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Cotton Pests and Diseases Detection based on Image Processing

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Abstract

Extract the damaged image form the cotton image in order to measure the damage ratio of the cotton leaf which caused by the diseases or pests. Several algorithms like image enhancement, image filtering which suit for cotton leaf processing were explored in this paper. Three different color models for extracting the damaged image from cotton leaf images were implemented, namely RGB color model, HSI color model, and YCbCr color model. The ratio of damage (γ) was chosen as feature to measure the degree of damage which caused by diseases or pests. This paper also shows the comparison of the results obtained by the implementing in different color models, the comparison of results shows good accuracy in both color models and YCbCr color space is considered as the best color model for extracting the damaged image.

Keywords*: cotton pests and diseases, color model, image processing, ratio of damage.*

1. Introduction

There are many harmful biological hazards like diseases, pests and others happened throughout the crop growing periods which caused numerous losses each year, so the correct identification and accurate analysis of harm was the first thing in the processing of prevention and control in order to achieve real-time, accurate prediction and control.

The leaf is the vital organs of crop photosynthesis, and also the place where the pests and diseases occur frequently. Yutaka Sasakin judged the cause of crops through the analysis of the reflection spectral curve of the normal part and the diseases pot part [1, 2]. Chen Jiajuan detected the cotton leaves hole and damaged edges based on the computer vision, which can automatically determine the extent of cotton pests from the surface [3].

In contrast to the approaches mention above, this research attempts to focused on the cotton image which damaged by the diseases or pests, the Machine Vision techniques and Image Processing methods were explored in this paper in order to the automatically detection of the cotton image.

2. Image Preprocessing

The effect of image segmentation directly affects the performance of the target recognition [4]. Before the image processing, At first the damaged image should be cut off, this preprocessing can reduce the influence made by the background. A polygon that similar to the edges of the leaves was used to cut the damaged image. The second preprocessing is image enhancement which made the image more suitable for background separated and feature extract, meanwhile it can eliminate the influence which made by the outside factors [5].

Image enhancement approaches fall into two broad categories: spatial domain methods and frequency domain methods [6]. The term spatial domain refers to the image plane itself, and approaches in this category are based on direct manipulation of pixels in an image. Frequency domain processing techniques are based on modifying the Fourier transform of an image. There is no general theory of image enhancement. As for the image processing machine perception, the best image processing method would be the yielding the best machine recognition results.

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As indicated previously, the term spatial domain refers to the aggregate of pixels composing an image. Spatial domain methods are procedures that operate directly on these pixels. Spatial domain processes will be denoted by the expression:

$$g(x,y) = T[f(x,y)] \quad (1)$$

Where f(x,y) is the input image, g(x,y) is the processed image and T is an operator on f, defined over some neighborhood of (x,y). The cotton image after enhancement is shown in Figure 1, it easy to separate and extraction the foliage shape after the processing of image enhancement (gray-scale transformation), but a lot of information about the color of diseases and pests were lost.

Gray image

Enhancement image

Figure 1. The Cotton Leaf Image after Enhancement

Histograms are the basis techniques for the numerous spatial domain processing. Histograms manipulation is very popular in image enhancement. It provide useful image statistics about image, meanwhile it's useful in other image processing applications, such as image compression and segmentation. In Figure 2, the original image contrast is higher, the distinction between the prospect and the background image is larger, it's easy to segmentation, and it provide the threshold for segmentation. Image histogram equalization processing was used in this paper to increase the contrast of the image, strengthen the edges of background image because the edge of background image is darker.

The original image

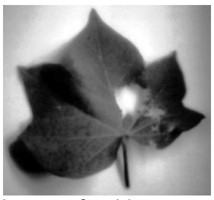
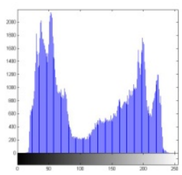
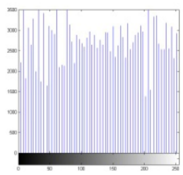


Image after histogram equalization process

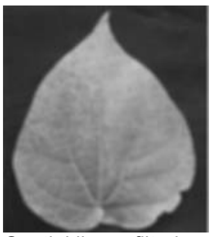


Histogram of the original image



Histogram of the image after histogram equalization process

Figure 2. Image after Histogram Equalization Process



Spatial linear filtering

Space nonlinear filtering

Frequency domain filtering

Color filtering

Figure 3. Image after Filtered

When we got the images, due to the influence of light intensity and the sensor temperature and other factors, the image was affected by noise pollution which made it hard for segmentation, so the process of filtering was used in this paper to eliminate the influence of noise. The Filtering general include spatial filtering and frequency domain filtering. We choose different filter for different images,but for the leaf cotton images which damaged by pests or diseases, the experiment shows better results after spatial linear filtering, but it also lost a lot of details; Space nonlinear filter is able to achieve better result while preserving the basic characteristics of information, and convenient. Frequency domain filtering can achieve better visual effects, however, for machine processing can't achieve a better result, for color images color filter also can obtain a better visual effects and machine processing results, poor details in the space nonlinear filtering. In summary, space nonlinear filtering or other methods can be selected to extract the pest and disease characteristics, the space of linear filtering, space nonlinear filtering, color filtering can be selected to extract of the whole leaf characteristics. Spatial linear filtering is simple and feasible and the results are good. The images after filtered were shown in Figure 3.

3. Comparison of the Color Model

3.1. RGB Color Model

The RGB color model is any additive color model based on the RGB color model. A particular RGB color model is defined by the three chromaticities of the red, green, and blue additive primaries, and can produce any chromaticity that is the triangle defined by those primary colors.

The three component image namely R component image, G component image, B component image were shown in Figure 4, we can draw a conclusion that the three component have a little effect by the illumination of the light. The White point of the image has little effect on image processing, the influence of the White point can eliminate in later image processing. And the G component image was used to the segmentation of the disease or pest image form the original image.

R component image G component image B component image

Figure 4. Component Image in RGB Model

3.2. HSI Color Model

The HSI color model [7, 8, 9] is very important and attractive color model for image processing applications because it represents colors similarly how the human eye senses colors. The HSI color model represents every color with three components: hue (H), saturation (S), intensity (I). The equations used for converting image from RGB color space to HSI color space are:

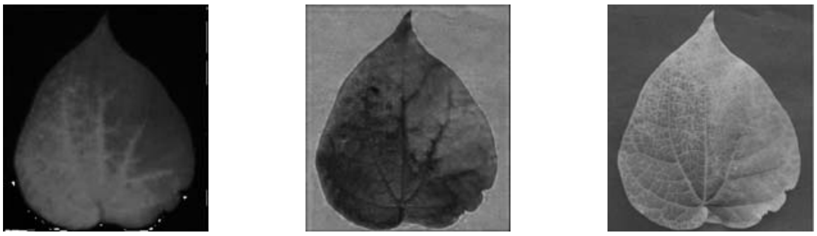
$$H = \begin{cases} \theta & B \le G \\ 360 - \theta & B > G \end{cases} \quad (2)$$

$$\theta = \arccos \left\{ \frac{(1/2)[(R - G) + (R - B)]}{[(R - G)^2 + (R - G)(G - B)]^{1/2}} \right\} \quad (3)$$

$$S = 1 - \frac{3}{R+G+B}[\min(R,G,B)] \tag{4}$$

$$I = \frac{R+G+B}{3} \tag{5}$$

As shown the component image in HSI color model in Figure 5, we can draw a conclusion that the difference between the disease spot and background is very large in I component image. Meanwhile I component can effectively suppress the influence which caused by the noise and strong light. So I component was used to the segmentation of the disease spot image and the background image.



H component image S component image I component image

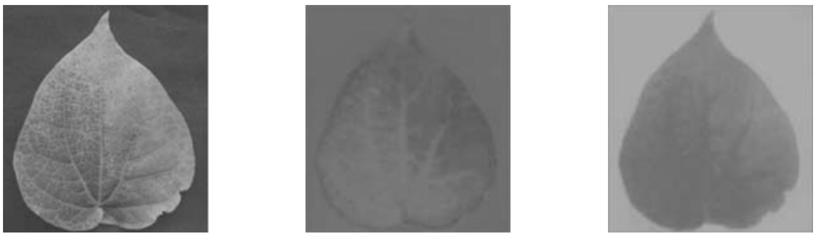
Figure 5. Component Image in HSI Model

3.3. YCbCr Color Model

The YCbCr color model [10, 11] has been defined in response to increasing demands for digital algorithms in handling video information, and has since become a widely used model in a digital video. It belongs to the family of television transmission color models. These color models separate RGB (Red-Green-Blue) into luminance and chrominance information and are useful in compression applications however the specification of colors is somewhat unintuitive. The equations used for converting image from RGB color model to YCbCr color model are:

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 65.481 & 128.553 & 24.966 \\ -37.797 & -74.203 & 112.00 \\ 112.00 & -93.786 & -18.214 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{6}$$

After the Color model transformed, the components image were showed in the Figure 6. The Y component image was chosen as segmentation image, because the disease spot and background boundary is clear in this component image and it's has little affected by light.



Y component image Cb omponent image Cr omponent image

Figure 6. Component Image in YCbCr Model

4. Feature Selection

From the above research the best component image were determined for the extraction of diseases or pests image form original image. The ratio of damage (γ) was chosen as feature in order to measure the degree of damage which caused by diseases or pests. The feature was also used to compare the extraction result in each color model we done before at the same time. The formula for measure the ratio of damage was:

$$\gamma = \frac{A}{A_t} \times 100\%) \tag{7}$$

In this formula A means the area of cotton leaf which caused by the diseases or pests, and At means the total area of cotton leaf.

5. Experimental Results

In the experimental research, the damage cotton plant which caused by the diseases and pests were used to test the results in different color space models. The computer we used in this paper was DELL computer, which the OS is Windows XP; the Processor is Intel core i5-2410M, 2.3GHz; the memory is 4GB of system RAM. The software we used is MATLAB R2011a. The extraction results image are shown in Figure 7 and Figure 8.

The original image | Extraction in RGB model | Extraction in HSI model | Extraction in YCbCr mode | Total area of cotton leaf

Figure 7. The Results of Extraction Diseases Cotton Image in Three Color Model

The original image | Extraction in RGB model | Extraction in HSI model | Extraction in YCbCr odel | Total area of cotton leaf

Figure 8. The Results of Extraction Damaged Cotton Image which caused by Pests in Three Color Model

The comparison of results shows good accuracy in both color models, nd the comparison of the results in the three color model were showed in the Table 1. The damage ratio (γd, caused by the diseases) of each color models are RGB color model (81.60%). HSI color model (43.15%), YCbCr color model (58.40%). The damage ratio (γp, caused by pests) of each color models are RGB color model (5.29%). HSI color model (4.90%), YCbCr color model (5.93%). And every color model has their own advantages and disadvantages, such as RGB model is over segmented, the area of the image diseases is too large.

Table 1. The Comparison of the Results in the Three Color Models

Damage ratio	RGB model	HSI model	YCbCr model
γd	81.60%	43.15%	58.40%
γp	5.29%	4.90%	5.93%

6. Conclusions

In this paper, a method to measure the damage ratio of the cotton leaf which caused by the diseases or pests based on machine vision and image processing was present. The result shows the image enhancement and image filtering we used in this paper can get a damaged image with strong features,

It shows good accuracy in extracting the damaged image form the cotton image in three different color model (RGB、HSI、YCbCr), and the comparison shows that Ycbcr color model is the best color model for extracting in this paper. The ratio of damage (γ) we choose is reliable.

The results is just from indoor experiment, when it come into real use, due to the random noise interference and cotton leaf shadows exist, the accuracy to measure the degree of damage may slow down, so the further research need focused on the algorithm to improve the accuracy and stability to measure the degree of damage.

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