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Research on the Straight Line Driving and Visual Navigation Technology of Agricultural Machinery

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Abstract

With the progress of agricultural technology and the continuous development of agricultural machinery, the importance of intelligent navigation technology is increasingly prominent. This paper studies the linear driving and visual navigation technology of agricultural machinery. Based on the analysis of Hough transformation in the straight-line driving of agricultural machinery, the working principle of the straight-line visual navigation of agricultural machinery is described. In view of image segmentation in visual navigation, the gray value segmentation method is used to segment the agricultural land image on OpenCV, observe and analyze the experimental image, and analyze its feasibility. Through the study of threshold segmentation, region and growth segmentation and neural network segmentation, the advantages and disadvantages of gray value segmentation are compared.

Keywords

Agricultural machinery; Straight driving; Visual navigation.

1. purpose and significance of the study

With the rapid progress of computer technology and automation technology, intelligent machinery is widely used in industry, medicine, military, agriculture and forestry.China is a large agricultural country. It has become the focus of attention to improve the efficiency of crop production, improve the safety of agricultural machinery operation and reduce the labor intensity. However, due to the late start of China's modern agricultural technology, coupled with the large agricultural population base and the wide and scattered cultivated land, the agricultural modernization technology of our major developed countries in Europe and the United States is relatively backward.Agricultural mechanization is the foundation of agricultural modernization, and advanced science and technology are the driving force to promote its development.Unmanned, mechanization is the only way of agricultural modernization, but also the development of agricultural modernization with Chinese characteristics.The linear driving and visual navigation technology of agricultural machinery has realized unmanned, mechanized and played an important role in promoting the process of agricultural modernization in China.Traditional agriculture is faced with many problems, such as the shortage of labor force, the decrease of soil quality, the environmental pollution of pesticide residues, the increase of agricultural cost and the waste of resources.In order to solve these problems, agricultural modernization technology is the best solution. Through unmanned mechanization, agricultural development will step into the scientific track and continue to promote the sustainable development of China's economy.

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2. Relevant research at home and abroad

The torii team at Kyoto University in Japan built an intelligent pesticide sprayer.In his color space, the least square method of horizontal scan line is used to identify the navigation path.This method uses color difference to segment images, which can effectively distinguish ridge, weeds and crops.

The Reid team of Illinois State University in the United States has studied the threshold image segmentation method, using the conditional probability of computing class nodes to classify and segment cotton crops under different soil backgrounds, and obtained feasible experimental data.

J.A. Marchant of the British silseo Research Institute has many researches on the visual navigation of agricultural robots.They use the filter to extract the row information, and use the high and low frequency characteristics of the filter to reduce the navigation error.

Shen Hongxia of Nanjing Agricultural University uses morphology to analyze and extract the morphological characteristics of farmland environment, uses mathematical morphology theory to filter out the fine texture in the picture, and uses edge extraction method to determine the relative position of agricultural robot and path to achieve visual navigation.

3. A summary of the straight line driving and visual navigation technology of agricultural machinery

In the autonomous navigation of agricultural automation equipment, the current common navigation methods are GPS navigation and machine vision navigation. Due to the objective conditions, only other methods can meet the performance requirements.The vision navigation system of agricultural machinery automatic straight line driving mainly uses the camera to collect the real-time image, and then through image processing, image analysis and image understanding, detect the straight line in the image, and then realize the navigation control.

Taking rice transplanter as an example, it is mainly composed of clutch operation mechanism, steering operation mechanism, speed gear operation mechanism, seedling plate lifting operation mechanism and supporting electric control system.The rice transplanter can achieve 180 degree steering and straight-line driving through the automatic steering system; based on the visual technology, it can meet the requirements of its visual navigation. On the basis of VFW technology, Matlab is used to collect images, segment rice seedling images, extract positions and fit reference lines in the windows environment, so as to realize the visual navigation function of rice transplanter.Agricultural machinery carries out digital processing (DSP, FPGA, etc.) on the image captured by vision sensor and light source sensor (CCD or CMOS camera), and then controls the execution.

4. Four image segmentation

4.1 Threshold segmentation

Threshold segmentation method is a relatively common and simple image segmentation method.Its computation is small and its performance is stable.Its basic principle is to divide the pixels into several categories by setting different characteristic thresholds, which is suitable for the images with different gray levels occupied by the target and background.Otsu algorithm is a better threshold method, which is segmented by the method of maximum variance between classes.We record t as segmentation threshold, the proportion of foreground points to image is W0, the average gray level is U0, the proportion of background points to image is W1, the average gray level is U1, the average gray level of image is u, the variance of foreground and image is g.There are:

$$u = w_0 \times U_0 + w_1 \times u_1$$

$$g = w_0(u_0 - u)^2 + w_1(u_1 - u)^2$$

Get:$g = w_0 \times w_1 \times (u_0 - u_1)^2$ Or:$g = \frac{w_0}{1-w_0} \times (u_0 - u)^2$

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When the variance G is the largest, we can think that the difference between the target and the background is the largest, and t is the best threshold.From the one-dimensional Otsu threshold selection method to the two-dimensional Otsu threshold selection method, the threshold segmentation method has been improved and optimized in other aspects.But it also has many limitations, especially in the selection of threshold, in other words, the gray value outside the pixel and the spatial distribution of the pixel will have a greater impact on the segmentation effect.

4.2 Regional growth segmentation

Region growing segmentation is a process of aggregating pixels or sub regions into larger ones according to specific requirements.Its basic principle is to take the pixel or region as the growth point, merge the growth points with similar properties through image information such as gray value, texture, color, depth, etc., and repeat the process until the stop condition is reached.

We take the gray matrix as an example. The first image is the original image in which the number represents the gray level of the pixel.The pixel whose gray value is 8 is recorded as the initial growing point as f (I, J).The difference between the gray value and the gray value of the growing point is 0 or 1.After one growth, the difference between F (i-1, J), f (I, J-1), f (I, j + 1) and the growth point in the second matrix is 1. After the second growth, f (I + 1) is merged. After the third growth, f (I + 1, J-1) and f (I + 2, J) are merged. So far, no pixel points meet the growth criteria and the growth ends.

$$\begin{bmatrix}1&2&7&4&3\\1&7&8&7&5\\2&5&6&1&4\\3&2&6&0&1\\1&2&1&0&1\end{bmatrix}\quad\begin{bmatrix}1&2&7&4&3\\1&7&8&7&5\\2&5&6&1&4\\3&2&6&0&1\\1&2&1&0&1\end{bmatrix}\quad\begin{bmatrix}1&2&7&4&3\\1&7&8&7&5\\2&5&6&1&4\\3&2&6&0&1\\1&2&1&0&1\end{bmatrix}\quad\begin{bmatrix}1&2&7&4&3\\1&7&8&7&5\\2&5&6&1&4\\3&2&6&0&1\\1&2&1&0&1\end{bmatrix}$$

Original image gray matrix growing point first growing region result second growing region result third growing region result

The key of region growing segmentation method is to choose suitable growing point, determine growing criterion and stop condition.In order to ensure the accuracy of image segmentation, we should pay attention to uniformity, connectivity, edge integrity and contrast.The region growing segmentation method has a good segmentation effect on the more uniform connected targets, but the disadvantage is that it needs to select the growing points manually, and the segmentation speed is slow when facing the large targets.

4.3 Neural network segmentation

Shenjiang network segmentation is a popular image segmentation method.Convolutional neural network is widely used in image classification and segmentation.The traditional convolutional neural network segmentation usually uses an image block from the surrounding pixels as the input of convolutional neural network for training and testing, and finally achieves the goal of image segmentation.Because each pixel block needs to be convoluted, the computation is also large.The full convolution neural network segmentation method is to transform the full connection layer of the traditional convolution neural network into convolution layer by layer, so that the image level classification is further extended to the pixel level classification, and at the same time, it is more efficient, avoiding the problem of repeated storage and convolution calculation.

5. Five Hough transformation

In the straight-line driving and visual navigation technology of agricultural machinery, the detection of straight-line is particularly important, and the straight-line can be extracted from the picture through Hough transformation.Its basic principle is to change the line y = KX + B into b = - KX + y.From the perspective of coordinate space, the pixels in X-Y image space are transformed into lines in K-B parameter space.Take the following figure as an example to briefly describe the principle.

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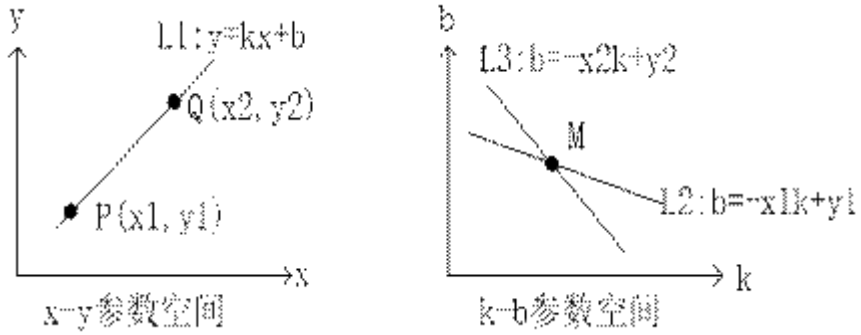
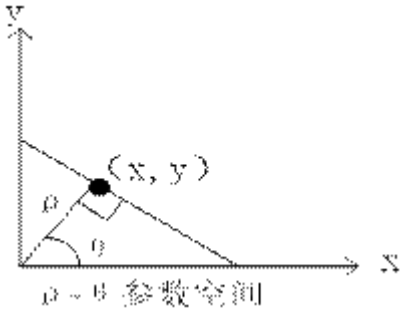


In the X-Y coordinate system, any two points P and Q on the L1 line correspond to the lines L2 and L3 in the K-B coordinate system respectively, while the intersection m of L2 and L3 in the B-K coordinate system corresponds to L1 in the X-Y coordinate system.M is the line to be detected.

For the detection of straight line in agricultural machinery, it can be determined b y a lot of intersecting points in the K-B parameter space in the X-Y image space (if many points in the X-Y image space intersect at one point in the K-B parameter space, then this intersection is the straight line we want to detect).If K is not defined, it can be determined by the distance angle parameter (ρ - θ) space,



In the distance angle parameter space, the relationship between point (x, y) and distance angle becomes:

$$\rho = x\cos\theta + y\sin\theta$$

So we can find the intersection point of sine curve in the distance angle parameter space to determine the straight line of agricultural machinery.

6. Comparison and conclusion of experimental pictures based on threshold segmentation of gray histogram

The threshold segmentation method is relatively simple, and has a good segmentation effect for the image with strong difference between the target and the background.Gray level histogram is widely used in image threshold segmentation because of its invariance of image translation, rotation and scale.The threshold segmentation method based on the gray histogram separates the target from the background area, avoids the blind search of the image in recognition, and greatly improves the efficiency and accuracy of image recognition.Next, we use a matlab program to segment the two images using the threshold segmentation method based on gray histogram. The program and effect are as follows:

I = imread ('c: \ matlab \ tee. BMP '); I1 = rgb2gray (I); figure; subplot (2,2,1); imshow (I1); title ('grayscale image') axis ([50250,50200]); grid on; axis on; [M, n] = size (I1); GK = zeros (1256); for k = 0:255 GK (K + 1) = length (find (I1 = = k)) / (m * n);

End subplot (2,2,2), bar (0:255, GK, 'g') title ('gray histogram ') xlabel ('gray value') ylabel ('Probability of occurrence ') I2 = im2bw (I, 150 /

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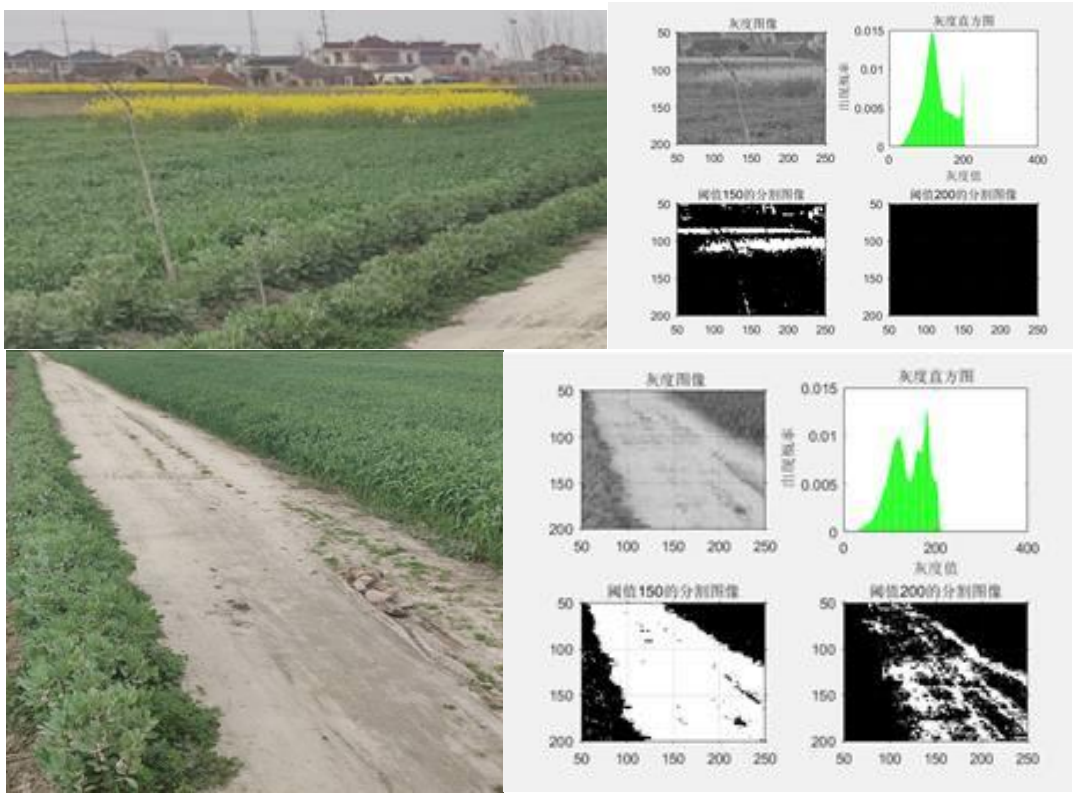
255); subplot (2,2,3), imshow (i2); title ('threshold 150 segmentation image') axis ([50250,50200]); grid on; axis on; I3 = im2bw (I, 200 / 255);% subplot (2,2,4), imshow (I3);Title ('segmentation image with threshold 200 ') axis ([50250, 50200]); grid on; axis on;



It can be seen from the first picture that rape flower and other crops can be clearly segmented by the threshold segmentation method based on gray value, and the segmentation image at threshold 150 is the most clear.In the second picture, there is a big difference between the target and the background. The contrast between wheat, broad bean and ridge is very obvious. Through the gray histogram threshold segmentation method, the navigation features of agricultural machinery in the image needed for navigation can be clearly segmented.It can be seen that the threshold segmentation method based on the gray histogram can still achieve the segmentation effect and accuracy in the case of large target background difference, which is more important in the straight-line driving and visual navigation technology of agricultural machinery. The conditions of agricultural machinery in the application process are relatively harsh and complex, and the calculation amount is small, so the image segmentation method with relatively simple calculation can effectivelyReduce the time of agricultural machinery in image processing, improve the reliability of agricultural machinery linear driving and visual navigation.

7. Outlook

The development trend of agricultural equipment is automation and intelligence. The development of high-precision autonomous navigation device is a new research to reduce the labor intensity of farmers and improve the automation of agricultural equipment.In China, the autonomous navigation ability of current agricultural automation equipment is not high. To realize the functions of agricultural machinery linear operation and visual navigation can improve the working efficiency and time utilization ratio of the unit, improve the working quality and reduce the cost, to a certain extent, reduce the work intensity of the driver, so as to improve the overall level.Although the linear driving and visual navigation technology of agricultural machinery has made some progress, most of them are still in the stage of theoretical analysis.Our existing agricultural machinery linear driving and visual navigation technology have certain limitations in the navigation control algorithm.In the face of complex farmland path, the detection algorithm model is relatively complex, and there is a certain

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distance from commercialization in practical application.We believe that in the future, there will be multi-sensor fusion in the straight line driving and visual navigation technology of agricultural machinery. Under the background of 5G rapid development, cloud computing is expected to be applied in the navigation technology of agricultural machinery. Similar to image segmentation, this kind of computing that requires a lot of computing can use cloud computing to make the image processing more accurate and fast.It is believed that through future research and practice, more accurate and efficient agricultural machinery equipment will be developed.

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