Research on Surface Crack Detection based on Laser Scanning and Image

Processing Techniques

Guangming Cai¹ Jiwu Wang¹ Mingcheng E¹ Wenliang Guo¹

Department of Mechanical and Electrical Engineering, Beijing Jiaotong University, Beijing, China, 100044¹ Sugisaka Masanori² Nippon Bunri University, Oita, Japan²

(jwwang@bjtu.edu.cn)

Abstract: The traditional Surface crack detection method based on artificial vision, due to low detection efficiency and high labor strength etc., can hardly fit the demand of the actual testing operation. In order to meet this demand, in this paper we propose a new method based on laser scanning and image processing techniques for surface crack detection. The analysis of experimental results has shown the feasibility, accuracy and effectiveness of this method, and detection results were quite satisfied.

Keywords: crack; detection; laser scanning; image processing

I. INTRODUCTION

For engineering structures, products, parts, etc., the crack resulting from various reasons will affect their regular service, durability and security. In many cases, the occurrence of crack is inevitable, and the propagation of crack is usually ongoing. In order to guarantee the safety of life and property, the crack detection is very necessary [1][2].

The commonly used methods for surface crack detection include manual detection, mechanical detection, optical fiber detection, laser detection, machine vision detection and so on. Among them, the manual detection has many shortcomings, such as low detection efficiency, high labor strength, poor quality and low detection reliability depended on many subjective factors. Mechanical detection is contact detection, and its detection efficiency is low. Both optical fiber detection and laser detection are high precision methods, but their cost is also too high. Although machine vision detection method based on image processing techniques is objective, non-contact, high accuracy and convenient, it also can not meet the demand. That is because images contain many interferences except crack, and there are no common and appropriate methods to eliminate these effects ^[3].

In this paper we propose a new method based on

laser scanning and image processing techniques for surface crack detection. The main steps of this method are as follows. Firstly, a red laser emitted a laser beam which formulated a straight laser line in the detected surface. Secondly, we used a CCD camera to capture target images from the detected surface. Thirdly, we applied the image processing techniques to judge whether the red laser line in the detection surface is continuous, to identify whether cracks are exist in the images. And the results of experimental have shown that this method can meet the demand of surface crack detection.

II. THE OVIEW

The core idea of this paper is to use machine vision instead of artificial vision for automatic detection of surface crack. Machine vision for crack detection depends on image processing technology ^[4]. Considering both the disadvantages of image processing technologies and the advantages of laser technology, we use a combination of them to detect surface crack.

The sketch map of the detection method is as follows.

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Fig. 1 The sketch map of the detection method

As shown in Fig.1, the 5 is a red laser. It emitted a red laser beam and formulated a straight red laser line in the detected surface (1). And, we used a CCD camera (4) to capture the image from the captured region (2). Then, we saw the CCD camera (4) and the red laser (5) as a whole thing, and let them move together along with the direction of movement. Therefore, we can capture the entire image information of the detected surface. In the end, we applied the image processing techniques to judge whether the red laser line in the detection surface is continuous, to identify whether crack is exist in the images.

III. THE BASIC PRINCIPLE AND

EXPERIMENTAL TEST

1. The basic principle of the crack detection method

In addition to crack, the interferences, such as stains, adhesive materials, texture etc., were also contained in the detected surface. Before identifying crack from the interferences, we need to know their differences. And the obvious difference is as follows. When there is a crack in the surface, the material in the crack region is no longer close and a gap will appear in the surface. On the contrary, the interferences usually do not have this feature ^[6].



Fig.2 The case without crack and interferences



Therefore, we can do the following analysis.

As shown in Fig.2, a red laser beam was emitted to the detected surface and most of it will be reflected back. And in the captured image, we can see a continuous red laser line. As shown in Fig.3, there is a case when surface contains crack and interference. In the crack region, the red-laser beam will through the crack and not be reflected back basically. In the interference region, there were still some of the red laser will be reflected back. Then in the captured image, we can see a red laser line which is discontinuous and uneven thickness.

2. Experiment

To verify the above analysis, we made the following experimental test.



Fig.4. Testing images: containing inferences. (a) Cement stains, (b) Adhesive materials, (c) Texture, (d) Ink stains.

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Fig.5. Testing image: containing crack

For the testing images that contain inferences, which is shown in Fig.4, the red laser line is continuous. As shown in Fig.5, the red laser line disconnected obviously in the crack region. According to the above results, we can see that the method for surface crack detection is feasible.

IV. THE IMAGE PROCESSING SYSTEM

In this paper, the surface crack detection method is based on image processing technology. And the image processing system is a core part of the crack detection method. Therefore, image processing system is directly related to the accuracy of the results of image processing.

1. Hardware program



As shown in Fig.6, we designed a hardware program for surface crack detection ^[5].

Fig.6 the hardware program

2. Flow chart of crack detection

The image processing flow chart of crack detection is shown as follows ^{[7] [8]}.



Fig.7. Flow chart of crack detection method.

- A. Original Image: Use a CCD camera to capture images.
- B. *Gray Scale:* Make the color image into the gray-scale image, so is suitable for image processing.
- C. *Analysis Region:* According to the least square method, we can get the analysis region (the red laser line region).
- D. *Threshold:* Apply Dual Threshold Method. And the required threshold could be got by calculating the histogram.
- E. *Judge the continuity:* According to the distribution of gray, we can select the analysis region. Then, in the selected region, we can judge the continuity by analysis the ratio of the target gray value.
- F. *Crack Measurement:* Combined with the analysis results of multiple images, we can measure the crack.
- G. Data Out: Save data to Access database.

V. THE PROBLEMS

For this crack detection method, we found the following problems by the experimental tests:

A. Cannot identify the micro-cracks: For the micro-crack (its width less than 0.2mm), the intermittent feature of the red laser line in the crack region is unobvious, which is shown in Fig.8. However, by increasing the intensity of laser and the magnification of the camera, we can solve this problem.



Fig.8. Testing image: containing a micro-crack.

B. *The impact of a large contrast ratio:* When the color of interferences is much difference from that of background, this method can not rule out the impact of interferences, which is shown in Fig.9.



Fig.9. Testing image: the color of interferences is much difference from

that of background.

C. *The impact of shooting angle of the camera:* Where the shooting angle of the camera is not perpendicular to the detection surface, this method can not rule out the impact of interferences, which is shown in Fig.10.





(a)

(b)

Fig.10. Testing images: containing ink stains. From left to right: the angle between the shooting direction of camera and detection surface is (a)90°, (b)45°.

VI. CONCLUSION

In this paper, we propose a new method based on laser scanning and image processing techniques for surface crack detection. For relying solely on image processing techniques, the crack detection method we have proposed can make up its shortage. The role of laser scanning is equivalent to the function of image filtering. It can effectively filter the interferences except crack form the image. Through experimental tests, we verified the feasibility of this method. However, any method has its shortcomings, this method also exist shortcomings. For example, it is difficult to detect the micro-crack (its width less than 0.2mm); this method has improved the control requirements of movement and detection angle for camera and red laser. The purpose of this paper is to explore new ideas for workers who engaged in the work of crack detection.

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