Path recognition method of agricultural wheeled-mobile robot in shadow environment

Zhao Bo, Mao Wen Hua
State Key Laboratory of Soil-Plant-Machine system
Chinese Academy of Agricultural Mechanization
CAAMS
Beijing China
zhaoboshi@126.com

Song Zheng He, Mao En Rong
College of Engineering, China Agricultural University
CAU
Beijing China
songzhenghe@cau.edu.cn

***Abstract*—This paper investigated the influence of the shadow environment on the path recognition for the vision navigation system of the agricultural wheeled-mobile robot. In base of path recognition in the ordinary environment, a new method based on the SOM neural network was applied to the path recognition in the shadow environment. Experimental results proved that the new method was effective on the shadow environment, and could obtain the target navigation path rapidly, reliably and accurately.**

Keywords- path recognition; shadow environment; vision navigation; agricultural wheeled-mobile robot; SOM neural network

I. INTRODUCTION

With the development of international precision agriculture, it is a great revolution for the precision agriculture based on mechanization, automatization and intelligentization in the 21st century. Therefore the agricultural wheeled-mobile robot is becoming the key issue to be researched all over the world [1]. Because of the increasing quality and decreasing price of sensors, the automatic navigation system of the agricultural wheeled-mobile robot is becoming a prevalent research, in which the machine vision and the satellite position are cores. The main task of the machine vision is to recognize the route accurately, orientate relatively, and check the obstacle in the navigation system. The machine vision has not only the good performance, but also can distinguish the crops and the weed, and check the insects. Because of its wide applicability, the various function, the high quality and the low cost, the machine vision is applied to the automatic navigation of the agricultural wheeled-mobile robot successfully, and is the critical part of the navigation system.

Current research is localization in the simple environment, and some traditional path recognition methods have successfully applied to the vision navigation system in the agricultural wheeled-mobile robot. However the research of the path recognition method in the some complicated environments is lesser, which include the shadow environment, the illumination change environment, the rainy environment, the wind environment, the weed environment, and so on. The traditional path recognition methods are not satisfied for actual situation in complicated environments. Therefore the research of the path recognition method in the complicated environments is important and necessary[2-5].

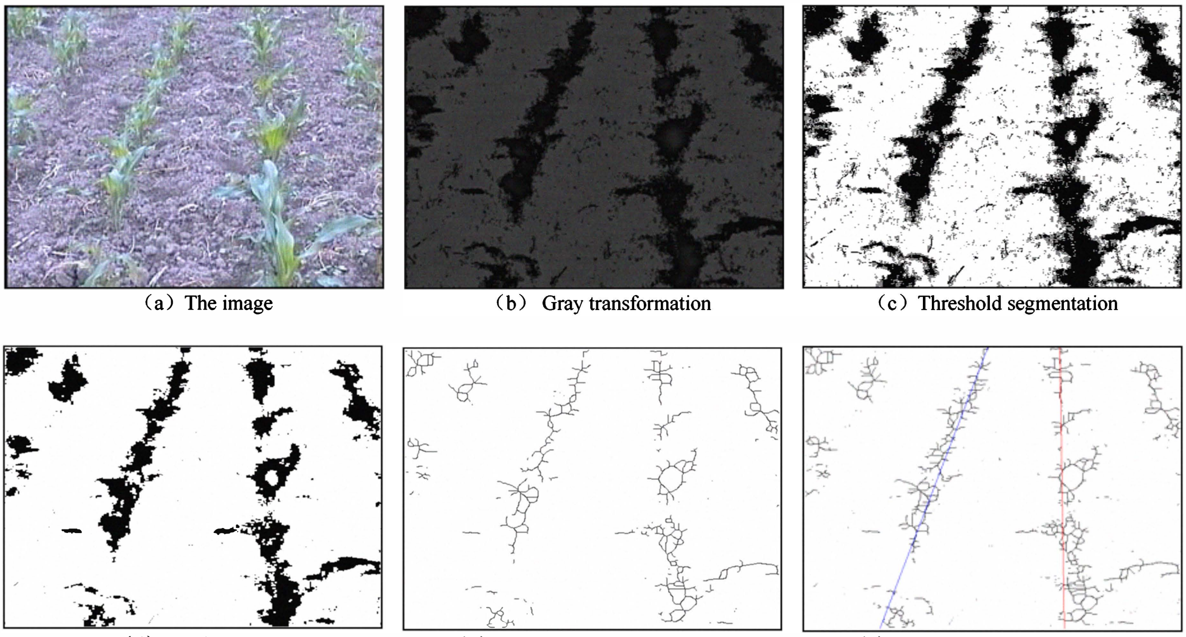
II. RECOGNITION OF NAVIGATION PATH IN ORDINARY ENVIRONMENT

For the vision system of the agricultural wheeled-mobile robot, the inputs are the actual field images and the outputs are the relative position of the robot, including the lateral deviation and the heading deviation. By image processing the crop rows are recognized and their coordinates on the image plane can be determined. According to the relationship between the image plane coordinate system and the world coordinate system, the relative position of the control points can be calculated, and the control parameters f the agricultural wheeled-mobile robot can be obtained.

The main step of path recognition in the ordinary environment is:

- Step 1: The color images were transformed to the gray images by the color model 2G-R-B, as shown in Figure 1 (b);
- Step 2: The gray images were segmented by the iteration method in order to acquire navigation object, as shown in Figure 1 (c);
- Step 3: The noise were removed by the erosion algorithm in order to improve the recognition rate, as shown in Figure 1 (d);
- Step 4: The centers of the crops roe were acquired by the center line detecting algorithm, as shown in Figure 1 (e);
- Step 5: The navigation lines were obtained by the Hough transformation algorithm, as shown in Figure 1 (f).

978-1-4244-5517-1/10/$26.00 ©2010 IEEE



(a) The image (b) Gray transformation (c) Threshold segmentation

(d) Erosion (e) the center line detecting (f) Hough transformation

Figure 1. Recognition of navigation path in ordinary environment

III. RECOGNITION OF NAVIGATION PATH IN SHADOW ENVIRONMENT

A. The influence of shadow to path recognition

In the process of crops growing, the information of the crops rows are seriously interfered by the shadow. The complicated shadow which include agriculture robot shadow, crops shadow, tree shadow, and so on, resulted in detecting the navigation lines difficultly, the reliability of agriculture robot decreased seriously. By the research, the ordinary path recognition method is not adapt to the shadow environment, as shown in Figure 2.Therefor, a new method must be researched to solve this situation, in order to improve reliability and adaptability of agriculture robot.

(a) The image (b) Gray transformation (c) Threshold segmentation

Figure 2. Image in the shadow environment

B. Path Recognition based on the SOM neural network

In this paper, the Self-Organizing Map (SOM) neural network was chosen to segmentation threshold.

The SOM, proposed by Kohonen, also called Kohonen network has had a great deal of success in many applications such as reduction of dimensions, data processing and analysis, monitoring of processes, vectorial quantification, modeling of density functions, clusters analysis, and with relevance for our work in image segmentation [6]. The SOM neural networks can learn to detect regularities and correlations in their input and adapt their future responses to that input accordingly. The SOM network typically has two layers of nodes and does a no lineal projection of multidimensional space about out-put discrete space represented by a surface of neurons. The training process is composed by the following procedures[7]:

- Step 1: Initialize the weights randomly.

- Step 2: The eigenvectors is fed to the network through the processing elements (nodes) in the input layer.
- Step 3: Calculate the similitude between the input eigenvectors and the neurons weight.
- Step 4: Determinate the winning neuron, the node with the minimum distance respect to input eigenvectors is the winner.
- Step 5: Actualization of the weights of the winning neuron and its neighborhood, adjusting its weights to be closer to the value of the input pattern.
- Step 6: If it has got the maximum number of iterations, the learning process stops, in other case it returns to the step 2.

For each input eigenvectors, the Euclidean distance between the input eigenvectors and the weights of each neuron $\varpi_{i,j}$ in the one-dimensional grid is computed (step 3) by:

$$d_j = \sum [x_i(t) - \varpi_{i,j}(t)]^2 \tag{9}$$

The neuron having the least distance is designated the winner neuron (step 4). Finally the weights of the winner neuron are updated (step 5) using the following expression:

$$\varpi_{i,j}(t+1) = \varpi_{i,j}(t) + \eta(t)\cdot[x_i(t) - \varpi_{i,j}(t)] \tag{10}$$

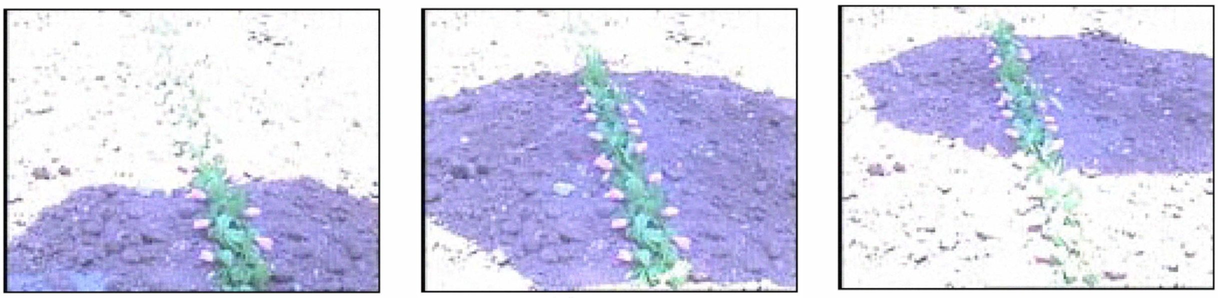
The $\eta(t)$ refers to a neighborhood set ($0 < \eta(t) < 1$).

IV. Experiment results and conlusion

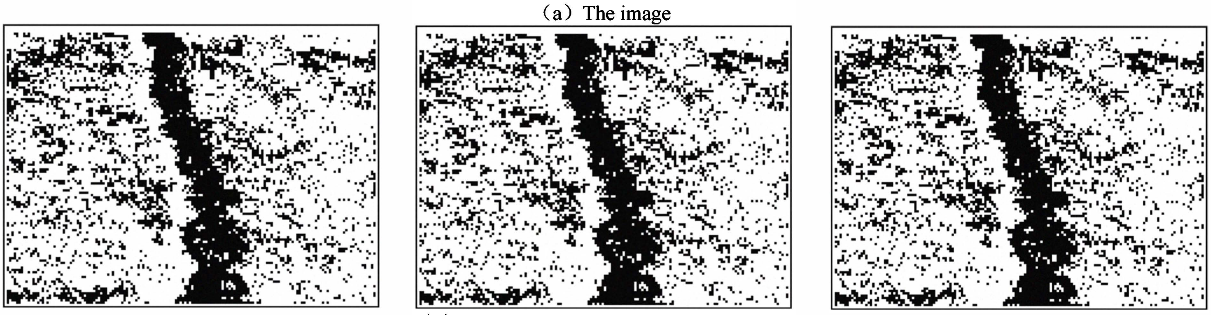
A. Experiment results

The camera to be calibrated is a WV-CP470 CCD camera with 16 ㎜ lens made by Panasonic. The dimension of CCD is 753（H）×582（V）. The U200 serial capture card made by DaHeng is used to capture images.

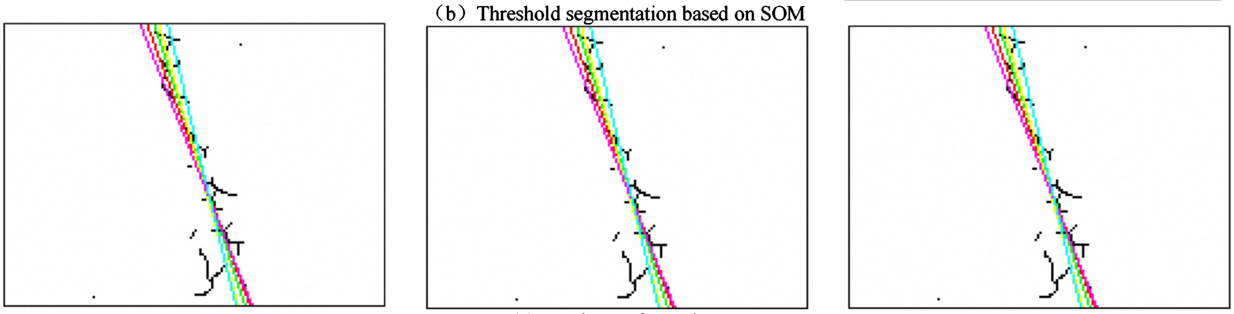
The method accuracy was tested in test paths constructed of common blue artifical plant. The two hundred different images were trained by using SOM method. The average cost time was 432 ms and the recognition correct rata was 98 percent, as shown in Figure 3(All images size is 640 × 480 in this paper.).



（a）The image



（b）Threshold segmentation based on SOM



(c)Hough transformation

Figure 3. Experimental results in the shadow environment

B. Conclusion

Experimental results prove that the new method is effective for the path recognition in the shadow environment, and can obtain the target navigation path rapidly, reliably and accurately.

ACKNOWLEDGMENT

This paper is supported by the key technology R&D program (No.2007BAD89B04) and the national high technology research and development program of China (No.2006AA10A305, 2006AA10Z254).

REFERENCES

[1] Reid J F, Stephen, Searcy W. Automatic tractor guidance with computer vision. SAE Trans[J]. 1987:673～693.

[2] Torii T. Research in autonomous agriculture vehicles in Japan[J]. Computers and Electronics in Agriculture, 2000, 25(1-2): 133-153.

[3] Debain C, Chateau T, Berducat M, et al. A guidance-assistance system for agricultural vehicles[J]. Computers and Electronics in Agriculture, 2000, 25: 29-51.

[4] Pinto F A C, Reid J F, Zhang Q, et al. Vehicle guidance parameter determination from crop row images using principal component analysis[J]. J. Agric. Eng. Res., 2000, 75: 275-264.

[5] John F R, Zhang Q, Noboru N, et al. Agricultural automatic guidance research in North America[J]. Computers and Electronics in Agriculture, 2000, 25: 155-167.

[6] Kohonen T. Self-Organizing Maps, Berlin, Germany: Springer-Verlag[J], 2001

[7] Mary C J，Marco M Heart Cavity Detection in Ultrasound Images with SOM. MICAI 2006[C], LNAI 4293, pp. 1211–1219, 2006.

[8] Astrand B, Baerveldt A J. A vision based row-following system for agricultural field machinery. Mechatronics[J], 2005, 15:251～269.

[9] Shi X L, Xu Z B, Xu J. Application of Kohonen networks for image segmentation[J]. Journal of Huazhong University of Science and Technology(Nature Science Edition), 2005, 33(9):13～14(in Chinese).