Using Computer Vision Technology to Realize Non-Destructive Monitoring of Greenhouse Plant Growth

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ABSTRACT. *In the past, when we tested greenhouse plants, we usually used artificial mode to achieve the purpose, but in fact, this way is likely to cause damage to greenhouse plants, so this paper will put forward a method of using computer vision technology to achieve non-destructive monitoring of greenhouse plant growth, and analyze the scheme. In the analysis work, the design method of computer vision system is mainly described. Then take the greenhouse plant seedlings as an example to test, collect the images transmitted by the system in the test, and diagnose the seedling growth situation according to the image information.*

KEYWORDS: *Computer vision technology; Greenhouse plants; Nondestructive monitoring*

1. Introduction

Greenhouse is a kind of plant cultivation technology commonly used in the development of modern agriculture, which has brought great help to the improvement of agricultural production capacity in China. However, in order to monitor the growth of plants in greenhouse and deal with related problems in time, we must judge the growth of greenhouse plants, while in the application of traditional greenhouse technology, it is necessary to enter the greenhouse manually to observe and sample each plant Accurate judgment can be obtained, which will inevitably cause damage to plant tissues, which is not conducive to the subsequent growth of plants. Under the condition of using computer vision technology, people do not need to enter the greenhouse to check one by one. At the same time, because of the high definition of the technical image, the institute does not need to sample, thus realizing the non-destructive testing, which shows that the research topic of this paper has the significance of promoting the application effect of greenhouse technology and improving the growth quality of greenhouse plants [1].

2. Computer Vision System Design

2.1 Design Basis

The computer vision system is constructed by computer, digital camera and USB cable. The configuration of the three in the design of this paper is shown in Table 1. In the design process, firstly, the computer is placed as the terminal for manual observation, secondly, the digital camera is installed in the greenhouse, and finally, the computer and the digital camera are connected by USB cable, so that the images collected by the digital camera can be transmitted to the computer. In addition, considering the image quality of the digital camera, the camera is fixed on the angle convenient for color shooting by the tripod during the camera installation process, and the height of the tripod is adjusted to keep the height distance between the camera and the seedbed at about 77cm; the shooting mode of the camera is adjusted to fix the focal length of each shooting of the camera, so that the camera can shoot under the fixed focal length In order to distinguish the plant from the background image, the garden board is placed on the plant, and the plant is in the middle of the shift, so as to ensure the contrast of the image; The 400W high pressure sodium lamp is used as the shooting light source. In conclusion, through preliminary test, it can be seen that the maximum error of system measurement is 1.5%, which meets the maximum error allowable value, indicating that the system is feasible [2-3].

Table 1 Basic Design Configuration

Configuration name	To configure
Computer	Intel P4 processor; 256M memory; Windows 2000 server operating system; VC + + 6.0 software development platform
Digital camera	Model Sony DSC P9; resolution 1600 × 1200 24 bit true color image
USB line	Nothing

2.2 Image Processing Method

The image processing method of this system is divided into four steps: median filter, segmentation of leaf crown and background, mathematical morphology operation, calculation of leaf crown projection area. See below for details of each step.

(1) Median filter

In the process of image acquisition, digital camera is likely to be interfered by

noise, resulting in some isolated pixels in the image, so we must use median filter to deal with this kind of problem (low-pass filter also has the ability to deal with this kind of problem, but median filter has more advantages in the plant monitoring of temperature chamber, so we choose this filter). The median filter is mainly realized by the nonlinear filter, that is, the sorting filter sent by the nonlinear filter is the median filter, which has two performances in dealing with the noise interference problem, that is, it can first suppress the noise interference degree, filter out the rash factors, and to a certain extent, it can play a role in shielding the noise, and the image processed by the median filter is more Add clarity, which is the incomparable advantage of linear filter. In principle, the median filter will first set an odd pixel window, and then move the window on the image in order, so that the gray value of the image in the window in each moving position can be obtained, then all gray values are arranged from small to large, and finally the middle gray value is selected as the output value of the window's central pixel. In addition, the window size of median filter will also affect the image processing effect, so it must be selected according to the actual situation. In this paper, the median filter window of 3×3 is mainly selected to ensure the quality of processing effect [4].

(2) Segmentation of leaf crown and background

According to the gray statistical histogram of plant growth image in Figure 2, it can be seen that the peak value of image gray is very obvious, but the third peak and the fourth peak (representing plant canopy and background respectively) have a large overlap. Under this condition, the two must be segmented, or not, it can not be accurately judged according to the image, but the direct segmentation will cause damage to the two, that is to say Under the condition of re overlapping, no matter which side of the overlapped part is removed, the overlapped part of the other side will be removed together, resulting in incomplete image, so other methods should be used for processing. First of all, according to the image color, the color of plant canopy is green, while the background is black, so the color difference can be used to achieve segmentation. Secondly, the segmentation method is analyzed: according to the principle of chroma, saturation and light intensity (HSV), the H component of the three belongs to the fixed color information. For this, the image is transformed into HSV image by using software, and then combined with the color information coordinates Different color images are separated, so the segmentation work is completed [5]. In addition, in order to ensure the quality of segmentation results, the maximum and minimum thresholds of H are tested in this paper. The results show that when the maximum threshold is 90 and the minimum threshold is 37, the segmentation effect is the best. Table 2 shows the segmentation maximum and maximum threshold test results.

Table 2 Segmentation Maximum and Maximum Threshold Test Results

Test group		Test result	
Maximum threshold	Minimum threshold	Segmentation ratio	Image damage rate
10	7	26.5%	81.1%

50	11	60.7%	59.7%
90	37	99.2%	0.3%

(3) Mathematical morphology operation

In any process of image information segmentation, noise points and holes will inevitably appear when the image is affected by the segmentation operation, so the image can not be used for analysis directly at this time, which needs to be processed by mathematical morphology opening and closing operation method. In essence, the opening and closing operation belongs to the combination operation method, which can calculate the corrosion and expansion of the image at the same time, and then repair it according to the calculation results. See formula (1) and formula (2) for the specific calculation method. In this paper, we use this method to repair the segmented image. From the results, the noise point of the image is 0, the hole is 1, and the hole in the background is not the analysis target, so it can be ignored. Figure 1 is the image effect comparison before and after mathematical morphology operation.

$$\text{Open formula-------} A \quad B = \left(A \neq B\right)7 \oplus B,$$

Formula (1)

$$\text{Closed formula-------} A \quad B = \left(A \oplus B\right)7 \neq B$$

Formula (2)

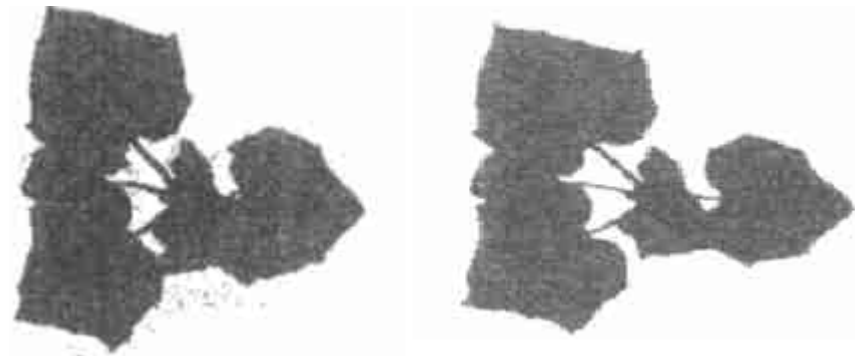Where a and B represent corrosion and expansion; 7 is the calculation coefficient

Figuee.1 Image Effect Comparison Before and after Mathematical Morphology Operation

(4) Calculation of projection area of canopy

According to the software display, the gray value of the white area after the image segmentation is 255, which represents the gray value of the black area at the canopy as an example, belonging to the background part. Therefore, in order to

distinguish the two, it is necessary to calculate the projection area of the canopy, and then carry out simple processing according to the calculation results. The calculation method of the projection area of the canopy is shown in formula (3).

$$\text{Calculation method of projection area of leaf crown} ------- \frac{A_1}{N_1} = \frac{A_2}{N_2}$$

Formula (1)

Where a1 represents the real area of the white round paper; N1 represents the pixel value occupied by the white round paper after segmentation; A2 represents the projection area of the canopy (mm2); N2 represents the pixel value occupied by the canopy after image segmentation.

3. System Test

3.1 Test Basis

Take "cucumber" seedlings as an example to test, put the above system in the greenhouse for image collection, the collection conditions are as follows.

(1) Using white paper as image background can reduce image segmentation error;

(2) The focal length of the digital camera was adjusted to 0.50m;

(3) The high pressure sodium lamp is used to realize the light length, and is installed in the reflector at the camera camera camera mouth, with the object distance of 0.30m.

3.2 Image Preprocessing

On the basis of the test, the cucumber leaf image is obtained (see Figure 2), and the histogram is obtained through the visual system processing. The background and leaf gray distribution of the image can be seen from the histogram are centralized, so the HSV threshold segmentation method can be used for segmentation (the best thresholds are 87 and 66 respectively after the test). Figure 3 shows the segmentation effect.
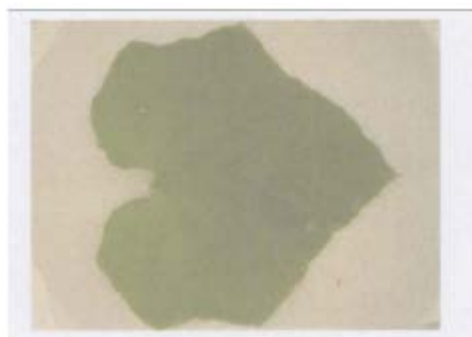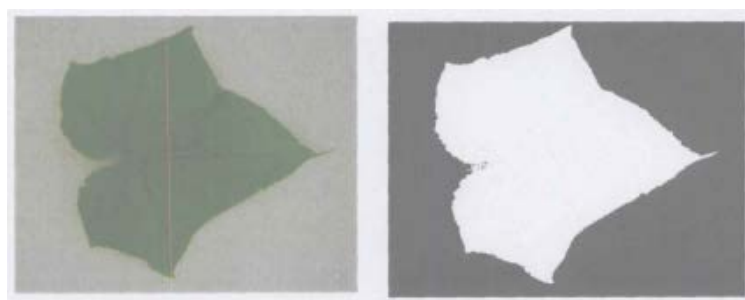
Fiure.2 Image of Cucumber Leaves

Figure.3 Segmentation Effect

Then, because of the influence of image color deviation, the background image is gray after segmentation, so it needs to be corrected. Here, we can achieve the purpose according to the three primary color theory, that is, in the three primary color theory, the phenomenon of color deviation occurs due to the nonlinear response between the incident light and the camera RGB channel, so we can first detect the color deviation of each channel in RGB space, and then according to the detection Results the gray distribution of each channel image was adjusted until the phenomenon of color deviation disappeared. In this paper, we use this method to eliminate 90% of the phenomenon of image color deviation and meet the test requirements.

3.3 Blade Diagnosis

The purpose of leaf diagnosis is to confirm whether the growth of the monitoring target can be determined by the computer vision system image, if so, it indicates that the system application is effective. In this paper, all the images are arranged according to the color depth, the relationship between the color of cucumber leaves

and its nitrogen content is analyzed, and then the sampling test is carried out. The results show that the nitrogen content of each cucumber under the computer vision system is basically consistent with the sampling test (the error is $\pm$ 0.01), which proves that the system is effective. Figure 4 shows the image arrangement of computer vision system.

Figure.4 Diagnosis Results of Nitrogen Content in Cucumber Leaves under the Image of Computer Vision System

In addition, Figure 4 is only part of the image, but in other tests, it is found that the error between the visual system diagnosis results and the sampling test results is too large. According to the analysis of this phenomenon, because there is a shelter over other cucumber leaves during the test process, resulting in uneven distribution of light intensity, so the seedbed shadow is also calculated into the leaves during image segmentation, thus forming Error. This result shows that in order to ensure the computer vision system to give full play to the energy efficiency in the non-destructive monitoring of greenhouse plants, it is necessary to ensure that the monitoring target has good lighting conditions, which is a problem that must be paid attention to in the application of the system.

4. Conclusion

In conclusion, the computer vision system can be designed by this method. The greenhouse plant growth image collected by this system can be used in the plant growth situation diagnosis. The error between the diagnosis result and the sampling analysis result is very small, which proves that this system is effective. In the whole system design process, we should focus on three key points, that is, image segmentation processing, image color deviation, and monitoring target lighting conditions. In the face of these problems, we must go through continuous debugging and adjustment to ensure that the system can give full play to energy efficiency.

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