# CRACK DETECTION USING THE EDGE PAIRING

Yoshihiro Sato†
†Faculty of Knowledge Engineering,
Tokyo City University,
Tokyo, Japan

Yue Bao††
††Graduate School of Engineering,
Tokyo City University,
Tokyo, Japan
bao@tcu.ac.jp

Yutaro Koya†††
†††Graduate School of Engineering,
Tokyo City University,
Tokyo, Japan

## ABSTRACT

This paper proposed a method detecting cracks that occurred in concrete buildings. In the maintenance of concrete buildings, cracks are an important indicator to determine the repair priorities. Until a few years ago, it was visually inspected by workers. Recently, the crack detection methods by using image analysis have been proposed. But, the methods are difficult to detect the crack on the concrete surface with unevenness and contamination. In this study, we propose an edge detection method using pairing. This method can detect crack with a high degree of accuracy. Therefore, the size and shape of the crack can be checked. Then, it is possible to perform noise processing using the shape and size. Experiments were carried out using this proposal method. As a result, it was confirmed that it is possible to detect 0.2mm or less cracks.

## 1. INTRODUCTION

Japan passes for 50 years from a high economic growth period, and concrete buildings more than the durable period are increasing now. It is impossible to restore all of these buildings at the same time. Therefore, prioritization of the restoration is performed, and it is restored from a building needing restoration sequentially. Thus, the prioritization technology is needed to perform the maintenance management of the concrete building. Cracks are usually used as indexes to evaluate the health of the concrete building. When cracks were discovered in wall of a concrete building, it can be judged that dilapidation is happening in the building. It is being announced in the guideline of Japan Concrete Institute that "When cracks more than 0.2 millimeters are discovered, the building loses soundness". [1] The building that spoiled soundness needs repairing. Thus, prioritization of the repair can be performed by the state of the crack.

Various crack detection methods are studied. At first, the standard detection method is mainly visual inspection by the worker. As for this method, a worker checks a concrete wall near by him. So, dust and cracks on the concrete surface can be confirmed too. Furthermore, the visual inspection can inspect width and the inside situation of the crack in detail. A state measuring the crack width with A crack-scale ruler is shown in figure 1. The inside of the concrete surface that cannot be inspected by a visual inspection can be inspected using a hammering test. However, the risks and personnel expenses of workers are very high. Furthermore, depending on the skills of the workers, the inspection results will differ. Therefore, it is not a highly reliable inspection.

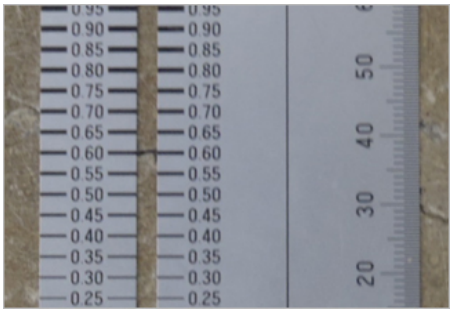


Fig1. A state measuring the crack width with a crack-scale ruler

By using image processing, detection precision does not change depending on individual differences and competence of workers. Also, you can save time to inspect walls with a large area. Therefore, time and cost aspect can be saved. Two image analysis methods are mainly used. The first is the detection method using wavelet transform. [2,3,4] This method uses frequency analysis. Cracks occurring on the concrete surface can reduce the influence of the brightness information on the photography image by applying frequency analysis. Thus, in the detection method using wavelets, it is possible to detect with the reduced noise of brightness. The second method is a probabilistic relaxation detection method using line emphasis. [7,8,9] The probabilistic relaxation method is a method extracting the shapes and the positions of cracks roughly by repeating local adjustment processing. This method performs two processes before performing the probabilistic relaxation method. "Subtraction preprocessing using a median filter" removes the light-dark change by inhomogeneity or the shadow of the light. In addition, "Multi-scale line emphasis preprocessing" reduces influence such as the wounds of the wall surface. Furthermore, the rough

cracks detected by the probabilistic relaxation method extract details by performing thresholding step by step.

In the method using wavelet transform transformation, noise is removed by using line tracking processing. Therefore, noise can be eliminated by adjusting the value of the extracted area in the contour line tracking process. However, there is also the possibility of removing cracks. Also, there are cases where parts that are not clearly cracked are extracted. [5,6] Figure 2 is a result of the detection method using wavelet transform. [5] As shown in figure 2, it is detected as disconnected cracks, and a place which is not cracked is detected. Since it is difficult to judge cracks by shape, it can only perform rough noise processing.

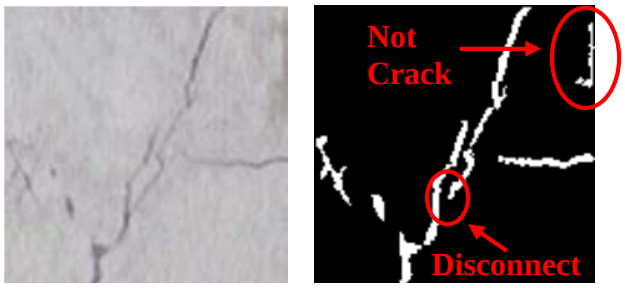


Fig2. A result of the detection method using wavelet transform [5]

The probabilistic relaxation detection method using line emphasis emphasizes linear features. If irregularity noises on the concrete surface is linear, it is emphasized as a crack. A result of the detection method by the probabilistic relaxation method using line emphasis is shown in figure 3. [7] As shown in figure 3, unevennesses of the concrete surface are emphasized. If a strict threshold value is set so as not to detect irregularity noise on the concrete surface, thin cracks cannot be detected.

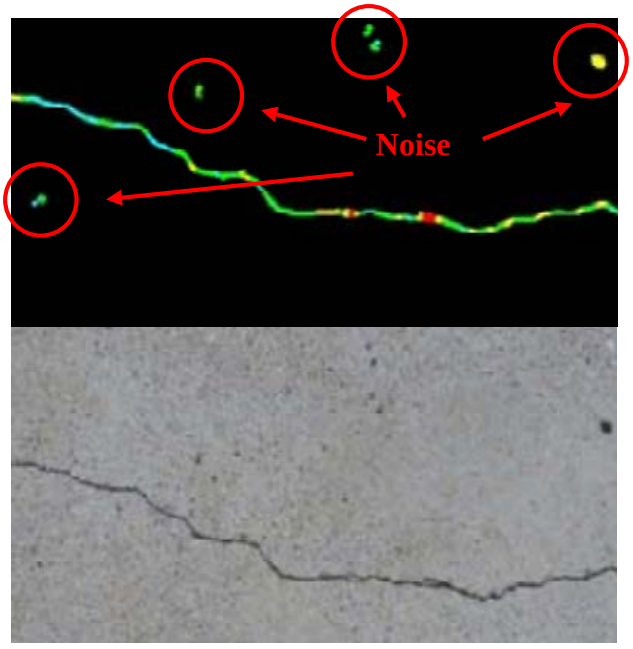


Fig3. A result of the detection method by the probabilistic relaxation method using line emphasis [7]

Therefore, it can be said that the accuracy of the conventional methods for the crack extraction by image analysis is not high. As for it, we think that the followings are the reasons. "A heterogeneous dirt of the concrete surface", "the resolution of the digital camera, a photography condition and performance", " Accuracy of image analysis method."

To improve the accuracy of image analysis, we propose a method to detect cracks using edge pairing. The proposal method can detect crack with high accuracy. So that, we can get the shape of the crack and do noise processing using the shape of cracks

## 2. CRACK DETECTION METHOD USING EDGE PAIRING

In this chapter, the crack detection processing of the proposal method is explained sequentially. A process flow of the proposal method is shown in figure 4.

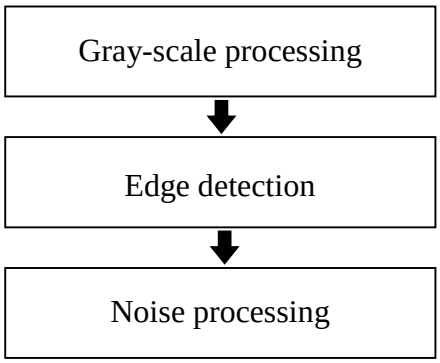


Fig4. A process flow of the proposal method

### 2.1. Overview of the proposal method

The proposal method assumes input of grayscale images. If a color image is inputted, a gray scale conversion is needed at first. The edge detection of an input image is performed, and all the cracks and the dirt are detected from the concrete surface. To extract cracks from the edge detection result mixing with noises, noise processing is necessary. Noise processing is performed using "shape" of the cracks. The detection result of the crack is a result that deleted the noises from the edge detection result.

### 2.2. Edge detection

The proposal method is a method with edge detection specialized in the crack detection, and It does not need a filter. In other words, it can be performed without depending on filter size. Therefore, edges of various widths can be detected by one-time processing.

The processing methods of this proposal method are as follows. First, image scanning is performed in the horizontal direction of one row. And, the difference value of the neighboring pixel value is calculated in a sequence.

If the difference value is larger than the preset parameter, we judge it to be a feature of the cracks. The crack is a slender hole. Changes in pixel values appear at both ends of the hole. Therefore, it is possible to find both ends of the groove by performing same processing from the opposite direction. Thus, it can be confirmed that there is a hole in between, so it is possible to detect cracks. The preset parameter can beforehand be set freely. In addition, this detection scans pixel by pixel, so crack detection can be done in one-pixel unit. In other words, the minimum detectable crack width depends on the image resolution of the input image. If there are three or more places where pixel values change, it cannot be judged whether they are paired. Furthermore, if pairs are not determined, cracks cannot be detected. At this time, the nearest neighbors are the pair. If the number of changes is odd, the point that is the farthest away from any point remains and is not considered as a pair. Also, points once paired will not be used again. And, if there is no pair, it will be detected as one dot edge.

The Processing result example is shown in figure 5. As shown in figure 5, the edges with various widths and the edges on one row having plural change points can be detected correctly.

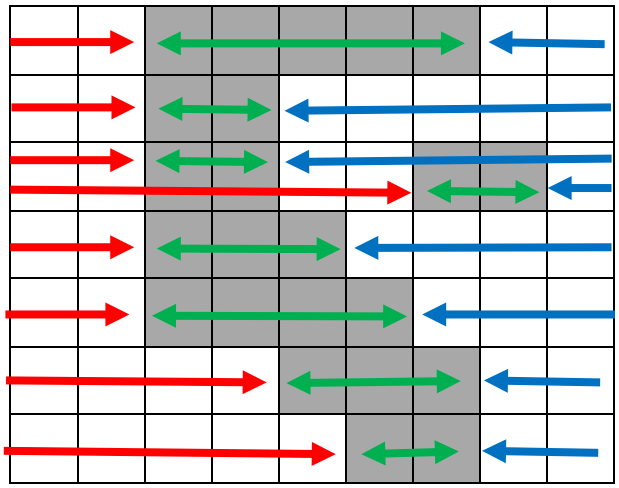

Fig5. Processing result example

### 2.3. Noise processing

The noise processing pays attention to whether cracks are "linearly similar". Thus, edges that are "linearly similar" from the detected edges are retrieved. In this study, a condition to be a straight line is defined as follows.

**"When Cracks were enclosed with a rectangle, the density is equal to an inverse of short side."**

The density calculates it from a rectangle and the ratio of the number of the constitution pixels of the edge. Figure 6 is the example which surrounded an edge with a rectangle. the density relationship between the straight line and the rectangle is shown in Equation 1. Equation 1 can be used for detecting "linearly similar" edges. In addition, even a complicated crack can be detected by lightly loosening the threshold value of density.

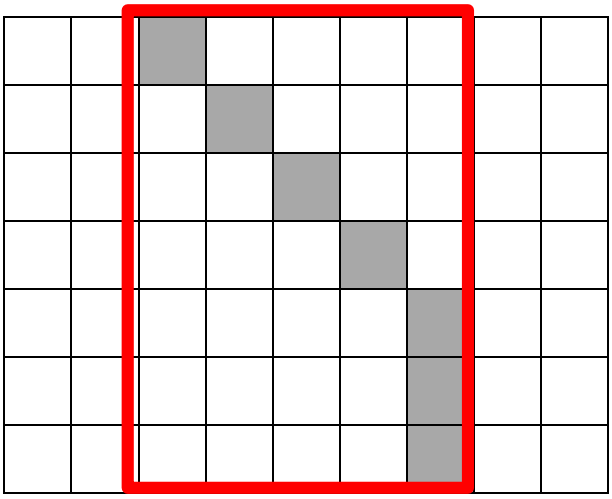

Fig6. The example which surrounded a straight line with a rectangle

Number of dots

*Line – 7 pixels*
*Rectangle – 35 pixels*
*Short Line of*
*Rectangle – 5 pixels*

*Line / Rectangle = 7 / 35*
*= **1 / 5 <= 1 / Short Line of Rectangle*** *--- (1)*

Those with a small number of pixels can be judged as fine edges. This small edge is judged "it is not a crack", and it isn't extracted. That is, a long linear edge is judged as cracks.

## 3. EXPERIMENT

### 3.1. Summary

We confirmed the usefulness of the proposal method by experiment. We photographed the cracks occurring in a concrete building and a concrete crack specimen. The building is a cafeteria of our university. The concrete crack specimen was made by the concrete laboratory of our university.

Fig7. Building No.14 of the Setagaya Campus in Tokyo City University

Fig8. Concrete crack specimen

### 3.2. Shooting equipment and conditions

The model name of the camera used for the experiment was set at NIKON D7200, and a resolution is 6016 * 4000 pixels, and at a distance of 3 to 7 meters and shot.


Fig9. NIKON D7200

### 3.3. Shooting procedure

As shown in figure 10, a tape measure is put on the ground to measure the distance between the camera and the concrete crack specimen. Figure 10 shows the scene of experiment using the concrete crack specimen.

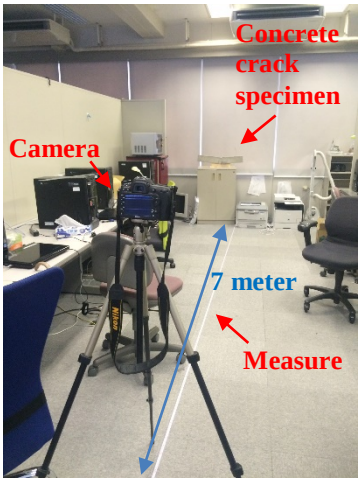


Fig10. the photographic scenery of the concrete crack specimen

As shown in figure 11, A Laser measuring instrument use to measure the distance between the camera and the concrete building. Figure 11 shows the scene of experiment using the concrete building. Figure 12 shows The Laser measuring instrument.

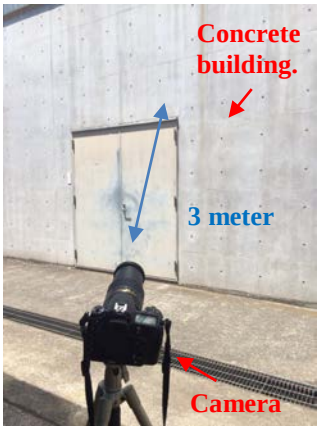


Fig11. the photographic scenery of the concrete building


Fig12. Laser measuring instrument

### 3.4. Result

In this experiment, at first, it is confirmed whether simple cracks can be detected. Then, we confirmed that the proposal method can detect cracks even from a long distance. An experiment to detect cracks of 0.2 millimeters from a distance of 3 meters was done. In this experiment, cracks occurred in the concrete building were detected. Figure 13 shows a photographed image from the distance of 3 meters and the detection result. In this shooting, we set the camera so that the image resolution becomes 0.1 mm.

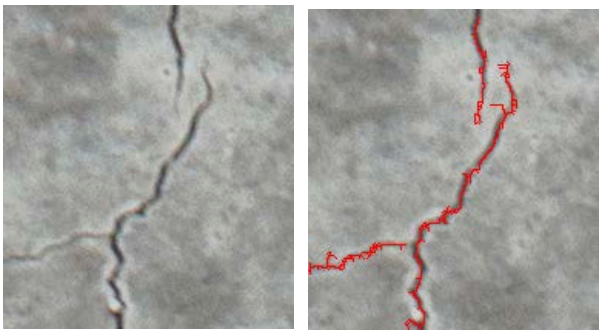

Fig13. a photographed image from the distance of 3 meters and the detection result.

By the detection result, we can confirm that the algorithm of the proposed method can detect cracks in the actual concrete building wall.

Next, an experiment was conducted to confirm whether the crack can be detected from a long distance

by our method. Furthermore, we confirmed whether the noise processing is effective or not for a noisy image in this experiment. Furthermore, we confirmed whether the noise processing is effective or not for a noisy image in this experiment. Figure 14 shows the detection results.

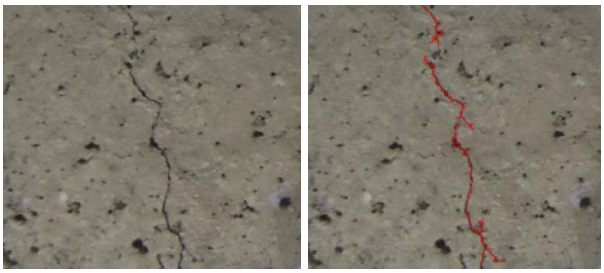

Fig14. a photographed image from the distance of 7 meters and the detection result.

By experimental results, it can be confirmed that cracks of 0.2 millimeters can be correctly detected. And, it was confirmed that noise around the cracks was not detected.

## 4. CONSIDERATION

We compared the detection result of our method to the detection result of the conventional method. Since the stochastic relaxation method using line emphasis is excellent in the conventional method, it was chosen as the conventional method for comparison. [9] Figure 15.a is the input image, figure 15.b is a detection result of by conventional method [9], and figure 15.c is a detection result of the proposal method. In figure 15.b, the detected cracks are outputted as black lines on a white background. In figure 15.c, the detected cracks are outputted as red line on an input image.

a.

b.

c.

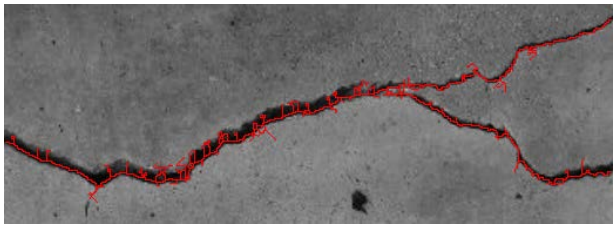

Fig15. Result comparison

As for the conventional method, unevenness on the surface of concrete was detected as crack. However, we can confirm that the unevenness on the surface of concrete is not detected as a crack by our method. The proposal method can detect cracks accurately than the conventional method. The crack detection method using image processing is depending on the performance of the digital camera. In our experiment we used a camera Nikon D 7200 with 2416 million pixels. The cracks of 0.2 millimeter in width were detected from a distance of 7 meters. In recent years, some cameras with 46 million pixels have been sold in around 90,000 yen. If a high-performance digital camera or telephoto lens is used, the minuter cracks with more distance can be detected.

## 5. CONCLUSION

Many crack detection methods were proposed. However, even with an excellent method among them, there was a problem that unevenness on the concrete surface were detected as cracks. In this paper, a method pairing detected edges is proposed. A concrete building and a concrete crack specimen were used for the crack detection experiments. By the experiments, the proposal method can detect cracks from a long distance, and it can detect cracks accurately than the conventional method is confirmed.

## 6. REFERENCES

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