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A Frantic Jumble Rail Fastener Precise Positioning Algorithm Research

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Abstract: Due to the driving safety requirements, rail line must have a high precision parameters of geometric line. The accuracy positioning of orbital characteristics directly affect the geometry line of precision. In order to solve this problem,building track image model combined with the feature of a frantic jumble orbit.The gray image edge detection and binarization, then using the method of projection and the cross positioning method determine the approximate scope of fasteners. Finally,using template matching algorithm based on mutual information accurate positioning fasteners.the experimental results show that this algorithm achieve a good results.
Keywords: orbital characteristics;Mutual information;canny operator.gray matching

I. INTRODUCTION

Rail is the basis of locomotive vehicle running.Track geometry linear affect the security and comfortable of locomotive running. The accurate positioning of orbital characteristics is the premise to obtain accurate parameters of track geometry linear. Traditional inspection and identification of rail fastener is used to edge detection and boundary tracking description or matching method of pattern recognition and so on. Literature [1] using external light source,processing light source image realize the pattern recognition of Fasteners.Literature [2] describe characteristics of fastener in the HOG histogram. Identify fastener in hamming distance of the adjacent algorithm. Literature [3] using video image processing detect recognition fasteners, puts forward the algorithm based on region statistics highlight locate at the edge of rail and sleeper, and use the relative location of fasteners of prior knowledge to realize positioning extraction of fasteners. To cut out the area of the fasteners use PCA dimension reduction method to extract feature of fastener. Gallery established fastener pattern recognition training and testing gallery, using nearest neighbor classifier achieved the identification of the fastener deficiency.But the recognition rate is low.Literature [4] against the United States track from coarse to fine the test strategy, test track first, and then detect spikes on either side of the tracks.Due to the differences between China and the United States track structure, the method of literature [4] in the difficult to directly used in domestic rail fastener detection.The above literature research is mainly to pattern recognition of fasteners, this article mainly to precise positioning of a frantic jumble rail fastener, late in order to accurately obtain the track geometry line line parameters.First design image model, according to the rail and the sleeper gray information with the improved Canny operator to distinguish the rail, sleeper and DaoZha area, coarse position obtained by projection and cross fasteners.Finally template matching based on mutual information can realize accurate position of fasteners.

II. BUILD A MODEL OF TAKING ORBITAL IMAGES

According to the needs of principle , should meet the following requirements when filming orbit, 1) single image to include sleeper, steel, fasteners.2) continuous shooting images of public area contains at least one fastener.3) public area contains at least one camera image fasteners.4) before and after, recording images about fastener size consistent as far as possible, reduce the distortion.Orbital images based on the above consideration, design model, as shown fig.1.

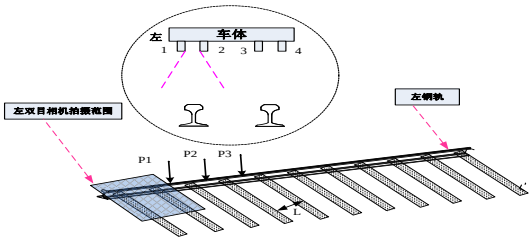


Fig.1 The model of taking image of orbit

Model use 4 CCD camera, 960 * 712 resolution, camera distribution in on both sides of the car body and vertical light rail surface, on both sides of the binocular cameras distributed on both sides of the rail to ensure fastener distortion is minimal.Single image on both sides of shooting range includes two sleeper, rail and fasteners, continuous image position from the sleeper spacing L = 700 mm, as shown in fig.1 (P1, P2, P3) location.The camera height is 600 mm, the size of the image of the actual 665mm * 1250 mm.

III. FASTENER AREA COARSE LOCATION AND EXTRACTION

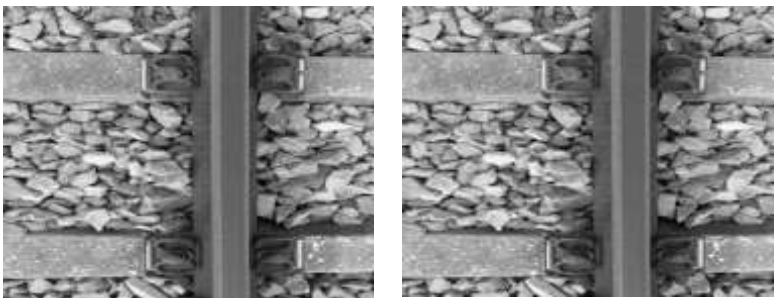
Because the gathering image contains the sleeper, rail, DaoZha area, such as if the whole image directly to buckle template positioning, cloud to calculate quantity and interference factors.So you need to determine the fastener roughly the area.

Realizing a coarse positioning fasteners regions is the key in the original image is accurate positioning the location of the rail and sleeper.On the way to actually have a frantic jumble railway collection and image analysis. Founding the rail, sleeper, and yesterday have different texture features, there are obvious difference between each other.Rail and sleeper positioning based on these characteristics and some special analysis method in image proce- ssing . Coarse positioning fasteners area by the position of the rail and the sleeper, and among the position relationship between prior knowledge to decide.Basic steps are as follows:

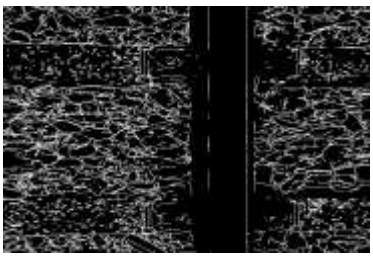
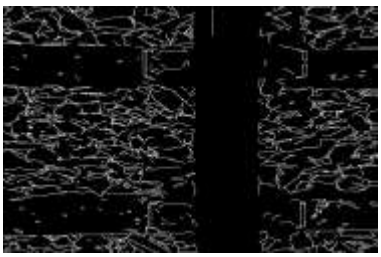
1) selecting a suitable edge detection operator to image edge detection and binarization
2) a horizontal direction and vertical direction of edge detection image projection
3) area scanning method was used to sleeper width of pixels for width, from left to right on the horizontal projection area scanning white spot pixel number, the minimum value for sleeper left border, same method area statistics scan from right to left, the right boundary of the rail.
4) rail pixel width as the width, using the same method on the vertical projection area scan statistics, rail around the border.
5) according to the prior knowledge extraction fastener roughly the area.

2.1 Edge detection

Image edge is one of the basic features, often contain a lot of useful information.Image edge is local charact- eristics of discontinuity, such as the pixel values of the mutation, texture structure mutation.Edge widely exists bet- ween different goals, is the important basis of image segmentation.Commonly used edge gradient operator with Roberts operator, Sobel operator and Canny operator, etc.This article mainly carries on the comparison to these three gradient edge operator, selecting suitable edge detection operator to deal with the image.



(a) the original image **(b)** gaussian transform image

(c) Prewitt operator (d) Roberts operator

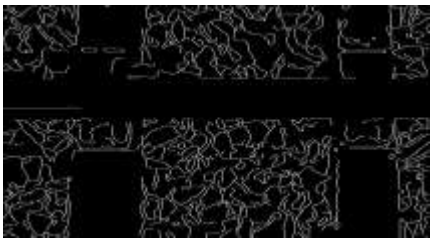
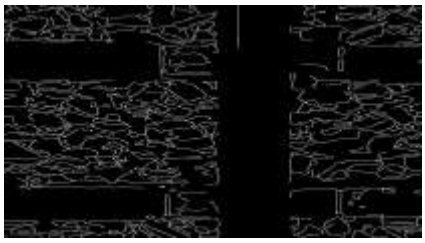

(e) Sobel operator (f) Canny operator

Fig. 2 Effect of image edge detection

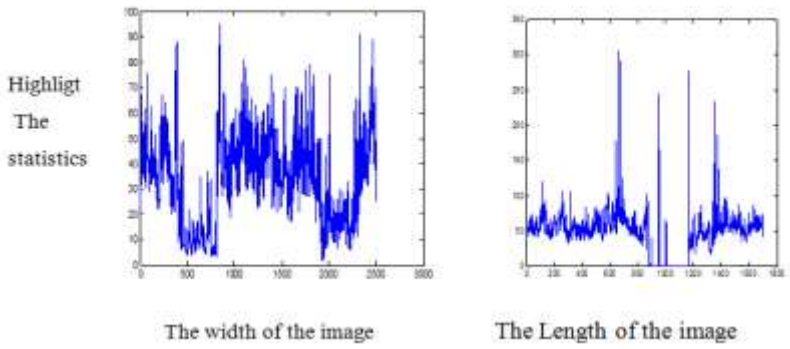
Fig. 2 illustrates the Canny edge detection operator, Canny edge detection operator is a kind of multi-stage optimization operator, has both can filter out noise and can keep the edge detection of image edge feature optimal filter.This paper choose Canny edge detection operator image processing.

2.2 rail and sleeper positioning

In view of the image, this paper sleeper width is about 400 pixels, the rail width is about 290.The original image through gaussian transform and Canny edge detection, based on the projection in horizontal and vertical direction.As shown in figure

(a) horizontal Canny Canny edge detection **(b)** a vertical edge detection

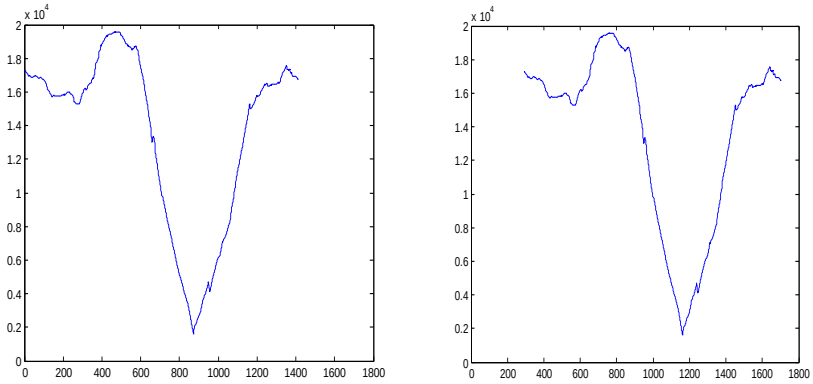


(c) horizontal projection **(d)** vertical projection

Fig. 3 Edge detection and projection

According to above changes can be seen through the window statistical projection edge, will highlight total sum within a certain width, and then from the left and right, respectively, in turn, scan.The minimum value is the left and right border.Region respectively as the width of the rail, sleeper width of pixel number.By the original image, the image contains two sleeper, therefore, will get four minimum area scan, respectively, two sleeper left and right border.Horizontal area scan results in figure 4 (a) and (b), the first sleeper around the boundary of 400 and 800, around the second sleeper boundary for 1910 and 2310, and obtained sleeper width to 400 pixels, vertical scanning area scan result is shown in figure 5 (a), (b), rail around the boundary of 870 and 1160.The rail width to 290 pixels.

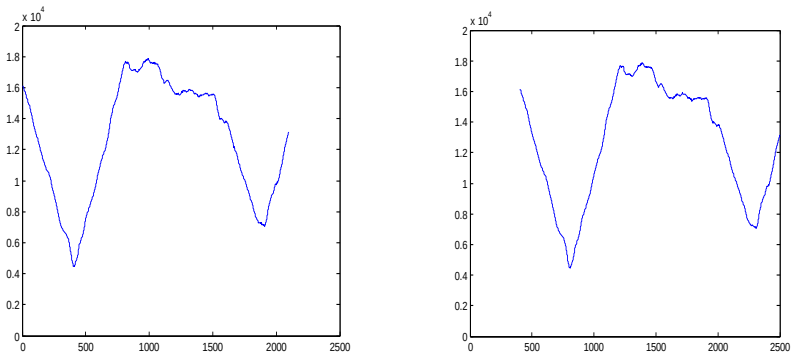
Area The Domain Bright Point System Meter



The Length of the image The Length of the image

(a) from left to right scan results **(b)** scans the area from right to left

Fig. 4 Vertical projection area scan results



The width of the image The width of the image

(a) from left to right scan results **(b)** scans the area from right to left

Fig. 5 horizontal projection area scan results

According to the prior knowledge to determine (relationship between rail fastener width) fasteners roughly the area.In order to facilitate calculation unity will buckle width to 210 pixels.Fastener area was determined by the edges and prior knowledge, as shown in fig.6.

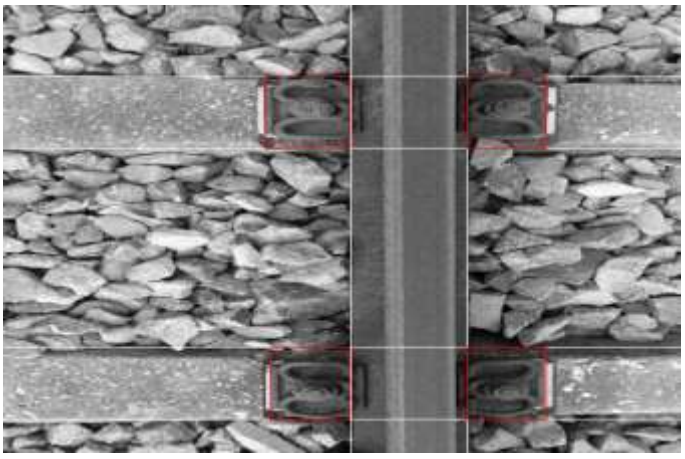


Fig. 6 fastener area

III. FASTENERS POSITION ACCURATE POSITIONING

As shown in figure 6, on both sides of rail fastener in rail and the sleeper, determine the position of rail and sleeper also determines the fastener roughly the area, according to the environment, we use mutual information template matching algorithm is accurate location of fasteners.Multi-source image grayscale distribution has a certain similarity, mutual information being able to measure 2 image grayscale statistics, once it has been widely used in the field are put forward.

Suppose that a system A exists N a different events $N = \{X_1, X_2, \cdots X_N\}$, the probability distribution of each event is $P = \{P_1, P_2, \cdots P_N\}$, then the system entropy is defined as $H(A) = -\sum P(A)\log P(a)$: To match two images, can think about the image gray scale random variable is set, Orders, $P_A(a)$; $P_B(b)$;and $P_{AB}(a, b)$ were gray histogram and their joint histogram, Studholme between it and the normalized mutual information to measure formula

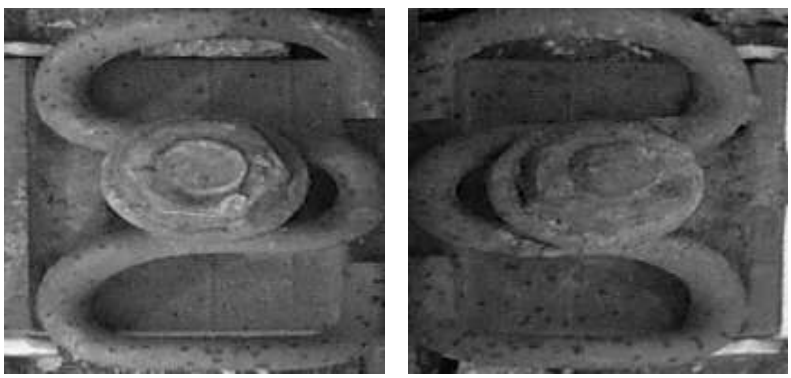
$$Y(A, B) = \frac{H(A) + H(B)}{H(A, B)}$$

其中

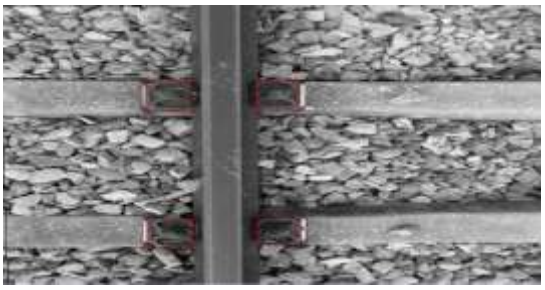
$$H(A, B) = -\sum_{a,b} P_{A,B}(a, b) \log P_{A,B}(a, b)$$

A And B the joint entropy.Matching the template diagram in fig.3 (a) in each position of black box to search, use the formula (3) calculate the mutual information of corresponding position with the location of the maximum mutual information is the best matching position, namely the precise location of fasteners.Because fasteners around the image is different, so the fastener template in left and right sides of the track, as shown in figure (a), (b) the left and on the right side of the fastener fastener template template respectively, and the figure

7 (c) a fastener accurate positioning.



(a)the left side of the fastener template **(b)** the right side of the fastener template



(c) fasteners accurate positioning
Fig.7 fastener location map

V. THE EXPERIMENTAL RESULTS AND ANALYSIS

In order to verify the validity of the algorithm in this paper, in view of this paper, the research content, from Shanghai longyang road base gathering image, the experiment using a PC, Windows 7 system, programming environment of Matlab software, the test image, a total of 500 pieces, a total of 2000 fasteners.This article algorithm comparing with the method of literature [5], table 1 for comparison method in accuracy and time.Can be seen from the result of the experiment, the algorithm of this paper to positioning of fasteners, there are 1956 fasteners to achieve the correct positioning, error for 44, this paper analyzes the reasons of error orientation is primarily a fastener be DaoZha serious, affect the positioning fasteners.From the run time can be found, if combined with external hardware development and the test speed limit, this algorithm can completely satisfy the real-time positioning detection.

Table 1 algorithm is compared with the literature [5] algorithm in this paper

	The elapsed time	accuracy
In this paper algorithm	299	69.8%
Literature algorithm	456	97.8%

VI. CONCLUSION

With the rapid development in high-speed railway track subsidence has become an important factor affecting the safety of railway, therefore, to realize accurate positioning of fastener is the important parameter for track geometry line, this article is based on the from coarse to fine strategy, according to the edge of rail and sleeper information, locating the sleeper area of the general location, and adopts template matching method based on mutual information and position to the precise location of fasteners.Through the test, for stable shooting environment, fastener shade than serious images, this algorithm can achieve rapid positioning.For some complex environment need to be researched.

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