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APPLICATIONS OF REGION DEVELOPING FEATURE IN WHEEL IMAGE SEGMENTATION

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ABSTRACT

Online detection of protection orbit round as an important part of the train, the tread wear parameters traffic safety is important. Like the wheel of the measurement techniques based on optical screenshots Dimensions dynamic detection 'access to a complete round of the contour image is essential. For the round image features is proposed based on region developing the round image segmentation algorithm. Round of the algorithm according to the different circumstances of the image characteristics through the base point, select the appropriate seed points and determine the appropriate growth criteria. After region developing, effectively extract the wheel contour image. Through a large number of the image verification, the segmentation results of the algorithm figure overlap area ratio is greater than 82%, the misclassification error area ratio of less than 0.01%. Round extract can be effective in a variety of circumstances of the contour curve has good noise immunity.

Keywords: *Round of Testing, Image Segmentation, Regional Growth, Single Connection Area Growth*

1. INTRODUCTION

Online detection of protection orbit round as an important part of the train, the tread wear parameters traffic safety is important. Literature [1] is proposed based on the structure of light and image analysis of wheel wear parameters online testing method, the method uses the line structured light projected onto the wheel, as shown in Figure 1, where the white bright line is the line structure light in the wheel on the projector. The projection of the rim tread shape contour obtained by CCD wheel wear parameters obtained after image analysis. Parameters crucial to the accuracy of the results of the image analysis of wear, and its process for image segmentation, thinning, pixel tracking, as well as the parameters calculated. Which to obtain a complete round outline pictured key technologies.

Currently, China used to round multi-use image segmentation algorithm wide value method [2-3], which Otsu method Otsu [4-5] for the traditional image segmentation method is widely used. But after the experiment, Otsu's used in round image segmentation, consider the lack of correlation between the pixels in an image, the experimental results can not meet the actual demand. In this paper, the round image features a round of regional growth the image segmentation new algorithm ISAWRG (image segmentation algorithm of wheel region developing).

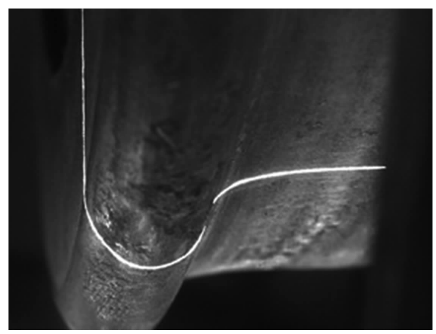

Figure 1: The Lines Structured Light Projector On The Wheel Set

Literature [6] can be seen in accordance with the definition of the image segmentation, image segmentation is the image is decomposed into a plurality of meaningful sub regions, but this decomposition is based on the object has a smooth uniform surface, and the image intensity is constant or slowly varying areas corresponding, i.e., each region having a certain uniform nature of literature [7]. Image segmentation method based on region developing directly similarity based on pre-determined criteria, to remove a number of characteristics similar to or the same as the pixel composition region [8-10]. Single connected region developing [11-14], region developing method is used more often than that in this growth pattern.

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2. WHEEL ON THE IMAGE CHARACTERISTICS

Round the image acquisition process, the different light intensities and outside interference causes the image gray dynamic changes in different target image the grayscale distribution and noise intensity varies. Figure 2(a) the background intensity weak wheel on the image, Figure 3(a) its histogram; Figure 2(b) is a standard wheel, Figure 3(b) of the image to its histogram; Figure 2(c) is a strong background intensity of the wheel on the image, Figure 3(c) its histogram. It can be seen from Figure 3, and the background pixel proportion of large, distributed largely in the area grayscale value is less than 50. Foreground pixels proportion less reaction foreground pixel gray value distribution for clarity, only the statistical gray value of not less than 50 pixels. The obtain histogram shown in Figure 4.

The wheel has the following main features:

1) Noise round the complex structure itself will be reflective, coupled with the impact of natural light, the noise distribution more random, and the relatively wide distribution. But the noise is mainly concentrated in the rim around the tread and the rim is the most sensitive part of the light. When the interference light is strong, the parts are first be noise generated interference strength will generate different intensity noise.

2) Background characteristics of the whole background pixel gray value distribution are more concentrated, clearly showing the clustering phenomenon.

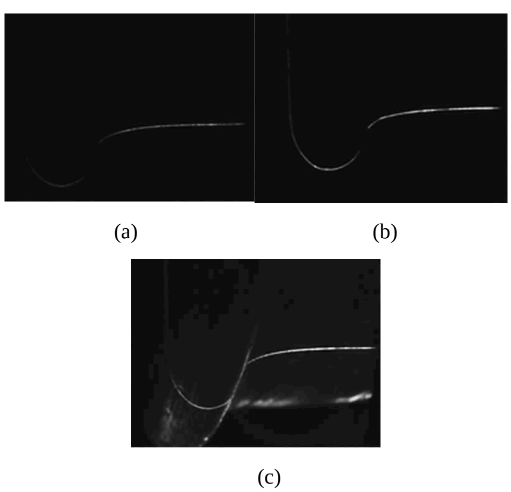

Figure 2: Background Intensity Of The Same Wheel Set On The Image

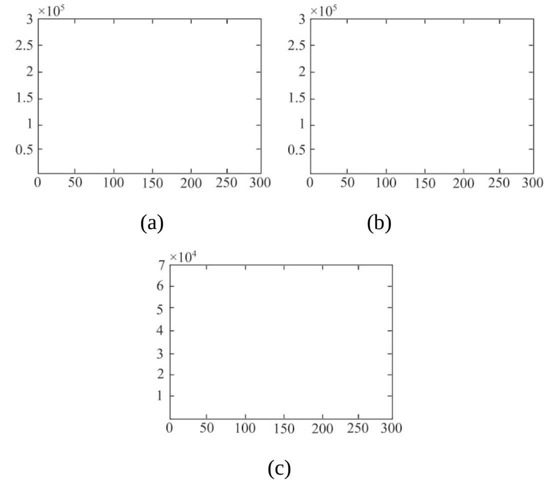

Figure 3: Figure 2 corresponds to the histogram

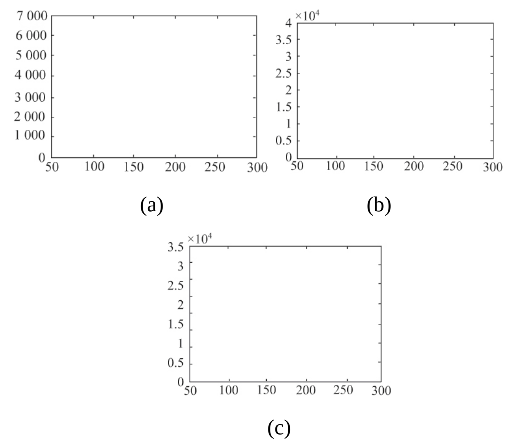

Figure 4: Only Statistical Gray Scale Value Is Not Less Than 50 Pixels Resulting Histogram

3. IMAGE SEGMENTATION ALGORITHM BASED ON REGION DEVELOPING ROUND

Fore-ground object light in the wheel for the wire structure on the projection shown in Figure 1 of a white bright line. Combining round growth characteristics of the image using the single connection area proposed image segmentation algorithm based on region developing round, each pixel in the image as a node in the connection diagram, and then, in accordance with certain growth criteria characteristics similar pixel node merge join up. Growth criteria are compared two gray differences between the adjacent pixels, set the width value is less than merge them to generate a new seed point.

2.1 The Growth Object Of Select

As can be seen from Figure 3 and Figure 4 histogram, a high degree of similarity of the

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background pixel, the gray value distribution is relatively concentrated, rendered obvious clustering phenomenon. Round image features selected background pixels of reverse thinking growth, the use of regional growth statistics, are isolated background set of points. Growing Point pixel gray value is set to 0, growing point, i.e. the foreground pixel gray level value is set to 255, in order to achieve the separation of the foreground and background.

2.2 Seed Selection

The seed should not select a relatively high pixel in the gray value in statistics classes, but also should not select relatively low gray value pixels, it should be more appropriate to select the pixels close to the center of gravity of clustering [15]. The wheel of the image concerned, P_{Base} is the distance of 70 millimeter of the rim inner side tread surface of the point [16], is an important point in the image. The distribution of the noise is a gradual transition from the rim portion to the tread portion. Therefore, a gradation value of the point P_{Base} will not be at the ends of the distribution of the gray value of the cluster, but the intermediate section. P_{Base} is near background pixels can be selected for seed point P_{Seed}. One is the search range α of P_{Base}. P_{Base} is the position of the follower wheel diameter size of the dynamic changes, there is a change in α, Let $\alpha=\{(x,y)\mid x_{\min}\le x\le x_{\max}, y_{\min}\le y\le y_{\max}\}$; second search range of γ in P_{Seed}, defined in the paper $\gamma=\{(x,y)\mid x_{\min}\le x\le x_{\max}, y_{P_{Base}}+L\le y\le y_{\max}\}$, wherein, $y_{P_{Base}}$ is the ordinate of P_{Base}, L for the partial the shift amount is greater than the vertical distance of P_{Base} to round the edge of the profile curve. Therefore, $\gamma\subset\alpha$, as shown in Figure 5.

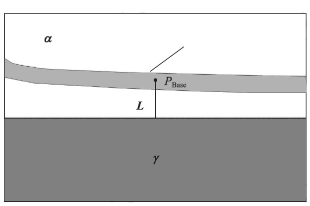

Figure 5: The Range Of α And γ Is A Schematic Diagram

1) Determining the position basis points

As the wheel diameter size dynamically change due to the position of P_{Base}, it can determine P_{Base}'s trajectory curve, the curve is monotonic and continuous. Known $P_{Base}\subset\alpha$, then P_{Base} abscissa collection $A=\{x\mid x_{\min}\le x\le x_{\max}\}$ set of ordinate B satisfy the correspondence mapping: A→B, then $B=\{y\mid y=h(x), x\in A\}$. Regional α segmentation, refinement and least-squares fitting the region α wheel of contour curves single-pixel monotonic continuous function. C and collection of the range of the function A satisfies correspondence mapping z : A → C, then $C=\{y\mid y=z(x), x\in A\}$. These two functions are monotone continuous exclude parallel, there is a point of intersection P_{Base} is this intersection. Let h^{-1} mapping inverse mapping.

$$P_{Base}=\{(x,y)\mid y=B\cap C, x=h^{-1}(y)\} \quad (1)$$

2) Determine the location of the seed

In order to select the appropriate seed point, can select γ near the average gray value of a given pixel point. A seed point search area γ size is $M\times N$, γ at any point in a $f(x,y)$ of the gray value of (x,y), calculated the average gray value of γ.

$$m_\gamma=\frac{1}{MN}\sum_{(x,y)\in\gamma} f(x,y) \quad (2)$$

Expand the area γ pixel matrix was the matrix:

$$\gamma=\begin{bmatrix}(x_0,y_0),(x_0,y_1),\ldots,(x_0,y_M), \\ (x_1,y_0),(x_1,y_1),\ldots,(x_1,y_M)\ldots, \\ (x_N,y_1),\ldots,(x_N,y_M)\end{bmatrix}$$

The point by point calculation of the gray value of each pixel and m_γ poor $f_D(x,y)=|f(x,y)-m_\gamma|$, if found to a certain point (x_s,y_s) satisfies

$$f_D(x_s,y_s)\le km_\gamma \quad (3)$$

Stop the operation of subsequent points, the point (x_s,y_s) is satisfied for the seed point P_{Seed}, where k is an adjustable parameter.

2.3 Determining The Growth Criteria

The algorithm uses a single connection regional growth, growth criterion: consider the pixels within

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the neighborhood points and the absolute value of the difference of the current seed pixel gray value less than or equal to the threshold of T. It can be seen from Figure 2 that the wheel on the gradation value of the image background distribution due to the light conditions and interference exhibit different distributions. It is difficult to choose a suitable and generic growth threshold. Based on the wheel on the image characteristics, according to the average grayscale value m_R of the pixels in the rim region R, and dynamically determine the growth threshold value of T. If m_R is less than m_1, background intensity is weak, the growth of broad value minus t m_R greater than m_2, the background intensity, the growth of broad value increases t. If m_R between m_1 and m_2, to retain the initial growth threshold.

Let R be the number of pixels for the N_R, $f(x,y)$ is the gradation value of each pixel of the R zone, the average grayscale value of all the pixels in the calculation region R.

$$m_R = \frac{1}{N_R}\sum_R f(x,y) \quad (4)$$

$$T = T_0 + \frac{\operatorname{sgn}(m_R - m_1) + \operatorname{sgn}(m_R - m_2)}{2} \times \Delta t \quad (5)$$

Wherein, m_1 and m_2, a non-negative parameter, $m_1 < m_2$, determined by experiment. T_0 is the initial width value, Δt is a step length.

Finally, the growth criteria for consideration in the neighborhood D pixel $(x_r, y_r) \in D$ with the current seed pixel (x_s, y_s) the gray value of the absolute value of the difference is less than or equal to a gate limit T, i.e.

$$\left| f(x_s, y_s) - f(x_r, y_r) \right| \le T \quad (6)$$

$$D = \begin{bmatrix} (x_s-1, y_s-1), (x_s-1, y_s), (x_s-1, y_s+1), \\ (x_s, y_s-1), (x_s, y_s+1), (x_s+1, y_s-1), \\ (x_s+1, y_s), (x_s+1, y_s+1) \end{bmatrix}$$

2.3 Program Design Process

According to the algorithm described above, the program flow is:

1) To search P_{Base}, by the formula (1) search P_{Base}, it is determined whether it satisfies $P_{Base} \in \alpha$, and if satisfied, then return to the coordinates of P_{Base}, otherwise exit the algorithm;

2) To determine the P_{Seed} and growth criteria by P_{Base} determining γ and R, and according to formula (2) and (3) determine P_{Seed}, by the formula (4) and (5) calculated growth door limit T-last in accordance with formula (6) determining the growth criteria;

3) Progressive scan image progressive scan, identify the pixels not yet vest;

4) Check the neighborhood D seed points as the center, check one neighborhood pixel grayscale values meet growth standards, to meet the then merge them to seed the queue, to be the next growth point and make the gray value $f(x,y)=0$, otherwise let $f(x,y)=255$;

5) Outward growth of newly merged pixels for the center, go back to step 4), check the new pixel neighborhood until the area can not be expanded further;

6) Growth terminated, return to step 3), to continue scanning until a pixel does not belong can not be found, the end of the entire growth process.

4. COMPARISON ISAWRG WITH OTSU

4.1 Segmentation Results Contrast

Based on the above, the use of VC++ 6.0 ISAWRG algorithm, experiment, take L=10, k=0.1, m_1=8, m_2=18, T_0=10, $\Delta t = 6$. The experimental image size 764×576 (coordinates into screen coordinates, in pixels). Figure 6(a) of Figure 2(a) ISAWRG segmentation result, the seed point $(x_s, y_s) = (593, 357)$, T=4; Figure 6(b) of Figure 2(b) ISAWRG segmentation result, the seed point $(x_s, y_s) = (598 \times 311)$, T=10; Figure 6(c) of Figure 2(c) ISAWRG segmentation results, $(x_s, y_s) = (609, 286)$, T=16. Figure 7 is the Otsu segmentation results in Figure 2 corresponding image.

Compare Figure 6 and Figure 7 can be seen, the wheel on the results of the image segmentation algorithm based on region developing significantly better than in the human visual Otsu algorithm.

4.2 Segmentation Results Contrast

In order to measure the effectiveness of the segmentation algorithm, this article from the correct segmentation area and error segmentation of area

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both comprehensive evaluation of segmentation methods, define evaluation criteria are as follows.

(a) (b)

(c)

Figure 6: ISAWRG Segmentation Results

(a) (b)

(c)

Figure 7: OTUS Segmentation Results

Overlap area ratio is $E_{cor} = \frac{S_{P\cap Q}}{S_Q} \times 100\%$.

Misclassification area ratio is $E_{err} = \frac{S_E}{S} \times 100\%$.

In the formula, P algorithm for automatic segmentation is obtained through the target area; Q artificial manual segmentation of the object region, expected to get the target area; automatic $S_{P\cap Q}$ extraction area and expect to receive regional intersection area; S_E error segmentation area, namely the intersection outside the region segmentation results area; S for wheel set image area. Apparently, E_{cor} bigger shows the algorithm for automatic segmentation is obtained through the target area closer to the target 's real situation, E_{err} more novel Ming error segmentation pixel number less, namely E_{err} bigger is better, the smaller the better. Table 1 lists the figure 3 images respectively by ISAWRG and Otsu after segmentation of E_{cor} and E_{err} results.

Table I: Evaluation Of Segmentation Results

图2	ISAWRG		Ostu	
	E_{cor}	E_{err}	E_{cor}	E_{err}
(a)	91.8	0	26.1	0
(b)	94.3	0	46.3	0
(c)	82.1	0.01	78.3	1.26

For Figure 2(a) and 2(b), either ISAWRG or Otsu has over-segmentation phenomenon, there is no belong to the background pixels as foreground pixels have been misclassified case, so E_{err} is 0. From Table 1 income data shows ISAWRG algorithm does have obvious advantages. Through to the 341 round image repeated experiments, we can conclude that the similar results.

4.3 The Analysis Of Experimental Results

Through the above results, the proposed algorithm advantages as follows:

1) Effective extraction of wheel contour curve, ISAWRG can adapt to a variety of light intensity. When the light is weak, as shown in Figure 2(a), Otsu algorithm can hardly recognize intracellular side portion of the target, ISAWRG still can effectively extract the portion of the target.

2) Strong anti-jamming ability, for Figure 2(c), as part of the background and target presence of gray level crossing, Otsu in dividing the target will also many pixel of the background into the wrong target pixel, so that the target submerged in the background; and ISAWRG in considering the image global and local information based on after segmentation, after a large number of background information filtering.

3) More conducive to wear parameter calculation, since 1) and 2) two big characteristics, ISAWRG results, the target information preserved, noise suppression, is conducive to the further abrasion parameters measurement. The above ISAWRG and Otsu show, ISAWRG has obvious advantages. After a series of images to the repeated verification, the results are effective extraction of the wheel contour curve, satisfy the requirements of wear parameter calculation.

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5. CONCLUSIONS

A detailed analysis of the wheel set image characteristic, discussed based on region developing image segmentation algorithm for wheel, wheel image characteristic, elaborates the algorithm growth object selection. And in accordance with the wheel image target strength and noise intensity, diversity, through the point position properly in the seed point selection and growth standards establishment.

The experiment proved the feasibility and superiority, and the algorithm and the Otsu algorithm the experiment result in comparison and analysis. It was proved by experiments, proves that the algorithm can be on different intensity of illumination and noise interference by complete extraction of wheel contour curve, can meet the requirements on image segmentation.

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