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A Novel Algorithm to the Design and Development of Lemon Leaf Fungal Disease Grading and Area Detection in Smartphones using Image Segmentation

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Abstract*: Lemon productivity faces many hurdles due to leaf disease. Human inspection of the stages of lemon leaf diseases is a tedious process, which consumes more time and sometimes leads to error. Without knowing the status of the leaf disease, spraying unlimited pesticides leads to many health issues as well as reduces the harvesting of lemon, which is used for medicine purpose. In order, to overcome such issues "Lemon Leaf Disease Grading System (LLDGS)" has been developed and the paper elaborately explains LLDGS which detects lemon leaf disease and its stages in order to reduce time and errors in diagnoses. Due to the rapid development of smart phones, LLDGS is developed using image processing techniques in android platform that would exceptionally help the farmers in the modern world. The research work is done especially for fungal disease because lemon plants are mostly affected by the fungal disease. The paper describes a novel algorithm for the design and development of LLDGS using image processing techniques to grade the lemon leaf diseases through a sample of 170 fungal diseased lemon leaf images. Finally, the paper presents the result and performance evaluation of LLDGS.

***Index Terms*: LLDGS, Image Processing, Leaf Disease.**

I. INTRODUCTION

India is rapidly developing in farming and agriculture is the backbone for any nation's development in the early stages. Due to industrial development, modern technologies and globalization concepts, agriculture is facing hurdles. Especially plant disease leads to huge loss of yield, crop, time, money, quantity, productivity, economy and quality of product [7]. Disease identification and grading is required in order to increase the productivity and overcome the above specified issues.

Identifying the status of leaf disease thorough smart phones will play a vital role in fruitful farming. Mobilized image processing is a relatively new technique for handy tasks and it has been an efficient tool to identify and grade the leaf disease sections. Section II is an outcome of the study on image to spray limited pesticides. This paper is organized into seven processing. Section III illustrates the by development of LLDGS and outlines the factors critical to successful development of LLDGS. Section IV briefly specifies LLDGS framework. In Section V, the algorithm of LLDGS has been described. Section VI discusses the results of LLDGS and section VII reports performance evaluation of LLDGS.

II. IMAGE PROCESSING

Image processing is frequently observed as arbitrarily operating an image to attain an artistic standard or to sustain a favored realism. However, image processing is more precisely defined as a means of conversion between the human pictorial system and digital imaging devices. The image processing purposes are Visualization to observe the disease that are not visible clearly; Image sharpening and restoration to create a better leaf image; Measurement of pattern to measure the level of disease in an image; Image recognition to distinguish the disease in an image [2]. The following section explains image processing in leaf disease grading.

III. LLDGS DEVELOPMENT USING IMAGE PROCESSING

A. Image Acquisition

Image acquisition is the first stage of image processing, where the leaf image is obtained through a mobile device. An android mobile can capture two types of images, such as high resolution image and low resolution image. Image must be acquired in digital form, basically an image represented by two dimensional function, f(x,y), where x and y are plane coordinates, and the amplitude of f at any pair of coordinates x and y [3]. An experiment has been conducted on lemon leaves that are collected for the research from the Pollachi farming area. Selectively, totally 170 images are captured by android smartphone with the resolution of 3120x4160 and Horizontal resolution of 72 dpi and Vertical resolution 72 dpi, with Bit depth 24 and JPG format.

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B. Image Pre-Processing

Pre-processing is the second of getting relevant information from the lemon leaf. The goal of pre-processing is to enhance the features of an image or to correct distortions for further image processing. The methods of achieving such objectives may be classified into image enhancement and image restoration. The pre-processing operations are such as image brightness and contrast, image enhancement, non-uniform illumination correction, Fourier transform and filtration [1]. In LLDGS development, image is resized and converted into bitmap for further processing.

C. Image Enhancement

The aims of image enhancement are to improve the visual appearance of the image and to provide a better transformed representation for future automated image processing [5]. An image enhancement process technique helps to improve the visual appearance of a leaf image and to convert the leaf image for better analysis by mobile devices. hue filtering and saturation filtering and are shown in Fig. 3.

Figure 1.(a) Histogram

Figure 1(b) Contrast Manipulation

Image enhancement has two main techniques which improve the quality and clarity of images by increasing contrast, enhancing human viewing, removing blur and noise, and revealing details of images.

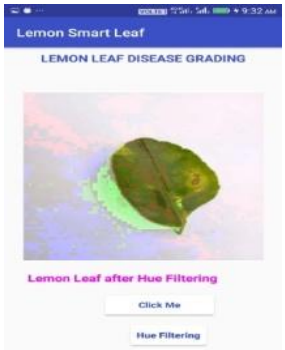

Figure. 2(a) Hue Filtering

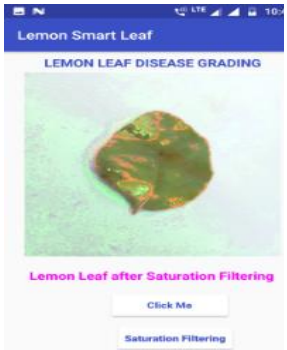

Figure .2(b) Saturation Filtering

They are ①Spatial Domain Method ②Frequency Domain Methods. Spatial based domain image enhancement methods are histogram equalization and contrast manipulation which directly works on pixels [4]. Fig 1(a) and 1(b) shows the result of the histogram equalization and contrast manipulation. And the main feature of spatial based domain technique is that it is theoretically simple to understand and the complexity of this method is low which favors real time implementations. Frequency domain methods are hue filtering and saturation filtering and which is shown in Fig. 3 (a) and (b).

D. Image Segmentation

Image segmentation is partitioning an image into multiple segments to get meaningful region for image analyzing. An image into regions is called as segments [6].

Figure 3(a) Segmentation after Hue Filtering

Figure 3(b) Segmentation after Saturation Filtering

Figure 3(c). Segmentation based on Thresholding

In this paper, segmentation after hue filtering, segmentation after saturation filtering and segmentation based on thresholding are demonstrated, in Figures 3(a) , 3(b) and 3(c).

E. Image Feature Extraction

Feature extraction methods can be carried out based on text basis, color basis and shape basis.

Mean	$\overline{x} = \frac{1}{N}\sum_{j=1}^{N} x_j$
Variance	$\mathrm{Var}(x_1 \ldots x_N) = \frac{1}{N-1}\sum_{j=1}^{N}(x_j - \overline{x})^2$
Standard Deviation	$\sigma(x_1 \ldots x_N) = \sqrt{\mathrm{Var}(x_1 \ldots x_N)}$
Skewness	$\mathrm{Skew}(x_1 \ldots x_N) = \frac{1}{N}\sum_{j=1}^{N}\left[\frac{x_j - \overline{x}}{\sigma}\right]^3$
Kurtosis	$\mathrm{Kurt}(x_1 \ldots x_N) = \left\{\frac{1}{N}\sum_{j=1}^{N}\left[\frac{x_j - \overline{x}}{\sigma}\right]^4\right\} - 3$

Table 1. Statistical parameters formulae

In this research, mean, variance, standard deviation, Skewness, and Kurtosis statistical parameters are calculated for feature extraction. It is identified that standard deviation produces better result for detecting the disease area and its grading. The following formulae are used to measure the parameters (Table 1):

IV. LLDGS DESCRIPTION

This section explains the methodology of the proposed work. Fig. 4 describes the architecture of the developed application to segment the leaf disease and to grade the disease. The inputs of the proposed architecture are various lemon leaf digital images, which are captured by Android mobile phones. The real image set of 170 lemon leaf images collected from Pollachi rural farming area which is located in India has been used as input for LLDGS.

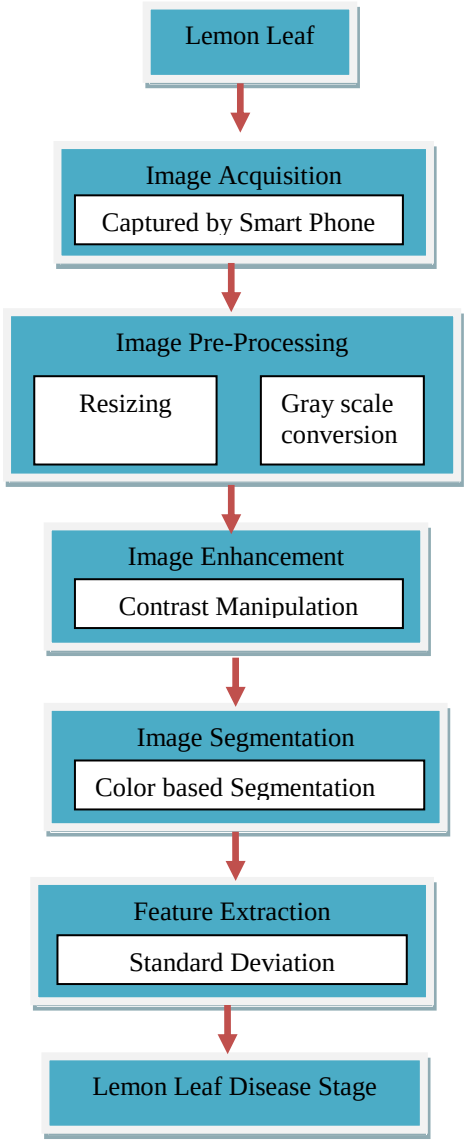

Figure 4. Architecture of LLDGS

V. ALGORITHM OF LLDGS

The below algorithm is used to detect the disease area and grade the leaf disease (Table 2). Lemon image acquisition will be done by smart phone, which is the first step of image processing. Image preprocessing is conversion of lemon leaf image jpeg format to binary format and resizing of the image.

1. Capture and Upload the Lemon leaf .jpg image from smartphone gallery.
   android.provider.MediaStore.Images.Media.
   EXTERNAL_CONTENT_URI);
   MediaStore.Images.Media.getBitmap
   (getContentResolver(), uri);
2. Convert the .jpg image to binary image.
   Bitmap b = Bitmap.createScaledBitmap
   (bitmap,1500, 1500, false);
   imageView.setImageBitmap(b);
3. Create a new scaled bitmap from existing bitmap image.
   Bitmap b = ((BitmapDrawable)bbb).
   getBitmap();
4. Each pixel should be stored in 4 bytes for RGB and Alpha translucency to pixel quality.
   b = b.copy(Bitmap.Config.ARGB_8888, true);
5. Get the height and width of the image.
   int width = b.getWidth();
   int height = b.getHeight();
6. Set the pixel alpha individual.
   int alpha = Color.alpha(p);
   alpha = alpha;
7. Subtract the value from pixel to change colour.
   int r = R; int g = G - 70; int bb = B;
8. Change alpha means opacity after changing the pixel.r,g,b values.
   int alpha = Color.alpha(p);
   alpha = alpha;
9. Set pixel into a bitmap and applying image effects based on new r,g,b and alpha values.
   b.setPixel(x, y, Color.argb(alpha, r, g, bb));
11. Set healthy part in black colour and unhealthy part in yellow colour.
12. Calculate average of bitmap r,g,b values of the segmented leaf image.
13. Calculate mean value for disease segmented image.
    int redmean = red / 3;
    int greenmean = green / 3;
    int bluemean = blue / 3;
14. Calculate variance.
    Variance = (VarianceSum * VarianceSum)/ len
15. Calculate Standard deviation calculation.
16. Based on the values of the Standard Deviation, detect the disease stage.

Table 2. LLDGS Algorithm

Image enhancement is done by manipulating the contrast of lemon leaf. Image segmentation is done to detect the fungal disease area by based on the leaf color after image enhancement and filtering. Finally, lemon leaf disease will be graded based on standard deviation values of the segmented image(Table 2, Figure 4).

VI. EXPERIMENTAL RESULTS AND DISCUSSIONS

This section given the summary of the design and development of LLDGS (LLDGS) application to detect the lemon leaf disease stages. It is also shown how LLDGS reduces the workload of farmers in detecting the lemon leaf stages and prevents the loss for the farmers. LLDGS has four segments. 1. Lemon leaf upload 2. Disease area detection 3.Disease stage detection and 4.Exit the LLDGS. Thus, it will serve better in the farmer's life and it will be a countless benefit to the farmers for making their life and work easy by detecting the lemon leaf diseases.

The LLDGS has smart capability of recognizing the disease area in addition to grading the disease. The research work predicts leaf disease grade assistance through smartphones using image as an input which can recognize lemon leaf disease stages which can be used frequently by the farmers.

A. LLDGS Home and Uploading

LLDGS application encompasses four buttons. Click me for uploading the leaf image from the smartphone gallery. Detect Area is to detect the disease affected area and Disease Stage is to detect and display the disease stage of the lemon leaf. Lastly the Exit button is to quit the LLDGS application. Fig. 6(a) obviously shows the LLDGS home page. Fig. 6(b) shows the uploaded of lemon leaf which is to detect the stage of the disease by clicking the Click Me button. When the Click Me button is clicked, smartphone gallery will open to choose the needed lemon leaf image. After the image is uploaded successfully, the disease stage will be displayed.

Figure 6 (a) Home Page

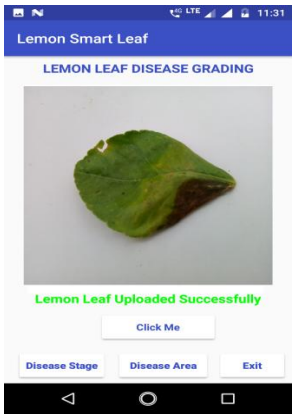

Figure 6 (b) Uploaded

B. Disease Area Identification and Stage Detection

Fig. 7(a) shows the disease area in the lemon leaf. Affected area is displayed in a different color in the leaf area. Healthy part will be in black. Fig. 7(b) shows the stage of the leaf disease. Table 3 clearly describes the correctness and incorrectness percentage of the LLDGS. Totally, 170 lemon leaf images have been used to test the result. The result proves that LLDGS provides better result and Fig. 8 provides the pictorial representation of the result of the LLDGS.

Figure 7(a) Disease area

Figure 7(b) Disease Stage

Input Lemon Leaves (LLDGS)	No of Images	Correct Result	Incorrect Result	Correct Result (%)	Incorrect Result (%)
Healthy	12	12	0	100%	-
1st Stage	91	87	4	95.60%	4.39%
2nd Stage	33	28	5	84.84%	15.15%
3rd Stage	34	30	4	88.24%	11.76%
Total	**170**	**157**	**13**	**92.35 %**	**7.64%**

Table 3. Correctness of LLDGS

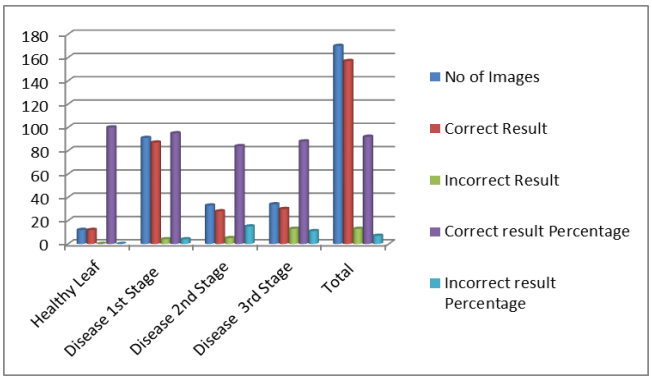

Figure 8. Correctness of LLDGS

VII. PERFORMANCE EVALUATION

The confusion matrix (Table 4) defines the performance of the LLDGS and it evaluates the performance of the developed method of grading the leaf disease.

Table 4. Confusion Matrix

170 Total no of lemon leaves		Predicted: Non – Diseased	Predicted: Diseased	
Actual	Non - Diseased	TN = 12	FP = 13	TN + FP = 25
	Diseased	FN = 0	TP = 145	FN + TP = 145
		TN + FN = 12	FP + TP = 158	

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Confusion matrix of the LLDGS defines in the Table 2 and in the table, TP – True Positive (TP) refers to correct predictions of diseased leaf / grade in image database.
TN – True Negative (TN) is correctly predicted which are not diseased lemon leaves.
FP - False Positive (FP) is incorrectly predicted which are diseased lemon leaves.
FN - False Negatives (FN) is incorrect predictions of non-diseased leaf / grade in image database.
Accuracy : Overall, how often is the classifier correct?
(TP+TN)/total = (145+12)/170 = 0.9235
Misclassified Rate or Error Rate : Overall, how often is it wrong prediction of disease stage?
(FP+FN)/total = (13+0)/170 = 0.0765
True Positive Rate : When it is actually yes and how often does it predict yes? also known as "Sensitivity" or "Recall"
TP/actual yes = 145/145 = 1.0000
False Positive Rate : When it is actually no and how often does it predict yes?
FP/actual no = 13/25 = 0.5200
Specificity : When it is actually no, how often does it predict no?
TN/actual no = 12/25 = 0.4800
Precision : When it predicts yes, how often is it correct?
TP/predicted yes = 145/158 = 0.9177
Prevalence : How often does the yes condition actually occur in sample?
Actual yes/total = 145/170 = 0.8529
F-Measures : 2 * (Precision *Recall) / (Precision + Recall)
F – Measures = 2 * (0.9177 * 1) /(0.9177 + 1) = 0.9571

Table 5. Performance evaluator formulas

Parameter	Value
Accuracy	TN + TP / Total no of images
MCR	(FP+FN) / Total no of images
TPR	TP / (FN + TP)
FPR	FP / (TN + FP)
Specificity	TN / (TN + FP)
Precision	TP / FP + TP
Prevalence	FN + TP / Total no of images
F-Measures	2 * (Precision *Recall) / (Precision + Recall)

Table 6. Performance Evaluation Result of LLDGS

Parameter	Value
Accuracy	0.9235
MCR	0.0765
TPR	1.0000
FPR	0.5200
Specificity	0.4800
Precision	0.9177
Prevalence	0.8529
F-Measures	0.9571

Table 5 describes the performance evaluator measurement of the LLDGS which is calculated by following the above prescribed formulas in Table 6.

VIII. CONCLUSION

This paper discusses the development and implementation of Lemon Leaf Disease Grading System (LLDGS). LLDGS were analyzed using various parameters such as Accuracy, Precision, Recall and F-Measures using 170 leaf real time images captured by smartphones. The results are statistically analyzed using confusion matrix and yields accuracy, recall, precision and f-measures as 92.94%, 100%, 91.77% and 95.71% respectively. LLDGS predicts fungal disease stage accurately and the result of the LLDGS assures that, the research work will increase the harvesting of lemon which is used as herbs to cure number of human health issues and diseases, and LLDGS will be more useful for the farmers, especially to overcome huge loss of yield, crop, time, money, quantity, productivity, economy and quality of product due to plant disease. Thus, LLDGS is tested with real data and found to be successful.

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