The Role of Image Enhancement in Citrus Canker Disease Detection

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***Abstract*—Digital image processing is employed in numerous areas of biology to identify and analyse problems. This approach aims to use image processing techniques for citrus canker disease detection through leaf inspection. Citrus canker is a severe bacterium-based citrus plant disease. The symptoms of citrus canker disease typically occur in the leaves, branches, fruits and thorns. The leaf images show the health status of the plant and facilitate the observation and detection of the disease level at an early stage. The leaf image analysis is an essential step for the detection of numerous plant diseases.**

The proposed approach consists of two stages to improve the clarity and quality of leaf images. The primary stage uses Recursively Separated Weighted Histogram Equalization (RSWHE), which improves the contrast level. The second stage removes the unwanted noise using a Median filter. This proposed approach uses these methods to improve the clarity of the images and implements these methods in lemon citrus canker disease detection.

***Keywords*—Lemon tree; Citrus Canker; Recursively Separated Weighted Histogram Equalization; Median Filter; Image Enhancement; Disease detection**

I. Introduction

In India, various citrus plants are cultivated in every state. However, the geographic areas of Andhra Pradesh, Karnataka, Punjab, Assam and TamilNadu are the leading citrus-growing states. The foremost important species and varieties of citrus grown in India are the loose-jacket oranges or santras, sweet oranges or tight jacket oranges, Sathgudl oranges, musambi oranges, acid limes or Kaghzi limes, and lemon. Several species of citrus might be affected by diseases like fungi, bacteria and viruses. In recent years, the foremost severe and customary disease is citrus canker, and it is considered a serious problem where lemon is mature on a large-scale. Citrus canker is seen on leaves, twigs, branches, fruit stalks, fruits and thorns and may lead to tree death and loss of yield. Citrus canker appears as yellowish spots or halos on leaves that gradually enlarge to 2 – 4 mm dark brown pustules. Canker on the fruit does not have the yellow halo seen on leaves. This proposed approach considers lemon leaves for detection of citrus canker disease and uses two major techniques to obtain clear, high quality images. The high quality images will facilitate easy disease identification. Within the past decade, various histogram equalisation and filtering techniques have been used to increase image quality in several applications such as eye and plant diseases. The proposed approach collects or captures unhealthy leaf images from outside and uses RSWHE and a Median filter to get high quality images. These high quality images are necessary for leaf disease detection. The following figures show various stages of citrus canker on the leaves.

Fig. 1. Initial stage of Citrus Canker

Fig. 2. Maturity stage of Citrus Canker

II. Evaluation of Proposed System

Researchers have implemented various techniques to enhance the images utilised in plant disease detection. A.Camargo and J.S.Smith[2009][1] utilised histogram equalization to distribute the intensities of an image and improve the image quality and visual appearance of the plant leaf images. Anjali Naik[2010][2] used histogram equalisation in dental disease detection to obtain high contrast images and better views of bone structure in radiographic images. T.Jintasuttisak and S. Intajag [2014][3] developed a technique called Rayleigh Contrast Limited Adaptive Histogram Equalization. Using this technique, the image contrast and overall appearance of images used to discover vision-related diseases was improved. Mary Kim and Min Gyo Chung

[2013][4] proposed another method, Recursively Separated and Weighted Histogram Equalization (RSWHE), to enhance the image contrast and brightness preservation. RSWHE offered higher leads in comparison to earlier methods in all aspects. With RSWHE, the input histogram was segmented into more than two sub-histograms recursively using mean or median values and a weighting process was applied to modify each sub-histogram and perform histogram equalization independently. Omprakash Patel, Yogendra.P and S.Maravi and Sanjeev Sharma[2013][5]reviewed many extensions of histogram equalization. Their analysis found that RSWHE produced less mean brightness error and a high peak signal to noise ratio. This method offers higher brightness preservation and contrast enhancement that conjointly offers scalable brightness preservation owing to its recursive nature. Samuel Oporto-Díaz, Rolando, Terashima-Marín [2005][6] proposed a method, sequential difference of Gaussian (DoG) filters, to detect microcalcification clusters in mammograms. DoG removes unwanted noise and classifies regions. G. Kale Vaishanw[2014][9] highlighted the uses of varied filtering techniques like Gaussian, Laplacian and Median filters. He emphasised the importance of image enhancement in X-ray lung images. He maintained that the filtering technique selection is based on both the application and process image enhancement. M.A. Shaikh and Dr. S.B.Sayyad[2014][10]used colour image enhancement in the agricultural domain. They implemented histogram equalization for contrast enhancement and compared linear (Wiener) filters and nonlinear(Median) filters. They observed that the Median filter was better at noise reduction and removed the blurred effect of the image. J.M. Durge, Prof. N.P. Bobade and Dr N.N. Mhala[2015][8] proposed to detect early stage lung cancer. They used the Median filter to enhance the image and suppress noise and other fluctuations of lung images.

Based on our literature review, we carried out our image enhancement using two different methods: histogram and filtering. Our proposed approach uses histogram equalization for contrast enhancement and filtering for unwanted noise removal.

III. Proposed Approach

The proposed methods play an important role in citrus canker disease detection by improving image quality with greater clarity. Here, we have developed two strategies to enhance the contrast and quality of the lemon leaf images: RSWHE increases the contrast of the image, and the Median filter removes the noise.

A. Mathematical Model

1) Recursively separated and Weighted Histogram Equalization (RSWHE)

RSWHE increases the contrast of an image in the following three stages:

a. Histogram segmentation: Consider the image X and calculate the histogram H(X). H(X) is then divided into the number of sub-histograms.

b. Histogram weighting: Change the sub-histograms using normalized power law.

c. Histogram equalization: Equalize the weighted sub-histograms independently over the changed sub-histograms.

*a) **Histogram Segmentation:*** This divides the histogram H(X) using the recursion level r and creates 2r sub-histograms based on the mean value. Consider a sub-histogram $H^t(X)$ over a range $[X_l, X_u]$ at a recursion level t $(0 \le t < r)$. The sub-histogram $H^t(X)$ mean value (i.e., X^t_m) is computed using the formula: $X^t_m = \sum^u_{h=1} k.\, p(k) / \sum^u_{k=1} p(k)$.

$H^t(X)$ divides into $H^{t+1}_L(X)$ and $H^{t+1}_U(X)$ based on $[X^t_m]$. Here, $H^{t+1}_L(X)$ and $H^{t+1}_U(X)$ over $[X_l, X^t_m]$ and $[X^t_m + 1, X_u]$, respectively.

*b) **Histogram Weighting:*** The histogram segmentation creates 2r sub-histograms $H_i^r(X)$ $(0 < i <= 2^r - 1)$. For r = 2, the histogram weighting changes the Probability Density Function p(k) of $H_i^r(X)$ as follows:

i) Calculate the maximum and minimum probability (p_{max} and p_{min}) using the equations: $p_{max} = max_{0 <= k <= L-} p(x)$ and $p_{min} = min_{0 <= k <= L-1} p(x)$.

ii) Calculate a cumulative probability α_i using $\alpha_i = \sum^u_{k=1} p(k)$ for $H_i^r(X)$.

iii) Change the p(k) into weighted p(k) using the following formula:

$$p_w(k) = p_{max} (p(k) - p_{min} / p_{max} - p_{min})^{\alpha i} + \beta \; (l <= k <= u)$$

Here, β adjusts the brightness and contrast of the image and β >= 0. The $p_w(k)$ is normalized using $_{pwn}(k) = {}_{pw}(k) / \sum^{L-1}_{k=0} p(k)$ and forwarded to the next module.

*c) **Histogram Equalization:*** The $p_{wn}(k)$ contains 2^r curves and bounds by the range $[X_l, X_u]$ of $H_i^r(X)$. This module equalizes all 2^r sub-histograms and combines all resultant images. It provides high quality images as its output.

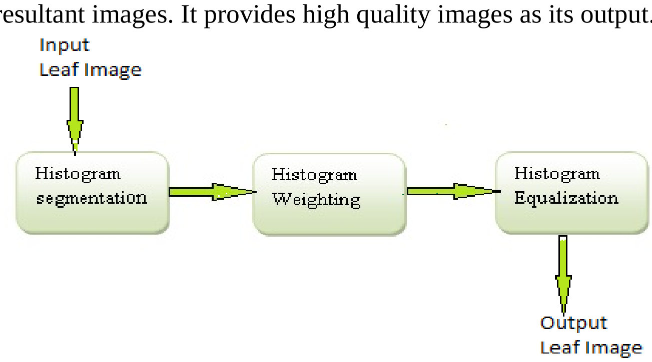

Fig. 3. A model of RSWHE

2) Median Filter

We can get the higher end in conserving, removing noise and isolating noise spikes using the Median filter. The median m could be a group of numbers in this group if half the numbers are less than m and half are greater. The median m could be a midpoint pixel value that is drawn from the neighbourhood sorted distribution values. It does not produce a new, unrealistic pixel value. The median operator arranges the values within the pixel element neighbourhood at each pixel element location. This reduces edge blurring and loss of image detail.

Algorithm:

Step 1: Select a 3 × 3 size two-dimensional centre window p(x, y) from the input image.

Step 2: Rank the pixel values p(x, y) within the selected window in ascending order and find the median, maximum and minimum pixel values (Pm, Pmax and Pmin).

Step 3: If the pixel value p(x, y)has the limit Pmin < P(x, y) < Pmax, Pmin > 0 and Pmax < 255, p(x, y) is taken into account as uncorrupted. Otherwise, p(x, y) is taken into account as corrupted.

Step 4: The corrupted p(x, y) has two categories:

Category 1: If Pmin < Pm < Pmax and 0 < Pm < 255, replace the corrupted p(x, y) with Pm.

Category2: Pmin considered a noisy pixel. Here, calculate the difference between each adjacent pixel across the ranked values, find the maximum difference and mark it as the next processed pixel.

Step 5: Apply steps 1 to 4 to the entire image until the process is complete.

Neighborhood Values:

126,127,133,115,119, 135,118,120,150

Max: 135

Min: 115

TABLE I. MEDIAN FILTER-NEIGHBORHOOD VALUES SELECTION

130	140	123	125	126
134	**126**	**120**	**118**	122
124	**127**	***150***	**135**	118
119	**133**	**115**	**119**	123
120	110	116	111	130

IV. EXPERIMENTS AND RESULTS

Image enhancement methods have been applied to various lemon citrus canker diseased leaf images using MATLAB. RSWHE has been used to increase the brightness of images, while the Median filter has been used for de-noising corrupt images.

Here, we have taken sample citrus canker diseased leaves images and applied RSWHE and Median filter and got high quality citrus canker diseased images.

Fig. 4. Original image

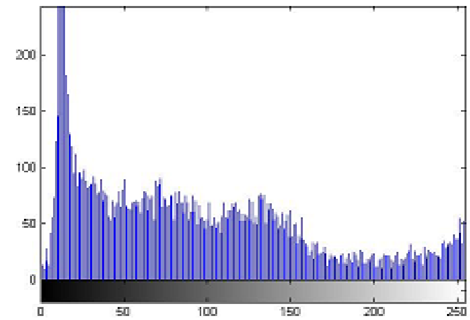

Fig. 5. Original Image Histogram

Fig. 6. Equalized Image

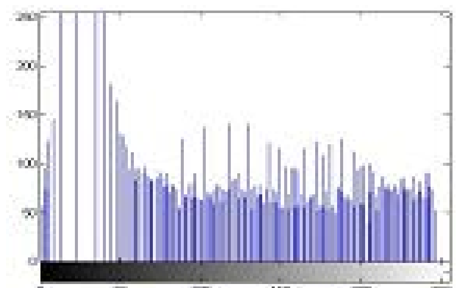

Fig. 7. Equalized Image Histogram

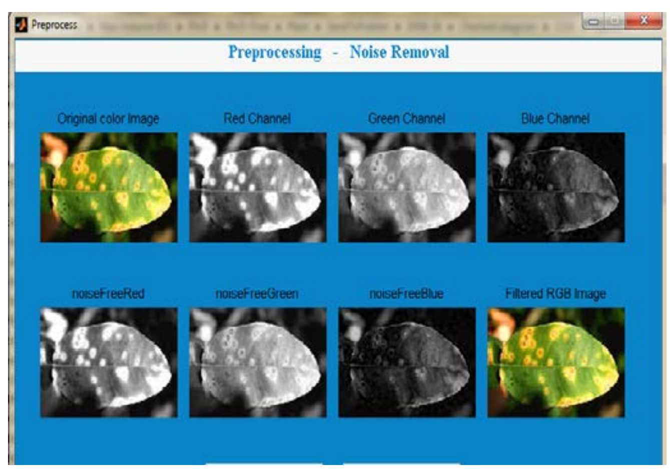

Fig. 8. Filtering process

V. CONCLUSION

Compared to the predominant strategies, our proposed approach has produced better image enhancement. This approach applies RSWHE and a Median filter to enhance citrus canker diseased leaf images. Using this method, we tend to get clear, high quality leaf images for further processing. This approach highlights the results of the enhancement process in citrus canker disease detection, showing that the visual illustration of diseased leaf images is improved.

In the future, enhanced citrus canker images will be taken and applied segmentation method which is used to extract the diseased portion. They may be utilised for citrus canker disease detection and the identification of disease level.

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