The Disease Assessment of Cucumber Downy Mildew Based on Image Processing

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***Abstract*—Cucumber downy mildew is a kind of disease which spreads very fast and isdangerous, in order to prevent the disease, peoplealways spray plenty of pesticides indiscriminately. Accurate assessment of the level of cucumber downy mildew is very important to the disease prevention and control. In a cucumber growing season, this paper collected the typical cucumber downy mildew leaf samples, and developed the downy mildew spot extraction algorithm by using leaf image scanning method, calculated the index of the disease. The average identification accuracy of downy mildew image reaches 98.3%, and average image processing takes 10.9 ms/picture. By compared with human eyes assessment and basic value, the result shows that the human eyes assessment method have strong subjectivity, dramatic changes and bigger error, while the image analysis method get the correlation coefficient for disease index and basic value of 0.9417, has obvious linear correlation.**

Keywords-Cucumber downy mildew; Image processing; Disease assessment; human eyes assessment; linear correlation

I. INTRODUCTION

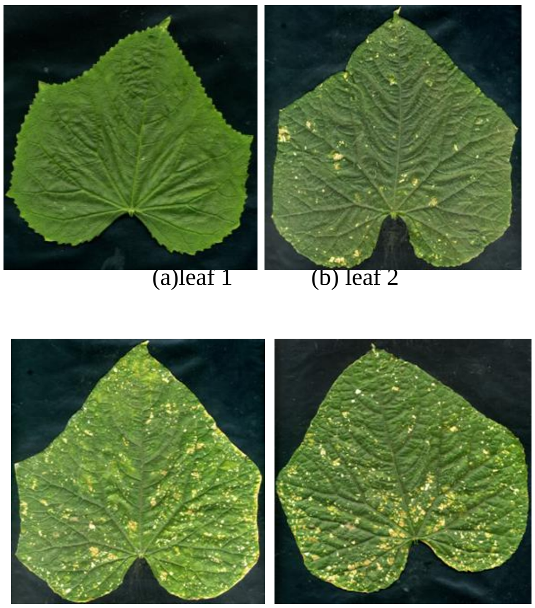
Crop disease identification based on crop leaf symptom is an important research content in plant protection [1-8]. In the middle of 80s, computer image processing and analysis technology was applied to disease detection and disease statistics. The image processing technology and fuzzy theory to preprocess the health and disease of pomegranate leaf image by SanjeevS [9], and they extract the features stored in the database, formatting the automatic recognition system of pomegranate disease recognition. The image processing technology and artificial neural network to extract treatment on Cucumber Downy Mildew and powdery mildew symptoms by Keyvan [10], via the back-propagation supervised learning method to train cucumber downy mildew and powdery mildew identification system. Dong [11] etuse the median filtering method to filter the noise ,separate the disease of cucumber downy mildew color, extractthe lesion surface color characteristic parameters and shape parameters, and format gray level co-occurrence matrix. the disease recognition rate is more than 96%. JiaJiannan [12] etseparatecucumber diseaseby using the method of Otsu image, indicating the feasibility of recognizing Cucumber Downy Mildew and cucumber by spot shape and neural network. XuLiangfeng[13]et proposed an adaptive weighted multiple classifier fusion method for identifying leaf diseases of maize. 7 common maize leaf disease pictures were tested, with an average recognition rate of 94.71%.Ye [14]et proposed an identification method of downy mildew of Cucumber Leaf based on visual saliency map, can identify the lesion of robust downy mildew from leaf color image accurately. Zhao [15] et eliminate the adverse effects of light used by Retinex algorithm for image enhancement, use automatic threshold method to separate spot imageinR-G gray space, extract color texture and invariant moments of the lesion, and used principal component analysis and support vector machine to classify common diseases of maize leaves.

According to the symptoms of crop leaves, image processing technology can be used to identify crop diseases. This paper optimizes the access to environmental disease leaf images, so as to get the image of good consistency, introducing dynamic variables to improve image quality and reduce the difficulty of image processing, using the linear operation of cucumber downy mildew. Based on the principles of disease evaluation and measurement, the baseline values are established and the validity of the image analysis algorithm is verified.

II. MATERIALS AND METHODS

A. *Acquisition of Sample*

The sample of cucumber for test was “Zhong Ke 958”, and used the leaves of cucumber as the research object, and the 110 leaf samples of natural infection of downy mildew acquired from the greenhouse of Shang zhuang experiment station of China Agricultural University (acquisition time: 2012.8.2-10.2). The scanner for leaf image capture is Epson perfection 2480, and the maximum optical resolution is 2400×4800 dpi, select black scan background, increase the contrast of background and leaves, to reduce the implementation difficulty of extraction algorithm, the experiment uses different resolution to scan leaf positive respectively. The images of leaf samples captured of typical different disease degree shown in figure1, the disease spot distribution of leaf 1 to 4 from less to more.



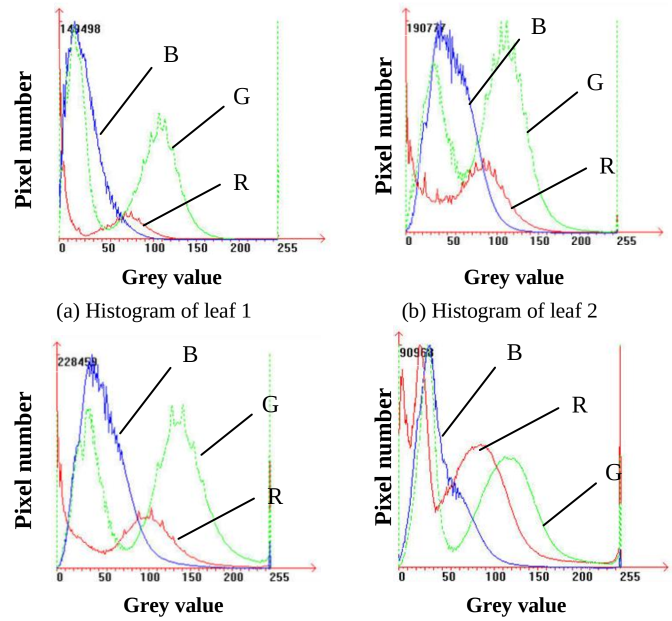
(a)leaf 1 (b) leaf 2

(c) leaf 3 (d) leaf 4

Figure 1. Cucumber leaves of different disease degree

B. Image Analysis

Analyzed the samples in Fig. 1 by the histogram analysis method, the results are shown in Fig. 2, it can be seen that blade R channel and G have bimodality, of which R channel trough distribution between 30-50 grey value, G channel trough distribution between 50-70 grey value, and obviously, the two peaks represent the black background and pixel concentrated areas of green leaves, rely on a single threshold is impossible to pick up the disease. From the curves in (a) to (d) of Fig. 2, it can be found that R channel and G channel increase with the distribution of disease spot, the part of grey value more than 200 appeared the trend of increase gradually, the entire waveform falling edge of the last shift to the right, and G channel growth significantly. It is consistent with the process of disease appeared, and it is the process of the disease spot characterized on leaves develop from nothing, from color, it is the process of pathological changes of leaf from green to yellow gradually, and the process is the grey value of the R channel and G channel increased gradually.



(a) Histogram of leaf 1 (b) Histogram of leaf 2

(c)Histogram of leaf 3 (d) Histogram of leaf 4

Figure 2. Histogram analysis of leaves of (a) to (d) in Figure1

C. Extraction of Disease Image

Given uniform image acquisition environment, image light change is small, it can be seen that the changes of color feature of disease spot is mainly caused by the composite value of R and G, so try to use simple combination of R and G to achieve the extraction of disease. To eliminate the leaf color difference of various plant growth period and different disease epidemic period, and to avoid unreasonable fixed threshold setting, by focusing on the analysis of disease spot in RGB space and the distribution of R and G on healthy leaf area, as shown in Fig. 3, extract normalized value of each image as a correction parameter can effectively reduce the color interference and false judgment. It can achieve effective separation by formula (1), and the results of image processing are shown in figure 4. By simple linear operation, extracts the disease spot in different disease distribution effectively, and implements fast separation of the disease spot and leaf and background.

$$B_{lack} = \begin{cases} 0 & 2 \times R - G > 80 \times (1 - N_I/3) \\ 255 & 2 \times R - G \leq 80 \times (1 - N_I/3) \end{cases} \quad (1)$$

$$N_I = \frac{R+G+B}{3 \times 255} \quad (2)$$

In the formula Black—Pixel value after segmentation, disease information for 0, background information for 255

NI—Normalized value of image

R,G,B—R,G,B component value of image RGB space

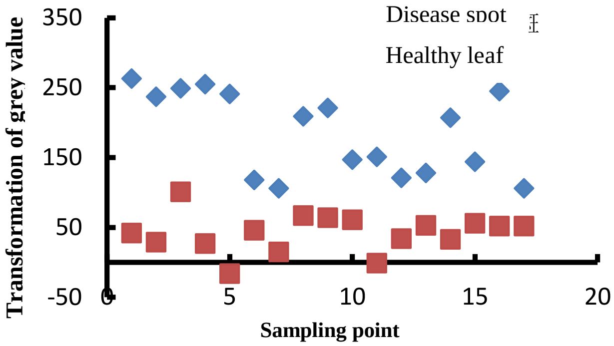


Figure 3. 2×R-G distributions of disease spot and healthy leaf

(a) Calibration image of leaf 1 (b) Calibration image of leaf

(c) Calibration image of leaf 3 (d) Calibration image of leaf

Figure 4. The calibration images of different condition of cucumber leaves

III. RESULTS AND DISCUSSION

A. Disease Classification Method for Cucumber Leaf

The determination of classification standard is the key of the direct impact on the illness unified analysis, but the classification standard of cucumber downy mildew is not the same for different countries. In China, the research started from the early 1960s, Fu Shuyun [18] introduced different classification standards of cucumber downy mildew, and the natural classification based on leaf, is divided into 5 levels. Yang Chongshi [19] and others introduced the development of classification standard of cucumber downy mildew in our country. The current national standard GB/T 17980.26-2000 [20] stipulated the classification standard of cucumber downy mildew (by leaf) as follows: level 0: without disease spot, Level 1: disease spot area below 5% of the total leaf area, Level 3: disease spot area is 6% - 10% of the total leaf area, Level 5: disease spot area is 11% - 25% of the total leaf area, Level 7: disease spot area is 26% - 50% of the total leaf area, level 9: disease spot cover more than 50% of the total leaf area. Considering that the standards above are expressed by the disease spot area percentage of the total leaf area, scanned leaf first in the following research, to process image analysis method(IAM), then selected 10 raters who have the experience of plant pathology management, to assess the disease by visual estimate method(VEM).

In order to avoid the error caused by single method, this paper set basic value for the disease condition of leaf, and the basic value use the national standard GB/T 17980.26-2000 [20] as a reference. Create the calibration images using the Boolean and operation with the processing result of leaf disease spot image, as shown in figure 4, and still select the same 10 raters to assess the calibration image after superposition. If they identify with the results of IAM, then use IAM result to replace the VEM result, otherwise retain their results or do the assessment again.

All the assessment results are calculated based on the disease condition, and the disease degree DS is the proportion of disease symptoms of leaf (percentage), as shown in formula (3).

$$\mathrm{D_S} = \frac{\mathrm{D_A}}{\mathrm{L_A}} \cdot 100\% \qquad (3)$$

In the formulaD_A is the disease spot area on the leaf
$L_A$is the area of leaf

B. Results Analysis

Select 29 leaves of different disease degree as experimental samples. After using VEM to the leaves by the 10 raters, use the average (AVG) value as the assessment results, as shown in table 1.

Use the scanner to scan the positive side of leaves, the computer configuration for the analysis algorithm of image scanned as follows: CPU: Intel Pentium (R) 3.06 GHz, memory: 1 GB, and the software environment is Microsoft Visual C++ 6.0. Extract the disease spot of the 29 leaves using the algorithm shown in formula (1), and judge the accuracy of identification, the result shows that the average recognition accuracy of downy mildew image reaches 98.3%, and average image processing takes 10.9 ms/picture. Calculate the disease severity by formula (3), then the 10 raters judge the disease based on the calibration images, obtain the new assesement results, and use the AVG as the basic value, as shown in figure 5. The results suggest that the assessment results of VEM are always bigger than the assessment results of IAM, and the assessment results of VEM and the assessment results of IAM have big difference with the basic value especially when the disease degree is bigger. The assessment results of the same leaf assessed by each rater is obviously different as it is shown in table 1, for example, the maximum disparity of leaf 28 is more than 50%, but after the raters review the calibration images, the disparity turn smaller. And as it is shown in figure 5, the error of the assessment results of VEM is bigger than the results of IAM, the results of IAM are similar to the basic value.

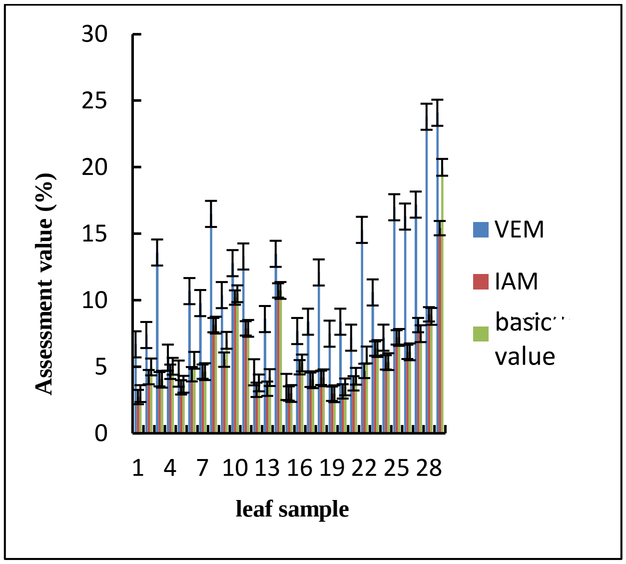


Figure 5. The assessment value of VEM and IAM and basic value

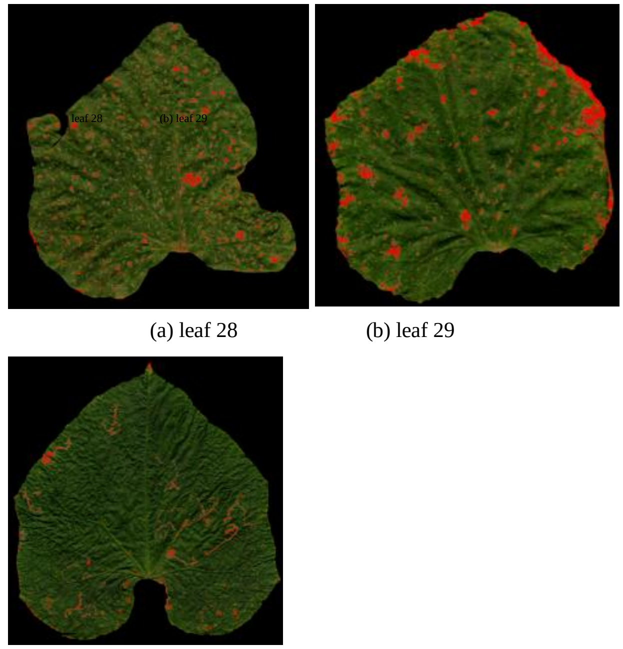
The differences mainly come from the followings:

The leaf color and disease condition degree of different plant growth period are different, which causes the characterization of color is different when the disease occurs, and it is easy to cause image segmentation errors. These results reflect the difference of the sample characteristics and the difference of the image characteristics. Light, surface reflection, saturation, hue, leaf age, symptoms, nutritional status, and even spraying time, may lead to the difference of leaf images.

The distribution of disease spot may lead to assessment error, for example leaf 28 and 29 shown in figure 6, due to the disease spot distributed full of leaf, and the assessment results of VEM are often exaggerated. But after assessing again based on IAM algorithm, the raters tend to agree with the IAM results or decline the VEM results.

In the processing of image capture, leaf folds cause the information missing, and in the processing of leaf acquisition, with no artificial cleaning, there will be pesticide residual and eluvial soil on the leaf surface, especially the lower leaves of plant, these bring the scatter noise of image, but the VEM can eliminate the noise.

Because the disease segmentation algorithm formula (1) is specific to the extraction of downy mildew information, so it may happen under segmentation when other disease occurs. Such as the leaf 4 shown in figure 6, it occurs the Liriomyza disease at the same time, by the VEM with the experience people can quickly rule out other diseases, but when using IAM to analyze the leaf with different kinds of diseases, there are potentially limiting factors, the features extracted are related to other disease features, and this need further research.



(a) leaf 28 (b) leaf 29

(c) leaf4

Figure 6. The calibration images of leaf 28 and 29

The correlation analysis results of the disease index obtained by IAM and basic value are shown in figure 7, the results show that the correlation coefficient R2 is 0.9417, have obvious linear correlation, but it still can be seen that the correlation in light disease degree is higher than in severe disease condition, the main reason is when the disease spot distributed full of leaf uniformly, the assessment results of VEM are big. Therefore, the IAM algorithm mentioned in this paper can be used in the disease feature extraction of cucumber downy mildew and as the assessment index of disease degree, comparing with VEM, IAM is rapid, simple, effective and low technical requirements for personnel, and has maneuverability and stability.

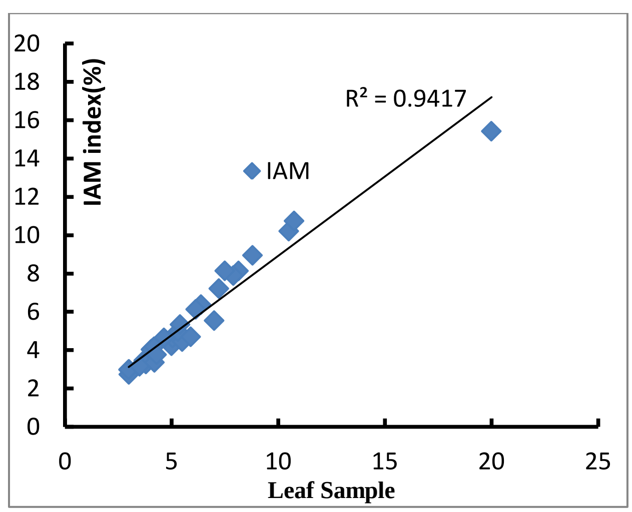


Figure 7. The correlation analysis of IAM and basic value

REFERENCES

[1] Zhan Wu Peng,Xue Wang. Study on the Method of Feature Extraction of Vegetable Diseases Based on Image Processing[J]. Advanced Materials Research,2014,3530(1044):.

[2] Xue Wang,Zhu Ma,Xin Wang,Dan Jiang,Xiaoxi Liu and Zhilei Jia. Study on automatic recognition of cucumber downy mildew based on color and shape features [J/OL]. Journal of Anhui Agriculture University, 2013 (06).

[3] Wang Xianfeng, Zhang Shanwen, Wang Zhen, Zhang Qiang. Identification method of cucumber diseases based on leaf images and environmental information [J]. Chinese Journal of agricultural engineering, 2014, (14): 148-153.R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[4] Wen Zhiyuan, Cao Leping. Citrus pest like hue multifractal and image recognition based on [J]. Journal of agricultural machinery, 2014, (03): 262-267.M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[5] Zhao Yaochi, Hu Zhuhua, Bai Yong, Cao Fengqin. An accurate segmentation method of DRLSE disease and insect images based on texture difference guidance [J]. Acta Sinica, 2015, (02): 14-19.

[6] Wu Yuanyuan, Li Qingbo, Diao Hong. Study on color image feature extraction of wheat leaf diseases [J]. Agricultural Mechanization Research, 2015, (10): 79-82.

[7] Tian Kai, Zhang Liankuan, Huang Zhihao, Li Jiu, Xiong et, eggplant. Brown streak leaf spots feature recognition method based on [J]. Journal of agricultural engineering, 2016, (S1): 184-189.

[8] Xie Zeqi, Hu Xiaowei, Zhang Huimin, Zhang Shanwen, Zhang Yunlong. Grade recognition algorithm of crop leaf diseases based on environmental information and color features [J]., agricultural science, 2016, (07): 428-430..

[9] Sanjeev S. Sannakki,Vijay S. Rajpurohit,V. B. Nargund,R. Arunkumar. Disease Identification and Grading of Pomegranate Leaves Using Image Processing and Fuzzy Logic[J]. International Journal of Food Engineering,2013,9(4):.

[10] Jia Jiannan, Ji Haiyan. Journal of agricultural engineering, [J]. recognition of cucumber disease lesion shape based on neural network and S1:115-121. 2013.

[11] Xu Liangfeng, Xu Xiaobing, Hu Min, Wang Rujing, Xie Chengjun, Chen Hongbo. Identification of corn leaf diseases based on multiple classifier [J]. Journal of agricultural engineering, 2015, (14): 194-201+315.11-16.

[12] Keyvan Asefpour Vakilian,Jafar Massah. An artificial neural network approach to identify fungal diseases of cucumber (Cucumis sativus L.) plants using digital image processing[J]. Archives Of Phytopathology And Plant Protection,2013,46(13):.

[13] Dong Pixia,Wang Xiangdong. Recognition of Greenhouse Cucumber Disease Based on Image Processing Technology[J]. Open Journal of Applied Sciences,2013,03(01):.

[14] Ye Haijian, Lang Rui, Liu Chengqi, Li Li Zhen. Recognition of cucumber downy mildew based on visual saliency map [J]. proceedings of the Chinese society of Agricultural Mechanics, 2016,05:270-274.

[15] Qi Zhao, Jiang Zhaohui, Yang Chun he, Liu Lianzhong, Rao yuan. Identification of leaf diseases in Maize Based on image technology [J]. Journal of Anhui Agriculture University, 2016, (02): 325-330.

[16] Fu Shuyun, Yao Jianmin, Fu Junfan. Study on artificial inoculation technique of cucumber downy mildew [J]. Journal of Shenyang agricultural college. 1984 (02):11-16.

[17] Yang Chongshi, Wang Wanli, Liu Gengchun, et al. Progress and practice in bioassay of cucumber downy mildew [C]. 2000

[18] People's Republic of China national standard. Guidelines for field efficacy trials (1) Fungicides against cucumber downy mildew [S]. 2000.

TABLE I. THE DISEASE ASSESSMENT RESULTS OF VEM

Rater / Leaf	1	2	3	4	5	6	7	8	9	10	AVG
1	5	5	6	10	10	5	6	5	5	10	6.7
2	4	3	6	10	5	6	10	5	10	15	7.4
3	7	5	8	30	5	10	15	6	20	30	13.6
4	4	2	6	10	2	10	8	5	5	5	5.7
5	2	1	5	5	5	8	5	4	5	5	4.5
6	6	3	10	20	10	15	15	8	10	10	10.7
7	5	2	15	15	10	10	12	9	10	10	9.8
8	8	2	20	30	20	15	20	10	20	20	16.5
9	4	2	10	20	15	8	15	10	10	10	10.4
10	6	10	10	20	15	10	16	9	10	22	12.8
11	5	5	15	30	10	15	18	10	10	15	13.3
12	1	2	8	10	5	3	5	2	5	5	4.6
13	6	5	4	10	10	10	8	5	20	8	8.6
14	8	8	15	20	10	20	20	6	20	8	13.5
15	1	1	0	10	5	5	5	5	0	3	3.5
16	2	3	3	30	10	4	6	6	5	8	7.7
17	3	4	10	20	5	5	10	7	10	10	8.4
18	3	5	10	20	5	10	20	8	20	20	12.1
19	2	5	8	15	5	8	10	7	10	5	7.5
20	3	3	8	20	5	8	10	7	10	10	8.4
21	2	2	10	10	5	8	12	7	10	6	7.2
22	4	4	25	20	5	20	15	10	20	30	15.3
23	3	3	15	20	5	15	20	7	10	8	10.6
24	2	2	5	10	3	8	25	6	5	6	7.2
25	4	4	35	30	10	20	25	10	20	12	17
26	4	6	30	30	5	20	20	8	20	20	16.3
27	5	5	20	40	10	20	25	7	20	20	17.2
28	10	9	25	60	15	25	30	9	30	25	23.8
29	12	12	25	50	20	25	40	15	20	22	24.1