Proceedings of the Third International Conference on Computing Methodologies and Communication (ICCMC 2019)
IEEE Xplore Part Number: CFP19K25-ART; ISBN: 978-1-5386-7808-4

A Review: Custard Apple Leaf Parameter Analysis and Leaf Disease Detection using Digital Image Processing

Appasaheb Gargade
Dept. of Electronics, School of Electrical Engineering
MIT Academy of Engineering Alandi
Pune, India
appagargade@gmail.com

Mr. S. A Khandekar
Dept. of Electronics, School of Electrical Engineering
MIT Academy of Engineering Alandi
Pune, India
sakhandekar@etx.maepune.ac.in

***Abstract*— The custard apple is known as sugar-apple, sweetsop. It is known as sitafal in some state in India. Custard apple is high in energy and an excellent source of vitamin C and manganese. It also provides iron, phosphorus and potassium. This fruit has low cholesterol, sodium and saturated sodium, which is good for health. This paper gives a survey on leaf parameter analysis, detection of healthy, sick or affected region of the leaf and classification of leaf diseases by using different methods for various plant. It is crucial and difficult for human eyes to detect the exact type of leaf diseases by naked eyes. Each plant leaf has different symptoms of various diseases. The algorithm designed for one plant does not work accurately, with other plant's leaf. Specialized algorithms for the custard apple plant is required to detect leaf diseases along with the leaf parameter analyzer. To identify the custard apple leaf diseases accurately, image processing and machine learning techniques are helpful. Leaf area, length, width are some of the very important contributors in plant growth analysis and photosynthesis.**

Keywords*— *Image processing, Machine Learning, Leaf area, Leaf disease, Custard Apple.

I. INTRODUCTION

Indian economy largely depends on agriculture, so for efficient growth of country, it is crucial to increase agriculture production. Agriculture yield depends on plant growth. Plant growth is mainly affected by light, water, minerals, nutrients and temperature [14]. Photosynthesis process and exchange of hydrosphere outside is done by plant leaves. Leaf parameters (leaf area, leaf perimeter, leaf maximum length, leaf maximum width) are the most important basis in scientific research, thus measuring these parameters quickly and accurately has great significance to study plant biological characteristics. Leaf area is an area of one side of the leaf, which is irregular in a shape. It represents the photosynthesis ability of the plant. Image processing algorithm is very important in image analysis by the camera. Traditional methods used for leaf area measurements are by using graph paper grid counting method, paper weighing method, regression equation method. These methods use simple principle, but they have the disadvantage of low accuracy and costing more time and materials [5]. The different Leaf area meter gives high accuracy, but the big leaf must be divided into small segments for measurement, which may lead to errors.

Plant disease is an abnormal state of plant that disturbs the growth of plants [7]. Plant leaves get affected due to different types of diseases. Identification and classification of different diseases are important. Leaf diseases affect yield. A solution to prevent and control these diseases is to detect and take appropriate action to reduce losses. The farmer can identify these diseases by bare eyes based on experience but has limitations such as a person's physical condition like fatigue, eyesight, working condition, improper lighting, weather condition and work pressure. Any error due to these, may lead to a wrong conclusion. Therefore, mechanized identification and segregation of leaf diseases is important and beneficial to the farmer in supervising plant growth and increase in yield [11], [12]. It also helps in early detection of disease symptoms as it appears on plant leaves [8].

Image processing steps such as image acquisition, image filtering, segmentation, image feature extraction are used to detect, classify leaf diseases and measure different leaf parameters [2], [3], [4]. The main origin of leaf diseases is viral, fungal and bacterial. The dominant challenges of sustainable development are to reduce the usage of pesticides, save the environment and increase the quality of yield. Precise, accurate and early diagnosis reduces the usage of pesticides. Different diseases commonly observed in custard apple leaves are anthracnose, leaf holes, leaf spots, brown margins on the leaves, nutritional deficiencies etc. [17].

A literature survey of different methods for leaf parameter analysis and leaf disease detection techniques for different plant leaves are given in section II. Block diagram for proposed workflow is given in section III. Leaf parameter calculation method is given in section IV. Section V gives the overall summery.

II. LITERATURE SURVEY

Many researchers had done work related to leaf parameter analysis and leaf disease detection. Following is related literature survey of work related to the topic.

A. Leaf Parameter Analysis

Authors of paper [5] propose a simple method for leaf parameter estimation using digital camera images of leaves. Five rupee coin is used for reference to calculate the area of the leaf. The results of this method are proportionate to the grid paper method. The average accuracy of approximately

97% is achieved using this method. A dataset of leaves from Pigeon Pea, Green Gram and Black Gram plants are used.

Paper [6] proposed the algorithm of image segmentation to classify image elements and calculate leaf surface with a threshold segmentation technique by using the constant threshold in gray color model and calculating the degree of green color in the HSV model. Segmentation technique is used to separate healthy surface from unhealthy surface of leaf. Leaf area estimation is done using linear regression analysis. The accuracy to separate unhealthy and healthy regions of leaf surface are 96.47 % and 98.72% respectively.

Utilizing digital image processing, the paper [10] studied and implemented an image parameter analysis system. The system uses morphological processing, image enhancement and boundary tracking to process plant leaves images. It uses a standard paper label of different sizes as reference for calibration. Measure the characteristics such as leaf perimeter, width, height and area. The result shows leaf width and height measurement error is less than 3.15%, leaf perimeter and area measurement error is less than 7%.

In this paper [13] computer vision-based method is proposed for leaf area measurement. The image sensor is used to capture plant leaf images. It is then transformed into HIS image. For the segmentation OTSU thresholding method is used. Morphological filtering is used to reduce noise. Blob analysis technique is used to fill holes in leaves to measure leaf area. This method is fast, accurate and efficient for measuring leaf area, perimeter as compared to other method using the leaf area meter.

In this method [14] leaf area is measured using image processing. Leaf image is acquired and stored in JPEG format. Image in the RGB of the leaf is transformed into CIELAB. OTSU's thresholding method is used. Region filling technique is used to fill leaf holes. Square object of know area is used as reference for calibration of leaf area. The results of measurement are compared with the grid counting method. Accuracy of 99% is achieved.

In this paper [15] graphical user interface was developed using an image processing toolbox of MATLAB. Around 50 sample leaves of various shapes and sizes were used for measurement of various leaf parameters like area, length, width, etc. Results of measurements were compared with the grid counting method.

The work in paper [16] uses image processing techniques to measure leaf parameters of cucumber. Results of measurements are compared with paper weighing, grid counting and leaf area meter. Leaf area, leaf maximum width and leaf maximum length are measured and compared with the other method's results. The average, standard deviation, coefficient of variation of leaf area measured using image processing is calculated. Leaf area is measured by taking circle, A3 paper as a reference. The result of image processing techniques has better repeatability, stability and accuracy.

B. Leaf Disease Detection and Classification

This work [1] proposes a knowledge-based system for diagnosis of mango plant diseases in Thailand. Mango plant growth gets effected due to variation in climate. Agriculture yield gets affected due to incorrect identification of plant diseases. The authors propose the systems that diagnose the affected leaves and give the probable solution. The plant diagnosis application uses a knowledge base system in the form of rule-based model obtained by the data mining technique. Dataset of 129 leaf images is used. The system has 89.92% of accuracy.

Authors of paper [2] proposed the system for detecting plant leaf diseases utilizing image processing MATLAB toolbox. Affected leaves of the plant are classified using hardware platform developed using Arduino based conveyor belt system. A genetic algorithm is used. Plant leaves of pepper, potato, tomato plants are used.

In this paper [3] machine learning mechanisms and image processing tools are used for disease detection and classification. SVM classifiers are used to get classification of diseases. The training and testing using 5 diseases and pest are done. Training set of 227 images and testing set of 121 images is used. The overall recognition rate was found to be 92.4%.

The main objective of paper [4] is leaf analysis and classification based on different leaf diseases. Proposed system consists of four major blocks: a) Image preprocessing b) leaf image segmentation using K- means clustering c) feature extraction using Gray level Co-occurrence matrix (GLCM) d) Disease classification by support vector machine (SVM). This method was implemented on Citrus plant leaves. Future work is required to improve classification accuracy.

Authors of Paper [7] segregate different tomato plant diseases such as tomato leaf curl, bacterial canker, tomato late blight, septoria spot and bacterial spot. The classification is done by feature extracting such as size, shape, texture and color of healthy and unhealthy tomato plant leaf images. Features extracted are given as input to classification tree. Plant leaves are classified into above mentioned diseases and if unaffected then the result is shown as healthy leaves. The classification of six types of tomato images has an overall accuracy of 97.3%.

The paper [8] proposed a system to identify nutrient deficiencies of leaves in paddy tree. By color comparison, pattern comparisons and making combination of pattern and colors, a nutrient deficiency such as NP, KP and NK is detected in paddy leaves using image analysis. NPK mean nitrogen, phosphorus and potassium. The result gives an average accuracy of 90%. The survey paper [9] is based on identification and segregation of cotton leaf diseases. The paper gives information about different cotton leaf diseases and their characteristics. Comparisons of different image classification and segmentation techniques are done.

The Paper [11] proposes the system using border segmentation techniques to identify and differentiate orchid plant leaf diseases such as sun scorch and black leaf spot. Filtering techniques and morphological processing techniques are applied. Other segmentation techniques are required for classification of other types of orchid leaf diseases. Result of implementation shows that percentage accuracy for detection of black leaf spot disease is 81.8 % and for sun scorch disease is 90.1%.

In this paper [12] the authors present the system for cotton leaf diseases detection such as alternaria, bacterial blight and myrothecium. The automatic plant disease identification system uses texture features, color and shape for classification. The dataset of the images is collected from Central Institute of Cotton Research, Nagpur, cotton farms in Buldhana, Wardha district and nearby farms in Maharashtra.

TABLE I. SURVEY OF LEAF PARAMETER ANALYSIS

Name	Plant Leaf	Method and Material	Parameters	Accuracy
Madhu Jadon et al. [5]	Pigeon Pea, Green Gram and Black Gram	Image Processing, Five Rupee Coin as Reference Object, 24 Megapixels Digital Camera (Nikon D5300)	Area	97%
Narumol Chumuang et al. [6]	Various Plants	Image Processing, Scanner (200 dpi resolution), Linear Regression	Area	96-98%
Zeng Demin et al. [10]	Clove	Image Processing, Paper Labels as Standard Reference, Digital Camera.	Perimeter, Area, Width, Height	Area and Perimeter 93%, Height and Width 97%
Lin Kaiyan et al. [13]	Various Plants	Image Scanner (Gemstar JT-DBG00), Computer Vision, Image Processing	Area	99%
Piyush Chaudhary et al. [14]	Peepal	Image Processing, CCD Color Camera (Soney: 16.1 mega pixels), Square Reference Object	Area	99%
V. D. Shivling et al. [15]	Various Plants	Image Processing, Flatbed Scanner	Length, Width, Area	99%
Tian You-wen et al. [16]	Cucumber	Image Processing, Circle as Reference, Digital Camera (Cannon 8 Mega Pixels)	Area, Length, Width	97%

TABLE II. SURVEY OF DETECTION AND CLASSIFICATION OF LEAF DISEASES

Name	Plant Leaf	Diseases	Method	Accuracy
Chutinan Trongtorkid et al. [1]	Mango	Anthracnose, Algal Spot	Knowledge Based System Obtained by Data Mining Technique, Used Decision Tree Model.	89%
Arya M S et al. [2]	Pepper, Potato, Tomato	Late Blight, Leaf Spot	Image Processing, Otsu's Segmentation Method, Color Co-Occurrence Methodology, Genetic Algorithm.	_
Pooja V et al. [3]	5 different plants	Mosaic, Alternaria Alternata, Anthracnose, Bacterial Blight, and Cercospora Leaf Spot	Image processing, Machine Learning Technique, Support Vector Machine (SVM)	92%
R. Meena Prakash et al. [4]	Citrus	Diseased Leaves	Image Processing, K-means Clustering, Gray-Level Co-occurrence Matrix (GLCM), Support Vector Machine (SVM)	90%
H. Sabrol et al. [7]	Tomato	Leaf Curl, Tomato Late Blight, Septoria Spot, Bacterial Spot, Bacterial Canker	Image Processing, Otsu's Segmentation Method, Gray-Level Co-occurrence Matrix (GLCM), Classification Tree.	97.3%
M V Latte et al. [8]	Paddy	Nutrient Deficiency: NP Defective, PK Defective, NK Defective (N: Nitrogen, P: Phosphorus, K: Potassium)	Image Processing, Color and Pattern Analysis.	90%
Wan Mohd Fadzil W.M.N et al. [11]	Orchid	Sun Scorch, Black Leaf Spot	Image Processing, Intensity Adjustment, Histogram Equalization, Disc, Median and Gaussian Filtering, Border Segmentation Technique.	86%
P. R. Rothe et al. [12]	Cotton	Myrothecium, Alternaria, Bacterial Leaf Blight	Image Processing, Gaussian Filter, Graph Cut Method for Image Segmentation, Color based and Shape Based Feature Extraction.	_

III. PROPOSED WORKFLOW

The proposed workflow sequence of custard apple leaf parameter analysis and leaf disease detection process is as below. The proposed system will be implemented in MATLAB (Matrix Laboratory) using the image processing toolbox, machine learning toolbox.

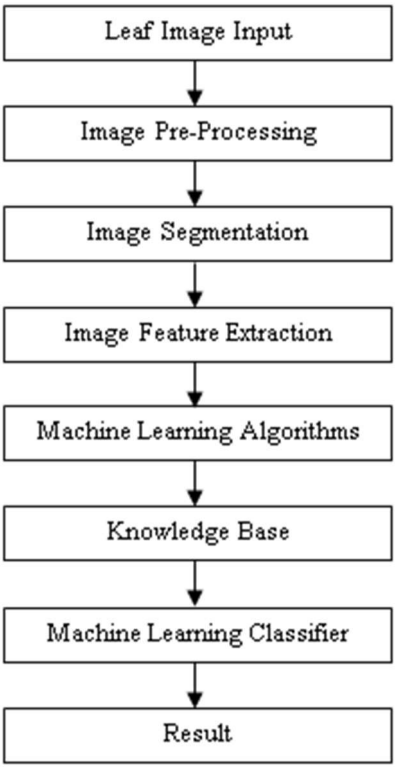

Fig. 3.1: Proposed Workflow Sequence

The steps of custard apple leaf parameter analysis, disease detection and classification are image acquisition, image preprocessing, image segmentation, image feature extraction and apply machine learning algorithm. The broad layout of solution is given in fig. 3.1.

Input Image: Image acquisition in image processing is an action of retrieving an image. Images of various leaves of custard apple are captured using a digital camera. Training set of images and testing set of images is constructed. It is the first step in the workflow sequence.

Image Preprocessing: Image preprocessing is used to enhance the quality of the image. Image preprocessing includes methods like binarization, image conversion, noise removal, contrast enhancement, reduce unwanted distortion.

Segmentation: Image segmentation is done to get region of interest (ROI). Image segmentation is the process of partitioning the image into multiple segments. Image segmentation is normally used to detect objects and boundaries in images.

Feature Extraction: In feature extraction, various features are extracted using feature extraction techniques. The task is to describe the regions based on selected representation. The region is represented by its boundary and boundary is described by its features like texture, color. This precisely describes the diseased region based on texture, color, shape.

The steps in machine learning techniques are access and explore data, preprocess data, develop predictive model, integrate analytics and systems, iterate. Some of the challenges in above machine learning steps are the lack of data diversity, lack of domain tools, more time consumption and lack of platform diversity. These challenges can be overcome by using MATLAB as it gives extensive data support, high quality industry standard libraries, interactive app-driven workflow features and platform diversity to run analytics anywhere.

The block diagram of the proposed work is given in fig. 3.2. In machine learning technique, the system is trained to the set of images with different patterns, different diseases and their specifications. The system uses the standard data set available for knowledge base. Custard apple leaf image data set of different diseases and healthy leaf images is used for training and validation purpose. Based on a feature extraction parameter, the algorithm predicts whether the leaf is affected by any disease and name of disease. The machine learning algorithm uses support vector machine (SVM) and K-means clustering for classification of diseases and to predict the condition of the leaf.

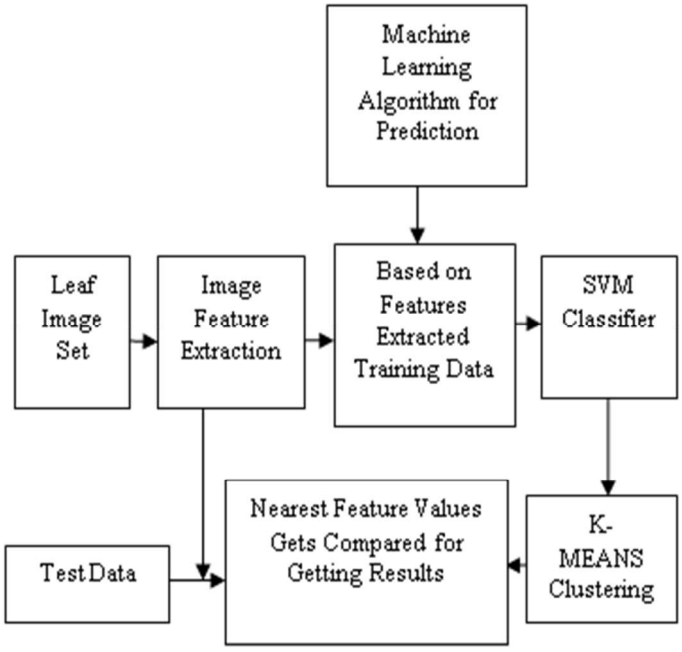

Fig. 3.2 Proposed Work Block Diagram

Support vector machine (SVM) is set of supervised learning that analyses data which are used for classification in leaf disease detection process. Support vector machine classifier is used for labelling purposes. It is memory efficient, effective in high dimensional spaces and versatile. This gives better and more accurate results. K-means clustering is an unsupervised learning algorithm. K-means clustering aims to partition N observation into K clusters. A cluster is a group of data that are grouped together due to similarities in their feature. It is used for labelling purposes.

IV. LEAF PARAMETER CALCULATION METHOD

For leaf parameter calculation, leaf and reference object's (of knowing dimension like length, width and area) image is captured. After image acquisition, image is converted from

RGB to grayscale image using *rgb2gray (x)* function. The conversion equation is as follows,

$$f(x) = 0.299 * R + 0.587 * G + 0.114 * B \qquad (1)$$

The gray image is converted into binary image by thresholding technique. Black spot, holes in the image are removed using morphological operation. Pixels in leaf and reference object's image are counted after labeling image. In MATLAB, by using *regionprops* function properties of images such as a count of pixels in the image are calculated. Function r*egionprops (L, properties)* measure set of properties for each labeled region in matrix L. Properties such as area, major axis length, minor axis length can be calculated. In resultant image, there are two components; the first is leaf image and the second is a reference object image. Let, N1 and N2 are number of pixels in leaf and reference object respectively, then leaf area (A) is given as [5]:

$$A = (A0 * N1)/N2\ (c.m^2) \qquad (2)$$

Where,

A is the leaf area calculated
A0 is a reference object known area (in c.m²)
N1 is the number of pixels in leaf
N2 is the number of pixels in reference object.

Leaf area will be estimated using the proposed method. The results of measurement are compared with the grid counting method (millimeter graph method).

Leaf Parameter measurement accuracy of this method depends on no. of pixels per unit area. Therefore, measurement accuracy can be increased by using a high-resolution digital camera which gives higher no. of pixels per unit area.

V. SUMMARY

In this paper, survey of leaf parameter analysis, identification and classification of leaf disease for different plant using image processing were carried out. The major steps in our proposed work on custard apple leaf parameter analysis are image acquisition, image pre-processing, image segmentation, features extraction and machine learning algorithm.

There is considerable scope for improvement and addition of features to leaf parameter analysis using digital image processing. The leaf parameter analyzer and disease detection system available in the market are still expensive and out of reach to common farmer. Custard apple is delicious fruit plant from dry land in India, as it normally grows in hot and dry climate. Specialist and low-cost systems are required to meet the requirements of farmer in dry area.

Leaf and fruit weight estimation feature can be added by using image processing and machine learning technique. Leaf and fruit weight estimation reduces the human handling of fruits and plant leaves. The machine learning algorithm provides better performance as machine learning technique can handle multi-dimensional and multi variety data in a dynamic environment.

REFERENCES

[1] Chutinan Trongtorkid, Part Pramokchon, "Expert System for Diagnosis Mango Diseases Using Leaf Symptoms Analysis", The 3rd International Conference on Digital Arts, Media and Technology (ICDAMT2018) .

[2] Arya M S, Anjali K, and Mrs.Divya Unni, "Detection of unhealthy plant leaves using Image Processing and Genetic Algorithm with Arduino", IEEE 2018.

[3] Pooja V, Rahul Das, and Kanchan V, "Identification of Plant Leaf Diseases using Image Processing Techniques", IEEE 2017.

[4] R.Meena Prakash, G.P.Saraswathy, G.Ramalakshmi, K.H.Mangaleswari, T.Kaviya, "Detection of Leaf Diseases and Classification using Digital Image Processing", 2017 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS) IEEE 2017.

[5] Madhu Jadon, Rashi Agarwal, Raghuraj Singh, "An Easy Method for Leaf area Estimation Based on Digital Images", 2016 International Conference on Computational Techniques in Information and Communication Technologies (ICCTICT) IEEE 2016.

[6] Narumol Chumuang, Sattarpoom Thaiparnit, Mahasak Ketcham, "Algoritham Design in Leaf Surface Separation by Degree in HSV color Model and Estimation of Leaf Area by Linear Regression", 2016 12th International Conference on Signal-Image Technology & Internet-Based Systems, IEEE 2016.

[7] H. Sabrol, K. Satish, "Tomato Plant Disease Classification in Digital Images Using Classification Tree", International Conference on Communication and Signal Processing, April 6-8, IEEE 2016 India

[8] M V Latte, Sushila Shidnal, "Multiple Nutrient Deficiency Detection in Paddy Leaf Images using Color and Pattern Analysis", International Conference on Communication and Signal Processing, April 6-8, IEEE 2016 India.

[9] Bhumika S.Prajapati, Vipul K.Dabhi, Harshadkumar B.Prajapati, "A Survey on Detection and Classification of Cotton Leaf Diseases", International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT) IEEE 2016 India.

[10] Zeng Demin, Cui Wei, Liang Lijing, "An Image Processing Based System for Leaf Parameter Measuring", IEEE 2012.

[11] Wan Mohd Fadzil W.M.N, Shah Rizam M.S.B, R. Jailani, Nooritawati M.T, "Orchid Leaf Disease Detection using Border Segmentation Techniques", 2014 IEEE Conference on Systems, Process and Control (ICSPC 2014), 12 - 14 December 2014, Kuala Lumpur, Malaysia.

[12] P.R. Rothe, Dr. R. V. Kshirsagar, "Automated Extraction of Digital Images Features of three kinds of Cotton Leaf Diseases" , 2014 International Conference on Electronics, Communication and Computational Engineering (ICECCE) IEEE 2014.

[13] Lin Kaiyan1,2 Wu JunHui1,2 Chen Jie1,2 Si Huiping*1,2, "Measurement of Plant Leaf Area based on Computer Vision", 2014 Sixth International Conference on Measuring Technology and Mechatronics Automation IEEE 2014.

[14] Piyush Chaudhary, Sharda Godara, A. N. Cheeran, Anand K. Chaudhari, "Fast and Accurate Method for Leaf Area Measurement", International Journal of Computer Applications (0975 – 8887) Volume 49– No.9, July 2012.

[15] V.D Shivling, Ajay Singla, C.Ghanshyam, Pawan Kapur, Savita Gupta, "Plant leaf imaging technique for agronomy", 2011 International Conference on Image Information Processing (ICIIP 2011).

[16] TIAN You-wen, WANG Xiao-juan, "Analysis of Leaf Parameters Measurement of Cucumber Based on Imagge Processing", World Congress on Software Engineering, IEEE2009.

[17] https://www.agrifarming.in/custard-apple-farming