Research on Vision Navigation of Weeding Robot Based on Image Processing

Cai Jinjin, Wang Ruiqi

[1]School of Electrical Engineering, Beijing Jiaotong University, Beijing, 100091, China

[2]School of International Education, Beijing University of Chemical Technology, Beijing, 100029, China

Keywords: weeding robot; image processing; machine vision

Abstract: Based on the analysis of the control system of weeding robot, this paper presents a video image processing method of weeding robot, and formulates the corresponding scheme. A real-time video image processing system for weeding robot is designed and tested in laboratory. The experimental results show that the system can accomplish high-speed video image processing and plant location, which lays a solid foundation for precise motion control of the end-effector of the weeding robot.

1. Introduction

Vision is the most abundant means for human to obtain information. Usually more than 75% of human information comes from the eyes. For drivers, more than 90% of information comes from vision. Similarly, vision system is one of the most important parts of robot system, and vision sensor is also a perception device for robot to obtain surrounding information.

When the robot works in a specific environment and the area is large, monocular vision can not meet the needs of robot navigation. It is necessary to combine multiple images to form a large field of view image so that the robot can work quickly and accurately in the corresponding environment. With the development of image mosaic technology, image mosaic technology has gradually been widely used in the robot industry. In the field of mobile robots, images with overlapping areas collected by visual system are mosaic to form large-view images, which can analyze the scene more accurately and provide help for robot operation.

When grass robot works in the field, the light intensity changes greatly, the background interference information is more, and the real-time requirement is higher. Therefore, this paper proposes a method for video image processing of weeding robot. This method realizes fast real-time processing of field crop video image and plant location, and can provide location information for precise motion control of end-effector of weeding robot.

2. System Overall Scheme

The main function of the system is to collect and analyze crop images captured by video equipment on weeding robot in high speed and real time, and to provide positioning data for end-effector.

In this scheme, Microsoft Visual Studio 2005 is used as the development tool to realize the gray processing, image segmentation and noise removal of the original image. OpenCV visual library is used to extract and locate the features of crop plants. The main operation of the software is to pre-process the plant image collected by the weeding robot, extract the feature and locate the plant, so as to achieve the acquisition of the plant location data in the field. The function modules of the system are shown in Figure1.

  DOI: 10.25236/aisct.2019.086

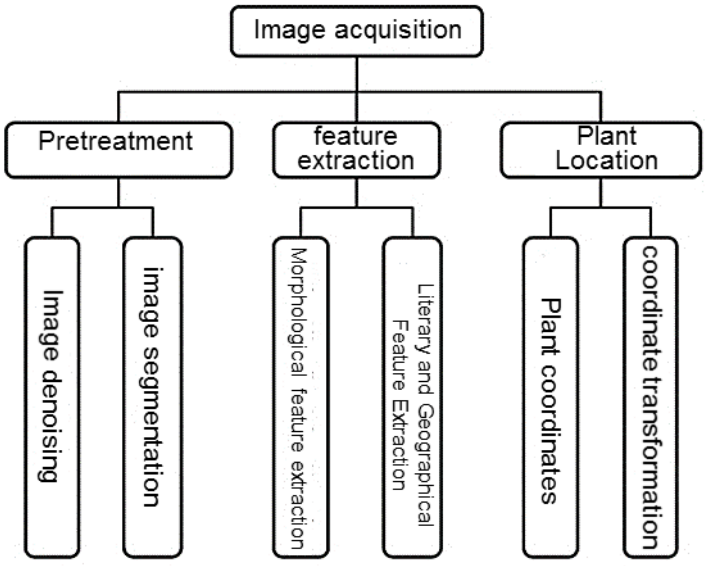

Figure1 System Function Module Diagram

Opencv is an Intel_open source cross-platform computer vision library. It can run on Linux, Windows and MacOS platforms. The code is written in pure C language. It realizes many general algorithms in computer vision, such as image processing algorithm, motion analysis and object tracking algorithm, camera calibration algorithm, pattern recognition and three-dimensional reconstruction. Most of the functions are assembled and optimized to make full use of the performance of Intel chips.

Table 1 Main Function Modules of OpenCV

Modular	Functional description	Modular	Functional description
cv	Core function library	cv	Core function library
cxCore	Data Structure and Linear Algebra Library	cxCore	Data Structure and Linear Algebra Library
HighGUI	GUI function library	HighGUI	GUI function library
ml	Machine Learning Function Library	ml	Machine Learning Function Library

OpenCV advantages are as follows: firstly, it has good portability and can run across multiple platforms; secondly, it contains a large number of application programming interfaces of C functions, which can run independently without external libraries, and can also use other external libraries at run time; thirdly, it is open source code, and the use, modification and distribution of program codes are not restricted by licenses; The algorithm is based on dynamic data structure encapsulated in IPL and has high flexibility. More than 50% of the functions are optimized by Intel when they are designed and assembled.

3. Test and analysis

3.1 Image Preprocessing

In image acquisition, because of the point noise caused by the change of light and the sway of plant, it is necessary to preprocess the collected crop image. Image preprocessing mainly includes gray processing, image segmentation and noise removal. The result of pretreatment is shown in Figure 2.

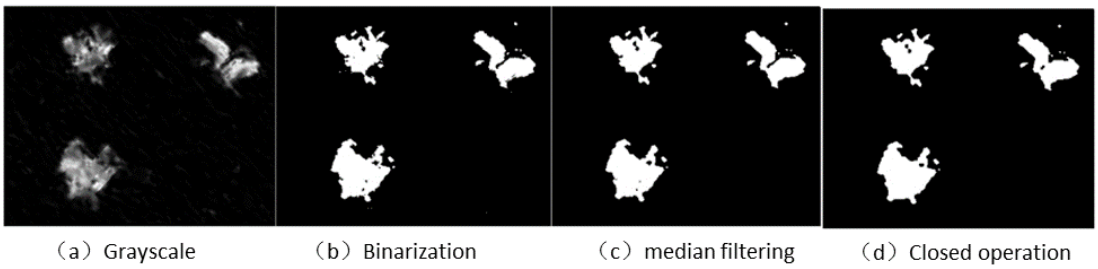

Figure 2 Pretreatment results

3.1.1 Gray processing

In crop images, the segmentation method of target plant language background plants is based on the color features of crop plants. Real-time Super-Green method (2G-R-B), normalized Super-Green method (2g-r-b) and chromatic aberration method (Cr) were studied and compared, as shown in Table 2. From Table 2, it can be concluded that the 2G-B-R segmentation method with super green is the best.

Table 2 Segmentation Error Table

ON	Ultra Green Method	Normalized Ultrafiltration	chromatic aberration
1	2. 29	15. 65	3. 49
2	0. 81	27. 05	2. 10
3	0. 87	25. 12	2. 35

3.1.2 Binary Image Segmentation

Because the process of image binarization will lose a lot of available information of the original image, it is very important to preserve the main features of the original image in the process of binarization preprocessing. In the gray image of this scheme, there are obvious differences in gray characteristics between the plant and the background, so the adaptive image threshold segmentation method is selected.

3.1.3 Image denoising

Mao Wenhua of China Agricultural University and others found that median filtering is better than domain average filtering. Therefore, the median filtering method is used to denoise the crop image, and the background noise is effectively eliminated.

3.1.4 Morphological filtering

In order to eliminate weeds and other small targets, the open operation algorithm is used to perform corrosion operation on the target, then expansion operation is performed. The area of the target plant is not changed obviously while separating the target plant and smoothing the plant boundary at the slim point. Morphological filtering is applied to effectively suppress the noise of the plant edge, make the plant edge smooth and clear, and eliminate the small noise points in the background image, which has parallelism and feasibility. The characteristics of fast implementation.

3.2 Image feature extraction

Because crop plants have different image features from their surroundings, these different

features can be extracted by digital image processing technology, which can provide location data for crop plant recognition and location. The main feature extraction methods are morphological, texture and spectral features.

There are many morphological features used in crop plant recognition, which can be divided into shape feature parameters and moment feature parameters. The shape characteristic parameters mainly include perimeter, area, width and length. Moment features include centroid, long and short axis of equivalent ellipse, aspect Ratio, circumference and center moment. Compared with the texture and spectral parameters, the extraction of morphological feature parameters is simple and fast.

3.2.1 Edge Detection and Extraction

In order to extract the boundary between the target plant and the background in the image, i.e. the region boundary whose gray level changes sharply in the image, the edge detection algorithm of Canny operator is used to extract the crop plant edge. Its advantages are noise suppression, less target edge loss, smoother and complete edge.

3.2.2 External Rectangle and Centroid

In the processing of geometry and graphics, the shape of polygonal objects is often approximated by an outer rectangle. The centroid of the plant can indicate its position in the image. Outside identified crops

Connecting rectangle and centroid position can provide positioning information for the end-effector of the weeding robot to complete the weeding task.

3.3 Coordinate Conversion of Crop Plants

The distance between crop and weeding robot (in the coordinate system of crop growth) can be obtained by using the centroid coordinate (in the image coordinate system) and the camera pinhole model ranging principle, which provides the basis for the action of weeding shovel. The coordinate transformation algorithm is validated by static scale image acquisition (camera 70.5 cm from the ground, angle 10.5 degrees). The results are shown in table 3.

Table 3 Error Table of Coordinate Conversion Algorithms

experimental group	Actual distance	Calculating distance	error	average error
	100	103. 4	3. 4	
1	200	189. 3	10. 7	11. 8
	300	278. 6	21. 4	
	100	102. 3	2. 3	
2	200	190. 5	9. 5	10. 1
	300	281. 5	18. 5	
	100	104. 1	4. 1	
3	200	181. 7	18. 3	16. 2
	300	273. 7	26. 3	
	100	103. 7	3. 7	
4	200	184. 5	15. 5	141. 1
	300	276. 4	23. 6	

From Table 3, it can be seen that the average error of the algorithm is less than 20 mm, which can satisfy the accuracy of plant location of weeding robot.

3.4 Result analysis

Because of the reasons of the test site and the surrounding environment (such as light intensity, etc.), there are many noises in the collected crop images. After image pre-processing, the crop contour obtained is more complete. However, with the increase of illumination intensity, there are great differences in gray-scale effect, which results in that part of the plant in the binary image is

not separated from the background. Although this has little effect on plant location, the accuracy of crop recognition can be improved by using multi-spectral camera to collect crop image information, which is not affected by changes in light intensity. However, the high cost of spectral camera limits its application in crop recognition.

Analyzing the time table of plant dynamic image processing, we can see that in image analysis and processing algorithm, using OpenCV computer vision library function can complete the real-time image processing task, but the occupancy ratio of image preprocessing is still high. Image Processing System of Weeding Robot for Collecting Crops

In the case of near rows (i.e. the central part of the image), ROI can be used to obtain the rectangular region information of crop rows, and then the above scheme can be used to obtain plant location information, which can effectively shorten the time of image processing and further improve the speed of real-time image processing of weeding robot.

4. Conclusion

Through the analysis and comparison of experiment and result, the image processing technology of weeding robot based on OpenCV effectively improves the accuracy of plant location. The detection program compiled by OpenCV can accomplish plant location quickly, and can basically eliminate the influence of light and shadow on image processing. The experimental results can satisfy the requirement of eliminating the influence of illumination and shadow on image processing. Accuracy and Real-time Requirements of Grass Robot Image Processing System

References

[1] Mao Wenhua, Wang Yiming, Zhang Xiaochao, et al. Advances in field weed identification technology based on machine vision [J]. Journal of Agricultural Engineering, 2004, 20 (5): 172-178.

[2] Hou Xuegui, Chen Yong, Guo Weibin. Field Machine Vision Navigation of Weeding Robot

[J] Journal of Agricultural Machinery, 2008, 39 (3): 106-112.

[3] Mao Hanping, Hu Bo, Zhang Yancheng, et al. Optimization of color features and threshold segmentation algorithm in weed recognition [J]. Journal of Agricultural Engineering, 2007, 23 (9): 154-158.

[4] Liu Liqiang, Xiang Jianting, Wu Zequan. Rapid identification of healthy seedlings based on color characteristics [J]. Agricultural science and technology and equipment, 2012 (6): 26-28.