The detection system for greenhouse crop disease degree based on Android platform

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Abstract

A detecting way based on Android platform was proposed in order to detect greenhouse crop disease degree in real time. This way employed the camera in mobile phone to acquire crop disease leaf image in the greenhouse. Firstly, the detection system was built by the Eclipse based on the Android development environment. The iterative threshold segmentation algorithm was used to separate the crop disease leaf area from background. And the fuzzy C-means cluster algorithm was adopted to extract the disease spots. After analyzed the impact of different fuzzy weighted index m value, the value of m was selected 2 for the disease spots segmentation. After that the crop disease degree was determined based on the relevant standards and the total disease index of greenhouse was got based on disease index calculation standards. Finally, the calculating data could upload to the network server and was used management cloud achieved synchronous computer terminal query. The experimental results show that the detecting way could non-destructed measure the disease index of leaf diseases with non-destructive and exact in greenhouse.

Keywords:

Android greenhouse crop
disease index
cloud management real time
non-destructive

1 Introduction

The leaf is one of the most important parts of the plant during its growth process. But the disease of the leaf will bring a lot of production and economic loss. In order to reduce the agricultural workers loss, we must promptly acquire crop disease messages to control the crop disease. The visual method [1] and weighing method [2] were often used to detect crop disease degree as traditional methods. The visual method was simple and convenient, but it was used personal experience with low measuring precision and difference. Weighing method had fussy operation and its steps were complicated, it couldn't conducive to the actual disease detection. Leaf area analyzer could accurately measure the leaf area, but it was expensive and couldn't measured level of disease [3]. Therefore, it is extremely important to study the rapid and timely determination of crop leaf disease level [4-6]. In recent years, researchers had a lot of research in the field of disease degree detection at home and abroad. Daniel A. etc. used past experience and disease standards of assessment to grad single leaf image of two groups of crop powdery mildew disease. The results show that the grading of diseases of crop powdery mildew degree could be estimated reliably and could be used for important disease system evaluation and research [7]. Aleixos etc. used the RGB value of the image and the spectral image technology to carry on the flaw detection and the classification of oranges. The accuracy rate was higher [8]. Zhanliang Chen etc. used computer image processing technology and adopted Otsu method to extract leaf area and lesion area [9]. Youwen Tian etc. designed a classification system for crop leaf disease. The system was transplanted by the Linux operating system and ARM9 processor. It used USB external contact scanning device of farming leaf image acquisition, and used the threshold segmentation method and corresponding algorithm in the blade image processing. Finally, the classification results were shown on the LCD screen. It's realized the combination of embedded technology and scanning device staged processing of crop diseases [10]. In summary, although these methods could detect crop disease level better, the detection method was experimented in laboratory after the crop leaves was collected. This detecting ways were operation not only complicated and time-consuming, but also some detection methods had destructive and defected the crop growth.

At present, the Android system smart phones were of many features, such as low price, the use of a wide range and good portability. At the same times, Android system is open and freely [11]. Therefore, this paper proposes a detection system based on Android mobile phone platform to research and development or the greenhouse crop disease degree. The system will calculate the disease index of crop in the greenhouse, and the degree of disease grading. Finally the data and the results were uploaded to the server, and then the function of the computer terminal synchronous query was realized.

2 Experimental materials and methods

2.1 IMAGE ACQUISITION

The images of crop leaves such as cucumber, tomato, pepper and eggplant were collected from NO.22 greenhouse of North Mountain vegetable base in Shenyang Agricultural University. Sample images were collected at 3 different points in the shed, and 5 strains were collected at each point. The cucumber, tomato, pepper and eggplant diseases leaf image were collected 32, 43, 35, 40 photos respectively.

2.2 ANDROID OS

Android is based on Linux platform. From the perspective of software hierarchy, Android consists of applications, application framework, Android run-time, librarian and Linux kernel. Among them, all programs in application layer are written by JAVA language. Application frame-work layer allows the developers to visit all API interfaces of the core application. Android run-time includes two parts, which are Core libraries and Dalvik virtual machine. Application framework is supported by librarian. Linux kernel depends on the Linux2.6 kernel version [12].

2.3 HARDWARE AND SOFTWARE PLATFORM

Image detecting system for degree of crop leaf disease based on Android OS mobile phone is consists of hardware and software. The hardware part is a 4.8 inch mobile phone - Samsung I939d (Samsung Corp, South Korea). The software part is built on Android SDK 22.6.2 (Software development kit), Java (Java development kit), JDK 8, Eclipse 4.4 and ADT 23.0.3 (Android development tools).

2.4 THE ANALYSIS METHODS

2.4.1 Leaf image segmentation

There are many methods of image segmentation, such as edge detection method, region segmentation method and threshold segmentation method. Among them the threshold segmentation method was a very effective and simple method. Adopted threshold segmentation method could get very ideal results because the leaf was great differences in the color of foreground and background. The iterative thres-hold algorithm was adopted to do image segmentation in this paper. The basic idea is that a threshold is chosen as the initial estimate, and then the initial value is continuously improved until it meets the given criterion according to some strategy [13].

2.4.2 Disease spot extraction

Disease spots area and normal area could be seen as two categories segmentation on the disease leaves, therefore fuzzy C-means cluster algorithm method was used to extract disease leaf spots. The fuzzy C-means cluster algorithm （FCM）was first proposed by Dunn [14] and perfected by Bezdek [15]. At present, it is the most popular kinds of fuzzy clustering algorithm. The FCM algorithm is an iterative algorithm with iteration along the reducing direction of the objective function to determine the best category. The objective function is as follows:

$$J(U,V)=\sum_{i=1}^{n}\sum_{k=1}^{c}\mu_{ik}^{m}|P_i-V_k| \quad i=1,2,\ldots,n, k=1,2,\ldots,c., \quad (1)$$

where U is a fuzzy membership matrix and P is cluster sample set {P1,p2,p3,…}. Where V is cluster center set {v1,v2,v3,…}. c is the number of cluster categories，and n is the number of pixels. Where μ_{aik}^{m} is referring to the membership of k samples to the i class and m is input parameters express for all types of membership size. Where $|P_i-V_k|^2$ is refer to Euclidean metric between P_i and V_k.

2.4.3 Disease grading and method of disease index

According to the field efficacy experiment guidelines, the disease spot area accounted for whole leaf area classification method was adopted in crop leaf disease degree during determine [16]. Since the relationship between the leaf spots area and the number of the disease spot pixels is proportional, the relationship between the disease leaf and the number of the disease leaf pixels. The degree of crop leaf disease can be expressed by the ratio between the number of leaf spots pixels and the number of the disease leaf pixels.

The calculating formula of disease index is as follows:

$$f=\frac{\sum(a\times b)}{T\times 9}\times 100, \quad (2)$$

where f is disease index and a is number of disease leaves each level. And b is value of disease leaves each level. Where T is total number of diseases crop leaves.

2.4.4 Data upload and management

A web site was designed and developed for the system of detecting way for greenhouse crop disease degree. The user could upload data through the Android phone (Greenhouse number, Plants number, Leaf number, Time, Crop name, Disease name, Disease index) to the server. And user could log on the website to query upload data. The SAE server (Cloud computing platform) was used in test phase.

3 Results and analysis

3.1 LOAD IMAGE

Click on "Load image" button on the main interface and select the image stored in the smart-phone to get the sample infor-mation of leaf disease. The result was shown in Figure 1.

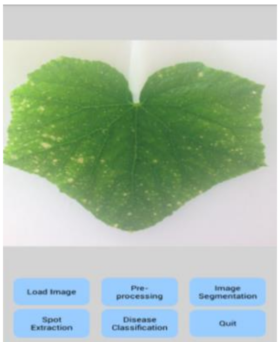


FIGURE 1 Load image effect

3.2 IMAGE PRE-PROCESSING

Click on "Pre-processing" button on the main interface. In this paper, *G* channel of original image was adopted to make enhancement filtering processing to realize function of image contrast enhancement. And this made the outline and edge image of the leaf and background clearer, and got the more obvious details. As a result, the segmentation step could be more convenient.

3.3 LEAF SEGMENTATION

Click on "Leaf segmentation" button to achieve the image leaf segmentation after image pre-processing. The initial threshold value was selected based on the section 2.4.1 in leaf image segmentation method. In RGB channels, the *R* channel was easier to do leaf segmentation because the edge between its leaf region and background region was obvious, while the *G* and *B* channel in leaf region and background region was very nearly hard to divide. The initial threshold was defined as 128 because leaf region and background region of the sample image is easy to separate at this value of 128.

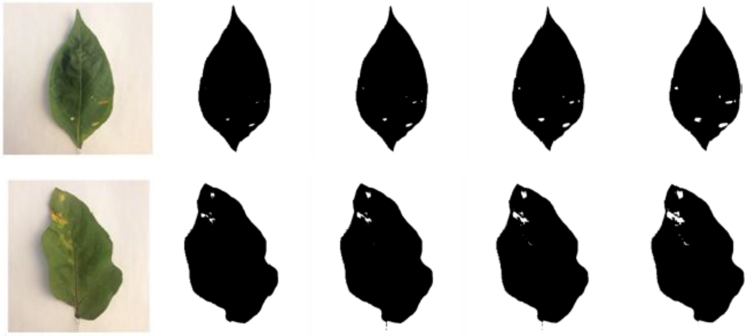
The final segmentation result was shown in Figure 2. It showed that the segmentation of the leaf region and the background region was well, the edge of the leaf was very clear, and the leaf region was reflected truly. Using the iterative threshold method could effectively separate leaf and background region so as to facilitate the subsequent data processing and grade the disease degree.

FIGURE 2 Segmentation results of leaf image

3.4 LEAF DISEASE SPOTS EXTRACTION

The FCM algorithm was used for leaf disease spots extraction to get better results. There were three parameters of FCM algorithm included feature vector of the sample, optimal cluster number *c* and fuzzy weighted index *m*.

1) The feature vector of the sample. The operation effect of cluster algorithm was associated with characteristics of the cluster samples [17]. Finally, the gray value of color components was chosen as the characteristics of the sample data through contrasting the three color space. Through the careful observation of crop leaf with disease spots, most colors of disease spots were found brown or white in this paper. So the RGB color information of the health leaf region and the disease spot region separately were acquired, and then their color features were analyzed on the *R*, *G* and *B* components of the health leaf region and the disease spot region. So the *R*, *G* and *B* three component value were chosen as the feature vector of the sample in view of some question of the application platform such as operation ability, operation time, and so on.
2) The optimal cluster number *c*. Our purpose was to separate the disease spot region from the crop leaf image, which means the image was separate into disease spot region and health leaf region. So the optimal cluster number *c* was set to 2.
3) The Fuzzy weighted index *m*. The fuzzy weighted index *m* was an important parameter in the process of fuzzy cluster, which determines the magnitude of the degree of fuzzy clustering. The larger *m* is, the fuzzier the classification is. When *m* was 1, the FCM algorithm was reduced to algorithm HCM [18]. In this paper, we obtained the fuzzy weighted index *m* for the best image segmentation, and the value of index *m* were selected 1.2, 1.5, 2 and 3 respectively. The results were shown in Fig 3. It can be seen from the Figure 3. The regional of disease spots were small when the value of index *m* took less than 2. It didn't conform to the actual situation. The regional of disease spots were closed to actual situation when the value of index *m* was selected 2. The regional of disease spots were increased and deviated when the value of index *m* took more than 2. So the value of fuzzy weighted index was selected 2 in this paper in consideration of the parameter *m* having the influence on the speed of segmentation.

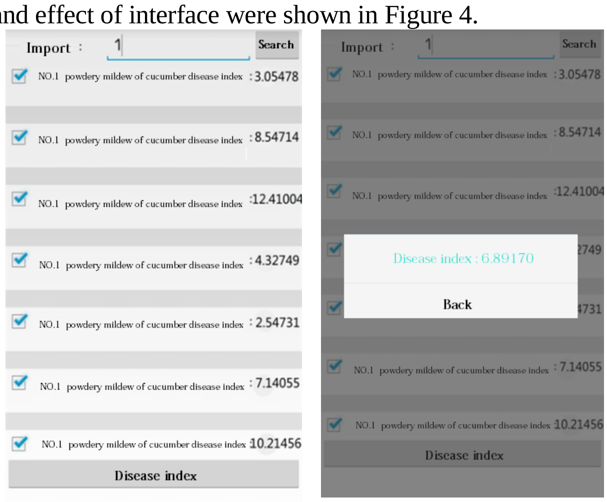


Leaf *m*=1.2 *m*=1.5 *m*=2 *m*=3

FIGURE 3 Segmentation results of different *m* value

3.5 DISEASE GRADING AND DISEASE INDEX CALCULATION

After all sample images were processed crop disease grades were gotten according to grading standards in chapter 2.4.3. Disease index of whole greenhouse crop was calculated using the formula (2). The results of the analysis and effect of interface were shown in Figure 4.



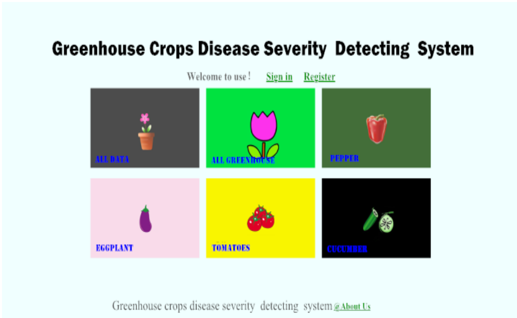
a) b)

FIGURE 4 Interface result of disease index calculation

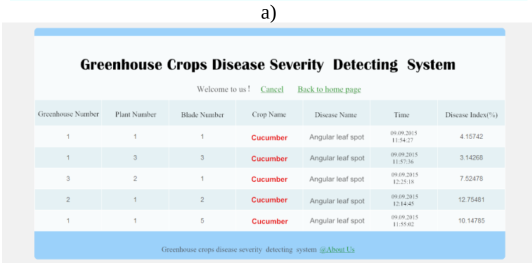
The Adobe Photoshop CS5 was used to get the number of leaf pixels and the number of leaf spots pixels, and the ratio k was 6.7564. In summary, the ratio k was basically same in two different measurement methods. Although there were some errors, it had little effect on greenhouse crop leaf disease grade determination.

3.6 CLOUD DATA MANAGEMENT

The data of greenhouse crop disease degree could be uploaded to the server after the disease index was completed. The user could log in the greenhouse crop disease degree detection system through personal computer web site and registered user name. This website could receive the data of Android upload remotely and realized the remote view, save and statistics function of the computer. The computer detection system was shown in Figure 5.



a)



b)

FIGURE 5 Interface result

4 Conclusions

The greenhouse crop disease degree detection system was designed and developed based on Android mobile phone platform in this paper. The Android smart phone camera was used to collect leaf disease image. Then according to the color characteristics of healthy leaves and lesion isolated from the disease leaves. The leaf area and lesion area were spitted and extracted using the efficient of FCM algorithm. The pixels number of the leaf area and lesion area were compared, and then the disease level was judged by the standard classification criteria. The disease index of the whole greenhouse crop could be obtained according to disease index, and the corresponding control measures could be put up according to the disease index. A powerful cloud data management technology was used in the system. The mobile phone side of the data could be uploading to the server. The computer could be achieved on the data statistics and query functions. Experimental results show that the system of greenhouse crop disease index measured accurate, error was small, saved time and effort, and non-destructive leaf. So the greenhouse crop disease degree detection system could be providing convenient, fast and practical information for agricultural workers.

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