolbox of MATLAB-7.01[14]. Once the network is created, it is trained by a set of data. (80 sample data in our experiment). The network uses the Lavenberg-Markquared algorithm for the training. The algorithm uses 60% of the input data for training, 20% input data for validation and the last 20%data for testing. The training, validation and testing of the huge dataset (80 samples) can be visualized in the Performance Plot shown in the Fig.4, and explained in the Section .V.

V. RESULT AND DISCUSSION

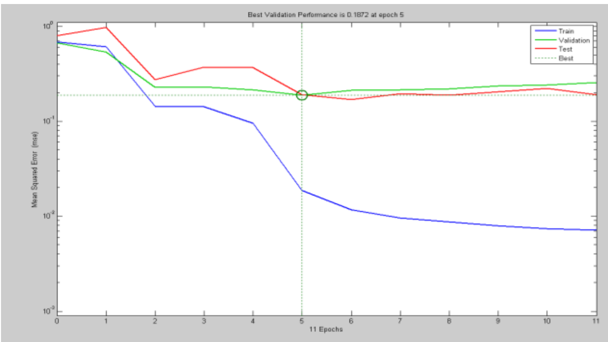


Fig. 4. Performance Plot

The Performance Plot is basically the plot of mean square error Vs epoch. From the Fig.5 it is shown that the training process is continued till the 5th iteration. From the 5th iteration onwards it is observed that the validation error greater than the testing error, thereby declining the training process.

The network response can be analyzed from the Confusion Matrix as shown in the Fig.5.The confusion matrix reflects the various types of errors that occurred for the final trained network. From the Fig.5 the diagonal cells in each table show the number of cases that were correctly classified, and the off-diagonal cells show the misclassified cases. The blue cell in the bottom right shows the total percent of correctly classified cases (in green) and the total percent of misclassified cases (in red).

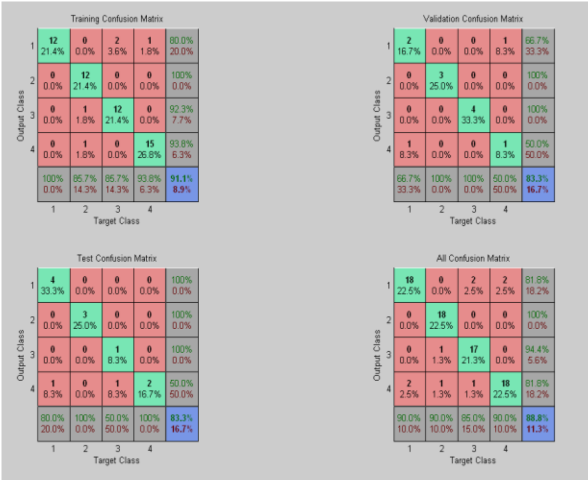


Fig. 5. Confusion Matrix

The Fig.5 shows the results for all three data sets training, validation, and testing. It is clear from the figure that total 91.1% samples are correctly trained by the neural network and 8.9% samples are incorrectly trained. 83.3% of samples are correctly validated and 16.7% of samples are incorrectly validated.

After training the neural network is tested by the 20 unknown test samples as shown in the Table-III. Fig.6 shows the confusion matrix for the test sample-6. From the matrix it is clear that the unknown sample is correctly classified as class-2 sample (i.e"*Himsagar*"leafs).

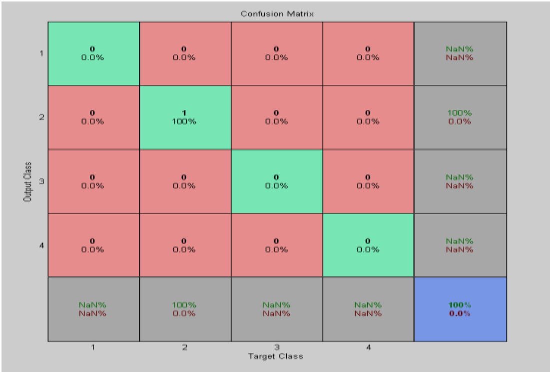


Fig. 5. Confusion Matrix for the test sample-6

TABLE I

SAMPLE TEST DATA SET OF 20 UNKNOWN MANGO LEAVES

Sl No	Test sample	L/W	A/P^2	Entropy	Output generated by ANN	% of correct classification
1	sample 1	4.841	0.0370	3.8401	1000	100%
2	sample 2	4.545	0.0372	3.8601	1000	100%
3	sample 3	4.434	0.0337	3.7081	1000	100%
4	sample 4	4.248	0.0371	3.7624	0100	0%
5	sample 5	4.765	0.0338	3.8102	1000	100%
6	sample 6	3.038	0.0330	4.5201	0100	100%
7	sample 7	3.705	0.0450	4.6570	0100	100%
8	sample 8	3.061	0.0420	4.4245	0100	100%
9	sample 9	3.119	0.0460	4.3001	0100	100%
10	sample10	3.119	0.0471	4.0351	0100	100%
11	sample 11	4.838	0.0341	2.4961	0010	100%
12	sample 12	4.055	0.0384	2.5010	0010	100%
13	sample 13	4.852	0.0343	2.4600	0010	100%
14	sample 14	4.900	0.0344	2.3571	0010	100%
15	sample 15	4.562	0.0340	2.4482	0010	100%
16	sample 16	3.910	0.0440	3.5581	1000	0%
17	sample 17	3.730	0.0450	3.6811	0100	0%
18	sample 18	3.720	0.0460	3.3141	0001	100%
19	sample 19	3.70	0.0450	3.8433	0001	100%
20	Sample 20	4.130	0.0390	3.3140	0001	100%

VI. CONCLUSION

In this paper the image processing technique and artificial neural network approach is used for the classification of the four varieties of mango leaves. The neural network is trained by 80 samples of mango leaves and it is then tested by an additional 20 unknown sample of mango leaves. Out of 20 test sample 15 are correctly classified while remaining 5 samples could not be classified by the system resulting the system gives 75%accuracy. The reasons for the miss classification could be probably the closed approximation of geometrical of morphological feature of the other kinds of mango leaves. For example, two "Langra" mango leafs were falsely identified as "Amrapali" leaves. After testing it is found that their geometrical features are very close to those "Amrapali" leaves. The feature work is under consideration to improve the performance with a larger variety of mangoes. We are also trying to extract the color feature from the mango leaves so that the classification can be done on the basis of color component also.

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