

# Estimation of Plant Leaf Area using Java Image Processing Techniques

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**Abstract**—Leaf area represents the amount of leaf material in ecosystems and controls the links between biosphere and atmosphere through various processes like photosynthesis, respiration, transpiration and rain interception. It is also helpful parameter in evaluating damage caused by leaf diseases and pastes, micronutrient deficiencies, water and environmental stress, need of fertilization for effective management and treatment. Precision agriculture production adapting rapid and accurate methods to measure plant leaf area. At presently, grid counting and Leaf Area Meter (Li3100) are used as conventional methods for leaf area estimation. These methods are simple in principle and highly accurate but tend to be time consuming. The above constraints can be overcome by proposed Leaf Area Meter (LAM); a Java based Image processing software application. The software application has many advantages like User friendly, fast, accurate and reusable. The paper discusses different Leaf Area (LA) estimation methods namely Instrument based Using Li 3100 Machine, Manual Graph based Method and Software based Method. Results show that LAM software gives 99.96% to 95.31% accurate results for different leaves except Jasud. Between two image formats, .jpg format shows comparatively less error than .png format.

**Keywords-** Leaf Area, Leaf Area Index, Image Processing(Java), Plant Leaves, Graphical Method for Leaf Area.

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## I. INTRODUCTION

The use of Information and Communication Technology in agriculture is increasing day by day. E-Agriculture is an emerging field with focus on the enhancement of agricultural and rural development through improved information and communication processes. Information Technology equipment and software become cheaper with technological advancement [12].

Leaf area index (LAI) is widely used to describe the photosynthetic and transpiration surface of plant leaves. LAI can be simply defined as the amount of leaf surface area per unit ground area, and has broad applications in eco-physiology, water balance modelling and characterization of vegetation-atmosphere interactions. Leaf area monitoring is an important tool in studying physiological features related to the growth, photosynthetic and transpiration process [9]. Leaf area is helpful parameter in evaluating, damage caused by leaf diseases and pastes, micronutrients deficiencies, water and environmental stress, need of fertilization for effective management and treatment. Leaf area determination can be done by direct methods, which involves the measuring of all the individual leaf areas or indirect methods, which are based on the relation of some plant characteristics with true leaf area obtained in destructive tests [9, 11].

<b>Environment</b>	<b>Java Runtime Environment 1.4 and above</b>
<b>Operating System</b>	Any with compatible JVM
<b>Processor</b>	PII or higher
<b>Scanner</b>	Document scanner with resolution of 50 to 1200 DPI
<b>Leaf Area Meter</b>	LI-3100 (Available in RRS, AAU, Anand)

Currently two methods are available to calculate leaf area and leaf area index.

- i) Graphical Method with Grid Counting
- ii) Using Leaf Area Meter Instrument

In Graphical method, Leaf Image is drawn on the Graph paper and Grid is counted [1]. In Leaf Area Meter Instrument method, Machine calculates the required parameters. Both methods have their pros and cons. The Graphical method is simple in principle and has high accuracy but time consuming. Leaf Area Meter Instruments are very costly (Eg. Li3100: 1.45 lacks) with large degree of error associated to it. Instruments are also heavy and not easily portable and require regular usage and maintenance. In this paper we have proposed a solution to calculate Leaf Area and Leaf Area Index using Information Technology Application [1, 10]. This application requires scanning of the leaf. After scanning, leaf area can be calculated using image processing technique. Scientists can use this scanned image for any number of times to calculate the above parameters. This application requires LAM (Leaf Area Meter) software and scanner to calculate Leaf Area and Leaf Area Index. Application also gives high degree of precision and results are fast and cheap compare to previous methods.

## II. MATERIALS AND METHODS

### A. Materials

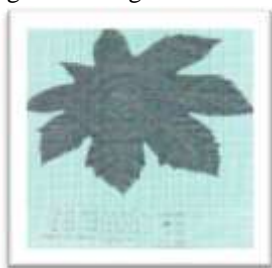
HP LaserJet M1005 MFP scanner, standard objects of various shapes (e.g. circle and square) of specific size (generally 5 cm) as a reference Object, standard graph paper (1mm), different plant leaves (e.g. Asopalav (*Polyalthia longifolia* L.), Pipal(*Ficus benghalensis* L.), Lady finger(*Abelmoschus esculentus* L.), Castor(*Ricinus communis* L.), Brinjal(*Solanum melongena* L.), Jasud(*Hibiscus rosasinensis* L.) etc..).

### Hardware and software requirements

### B. Methods

### 1. Graphical Method

The Leaf under experiment was placed in the scanner and scanned on the graph paper having smallest grid size of 1 mm. The total number of grids covered by outline edge of the leaf was calculated with the principle that if edge outline occupied more than one half grids treated as one otherwise zero (For rounding purpose). Based on this grid count LA and LAI are calculated [10].



### 2. Leaf Area Meter Instrument method

Leaf is placed between the guides on the lower transparent belt and allowed to pass through the LI-3100. As the leaf travels under the fluorescent light source, the projected image is reflected by a system of three mirrors to a scanning camera.



This unique optical design results in high accuracy and dependability. An adjustable press roller flattens curled leaves and feeds them properly between the transparent belts. This provides for accurate measurement of small grasses, legumes, aquatic plants and similar types of leaves. As samples pass under the light source, the accumulating area in cm<sup>2</sup> is shown on the LED display. Calibration adjustments are easily accomplished using a standard area calibration disk (included) and turning the calibration screw located near the display.

### 3. Proposed Image Processing Method

This technique is based on Java based image processing to calculate leaf area and leaf area index [13]. This software is called LAM (Leaf Area Meter) software. The software consists of User Friendly Graphical User Interface to make it simple in use. The methodology is as under [7].

#### Methodology

The java based image processing software works with following methodology (see fig. 1).

1. Take a leaf from the tree/plant.
2. Scan the leaf as a black and white image using the Scanner with different DPI (dots per inch) settings (150,200,300,600).
3. Store the scanned image as .jpg and .png file.
4. Open the image and crop the image to remove unnecessary scan areas from the image.(Using image editor like Microsoft paint, Microsoft Picture Editor etc..)
5. Run Java Image Processing Software to calculate leaf area in cm \* cm and mm \* mm.
6. Display results.

### I. Getting an Image

The leaf whose area is to be estimated is scanned with help of any available scanner (in this case HP LaserJet M1005 MFP scanner) at 150, 200, 300 and 600 dots per inch (dpi) respectively. For clear and better precision we have scanned the images in two different formats namely .jpg and .png. For the calculation of number of pixels in image processing it is necessary to convert the scanned image in to black and white image [14]. But we have directly scanned all the images in black and white format with the help of scanner. Sometimes for some leaves if after scanning the rid of the leaf is present in white colour then we have to rescan the same image for betterment of the results [6].

### II. Image Cleaning - Crop the image if required

After scanning if there is some noise in the image or some extra dots present due to the device error, then we have to crop the required image only. The software is in its inception stage, so sometimes manually we have to remove the unwanted dots and image disturbance.

### III. Java Image Processing

Finally we run the software by using the GUI or CUI interface. We have to use the respected commands of java for running the program. First time we run the program for .jpg images. And the program gives output of 150 DPI, then for 200 DPI, then for 300 and 600 DPI respectively. The same loop will run once again for .png images [13].

### IV. Output

After completion of all the iterations we store the results in Excel file for statistical purpose. The output will be given in number of pixels. Based on pixels and dpi of the image leaf area is calculated in CM<sup>2</sup> and MM<sup>2</sup>.

Image dpi	No. of pixels in inch	One Pixel area in cm*cm
150	22500	0.0002867
200	40000	0.0001613
300	90000	0.00007168
600	360000	0.00001792

$$\text{Leaf Area in cm}^2 = [\text{Image Pixels}] * [\text{Pixel area in cm} * \text{cm}]$$

### III. RESULTS AND DISCUSSION

To test the performance of new software method, leaves were selected from different plants with varying size and shape. Along with this computer generated shapes i.e. square and circle (5x5 cm<sup>2</sup>) were taken. We have selected the leaves of Jasud (Hibiscus), Brinjal, Castor and Asopalav which have different dimensions [8]. The area of leaf calculated by three methods namely Graphical, Leaf Area Meter and our proposed method (Java and image processing). Among this the Graphical method (square grid method) was considered as a standard method. Table 1 lists the measurement results by all three methods with relative

error. The Relative error can compare values and describe the accuracy of measured values. Relative errors of leaf area calculated by Java and image processing method indicate that the relative error value is smaller and the accuracy is higher as compared to leaf area meter.

In all three methods if we compare between graphical and leaf area meter, the relative error are 5.92, 4.88, 0.49, and 4.38 for Asoplav, Brinjal, Jasud (Hibiscus) and Castor respectively. In compare to this Java with image processing leaf area measured at DPI i.e. 150, 200, 300 and 600. The relative error at 600 DPI in .jpg and .png formats is minimum. The relative error at 600 DPI for .jpg format is -0.04, -0.96, -4.90 and 0.28 and for .png format are 1.12, 0.74, -3.32 and 2.18 for Asoplav, Brinjal, Jasud (Hibiscus) and Castor respectively. So between two image formats the .jpg format shows relatively less error as compared to .png format except in case of Jasud (Hibiscus). But the relative errors at 150, 200 and 300 DPI for .jpg format are higher than .png format except in the case of castor.

During testing of the system, squares (5X5 cm<sup>2</sup>) and circle of (5 cm<sup>2</sup>) were scanned and then put into the application. The relative errors at 150 DPI for .png format are minimum than .jpg format as well as 200, 300 and 600 DPI. Similar results of relative error have been observed at 600 DPI for various geometry shapes [3, 4].

Finally to calculate damaged leaf area, as compared to graphical method in java and image processing techniques at all DPI the relative error is higher i.e. 4.17 to 20.83 in .jpg format as well as 8.33 to 16.67 in .png format. The result may indicate that if measurement area is smaller than the relative error is higher.

#### IV. CONCLUSIONS

This work describes digital image processing techniques to calculate leaf area, the implemented algorithm proved to adequate to compute the leaf areas. The graphical method has very high accuracy, but takes more time to measure leaf area. The image processing method also have high precision and accuracy, it takes less processing time and cost effective also. Leaf area measured at DPI i.e. 150, 200, 300 and 600 and found that the relative error at 600 DPI in .jpg and .png format is minimum. Between two image formats the .jpg format shows relatively less error as compared to .png format except in case of Jasud (Hibiscus) and the relative errors at 150, 200 and 300 DPI for .jpg format are higher than .png format except in the case of castor. Similar results of relative error have been observed at 600 DPI for various geometry shapes taken for reference purpose. At last for damaged leaf area at all DPI the relative error is higher in .jpg and .png format as compared to graphical method.

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Particulars	Graphical	Leaf area meter		Java and image processing (area in cm <sup>2</sup> )							
				150 dpi		200 dpi		300 dpi		600 dpi	
	[1]	[2]	Rel. Error	[3]	Rel. Error	[4]	Rel. Error	[5]	Rel. Error	[6]	Rel. Error
Name of object											
Asopalav-JPG	79.57	84.28	5.92	76.37	-4.02	78.31	-1.58	78.26	-1.65	79.54	-0.04
Asopalav-PNG	79.57	84.28	5.92	80.39	1.03	80.47	1.13	78.26	-1.65	80.46	1.12
Brinjal-JPG	70.49	73.93	4.88	67.87	-3.72	68.66	-2.60	69.40	-1.55	69.81	-0.96
Brinjal-PNG	70.49	73.93	4.88	71.00	0.72	71.05	0.79	71.03	0.77	71.01	0.74
Jasud (Hibiscus)-JPG	59.35	59.64	0.49	54.68	-7.87	54.87	-7.55	56.02	-5.61	56.44	-4.90
Jasud (Hibiscus)-PNG	59.35	59.64	0.49	57.34	-3.39	57.38	-3.32	57.39	-3.30	57.38	-3.32
Castor-JPG	143.93	150.23	4.38	137.68	-4.34	143.22	-0.49	141.92	-1.40	144.34	0.28
Castor-PNG	143.93	150.23	4.38	146.91	2.07	147.02	2.15	147.04	2.16	147.07	2.18
SQUARE-JPG	23.47	***	***	22.98	-2.09	22.97	-2.13	22.94	-2.26	23.34	-0.55
SQUARE-PNG	23.47	***	***	23.55	0.34	23.56	0.38	23.58	0.47	23.58	0.47
CIRCLE-JPG	18.48	***	***	17.57	-4.92	17.87	-3.30	18.3	-0.97	18.37	-0.60
CIRCLE-PNG	18.48	***	***	18.75	1.46	18.77	1.57	18.77	1.57	18.78	1.62
Damaged-JPG	0.24	***	***	0.27	12.50	0.25	4.17	0.28	16.67	0.29	20.83
Damaged-PNG	0.24	***	***	0.28	16.67	0.28	16.67	0.26	8.33	0.27	12.50

Table 1: Comparison value of Leaf Area measured by all three different methods as well as relative error over standard method (graphical).



Figure 1: Process Flow