Fast Position and Accurate Segmentation Algorithms for Detecting Surface Defects of the Thermal-State Heavy Rail Based on Machine Vision

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ABSTRACT

Color imaging in the hot rolled condition provides the better reaction of heavy rail on surface defects. In this paper, it proposes a series of novel algorithms of accurate position and segmentation of surface defects of heavy rail. An image acquisition device is designed on the adjustable camera bracket with the linear array CCD, and based on the correlation among pixels at the image level, a fast positioning method is developed for searching the Region Of Interesting (ROI) of the surface defects. Using the Mean-Shift image filtering algorithm which features multi-parameter kernel function, amendments to the sampling point weights and regional search with the nearest neighbor sampling points, accurate segmentation of the identification character is easily achieved by K-means clustering. Experiments show that this algorithm for the identification of the heavy rail surface defects is proven to be more rapid in testing the inclusions, cracks and oxide skin defects with a good promotional value.

Keywords: Mean-Shift, Position and Segmentation, Region Of Interesting (ROI), Rolling Heavy Rail, Surface Defect

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1. INTRODUCTION

With the development of railway transportation business towards high velocity and heavy loading, the quality of heavy rail is meeting more severe challenge than ever before. Especially the quality of heavy rail’s surface has been placed more and more attention in recent years. The automatic inspection of surface quality has become a major and important technology for main heavy rail enterprises, which is applied to detect the surface defects, such as surface crack, percussion damage, surface scratch, steel pit, etc. However, compared to the conventional automatic physical and chemical inspection for the heavy rail, this inspection has now come across its bottleneck during the whole rolling technology course.

In terms of the surface defects of heavy rail, the current detection methods include visual observation, electric eddy current testing, magnetic particle testing, liquid penetrant testing, ultrasonic testing, laser optothermal testing, mango-optic testing and machine vision testing etc.

The visual observation method is operated by checkers’ eyesight. With the help of strong lightening and the amplifying lens, a group of checkers inspect all heavy rail’s surface when heavy rail is moving at low velocity of about 0.5~1 m/s. When suspected defects on the surface are found, the moving heavy rail stops to be verified carefully.

The principle of electric eddy current testing is described as follows: when the electric eddy current sensor moves close to heavy rail surface, an eddy magnet field whose direction is opposite to the sensor’s would offset the magnitude and phase of the current in the sensor’s coil, which results in a certain changes of the coil impedance. This alternating impedance characterizes the surface defect if all other non-defect factors are constant.

In magnetic particle testing, partial magnetic field would locate within the surface defect if the full magnetic field produces around the whole bulk material. So if the magnetic particles scatter evenly on heavy surface, the surface defects could be found by changing character of the surface magnet flux. Similar to this way, leakage magnetic field testing uses the alternating quantity of the leakage magnetic flux to acquire the defect variety and size.

Liquid penetrant testing method uses the capillary principle to detect possible surface flaws. After the penetrating fluid has been fully infiltrated to heavy rail’s surface, the surface’s residual liquid is cleaned. By means of the adsorption of the developer, the defect’s residual liquid will come forth on the surface, which makes it visible of the defects’ distribution and type.

Infrared inspection technology is also used for detecting the surface defects. The induction current produced within the steel surface and because of the skin effect of high-frequency induction, the current location depth is less than 1 mm. More electric energy would consume per unit length in the area of the surface defects than normal place, which brings a local temperature rise that is controlled by average depth of the defect, coil working frequency and other physical parameters, such as the quantity of given input electrical energy, the electrical and thermal performance of the heavy rail and the moving speed of the heavy rail and so on. If every working condition keeps fixed, the defect depth can be worked out only by the temperature alternation which could be measured via infrared inspection technology.

Laser optothermal technology could be used for detecting the surface defects of heavy rail. When a beam of modulated laser is shined on the surface of heavy rail, both infrared radiation and local temperature would alternate in the defect area. The variety, size and position of the defects can be acquired accurately by testing the optothermal signal.

Ultrasonic testing is a usual method in non-destructive inspection field, and the pulse reflection type ultrasonic is widely used, which could be applied to detect surface defects sometimes.

Mango-optical effect testing is tried to be used to detect surface flaws. The essence of this technology is as follow: the changes of magneto field caused by the surface defect result in the
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