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Detection crack in image using Otsu method and multiple filtering in image processing techniques

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ABSTRACT

Cracks in concrete structures can indicate major structural problems and can harm the appearance of monolithic construction. This article presents a new approach in image processing for detecting cracks in images of concrete structures. This method involves three steps: First; change the image to a gray and using edge of the image and use Sobel's method and development of an image filter using Sobel's filter for detecting cracks. Second; using a suitable threshold in a binary image and classifies all pixels two categorizations background and foreground, and gets the region area after that use filter area and changes the area if less than the specific number to back. Third; after using Sobel's filtering to elimination of residual noise, and detecting major cracks using Otsu method. This paper describes a method for detection crack patterns in cement use image processing techniques. The advantage of this method is clearly and accurate detection of cracks in images. Experimental work shows that our method is improved relatively to the other widely used techniques.

1. Introduction

Cracks are one of the most serious defects in concrete structures because when they are developed, they tend to reduce the effective loading area which is leads to increase of stress and subsequently failure of the concrete [1]. Although cracks originated at the sections surface, it is difficult to detect visually if the crack width small [2]. The hydrated cement deterioration takes place due to many factors; the combination of these factors returns different configuration of cracks in concrete. Each mode of cracks will yield diverse damage and failure modes in concrete structures [3]. Fresh concrete subjected to crack during tropical or cold conditions [4–8], especially if it is insufficiently cured. The trend of concrete to cracking due to temperature emanating from weather condition or even the hydration process has been known since the beginning of concrete technology [3]. The most widely applied techniques for examining cracks in concrete are scanning electron microscopy and optical fluorescent microscopy [9–13]. Two tools should be adopted to characterize cracks: one for observation and one for quantitative analysis. Currently developments in microscopy and image processing and analysis techniques render powerful tools for quantitative micro-structural investigation of concrete and let the crack pattern in these materials to be measured [3]. In this article, we use experimental program to investigation many objectives. Use experimental program to find the specimen, and use this image of a specimen to find a new approach to detection crack in image processing.

2. Experimental program

2.1. Equipment

For Uniaxial tensile test using Universal Testing Machine (Instron 5882), the Loading speed ratio was 0.4 mm/min which was controlled under the displacement control mode.

2.2. Test method

Data collection, including capacity and strain. The test method referred to the Japanese standard. The strain data was measured by the 10 mm LVDT which was fixed on both sides of the sample. And the sampling frequency was 1 Hz. The sample and the LVDT were shown as in Fig. 1.

The prepare and product is located in a laboratory at Wuhan University of Technology. The main steps of producing the crack in this specimen as follows; firstly is to put the specimen in

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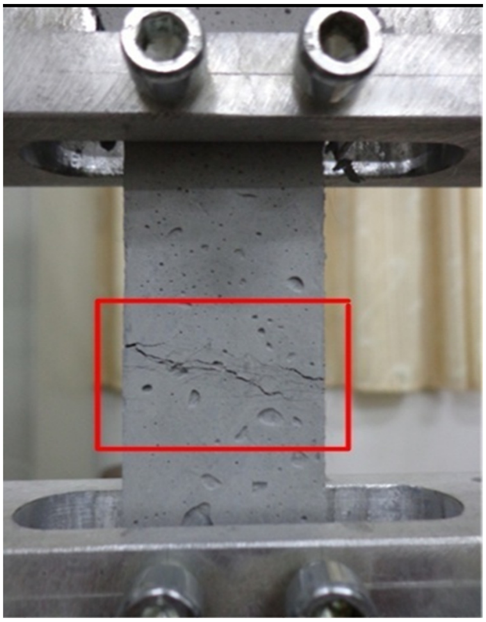

Fig. 1. The specimen in this paper.

Universal Testing Machine (Instron 5882), and second step is to apply automatic loading down as the same time reading the magnitude of applied loading in the programmer; then the next step is performed if the cracks start; by locating the digital camera as shown in Fig. 1.

3. The proposed method

The object of this paper is propose new approach at binarization method in image processing for detection crack in image by optical fluorescent microscopy, as well as use combination method to detection crack in this image. The proposed algorithm consists of three steps (Fig. 2):

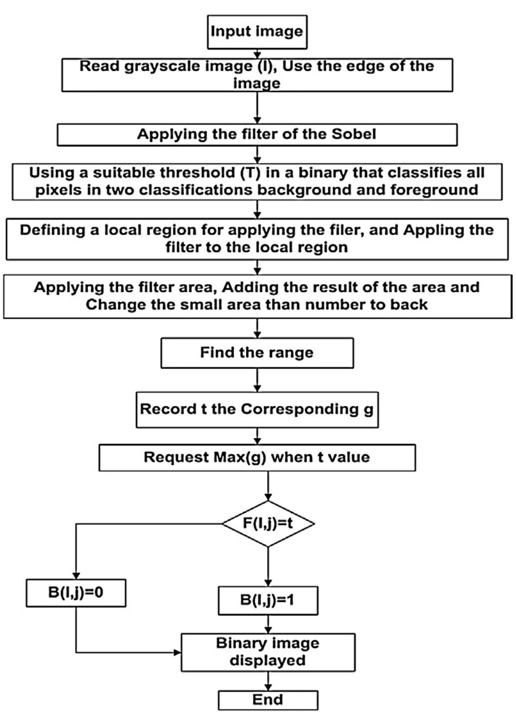

Fig. 2. Flow chart of the proposed method.

First step:

(1) Use the image (I) RGB, and change the image to gray.
(2) Use the edge of the image.
(3) Use the filter of the Sobel.

Second step:

(4) Using a suitable threshold (T) in a binary image that classifies all pixels in two classifications background and foreground. According to this equation.

$$I = \begin{cases} 1 & \text{im} > T \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

(5) Use the function (bwlabed).
(6) Use the function (region props) to get the region area, and get the filter area.
(7) Change the small area than 30 to back.

Third step:

(8) Use the Otsu method [14]. The main idea in proposed method to detection crack in this paper to depend of Otsu method.

3.1. Otsu algorithm analysis

The Otsu method is the basic idea let the threshold image into two groups. The target number of pixels representing the ratio of the image ω_0, the average gray level μ_0, the Background image represent the ratio of the number of pixels ω_1, the average gray level μ_1. The total average gray level of the image is: $\mu=\omega_0(t)\mu_0(t)+\omega_1(t)\mu_1(t)$. From the minimum value to the maximum gradation value gray traversal t, When making value $g=\omega_0(\mu_0-\mu)^2+\omega_1(\mu_1-\mu)^2$ Segmentation is the optimal maximum threshold. On the Otsu method can be understood as follows: the formula is actually between-class variance, threshold segmentation of the target and the background of two parts of the whole image, and the target value μ_0, probability ω_0, background values μ_1, probability ω_1, total mean μ, according to the definition of variance that was the style. Gray distribution of variance is a measure of homogeneity. Suppose $f(x, y)$ to $N \times M$ image (i, j) gray value at the point of, the gray level μ, let's assume $f(i, j)$ value $[0, m-1]$. Suppose $p(k)$ the gray value k frequency, then:

$$p(k) = \frac{1}{MN} \sum_{f(i,j)=k} 1 \tag{2}$$

Suppose t is a gray value threshold segmentation of target and background are as follows:

$$\omega_0(t) = \sum_{0 \le i \le t} p(i) \tag{3}$$

Target part points:

$$N_0(t) = MN \sum_{0 \le i \le t} p(i) \tag{4}$$

Background section ratio:

$$\omega_1(t) = \sum_{t < i \le m-1} p(i) \tag{5}$$