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Research on Sub-pixel Edge Feature Extraction and Measurement Based on Polynomial Fitting

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Abstract: In the field of image processing,a very classic problem is image segmentation.Moreover,the extraction of image edge features is a very important link in image segmentation.This paper construct a sub-pixel edge feature extraction model based on polynomial fitting,and solve the problems of edge extraction and corrected scale measurement.

Keywords: Image segmentation;Edge extraction;Sub-pixel;Sliding window

1. Edge detection

We first binarize the image to obtain a binary image,and then perform edge point detection on the obtained image.First,we use SUSAN corner point detection,assuming that the edge point is a corner point,that is,the response value is severe Pixels that change and shape very drastically.Many features in the experimental image are ignored,so the detection accuracy is very low.We use Canny for edge detection,and the final test accuracy is still low.In the end,we use a polynomial fitting sub-pixel edge detection algorithm to get an image with obvious edges.Then we use the test picture in the question as the standard to determine the edge of the image For sub-pixel points with sharp contour color changes,a complete edge contour image and curve edge point data are obtained,and finally the total contour curve number and the number of points and length data on the curve are calculated and output.

1.1 SUSAN corner detection algorithm

We first use the traditional SUSAN corner detection algorithm to determine the USAN area by placing a circular template,count the number of core pixels,apply the corner response function and non-extreme suppression The method obtained the corner points of the image,that is,the”breakpoints”,and use these”breakpoints”to change the color,but because it detects too much Interference point.Next,we use the Canny algorithm to detect the edge points of the image.

1.2 Canny edge detection algorithm

When using the Canny edge detection algorithm to find the edge curve,we filter the image noise,calculate the gradient amplitude and direction after removing the influence of the edge burr,and suppress the gradient amplitude with non-maximum value,and then use the double threshold algorithm Perform detection and connect the edges,and finally suppress all weak but not strong edges through tracking.However,the edge of the image in the recognition frame cannot be completely detected.

1.3 Sub-pixel edge detection algorithm based on polynomial fitting

According to the pixel value distribution of the image,we use a cubic polynomial to fit the edge of the image to achieve sub-pixel positioning,pick points near the edge,and perform sub-pixeledge detection.

First,we use the Sobel operator to coarsely l ocate the edge of the image,and initially detect the edge of the image.According to the characteristics of the edge point,we take 3 points in the small neighborhoods on both sides of the edge point to construct the edge model function.Get the coordinates of the sub-pixel points and the coordinates and number of the edge points of the image,and get the complete image edge contour.

We use python to write a program to traverse the coordinates of all points,calculate the slope between the two points in pairs,and generate a slope data about the edge points of the image.Using the same method,we traverse this file,and make the difference between the slopes.

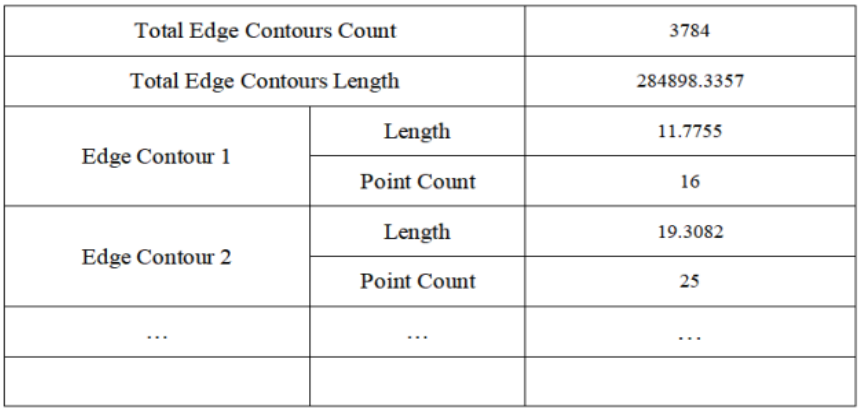
Here we useδto represent the difference in slopes.The next problem is to select a suitable threshold to determine the lower limit ofδto calibrate the critical point where the edge cont our color changes.In order to find this threshold,we have made a lot of attempts.

Next,we took the edge detection picture given in the question as the test picture,and conducted multiple tests to determine the threshold that can eventually reach the test picture standard.

Apply the final threshold to the three pictures to get the final edge contour curve.Finally,the length of the edge contour and the total edge contour number of Pic1_1 is output as shown in the tables:

2. Corrected scale measurement

We first use three calibration plate images with different angles to extract the contour and point features of multiple images in halcon to generate the camera coordinate system.Aftergettingthecalibratednon-distortioncalibrationboard,read in the picture to be tested,calculate the coordinates of the edge points through edge detection and mark them,use internal and external parameterstoconvertthetwo-dimensionalcoordinatesintothree-dimensionalcoordinates,calculate the deviation and get the contour of each edge Length,and finally calculate the total edge profile length.



Total Edge Contours Count		3784
Total Edge Contours Length		284898.3357
Edge Contour 1	Length	11.7755
	Point Count	16
Edge Contour 2	Length	19.3082
	Point Count	25
…	…	…

Table 1. Edge counter data output format

2.1 Distortion correction

The main types of camera distortion are radial distortion and tangential distortion.The radial distortion is caused by the shape defect of the lens,and the tangential distortion is caused by the non-parallelism of the lens and the imaging plane.Here we mainly study the tangential distortion.distortion.

First,complete the camera parameter setting in halcon according to the camera calibration model formula(1),where X,Y,and Z are real world coordinates;s is an unknown scale factor;K is the parameter matrix within the camera(K is two Matrix product),(u,v)is the pixel coordinates of the image coordinate system,f is the focal length of the pixel unit,and c is the center point of the image pixel.

$$s\begin{bmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} r_{11} & r_{12} & r_{13} & t_1 \\ r_{21} & r_{22} & r_{23} & t_2 \\ r_{31} & r_{32} & r_{33} & t_3 \end{bmatrix}\begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} \qquad (1)$$

After setting the parameters,we read 3 images of the calibration board taken from different angles,check all the calibration points in the image to determine the effective area of the calibration board,write the calibration program to complete the calibration of the calibration board,and finally save the internal and external parameters to the disk,And generate the final corrected and undistorted calibration plate image.

2.2 Image correction

After obtaining the calibrated calibration plate,we first need to"righten"the original image.We use linear regression and Hough transform to fit the bottom line of the image,and then calculate the inclination angle of 1°,and straighten the original image.Rotate the hour hand by 1°to get the normal image,and then we use the camera internal parameters and pose to complete the correction of the measured image,and create a projection map to describe the mapping between the picture to be measured and the plane Z of the coordinate axis system is zero,and we get the corrected test image.

2.3 Size measurement

Considering that the calibration board and the picture to be measured are at the same level,we decided to use the method of reference calculation.For objects on a flat target,we use Or1 to represent the physical radius of the circle on the left and right sides of the outermost edge,and Ol1 to represent the upper and lower straight lines of the outer edge The actual physical length of,using the same representation method,Or2 represents the actual physical radius of edge 2,Or3 represents the actual physical radius of edge 3,Ol4 represents the actual physical length of edge 4,Or5 represents the actual physical radius of edge 5,Or6 represents The actual physical arc length of the edge 6,and Ol6 represents the actual physical side length of the edge 6.

The calculation formula for each target size is as formula(2),where Ox is the actual size of the object to be measured,Ow is the pixel space size of the object to be measured,Cr is the pixel space size of the reference object,and R is the three-dimensional space size of the reference object,can be input from the outside world.

$$O_x = O_w * \frac{R}{C_r} \qquad (2)$$

Next,we use the multi-channel extraction algorithm in OpenCV to achieve the contour extraction of the target object,use the find Contours()function to complete the edge search of the target image,and finally get each contour edge curve to be measured.

Using the same edge curve function as in question 1,we traverse each target to be tested and the reference calibration board to obtain the pixel space size of each target,write the program and input the obtained data into formula(2),and finally get the required value The length of the edge contour is output to the Edge Contours Length Output table,and the solution is completed.

3. Conclusions

In the detection of image edge contours,we tested multiple algorithms including SUSAN corner detection and Canny edge detection,and finally selected the best polynomial fitting sub-pixel edge detection algorithm,the sub-pixel edge feature extraction algorithm based on polynomial fitting can identify each edge arc segment very accurately.We test the threshold of the slope transition of the edge point of the image to mark the threshold of the transition of the curve edge,and determine the use of different colors to draw the contour of the curve edge.

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