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LETTER TO THE EDITOR

Image Feature Fitting Extraction Technology of Micro-root System in Multi-scale Farmland

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In order to accurately observe, sample and measure the root growth of farmland plants,in this paper, the root system monitoring system is used to obtain the pictures of multi-scale farmland roots. Based on Matlab digital image recognition method, the root image software consisting of image geometric distortion correction, image mosaic, root image extraction and root area calculation is programmed by SIFI and OTSU method. Using this software to study and analyze the acquired digital images of the roots.The results show that the root image splicing and extraction analysis system based on Matlab preliminarily realizes the in-situ identification of the root characteristics of farmland plants. The system can improve the work efficiency of the root image of farmland plants and provide help for calculating the root area.

Farm plant roots; Matlab; image mosaic; root extraction

1 Introduction

As one of the three major organs of plants, roots are the supporting part of crop growth system, which plays an important role in crop growth and development, yield formation, water use efficiency and soil respiration. However, roots grow underground, making it difficult to obtain reliable, continuous information on root growth and development. At the earliest in the early 18th century, Hailes in Germany began to study plant roots. Ma Yuanxi of China began to observe the growth of wheat roots by direct excavation method in 1963.The early research methods of plant roots were excavation method and soil drilling method. Although these two methods are simple and intuitive, they are laborious, time-consuming, and have damage to roots and soil. They cannot be fixed and dynamically observed, and they are limited to crops. Research on soil moisture and yield related to growth and development. It is a technique developed in recent years to observe the root growth dynamics through micro-root canals at a fixed point and in situ. It is less destructive and overcomes many defects of the sampling method. In recent years, some foreign professional equipment companies have begun to develop specialized instruments and equipment to measure root growth and distribution quickly and accurately with low-damage methods. Such as: CI-600 root growth monitoring system of American CID Company; micro root canal observation system developed by Bart; Canada ET-100 root ecological monitoring system. George, Costa, Keith, etc. developed software RMS for data image measurement root lengths, which are useful for micro-root measurement and can save a lot of time. At present, there are two types of root image analysis systems mainly used in the analysis of micro-root canal methods in China: one is the WinRHIZO Tron series analysis software that directly uses foreign and CI-600 plant root growth monitoring systems. The principle is CCD linear scanning in each The first layer acquires a 360° image, but the root system cannot be automatically recognized due to the influence of the soil background on the image; The other is China's Liu Jiuqing, Liao Rongwei, etc. using Visual C++ programming image recognition technology to carry out quantitative identification software for root growth. Both types of systems do not have an automatic splicing function, and only images of ≤22.6 cm×20.1 cm can be analyzed at a time, so the entire root profile image cannot be obtained.

Che Chang published an article in Ekoloji Issue 107, 2019.The title is: "Fusion Method of Three-Dimensional Building Construction Drawing Mosaic and Fusion Based on Environmental Protection Engineering".This paper proposes an image mosaic fusion method based on environmental protection engineering. (Hassan et al., 2017)The image feature points are first extracted; then the feature points are rigidly transformed. Second, get point-to-point information and solve the transformation matrix. The image registration is completed by the least squares method, and the image mosaic and fusion are realized.

Mairhofer et al. proposed a method based on Fourier transform for plant root image mosaic. The fast Fourier transform method was used to improve the image processing quality, shorten the image processing time, realize real-time image processing, and facilitate image processing and data statistics. This method was used to splicing the root image collected by the micro-root tube into a complete root image. This method could provide comprehensive root growth information for the study of the mechanism of action of plants growing on slopes, and provided a reliable data source for plant roots research, but it was not comprehensive and can only be used to study plants growing in slopes. Flavel et al. used computer vision technology combined with image processing method to extract the image features of plant roots under complex background, and completed the isolation of plant roots from the images taken in natural scenes, and extracts the characteristic parameters of plant roots.

2 Idea Description

2.1 Test location and time

The field root image acquisition in this study is a large root section observation field of the Jinzhou Farmland Ecosystem Field Observatory. The observation site was built in 2011 with 12 observational plots, each with an outer diameter of 58 mm × 1.5 m × The glass micro-tubes are 4 mm thick (in-line) and 58 mm × 2 m × 4 mm thick (45° obliquely inserted), and the test crops are farm plants (Honget al.2017).

2.2 Image acquisition method

The image acquisition system is a self-developed plant root growth monitoring system SIAAE-01 1/4 inch CCD camera with 300,000 pixels. Each time the camera is rotated on the same level by translation to a partially overlapping image. The selected image is 4 clear pictures taken continuously on July 1, 2011.

3 Results

The process of image processing is divided into three parts: image stitching, root image extraction and root area calculation.

3.1 Image stitching

Image stitching uses feature-based IBR image stitching. Compared to GBR, IBR is a kind of image sampling and rendering technology that produces new visual effects. It does not need to sample the auxiliary information contained in the image. Feature-based image stitching is divided into four basic steps: feature extraction, feature matching, projection model creation, and image fusion. The root image sequence of a set of overlapping parts is spatially matched and aligned, and an original image is subjected to downsampling to obtain an image, and then the new image is downsampled, and the set of the plurality of sets is repeated, after being sampled and synthesized. A complete, high-definition new root image is formed that includes a wide viewing angle scene of each image sequence information.

Take 4 images of the roots of farmland plants acquired on July 1, 2011 as an example. Based on the IBR algorithm described above, the program is programmed to implement image stitching. Image distortion correction before image stitching, firstly, the acquired root images are named according to the shooting order by 1, 2, 3, 4 (Fig. 1);The original image is rotated and then the arc is removed; when the image is spliced, the images 1 and 2 are sequentially read in the order of the image; the SIFT operator is used to acquire the image feature points and the feature descriptor features, and the SIFT algorithm has the advantage of finding the pole in the scale space. Value points, extracting position, scale, and rotation invariants, the extraction speed is fast, and the noise is also maintained to a certain degree of stability. Then, the features of the two images are extracted separately, and the features are described. The features processed by the feature-based matching generally include color features, texture features, shape features, spatial position features, etc., and image registration is required. Find the corresponding transformation matrix between the images. Furthermore, the feature points are coarsely matched, and the coarse matching can obtain the relationship of the feature points of the primary matching often with mismatch or one-to-many relationship, perform fine matching, and establish a one-to-one relationship between points and points. The feature point pairs between the calculated images are the correctly matched feature point pairs, thereby calculating the corresponding matrix between the images (Feng et al.2016).

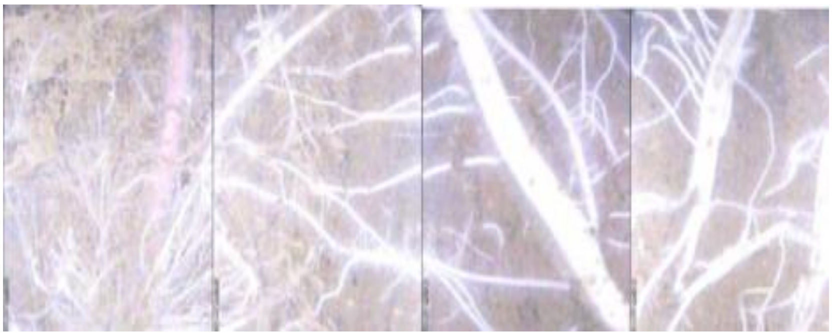

Figure 1 Picture of the root before splicing

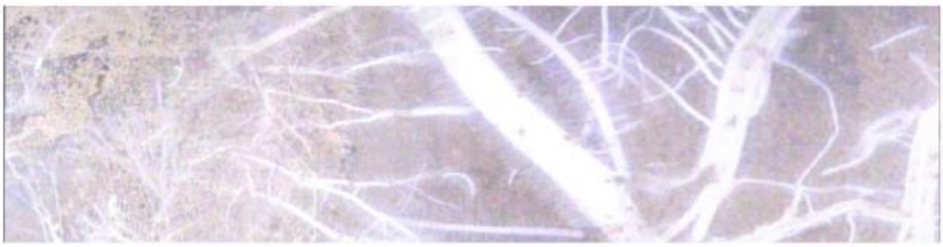

Figure 2 360° root system after splicing

3.2 Root image extraction and area calculation

The Otsu method in Matlab is used to find a suitable threshold for the image. It is based on the grayscale characteristics of the image. The grayscale based segmentation divides pixels above a certain grayscale into one region, which will be lower than a gray. The pixels of the degree are divided into another area, and the image is divided into two parts: the background and the target. The Otsu method is also considered to be the best and fastest global thresholding method (Hoang et al. 2016).The larger the variance between the background and the target, the greater the difference between the two parts that make up the image. When part of the target is divided into the background or part of the background is divided into the target, the difference between the two parts will be smaller. Therefore, the segmentation that maximizes the variance between classes means that the probability of misclassification is minimal. The operation procedure is as follows: In the operation interface, click to open the spliced root picture, select "TOTAL.BMP" in the file directory, and then click "Image Binarization" under "Image Processing" menu, then it will pop up. A new dialog "Image Binarization Threshold". When the grayscale image is converted into a binary image, the threshold setting of the software adopts two methods: one is to manually obtain the threshold by calling the IM2BW function, and the threshold is set by the scrollbar interface, and the currently set threshold is displayed above the scroll bar, set the threshold to adjust the accuracy of the obtained root contour. It is reasonable to set it to between 0.8 and 0.9. When the mouse sets the scroll bar to a certain position, the right side of the interface can be displayed. Out of the image to be obtained; Another method is to call the Graythresh function, which uses the maximum interclass variance method to get a threshold, which is used for image binarization. Using this function to obtain a threshold can better convert a grayscale image into a binary image than an artificially set threshold. The contour of the root system is extracted by obtaining a better segmentation effect manually and automatically. After the image is binarized, click on "Calculate Root Area Ratio" under the "Image Processing" menu. At the bottom right, you can show the ratio of the root area to the entire image area.Finally, click the Save button to save the resulting image and the program ends. The results obtained by running the program based on the extracted root contour are as follows: The root ratio is shown to be 15.632% of the image, and the root area is calculated (Fig. 3).

Figure 3 360° root system after splicing

The root system extraction software of farmland is indispensable in the study of root system. The soil moisture characteristics affect the morphology and distribution of roots. The shape and distribution of roots also affect the water absorption capacity of farmland plants. However, the soil background is complex and will remain in image processing. Under the more serious noise, fast and accurate root splicing processing software is indispensable. The domestically used CI-600's own WinRHIZO software does not have the automatic splicing function, so it can not achieve continuous analysis of CCD camera images.

At the same time, when analyzing the image of the soil background, it is necessary to manually select the root trajectory, which increases the huge workload. Due to these inconveniences, Zhao Xiangyang uses the traditional matching method Harris algorithm, Harris algorithm extracts the corner points for image feature matching, but the calculation speed is slow, not suitable for the splicing of a large number of root images, compared with the image stitching SIFT algorithm mentioned by the author, It can accurately and quickly realize the complex root image stitching function of the background(Glavatska et al.2017).This study applied these methods to carry out the root image of farmland plants, and laid a working foundation for the impact of environmental stress on the root growth of farmland plants. However, the results extracted by this system are the root area ratio. In order to better understand the relationship between root growth and soil moisture, plant development and response to environmental stress, the root system must be graded. How to extract the root system under complex soil background And distinguishing between dead roots and live roots will be a problem that software development must solve.

4 Discussion

Based on Matlab's self-written root splicing and image binarization, the expected effect of software design is achieved, and the work efficiency of farmland plant root image finishing is improved. The SIFT algorithm extracts fast speed, and does not need to accurately control the camera cloud top. When the matching accuracy is not very high, the panoramic image can be directly generated to meet the practical application requirements of the root analysis, and the noise can be maintained to a certain degree. Sex, the image stitching effect is good. Combine the images into a seamless and smooth image without guaranteeing a smooth transition of image color brightness. Different thresholds will result in different root image ratio results. By setting the threshold value by Ostu, both automatic and artificial methods can be used to obtain a suitable threshold for binarization. Through software splicing, rapid measurement and analysis of root field observation and root ratio are realized, but different types of soil background are complex, and application of the software on other types of soil needs further application and improvement.

The system can not only splicing and extracting the root image of farmland plants at multiple scales, but also processing the root image of other crops, but the calculated proportion of the roots is not directly calculated. The area and volume of the root system cannot be directly calculated. The result is that the root system is sampled to obtain the actual root and image conversion ratio, and this work will be carried out later.

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