Steel surface pit defect detection algorithm research based on trigonometric function

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Abstract

In order to inspect steel surface pit defects, this paper proposed a in-time detection algorithm based on trigonometric function. This algorithm calculates Similarity degree between detection area and pit defects. The suspicious pixels are obtained then. Afterwards, the area in which the suspicious pixels are is judged that whether this area has pit defects. Experiments results indicate that the algorithm in this paper has a high detection rate for pit defects while a low error detection. This can guarantee the accurate detection for steel surface pit defects.

Keywords

Steel surface, pit defect detection, trigonometric function.

1. Introduction

As a important raw material of machine part, steel rod is a main product in current steel industry. So the quality of steel rod is very significant. But because of the low processing level in our country, many high quality steel product still needs import from other country. In the process of produce steel rod, the product generates some defects as a result of the bad maching equipment. For instance, pit, scratch, and so on [1, 2]. This can be seen in Fig.1.

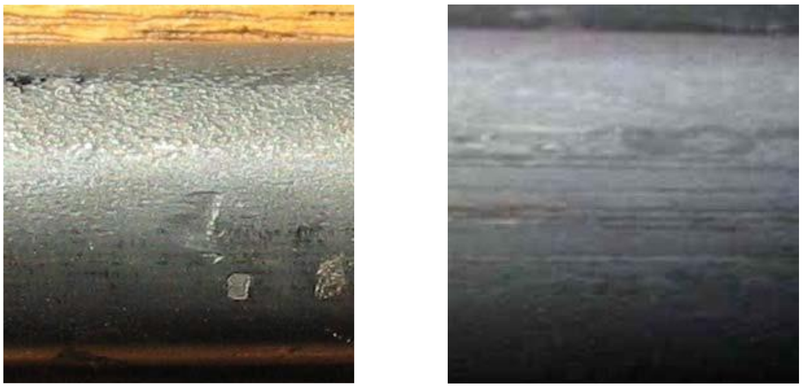

Fig. 1 Steel rod surface defects

Realization of the rod's online surface defects detection and finding out the causes become the key link of quality control and process improvement, besides, it can provide data support for the following quality rating, reducing the workers' labor intensity and improving the production efficiency. The technology of machine vision has high speed detection and accuracy [3, 4]. Besides, it can reappear the situation of production surface quality. So many companies make a huge investment to research this technology. So far, the detection technology for hot rolled steel bar surface defects based on machine vision is well-established in developed countries, and they have had relative detection system being in use. However, the research in this field of our country just started and has large gaps with developed country. This affects the market competitiveness of our country's hot steel bar product to some degree. So the develop and research of this technology is in urgent need.

2. Analysis of steel rod surface pit defect

Through statistics, the steel rod surface image has some characteristics.

The image contains a lot of black background information on both sides, which will decrease the accuracy of defect detection. So we need to segment images. This can remove unwanted background images and retain the bar surface information.

Because of the existence of diameter machining error and up to down beating of the rod during process, the image of the rod surface has a certain distortion, so we need to align the rob (or straighten the rod) to test easier. The vibration factor makes the most of the red steel reflected light can't enter into the camera which shows a dark color. Only a little part of light can get into the camera and form a brighter area. The reflected light can't enter the red steel part of the camera in a gray color in the image, for this reason the detection difficulty is increased. Because the contrast ratio of dark area is less obvious, so the difficulty of detect detection is increased.

Camera has disturbance and loss of signal during collecting images, so there are noisy signal and other interference factors in the image. This noise needs to be reduced.

Gray value is lower in the dent defect place than in surrounding. Surface defect and background gray value have great differences in different background luminance, so it is difficult to detect it by simply using contrast. In addition, the margin of dent defect is not obvious, so it is difficult to effectively find defect by using easy method of detecting the margin.

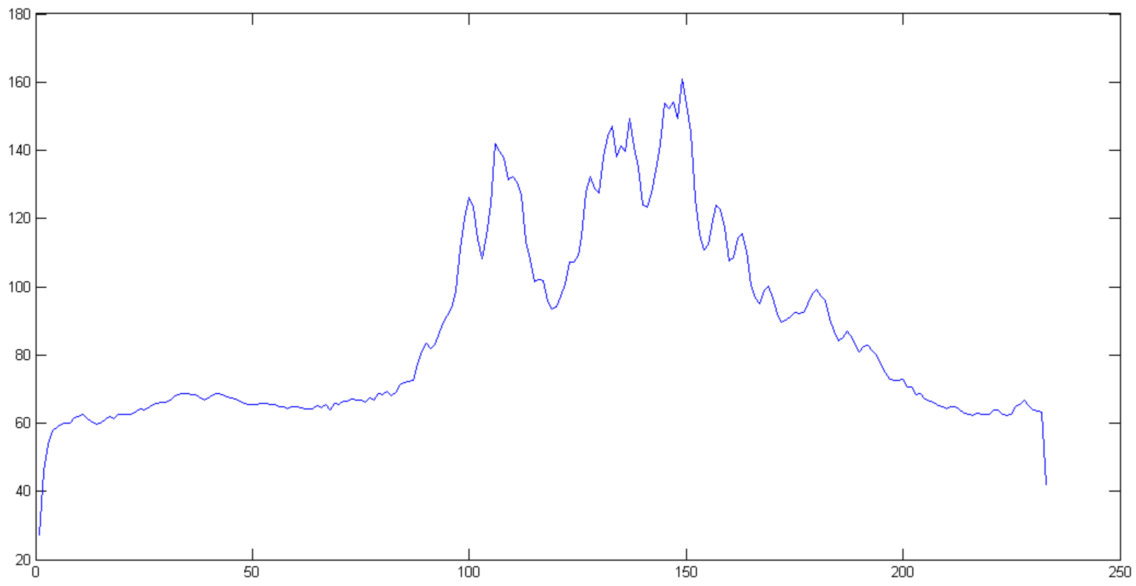

Fig. 2 Row pixel gray distribution of steel rod surface with pit defect

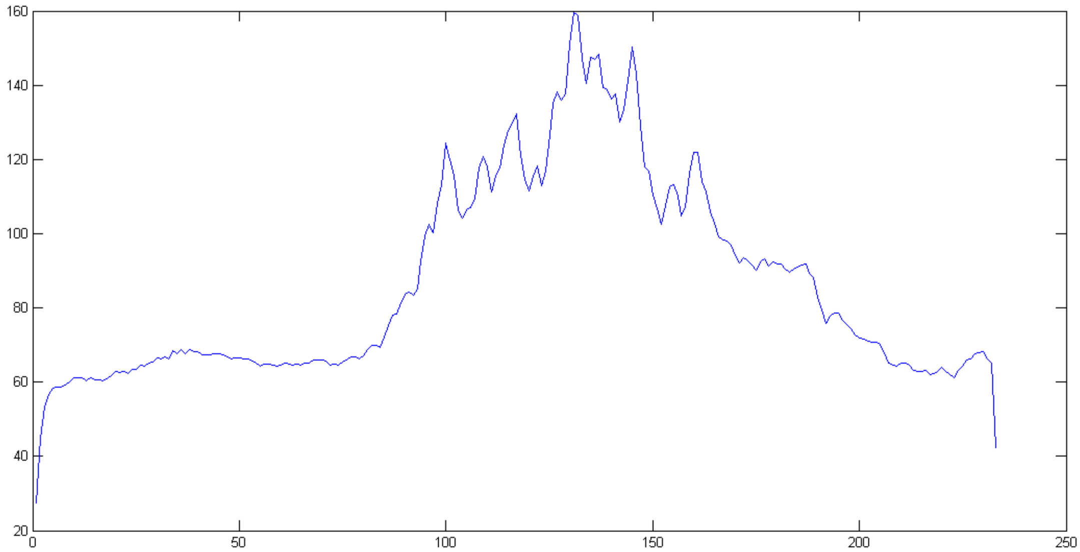

Fig. 3 Row pixel gray distribution of steel rod surface with no defect

By analyzing indentation defect characteristics, we found that most one dimensional shape is like shown in Fig.2. In the middle of dent area, pixel gray value is low, but gray value gradually become higher in the two sides and much noisy signal has this similar character. As is shown in the Fig.3, the gray value of marked noisy signal is also low in the middle area and it is high in the two sides. So it is difficult to simply use line pixel or the column of pixels to determine whether there is dent defect. Additional analysis finds that dent defects all have the above properties in the horizontal and vertical, but noisy signal only has this similar character in some signal direction. So it is difficult to detect picture for dent according to the difference between dent defect and noisy signal. This chapter determines dent defect at the same time in the horizontal and vertical of chart. The Fig.4 is a three-dimensional distribution map which contains defect of red steel surface. As we can see from the figure, dent area has obvious color transformation. Therefore, detection in the two-dimensional direction is obviously better than the detection in the one-dimensional direction.

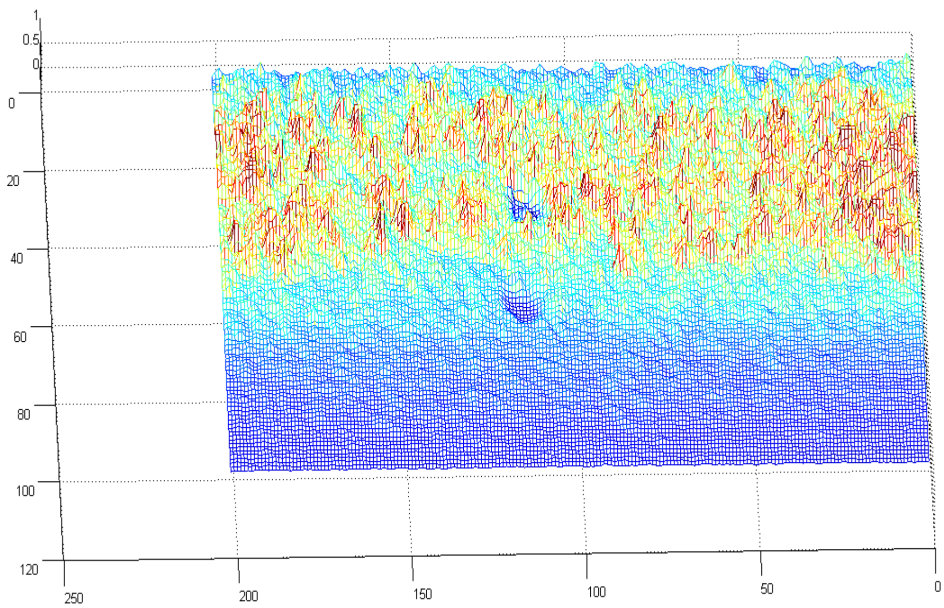

Fig. 4 Three-dimensional distribution of steel rod surface with pit defect

3. Pit defect detection algorithm

Quadratic function image has an explicit analysis expression, but it has no periodicity. The integration of the product of the constant function and it is not equal to zero. And the shape of the pit has some discrepancy with the dent defect on the image of the surface of the red steel. The pit shape is slender in the defect and the slope is usually steep. The numeric value of the quadratic function changes slowly and the slope is small. It falls short of the characteristics of indentation defect. Sym6 wavelet has the characteristics of steep slope and the integration of the product of the constant function with it is equal to zero. But it has not an explicit analysis expression. And it is difficult to calculate convolution with image pixel point. The sinusoidal function is most consistent with the shape characteristics of the dent defect and the integration of the product of the constant function with it is equal to zero. This can eliminate the effect of flat area in image on defect detection. But the noise still has a certain impact on it. This will introduce the relevant algorithms to eliminate the impact.

In summary, a sinusoidal function of one cycle in this article as shown in Fig.5 is selected as a kernel function. The function is easy and its integral is zero in one cycle. This ensures that the smooth part of the image has a smaller sinusoidal response value, and the convolution value is larger in the position area similar to the shape of the dent.

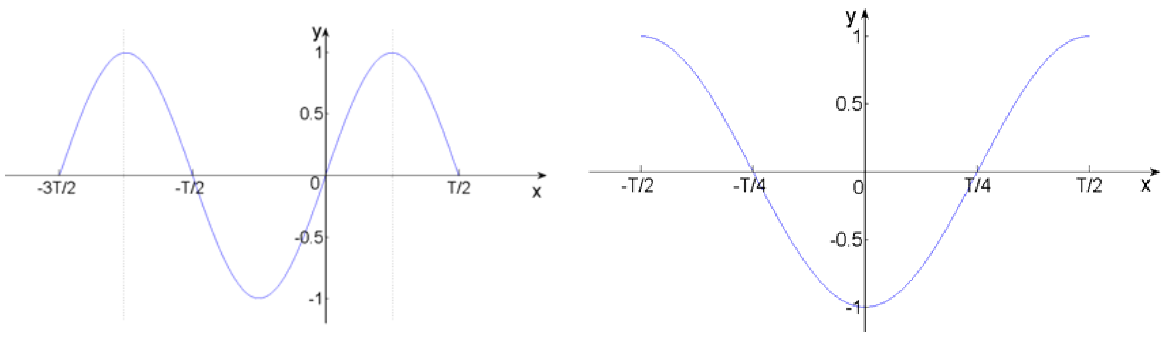

Fig. 5 Sinusoidal kernel function for detect pit defect

To pit defects, the minimum gray value usually appears at its center. In order to guarantee a large sinusoidal response value in the indentation defect, we shifted the sine function to the right by a quarter of a period in this article. As is show in Fig.5, the minimum gray value point of the indentation defect can corresponds to the lowest point of the sine function. In addition, the frequency choice of sine is also very important. This depends on the size of the indentation detection. Large size is easy to remove noise interference, but it is easy to miss small indentation defects and it takes a long time to calculate. Small size means that calculation quantity is small. Moreover, there is a large sinusoidal response for indentation defects of size, but it is easy to be influenced by noise and lead to wrong judgment. There for it is necessary to consider the accuracy and rapidity of the detection for the periodic selection of sine function.

There are two types of indentation defects in the image of the actual bar surface. One is that the background gray level of the defect is relatively uniform, as is shown in the first defect in Fig.6. Another defect is the background in the twilight zone. This is also shown in Fig.6.

Fig. 6 Gray level situation of steel rod surface pit defect

4. Experiment results and analysis

In order to verify the effectiveness of the proposed algorithm, we use error detection rate and miss detection rate to test the performance of it. 2130 non-defect images and 35 pit-defect images are chosen to this experiment. The test result is shown in Table 1.

Table 1 Algorithm test results

Image of detection	Test results		
	success	failure	accuracy
defective	34	1	94.28%
Non-defects	2127	3	99.86%

As we can see from table 1, the algorithm proposed in this paper has higher detection rate to the pit defect on steel rod surface while has low error detection rate.

5. Conclusion

The pit defect detection algorithm proposed in this paper based on trigonometric function has an advantage of easily calculation. And it can find the suspicious pixels accurately. This algorithm is insensitive to noise and easily used. Its disadvantage is that it can only detect image with one pit defect. This algorithm is only used to inspect pit defect. This is its fault. We would consider new method to detect more defects in one algorithm in the future.

Acknowledgements

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