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Intelligence System for Leaf Extraction and Disease Diagnostic

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***Abstract*—** Agriculture encompasses agricultural production and the environmental goods and services. Plant species classification, recognition of medicinal value and identification of diseases are most important tasks in agriculture. For these applications a primary requirement is obtaining the target leaf. Thus, leaf extraction is an important step for variety of these applications. But it is still a challenging problem especially for the images with complicated background such as with some interference and overlaps between two adjacent leaves. Hence a leaf extraction algorithm has been developed using two approaches: contour analysis approach and marker controlled watershed segmentation method. The contour analysis approach employs contour regions to detect the boundaries of the objects. The target leaf is obtained using the connected edges of the contour boundary. The second approach, marker-controlled watershed segmentation method is applied on the gradient images of Hue, Intensity and Saturation of the HSI color space, separately. The solidity (integrity) measure is then used to evaluate how well the segmented image is for extraction of the target leaf and determine the final leaf extraction result. The extracted leaf is given as an input to the disease diagnosis system for analysis of disease on the given leaf.

***Keywords*—** leaf extraction,contour analysis,marker controlled water shed segmentation,solidity measure

1. INTRODUCTION

This project demonstrates how to extract object from complicated background and diagnose the diseases. This system accepts images as input from the user, processes it by extracting the object of interest, in this case a leaf. After acquiring the object of interest (leaf) the phase of disease diagnosis is performed on it. The result is sent back to the user. The user interaction can take place in three ways, a mobile based application, a web based interaction and a front end on a standalone system where the application is installed. The system provides functionality for a user to diagnose for diseases in a leaf. With the use of this system the user can diagnose diseases unknown to him and also can find remedy for these diseases.

This project involves two modules, where the first module includes leaf extraction from complicated background and the second module involves disease diagnosis on the extracted leaf. The user input is accepted from 3g enabled mobile phone, a web based user interface and stand alone system, where each user is provided with user accounts. The interaction with the user is very engaging. The administrator has authorization to create user accounts and analyze the results of each user. The administrator also provides result to each user on his specified e-mail id. This project is developed using two tools, MATLAB and Lab VIEW. For the mobile based application, an android application drop box is used to receive the user input on to the server. Drop box provides a very compelling interface for the user. An drop box account is to be created for the user to transfer the captured pictures on to the server. The drop box application utilizes both the Wi-Fi and gprs technologies. For the leaf images with complicated background, the traditional methods such as thresholding, edge detector and morphological processing cannot perform well to segment the target leaf from the complicated background due to their limitations. Hence in this project the K-means clustering approach is used for non green background elimination and leaf extraction and pattern recognition with contour tracing is used for disease diagnosis. The process of leaf extraction and disease diagnosis is subtle approach to automatically diagnose the disease on the leaf. Various other applications like plant recognition, medicinal values of the leaf also can be incorporated in future.

1.1 MOTIVATION

Farmers in rural India have minimal access to agricultural experts, who can inspect crop images and render advice. Delayed expert responses to queries often reach farmers too late and also those living in remotes areas face difficulties where access to assistance via an internet connection can become a significant factor.

Detecting disease of plant in a timely fashion plays a key role in cultivation. Manual identification of disease is carried out by expert in practice. However, this requires continuous monitoring of crops by experts which might be expensive in large farms.

The purpose of this project is to develop an algorithm for the automatic extraction of plant leaf from the images with complicated background and diagnose the leaf for diseases. The process of leaf extraction is a very important process for variety of applications. Traditional approaches lacked the ability to extract the target leaf automatically. Hence a motivation to develop this project was to provide an automated leaf extraction system which evolves in the ongoing technology of machine vision. The diverse field of agriculture which has lacked the attention from the field of computer science was also a very strong motivating factor to develop this project.

1.2 Existing System

In the existing system there is no automatic interaction, each process is done by manually. So the manual system controlled or manipulated by a human operator such as computer and each process would be done by step-by-step.

Fourier-Mellin correlation approach, curvature was used to describe boundaries of both completely visible and partially occluded leaves. Completely visible leaves were identified by aligning the curvature function of each leaf with that of each of the models. Functions were aligned to minimize local differences in curvature. A Fourier-Mellin correlation was used to calculate scale factors for resampling curvature functions of partially occluded leaves. Partially occluded leaves were identified by aligning the resampled curvatures with each of the models. However, this technique cannot work well to identify the aggregate boundaries of multiple leaves.

Franz et al. further developed an algorithm to extract boundaries of occluded leaves by using an edge detection technique to link endpoints of leaf edge segments. But user intervention was required at various steps during the process of this approach.

Joao Camargo Neto et al. proposed an approach for automatical extraction of individual leaf from young canopy images using Gustafson-Kessel clustering and a genetic algorithm. In this approach, Gustafson-Kessel clustering technique is applied to divide the images into a number of small regions firstly, and the genetic algorithm was then employed to combine the image regions into an integrated leaf. This approach can work well for the young canopy images in which the contrast between leaves and the background is clear and leaf overlap is small.

Deformable templates using active contours were proposed by Manh et al. to locate boundaries of green foxtail leaves [4]. This approach attempted to combine color separation and shape feature analysis into a single operation. But it needed to manually select energy level or color.

1.3 Proposed System

The web based intelligent system for object recognition and disease diagnosis system offers complete and easy solution for identifying diseases in a leaf. The benefits of this system are: the user can diagnose a diseased leaf without much difficulty. The user can also be assured of the result as a systematic pattern matching approach is employed for diagnosing a diseased leaf. The main objective of the system is to accept images with complicated background extract the region of interest (leaf) and diagnose it for any diseases. The goal is to provide an easily accessible leaf extraction and disease diagnosis system which consists of a user friendly interface, secure transmission of images, precise extraction of region of interest and an immaculate disease diagnosis system.

2. REQUIREMENT ANALYSIS

2.1 Hardware Interfaces:

For the communication protocol the program needs these protocols to be installed:

- TCP for the client to connect to the server in online mode.
- Storing devices (flash, optical disks etc.) for the client to take a test in offline mode.
- Drivers for web camera to implement continuous monitoring.

2.2 Software Interfaces

- Operating System: Windows XP SP2 or Higher
- Front End: VB.NET 2008
- Back End: MATLAB / LabVIEW
- Database: Microsoft SQL Server Website Development : Joomla 1.5

3. OVERALL DESCRIPTION OF PROPOSED SYSTEM

3.1 Flow of Study

1. Input Image: The input image would be taken from any high resolution camera or web cam.
2. Pre-Processing the image: Preprocessing constitutes the earlier phases, which produce a translation output image for feature extraction

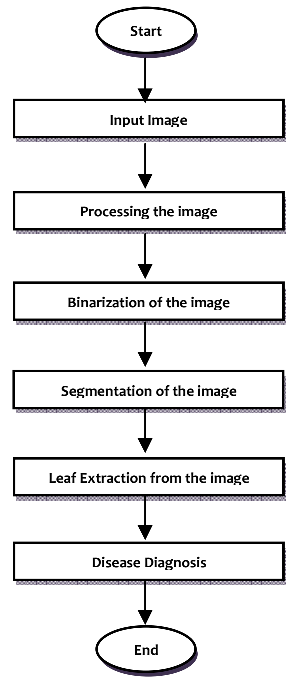

Fig.3.1: Data flow diagram

3. Binarization of the image: Convert the intended image into Binary image. A binary image is a digital image that has only two possible values for each pixel. Typically the two colors used for a binary image are black and white though any two colors can be used. The color used for the object(s) in the image is the foreground color while the rest of the image is the background color.
4. Segmentation of the image: Image segmentation is the process of dividing an image into multiple parts. This is typically used to identify objects or other relevant information in digital images.
5. Leaf Extraction from the image: After segmentation of image extract the intended leaf from complicated background.
6. Disease Diagnosis: The final step is disease diagnosis. Diagnosis is a process of identifying a disease from intended leaf.

4. IMPLEMENTATION OF PROPOSED SYSTEM

The implementation of proposed system includes two tools.

1. MATLAB
2. LabVIEW

4.1 Processing in MATLAB Phases of Leaf Extraction

1. Non-green background elimination

The color of leaf image is often green or different color by visualization, The first step of leaf extraction is non-green background elimination. In the existing system the OTSU thresholding method was used for the non-green background elimination. The existing system faced challenges in overcoming the shining problem on the leaf due to which some part of the leaf often gets eliminated. to overcome this problem k-means clustering method is employed which efficiently dealt with the shining problem Finally Morphological image processing approach is further applied to deal with details and the small holes.

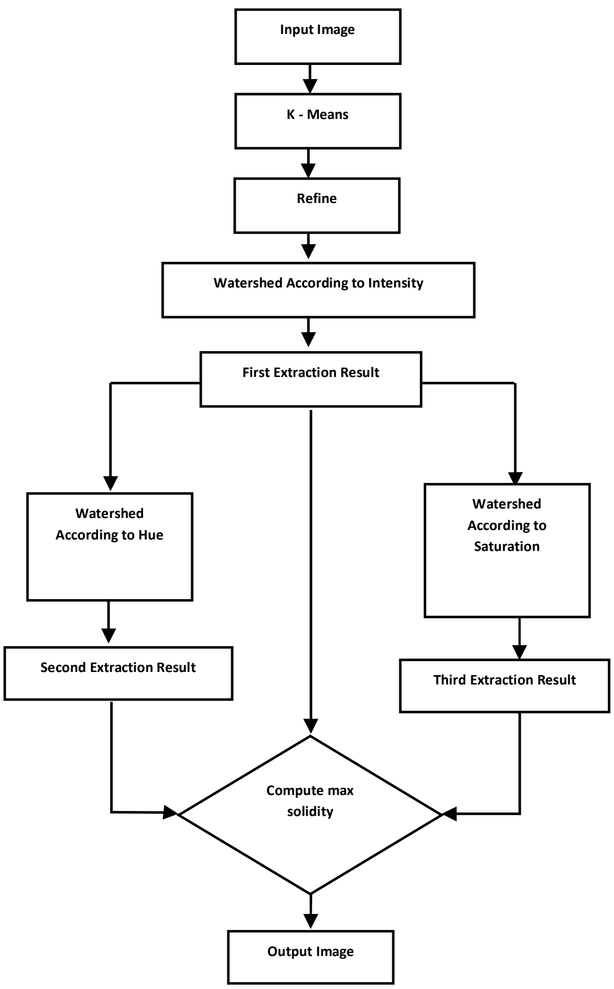

Fig 4.1 Architectural Block diagram

K-means clustering:

K-means clustering is a method of cluster analysis which aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean.

Equation:

Given a set of observations (x_1, x_2, …, x_n), where each observation is a d-dimensional real vector, k-means clustering aims to partition the n observations into k sets ($k \le n$) $S = \{S_1, S_2, \ldots, S_k\}$ so as to minimize the within-cluster sum of squares

(WCSS):

$$\underset{\mathbf{S}}{\arg\min} \sum_{i=1}^{k} \sum_{\mathbf{x}_j \in S_i} \left\| \mathbf{x}_j - \boldsymbol{\mu}_i \right\|^2$$

where μ_i is the mean of points in S_i.

2. Marker-controlled watershed segmentation

The watershed method is an image segmentation method that divides an image into some regions based on the topology of image. The marker-controlled watershed method is applied on the HSI color images instead of the grey-scale image. The original color leaf image is transformed into HSI space which consists of H (Hue), S (Saturation) and I (Intensity) values. The HIS model can decouple the intensity component from the color carrying information (hue and saturation) in a color image.

The processing steps of marker-controlled watershed segmentation are as follows:

1) Compute the gradient map of the I (Intensity) image and do histogram equalization.
2) Apply the opening-by-reconstruction operation to the gradient map and the result is denoted as *Iobr*.
3) Apply the closing-by-reconstruction operation to the above produced image and get the result denoted as *Icbr*.
4) Compute the local maxima of *Icbr* as the markers.
5) Adopt the 'minima imposition' technology to eliminate all other minima except the makers. This technology imposes the markers positions as the global minimum.
6) Employ the watershed method to the result image with the generated markers and produce image segmentation.

4.2 Processing in LabVIEW

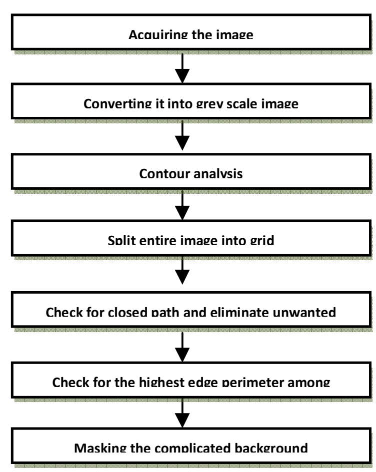

Fig. 4.2: Architectural Block diagram

5.4.2 Phases of Leaf Extraction

The proposed system follows 7 phases for Leaf Extraction process.

1. Acquiring the image
   - Acquire the image in RGB format.

- The image can be acquired from camera, folder of images which takes input from user interface or website.
- The range for RGB values vary from 0-255 for R, G and B respectively

2. Converting RGB image to grey scale image
- Tedious task to control all the three R, G and B parameters.
- Conversion to grey scale requires controlling single parameter.
- Value for grey scale parameter ranges from 0-255.
- Preferably using the HSL color space considering the luminance parameters.

3. Contour analysis- controlling measures
- Edge threshold:- defines the threshold to set the pixel value, for ex- a threshold value 50 indicates that if the pixel value exceeds the threshold value, the pixel value is set to 1 else 0.
- Search step size: - a parameter to divide the contour region in various steps to enhance execution (splitting into cells).
- Minimum length: - considers the pixel with minimum length.
- Search direction: - used to define the direction of searching in contour region(Top, Down, Left and Right).
- Distance range: - used to define the gap between the pixels of boundary.

4. Split to grid
- A single contour region cannot be used for the whole image.
- The lighting parameter changes in the entire image.
- A grid of 16*16 grids.

5. Check for closed path
- If the contour for the leaf is considered then it consists of a closed path.
- The closed path for each of the object in the image has to be calculated.
- The unwanted background is eliminated (Barks, Branches).
- Check for the case of occluded leaf if it exists employ the method for calculating highest edge perimeter

Extraction Method	Successful number	Success Rate	Failed Number	Failure Rate
Based on marker controlled watershed Segmentation algorithm	42/50	84%	8/50	16%
Based on contour analysis approach	39/50	78%	11/50	22%

Extraction Method	Successful number	Success Rate	Failed Number	Failure Rate
Based on marker controlled watershed Segmentation algorithm	42/50	84%	8/50	16%
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Table: Leaf extraction and disease diagnosis results

6. Check for highest edge perimeter
- In case of occluded leaves the highest edge perimeter has to be found to obtain the intended leaf.
- The intended leaf can be recognized based on the value of edge perimeter that is highest.

7. Masking
- Once the intended leaf is identified the remaining region is masked.
- Masking refers to changing the pixel value of the unwanted region.

Contour Analysis consists of mainly 5 controlling measures, as given below.

1. Edge threshold:- defines the threshold to set the pixel value, for ex- a threshold value 50 indicates that if the pixel value exceeds the threshold value, the pixel value is set to 1 else 0.
2. Search step size:- a parameter to divide the contour region in various steps to enhance execution (splitting into cells).
3. Minimum length:- considers the pixel with minimum length.
4. Search direction:- used to define the direction of searching in contour region(Top, Down, Left and Right).
5. Distance range:- used to define the gap between the pixels of boundary.

CONCLUSION

A well defined approach for leaf extraction and disease diagnosis has been proposed. A new algorithm which can automatically extract the target leaf from the images with complicated background and perform disease diagnosis on them is successfully developed using the contour analysis approach and marker controlled watershed segmentation method. The target leaf is extracted using the connected edges of the contour region and pattern matching feature is applied for disease diagnosis using the contour analysis approach. For the marker-controlled watershed segmentation method the target leaf is extracted by applying the watershed segmentation to the Hue, Intensity and Saturation images separately which contain both the intensity and color information. Finally, the solidity measure is used to select the best leaf extraction. Both the approaches effectively extract the object of interest and by employing the pattern matching feature for disease diagnosis a success rate of 84% are achieved.

6. FUTURE SCOPE

The marker-controlled watershed segmentation sometimes results in a failed leaf extraction. The main reason of failed leaf extraction is that the edge of some overlapping leaves is not clear. The hue, saturation and intensity of each leaf are very close to other non-target leaves. It is difficult to distinguish these leaves even manually. Therefore, it is difficult for watershed algorithm to set up a dam at the edge, which results in failed leaf extraction. Hence an alternative for segmenting the image can be considered.

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