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Characterization of Leaf and Comparison with Optical and Millimetre Wave for Identification

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Abstract

By optical photography, we can identify various leafs and vegetation canopies by their variations in color, variations in size and shape, and other optically visible parameters. If we see the same leaf and vegetation canopy with the help of millimetre waves by the techniques of imaging, transmissivity, reflectivity, emissivity, we can get more information regarding the plant and the leaf growth, leaf constituent's material such as water, phosphate, nitrate, magnesium, potassium and many other material present in the leaf or vegetation canopy. In brief, with the help of millimetre wave and using various above mentioned techniques we can get more information which otherwise not visible apparently. Within the millimetre wave range, we can use 22.235 GHz, 31.4 GHz, 35 GHz, 54GHz, 94 GHz frequencies. This multi frequency within millimetre wave can give us the data for proper imaging. As we know, in a present day scenario, imaging means outward photography by optical waves in optical wavelength, in infrared wavelength (for thermal photography) and microwave-millimetre wave imaging of the inner constituent material. With the appropriate software we can plot various image processing mapping for better understanding. Some of our observations with image processing approach are given below to invite more inputs from other researchers.

Keywords: Millimetre Waves, Leafs, Radio Meter, Imaging, Histogram, Sobel Edge Detection

Introduction

Active research is needed in the area of leaf recognition to utilize huge number of plant species for their medicinal properties and also as an alternative energy sources. In recent times, computer vision methodologies and pattern recognition techniques have been applied towards automated procedures of plant recognition. Using MATLAB software the leaf recognition program becomes simple and efficient. In this paper we have taken the image of leaf at 94 GHz and with the use of the MATLAB block models and techniques like histogram and sobel edge detection are taken into account for the analysis. Based on specific characteristics extracted from photography it gives an approach where the plant is identified based on its leaf features such as histogram and edge detection and classification. In further section we will talk about the experimental setup used for taking images at 94 GHz and the histogram and images obtained by edge detection followed by results and then conclusion.

Wu et al. [1], extracted 12 commonly used digital morphological features which were orthogonalized into 5 principal variables using PCA. They used

1800 leafs to classify 32 kinds of plants using a probabilistic neural network system. Wang et al. [2], employed centroid contour distance (CCD) curve, eccentricity and angle code histogram (ACH). Fu et al. [3] also used centroid-contour distance curve to represent leaf shapes in which an integrated approach for an ontology-based leaf classification system is proposed. For the leaf contour classification, a scaled Recognition of plants by Leaf Image using Moment Invariant and Texture Analysis CCD code system is proposed to categorize the basic shape and margin type of a leaf by using the similar taxonomy principle adopted by the botanists. Then a trained neural network is employed to recognize the detailed tooth patterns.

Due to the different shapes and sizes of image blocks of leafs; they could be separated and extracted from sources. Then, by using image analysis tools from Matlab, these characters such as sizes, radius, perimeters, solidity, and eccentricity could be calculated. Then, using them as input data, create a radial basis function divide the input data into two parts. Select one part to train the network and the other to check the validity of the model. Input data from other image frames under the same condition could be used to check the model. The

world of plants is very vast than the worlds of animals or birds or bugs. More general image classification methods are used, because it is awidespread topic, and there are a lot of well-known features (such as color histogram, SIFT (Scale invariant feature transform), HOG (Histogram of oriented gradient), Shape descriptors, OCR (Optical Character Recognition). In order to focus on the main structure of the program, the MATLAB implementation, the database retrieving and specific feature creation, we will take benefit of the built functions available in MATLAB for Digital Image Processing. The final program provides a segmentation algorithm. In addition, like in most of the image recognition programs, a database of plant or leaf picture has to be done, as well as a learning method to extract the features for the database, and amatching method to retrieve the best match from the database. Several additional small programs have been implemented to gather information for results. Despite the high technical aspect of this project, dealing with leafs, gives it abiological connotation. Some basic knowledge about leafs have to be learned and concepts about how the biologists themselves recognize leafs has to be studied. The next two paragraphs are devoted to these experiences.

Precision Botany (PB) refers to the application of new technologies in plant identification. Computer vision can be used in PB to distinguish plants from its species level, so that an identification can be applied on the size and number of plants detected for the classification purpose. This is focused on the application of computer vision for identification purposes of species in stemonoporus genus. Leafs can be of many different shapes: Primarily, leafs are divided into simple - single leaf blade with a bud at the base of the leaf stems; or compound - a leaf with more than one blade. All blades are attached to a single leaf stem. Where the leaf stems attaches to the twig there is a bud. Leafs may be arranged on the stem either in an alternate arrangement - leafs that are not places directly across from each other on the twig; or in an opposite arrangement - 2 or 3 leafs that are directly across from each other on the same twig.

Leaf arrangements are pretty straight forward to figure out. Need to look for the node sand then determine how many leafs are coming off each node. If there's only one leaf per node, then need only to determine whether the arrangement is alternate or spiral and it's usually pretty obvious. So that's it for basic leaf terms, in conclusion this basic learning has been of great use as it helped understand how professionals approach the sensitive task of recognizing leafs. Many factors come into play, whether the color, the shape, the symmetry of the leaf or some more subtle as simple

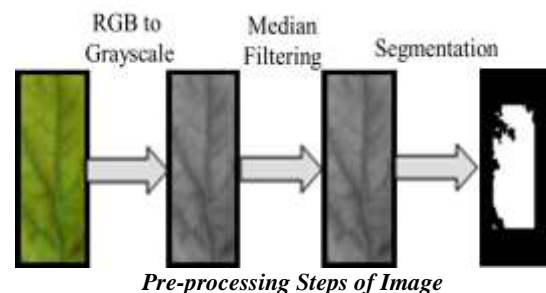
or compound leafs. The accent has been put on the important role of the leafs; with their alternate disposition or their palmate nerves they are many clues for recognition.

Identifying a landscape or garden plant requires recognizing the plant by one or more characteristics, such as size, form, leafshape, flower color, odor, etc., and linking that recognition with a name, either a common orso-called scientific name. Accurate identification of a cultivated plant can be very helpful inknowing how it grows (e.g., size shape, texture, etc.) as well as how to care and protect it from pests and diseases.

Image Pre-processing

Before the operations, some of the leaf images are rotated manually for helping theprogram to arrange leaf apex direction to the right side. Afterwards, automatic pre-processing techniques are applied to all of the leaf images. These pre-processing steps are illustrated on an image as seen in Figure 1, while ignoring the color information.

Figure: 1



As a result, only Gray component for each pixel is computed from the color image by:

$$Gray = 0.299 * R + 0.578 * G + 0.114 * B$$

Where, R, G and B correspond to the color of the pixel [7, 8], respectively. The rectangle of interest (ROI) of the leaf image should include all the pixels their Gray values are smaller than a specific threshold [9], and then the binary image of the leaf is retrieved. In this approach the threshold is automatically gotten according to the histogram of the leaf Gray image. Then the contour of leaf can be extracted.

There are two types of representations, an external representation and internal representation. An external representation is chosen when the primary focus is on shape characteristics. An internal representation is selected when the primary focus is on regional properties such as color and texture. Sometimes the data is used directly to obtain the descriptors such as in determining the texture of a region, the aim of description is to quantify a representation of an object. This implies, one can

compute results based on their properties such length, width, area and so on.

Histogram stretching is used to enhance the contrast

Contrast is the difference between maximum and minimum pixel intensity. An important class of point operations is based upon the manipulation of an image histogram or a region histogram. The most important examples are described below.

Frequently, an image is scanned in such a way that the resulting brightness values do not make full use of the available dynamic range. By stretching the histogram over the available dynamic range we attempt to correct this situation. If the image is intended to go from brightness 0 to brightness 2^B-1 , then one generally maps the 0% value (or *minimum* as defined) to the value 0 and the 100% value (or *maximum*) to the value 2^B-1 . The appropriate transformation is given by:

$$b[m, n] = (2^B - 1) * \frac{a[m, n] - \text{minimum}}{\text{maximum} - \text{minimum}}$$

This formula, however, can be somewhat sensitive to outliers and a less sensitive and more general version is given by:

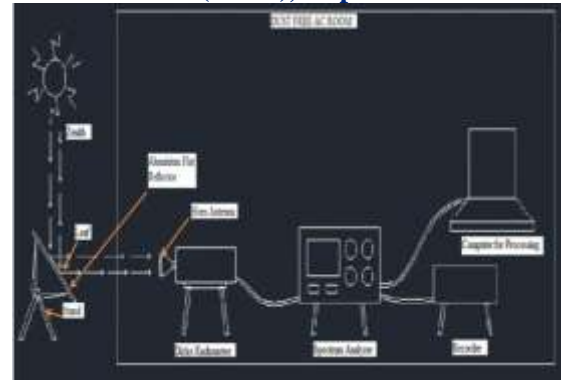
$$b[m, n] = \begin{cases} 0 & a[m, n] \leq p_{low}\% \\ (2^B - 1) * \frac{a[m, n] - p_{low}\%}{p_{high}\% - p_{low}\%} & p_{low}\% < a[m, n] < p_{high}\% \\ (2^B - 1) & a[m, n] \geq p_{high}\% \end{cases}$$

We can increase the contrast of the image. The formula for stretching the histogram of the image to increase the contrast is:

$$g(x, y) = \frac{f(x, y) - f_{min}}{f_{max} - f_{min}} * 2^{bpp}$$

Experimental setup

The setup shown below is used for taking the image of a leaf at 94 GHz in which the mm waves collected from the zenith by the leaf whose images is to be taken is reflected. The reflected mm waves are then received by a Dicke radiometric system and processed by image processing scanning system. For housing this setup the atmosphere must be cool and dust free.



Experimental setup for Millimetre Wave Imaging

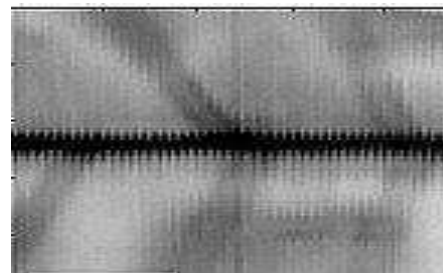
In millimetre wave we took the image of the same leaf at 94 GHz. Plant leaf has many features which need to be observed by multispectral mode. We took image in optical range and also in millimetre wave. In optical image we got some information by simulation analysis. In millimetre wave frequency the simulation repeated by making the suitable leaf model. The experimental setup as shown above has one radiometer at 94 GHz and spectrum analyser. The image is taken by keeping the aluminium reflector in zenith mode.

Figure: 3



Optical image of leaf

Figure: 4



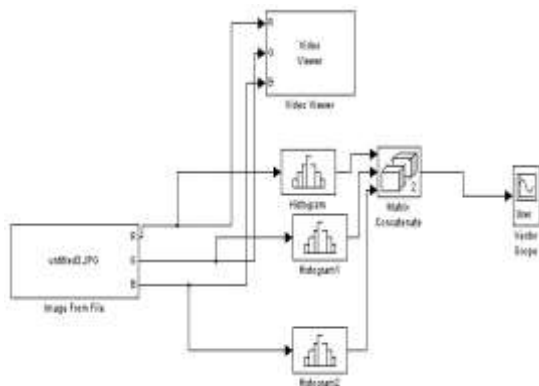
Millimetre Wave image of leaf at 94 GHz

Figure: 2

Histogram

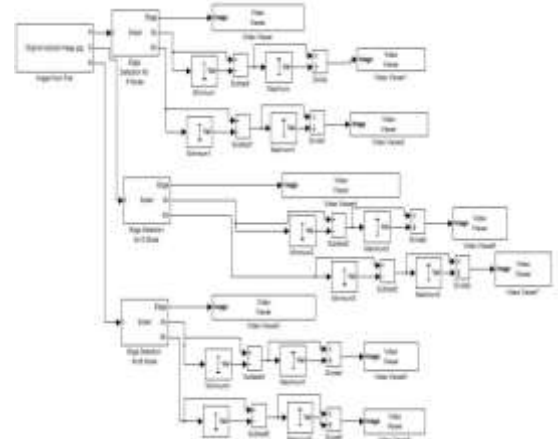
Sobel edge detection

Figure: 5



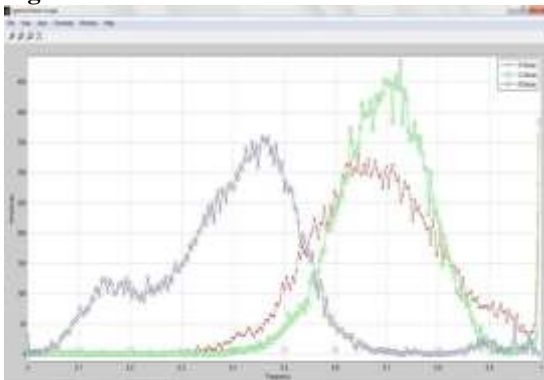
Simulink Model for making Histogram

Figure: 8



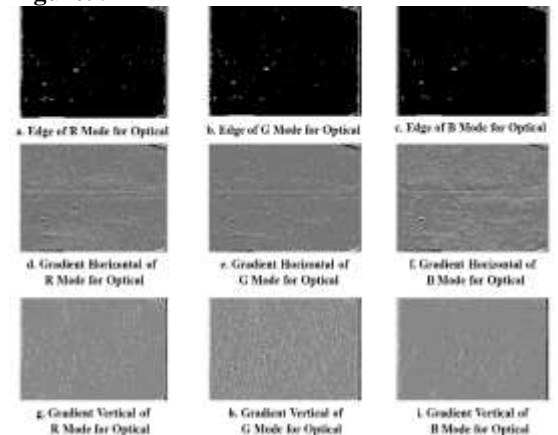
Simulink Model for Sobel Edge Detection

Figure: 6



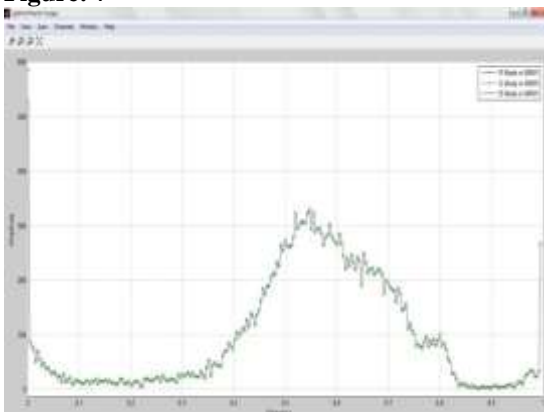
Histogram of Leaf for optical image

Figure: 9



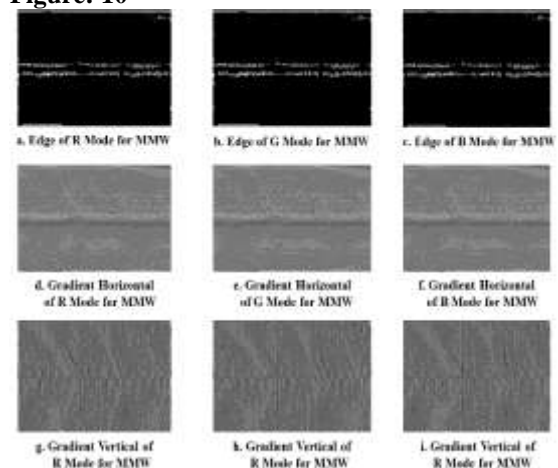
Sobel edge detection of optical image of leaf

Figure: 7



Histogram of Leaf for millimetre wave at 94 GHz

Figure: 10



Sobel Edge Detection of millimetre wave image of leaf at 94 GHz

Results and discussion

The histogram of optical image of the leaf obtained in red, blue and green mode, it is found the R, G, B for optical are different with each other giving the


clues for various information of the leaf image. While in millimetre wave image histogram in R, G, B mode gives the same pattern and amplitude, this indicates the uniformity of the image pixels in millimetre wave range. So, in millimetre wave image pattern analysis of various leafs will give decisive information about the type of leaf through their histogram analysis. We have also give this observation that the histogram tells us the radiation pattern absorbed by the leaf in millimetre wave and radiation scattered back in millimetre wave range. This approach along with the sobel-edge detection will give more information about the various type of leaf, sobel edge detection in optical and in millimetre wave are distinctly different from each other and in millimetre wave we get further more information of leafs. In this paper we presented the methodology but it can be applied to many botanical species.

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Author Bibliography

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