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A Hybrid Method for Enhancement of Plant Leaf Recognition

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Abstract— This paper focuses on the preprocessing technique for CAP-LR (Computer aided plant classification through leaf recognition). Pre-processing is the basic step to reconstruct the image with some useful feature. This technique is essential for the enhancement of leaf images which increases the efficiency of the subsequent tasks of the leaf recognition system. In this paper, an hybrid approach is proposed which is a combination of contrast stretching and adaptive thresholding that simultaneously adjusts the intensity level of leaf images using boundaries is developed. The validation of proposed system is carried out based on the defined parameter matrices. The experimental results shows that the proposed method proves efficient when compared to other traditional methods.

Keywords- image enhancement; Histogram equalization; Contrast stretching; intensity adjustment; Adaptive Thresholding; Median filter; wavelet filter.

I. INTRODUCTION

The application of digital image processing techniques for the problem of automatic leaf classification began two decades ago and it has since been proceeding in earnest. In industrial agriculture this technology found some of its earlier applications to be widely used. Image sequence processing techniques are used to solve problems in environmental biology. Plant is important for environment protection. However, the problem of plant destruction becomes worse in recent years. Hence many types of plants are at the risk of extinction. To protect plants and to catalogue various types, construction of automatic plant recognition system is an important step towards conservation of earth's biosphere. There are several ways to recognize a plant like flower, root, leaf, fruit etc. In recent times computer vision methodologies and pattern recognition techniques have been applied towards automated procedures of plant recognition [2,3]. Plant leaves are approximately two-dimensional in nature and the shape of plant leaf is one of the most important features for characterizing various plants species. It helps in the development of an automatic method that can correctly discriminate and recognize leaf shapes of different species. These applications require high accuracy for the estimation of dynamic changes. Automatic classification and recognition system for plant is essential and useful since it can facilitate fast learning of plants [4,7].

Leaf images normally changes to blurred images by the presence of noise, low or high contrast both in the edge area and image area. Preprocessing an image include, removal of noise, edge or boundary enhancement, automatic edge detection, automatic contrast adjustment and segmentation. As multiple noise damages the quality of nature images, improved enhancement technique is required for improving the contrast stretch in leaf images. Mostly the images in natural surface posses low contrast as the features have a low range of reflectance in any waveband which effects the further development process of CAP-LR. CAP-LR generally includes the following steps: preprocessing, feature extraction, classification and recognition. However, blurness and presence of unwanted noise on leaf images result in false classification. Thus image pre-processing such as image enhancement techniques are highly needed to improve the quality of leaf image.

Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing `better' input for other automated image processing techniques [1,5]. During this process, one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task. Image enhancement techniques are used to highlight certain features (i) increasing the contrast, (ii) changing the brightness level of an image so that the image looks better. In this paper, a hybrid approach [12] that simultaneously removes noise, adjusts contrast and enhances boundaries is presented.

The paper is organized as follows, Section 2 of the paper introduces the concept of traditional enhancement techniques which improves the pixel intensities. Section 3 explains the working of contrast stretching and adaptive threshold method. The proposed hybrid model for improving the pixel intensities and improve the quality of blur is explained in section 4. Section 5 discusses the experimentation, their performance measurement and results. Finally, the conclusions and references are discussed in section 6.

II. ENHANCEMENT TECHNIQUES

Image enhancement processes consist of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or machine [6]. Meanwhile, the term image enhancement is mean as the improvement of an image appearance by increasing dominance of some features or by decreasing ambiguity between different regions of the image [7,13]. Some enhancement techniques are shown in figure 1.

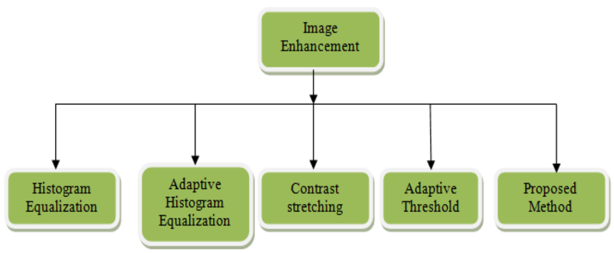

Figure1. Different Types of Image Enhancement Techniques.

Contrast stretching is the image enhancement technique that commonly used for digital images. Till now contrast stretching process plays an important role in enhancing the quality and contrast of medical images [10, 11]. This study proposes 5 techniques for contrast enhancement based on local contrast, global contrast, partial contrast, bright and dark contrast.

A Contrast Stretching Technique

The contrast of an image is the distribution of its dark and light pixels. A low-contrast image exhibits small differences between its light and dark pixel values. The histogram of a low-contrast image is narrow. Since the human eye is sensitive to contrast rather than absolute pixel intensities, a perceptually better image could be obtained by stretching the histogram of an image so that the full dynamic range of the image is filled.

The basic idea behind contrast stretching [5] is to linearly increase or decrease the contrast of the given image. This can be done by specifying the input/output relationship. For example, observe the following input/output relationship shown in figure 5 below. In this figure the intensities of the pixel have been normalized from 0(black) to 1(White). Input image intensity (x-axis) is denoted by 'r' while output image intensity (y-axis) is denoted by's'.

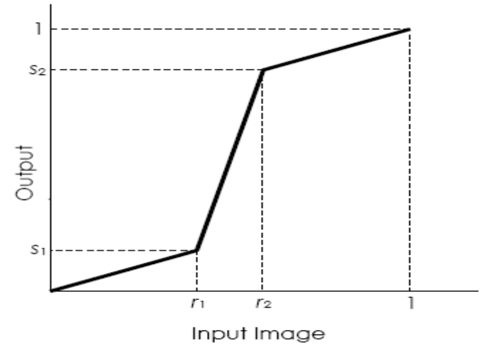

Figure 2. Pixel Intensities

In this figure 2, small dynamic range input intensity (as represented by the difference between r2 and r1) is being mapped to a wider dynamic range at the output image (as represented by the difference between s2 and s1). Thus, one can see that the transformation function has stretched the contrast of the input image. In this manner, one can see that some of the darker or black pixels are mapped to brighter pixels.

A few observations that are made from the mapping function [5] are given below:

1. If s1 equals to r1 and s2 equals to r2, then output image will be exactly identical to the input image. In this case there is no change in the contrast between the output and input image.

2. If s1 = 0, s2 = 1, and r1 = r2 then output image will consist of only black (0) and white (1) pixels. This function is known as the binarizing function.

3. If r1 > s1 and r2 < s2 (as shown in figure 4), then all pixels in between r1 and r2 of the input image will be stretched between the pixels s1 and s2 of the output image. Pixels less than r1 in the input image will be darker in the output image and pixels greater than r2 in the output image will appear brighter in the output image.

4. If r1 < s1 and r2 > s2, then all pixels in between r1 and r2 of the input image will be compressed in between pixels s1 and s2 of the output image. Pixels less than r1 (dark pixels) in the input image will be brighter in the output image and pixels greater than r2 (bright pixels) in the output image will appear darker in the output image.

B Adaptive thresholding method

Thresholding is called adaptive thresholding when different thresholds are used for different regions in the image [6,14]. This may also be known as local or dynamic thresholding.

Consider a grayscale document image in which g(x, y) € [0, 255] be the intensity of a pixel at location (x, y). In local adaptive thresholding techniques, the aim is to compute a threshold t(x, y) for each pixel such that

$$O(x,y)=\begin{cases}0, if g(x,y)\le t(x,y)\\ 255, otherwise\end{cases}$$

In Sauvola's binarization method, the threshold t(x, y) is computed using the mean m(x, y) and standard deviation s(x, y) of the pixel intensities in a w × w window centered around the pixel (x, y) as

$$t(x,y)=m(x,y)\left[1+k\left(\frac{s(x,y)}{R}-1\right)\right]$$

where 'R' is the maximum value of the standard deviation (R = 128 for a greyscale document), and 'k' is a parameter which takes positive values in the range [0.2, 0.5].

The local mean m(x, y) and standard deviation s(x, y) adapt the value of the threshold according to the contrast in the local neighborhood of the pixel. When there is high contrast in some region of the image, s(x, y)~R which results in t(x, y) ~m(x, y). the result is same as that of Niblack's method. However, the difference comes in when the contrast in the local neighborhood is quite low. In that case the threshold t(x, y) goes below the mean value thereby successfully removing the relatively dark regions of the background. The parameter k controls the value of the threshold in the local window such that the higher the value of k, the lower the threshold from the local mean m(x, y).

III. PROPOSED ENHANCEMENT TECHNIQUE FOR LEAF IMAGE

The proposed leaf image enhancement technique consists of the following 4 steps.

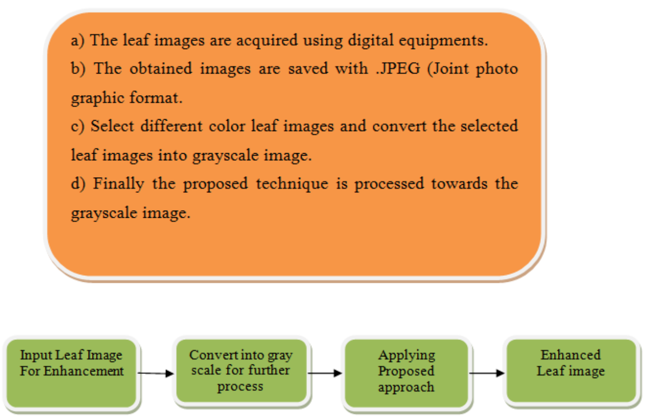

Figure 3. Proposed Enhancement method for leaf image

The above figure 3 shows the proposed approach for leaf image enhancement. Contrast stretching is normalization technique, aims to improve the image through stretching the range of intensity values. Those intensity values are rescaled usually through the analysis image histogram. Generally contrast stretching is employed when the gray level distribution is narrow, due to poor illumination, lack of dynamic range in image sensor. The technique aims to adjust histogram to achieve the higher separation between foreground and background gray level distribution. However it is difficult to remove noise when gray levels are similar to object. So, in contrast stretching the image intensity is adjusted and the enhanced image is obtained which is noisy and the details of object in images are not well clearly.

To separate the objects from image the foreground and background separation is done to extract the objects. Thresholding is a basic and frequently applied technique for gray level image separation. In the gray level of regions the image are distinguishable from the background. The enhanced image obtained after intensity adjustment can be threshold in order to obtain selected features of interest from the background. Threshold is implemented in frequency domain.

IV. EXPERIMENTAL SETUP AND RESULTS

The experiments are conducted using matlab 7.1. Ten leaf images are taken as benchmark images. To test the accuracy of the filtering algorithms, four steps are followed.

i) First, an uncorrupted Leaf image is taken as input.

ii) Secondly speckle noise and Gaussian noise is added alternatively to a leaf image.

iii) Thirdly, filtering algorithm is applied to noisy image.

iv) Fourth, the performance evaluation is estimated based on the parameters PSNR, MSE, UQI, Energy and ET.

The following figure 4 shows the sample input leaf data for processing.

Figure 4. Sample Dataset

The reconstruction of an image has the dimensions of 256 pixel intensity. Most of the images used are leaf images with different shapes. Normally the value of PSNR, Energy & UQI must be high which produces good quality image. Whereas the MSE and ET value must be low value to act as a good algorithm.

a.)Peak Signal to Noise Ratio

The PSNR is defined in logarithmic scale, in dB. It is the ratio of peak signal power to noise power. Since the MSE represents the noise power and the peak signal power, it is unity in case of normalized image signal. The image metric PSNR is defined as:

$$PSNR = 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) = 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$$

TABLE 1 PARAMETER EVALUATION USING ENHANCEMENT METHOD

	PSNR	MSE	UQI	Energy	ET
AHE	15.57	1816.17	0.5	0.2	0.57
HE	14.5	2325.07	0.55	0.13	1.05
CS	19.87	673.73	0.92	0.23	0.47
AT	17	1417	0.45	0.61	0.52
PM	21.87	514	1.24	0.33	0.27

The above table 1 shows the parameter evaluation using enhancement method. The proposed method gives suitable results on the basis of PSNR, MSE, UQI, Energy and ET.

The following figure 5 shows the PSNR value for different enhancement method. The PSNR value must be high for a better image.

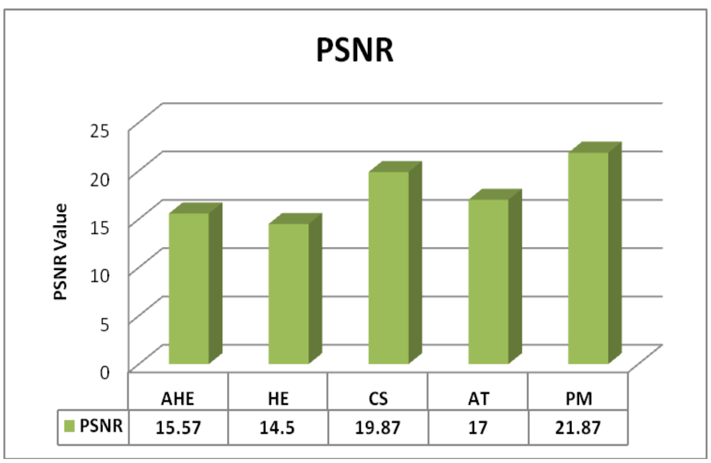

Figure 5. PSNR value for Proposed Method

b.) Mean Square Error (MSE)

The metric MSE is defined as:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}||I(i,j) - K(i,j)||^2$$

For two $m \times n$ monochrome images I and K, one of the images is considered a noisy approximation of the other.

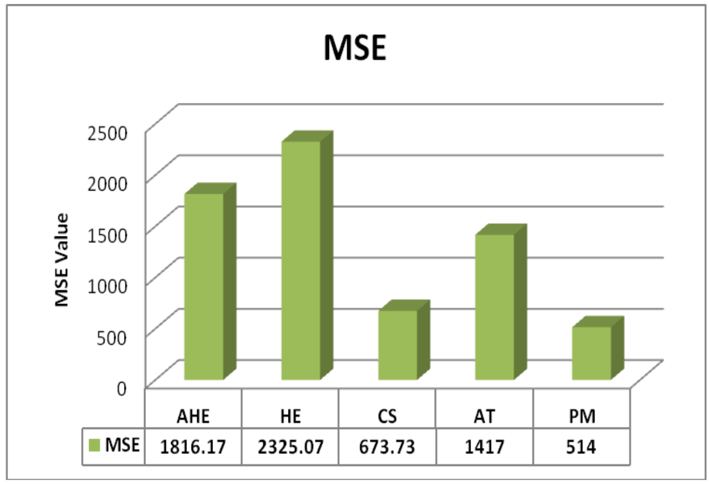

Figure 6. MSE value for Proposed Method

The above figure 6 shows the MSE value for different enhancement method. The MSE value must be low for a better image. The proposed method gives suitable results by producing low MSE value.

c.) Energy

The gray level energy indicates how the gray levels are distributed. It is formulated as,

$$E(x) = \sum_{i=1}^{x} p(x)$$

where E(x) represents the gray level energy with 256 bins and p(i) refers to the probability distribution functions, which contains the histogram counts. The energy reaches its maximum value of 1 when an image has a constant gray level.

The larger energy value corresponds to the lower number of gray levels, which means simple. The smaller energy corresponds to the higher number of gray levels, which means complex.

The following figure 7 shows the energy value for different enhancement method. The proposed method proves efficient by displaying high energy level.

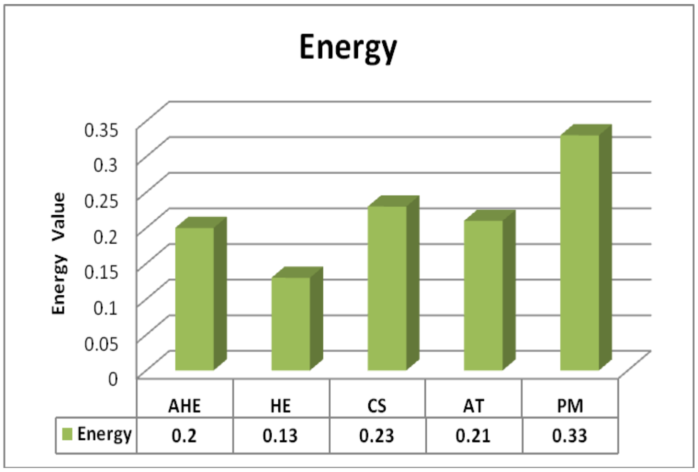

Figure 7. Energy value for Proposed Method

d.) UQI

UQI measures image similarity across distortion types. Distortions in UQI are measured as a combination of three factors; Loss of correlation, Luminance distortion and Contrast distortion. Let {xi} and {yi} =1,2,...,N be the original and the test image signals, respectively. The universal quality index [] is defined as

$$UQI = \frac{4\sigma_{xy}\overline{x}\overline{y}}{[\sigma_x^2 + \sigma_y^2][(\overline{x})^2 + (\overline{y})^2]} \quad (4)$$

where

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i \qquad \bar{y} = \frac{1}{N}\sum_{i=1}^{N} y_i$$

$$\sigma_x^2 = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2 \qquad \sigma_y^2 = \frac{1}{N-1}\sum_{i=1}^{N}(y_i - \bar{y})^2$$

$$\sigma_{xy} = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})(y_i - \bar{y})$$

The dynamic range of UQI is [-1,1]. The best value 1 is achieved if and only if yi=xi for all i=1,2,…,N. The lowest value if -1 occurs when yi=2 x –xi for all i=1,2,…,N.

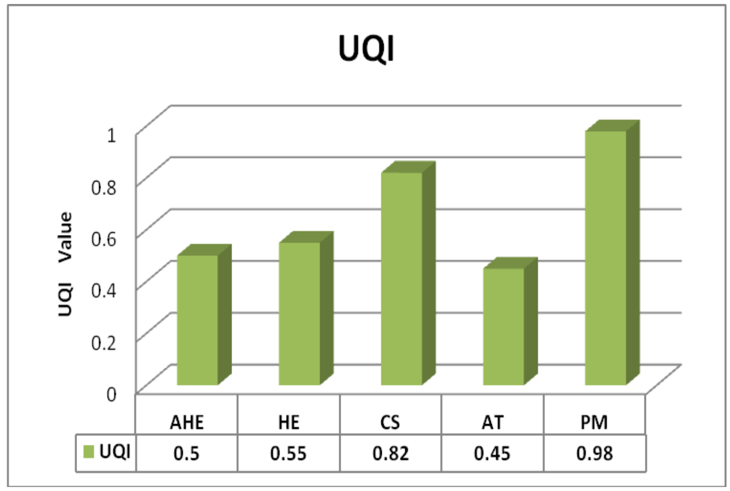

Figure 8. UQI value for Proposed Method

The above figure 8 shows the UQI value for various enhancement methods. The proposed method gives desirable results with high UQI value.

e) Evaluation Time

Evaluation Time (ET) of a filter is defined as the time taken by a digital computing platform to execute the filtering algorithms. Though ET depends essentially on the computing system's clock time-period, yet it is not necessarily dependant on the clock time alone. Rather, in addition to the clock-period, it depends on the memory-size, the input data size, and the memory access time. However, the measure ET is very important in case of real-time application.

The execution time taken by a filter should be low for online and real-time image processing applications. Hence, a filter with lower ET is better than a filter having higher ET value when all other performance-measures are identical. The following table 5 shows the ET value for different filters.

The following figure 9 shows the ET value for different enhancement method. The ET value must be low for a better image. The proposed method gives efficient results.

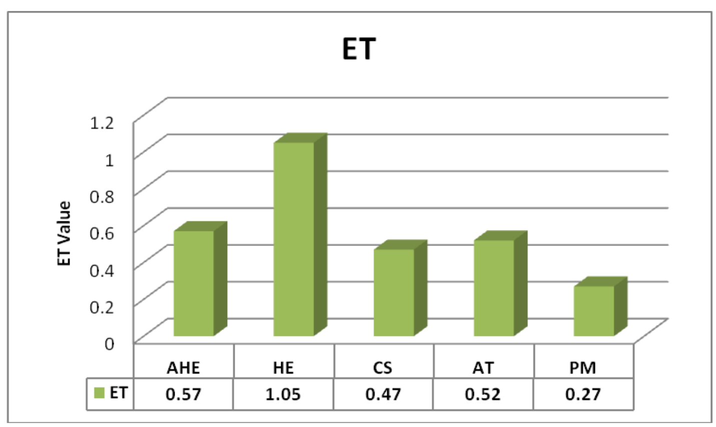

Figure 9. ET value for Proposed Method

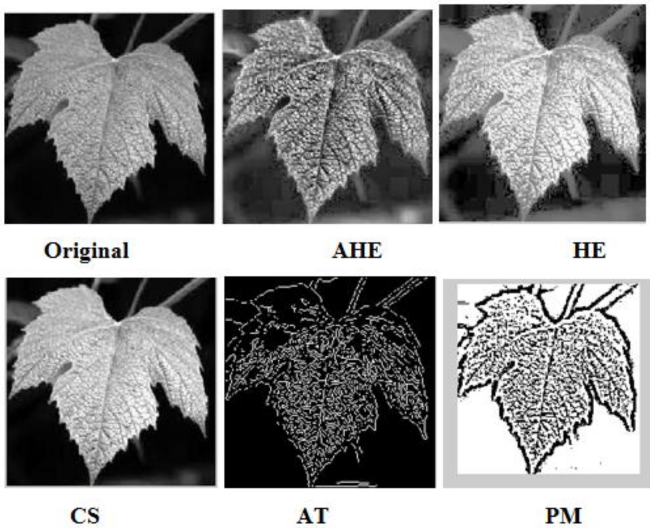

Figure 10. Image results for different enhancement method

The above figure 10 shows the image results for different enhancement method. The proposed method gives the expected results where the boundary are enhanced better when compare to other methods.

V. CONCLUSION

The Computer aided identification of plants has gained more attention and is proving to be a very important tool in many areas including agriculture, forestry and pharmacological science. In addition, with the deterioration of environments, many of the rare plants have died out, and so, the investigation of plant recognition can contribute to environmental protection. This paper focused on the preprocessing step of CAP-LR. Leaf images normally changes to blurred images by the presence of noise and low or high contrast both in the edge area and image area. Preprocessing an image include removal of noise, edge or boundary enhancement, automatic edge detection, automatic contrast adjustment and segmentation. As multiple noise damages the quality of nature images, improved enhancement technique is required for improving the contrast stretch in leaf images The image enhancement is an important step discussed. In this paper, an approach that simultaneously adjusts contrast and enhances boundaries is presented. Experimental results shows the proposed method gives suitable results when compared to other traditional method taken for study.

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