Research Progress of Digital Image Cracks Recognition

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Abstract. Cracks are one of the most important threats to the safety of vintage pavements, dams, and bridges. Regular inspections are required to ensure the normal uses. Comparing to traditional manual detection methods, digital image crack recognition has the advantages of high efficiency, rapidity, and accuracy. With the continuous update of digital image recognition algorithms, the accuracy and speed of calculations are constantly increasing, therefore more and more attractions have been drawn in this field. The basic principles and development status of digital image cracks recognition technology are described in this paper.

Keywords: Cracks recognition; Image enhancement and denoising; Image segmentation.

1. Introduction

With the rapid development of computer technology, multimedia technology, and artificial intelligence technology, digital image recognition technology has gained extensive attention in many fields, such as architecture, scientific research, education, healthcare and petroleum fields, and it has become one of the most important technical methods for these fields. For example, the automatic license plate recognition technology used in the traffic control system, the computer vision technology in robotics, and the facial recognition technology in mobile phones, etc.

While cracks recognition using the digital image is one of the most application of this technique. The aged pavements, dams, and bridges would eventually have cracks which could lead to serious safety problems. To ensure the safety of these constructions, scheduled inspections are one of the most important maintenance working routine. In the traditional methods, human eyes are the major "detector", which largely depends on the experience of the people who did the inspection, mistakes are unavoidable. The automatic cracks detection techniques are highly demanded. In recent years, domestic scholars have proposed a number of pavements cracks recognition methods based on digital image processing. Zhang Hongguang et al. proposed an artificial life algorithm for cracks detection. Through different artificial biological division and cooperation, cracks were recognition successfully. On this basis, he also proposed the Agent algorithm and made progress in dealing with noise, oil and black spots in pavements. Wang Chaowei et al. applied the topology inversion theory to pavement cracks detection, which improved the accuracy and rapidity of detection. In addition, there are various applications of the cracks identification method based on the threshold method, the standard algorithm

of digital image cracks recognition includes image preprocessing, image segmentation, edge detection and recognition, and analysis, as shown in Figure 1. In this paper, we will briefly introduce the basic principles and development status of digital image cracks recognition technology.
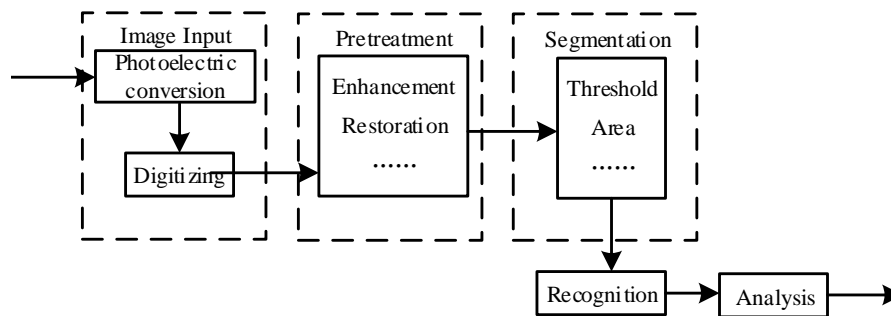
Figure 1. The general process of the digital image processing.

2. Image Input - Image Acquisition

The first step in digital image processing and recognition is image acquisition. The quality of the acquired image directly determines the degree of difficulty in image processing and recognition. Currently, digital image acquisition mostly depends on digital cameras. There are some methods for performing comprehensive image acquisition in combination with other information in addition to directly obtaining the image information required for recognition by a digital camera. For instance, Shi Shuyuan et al. proposed the image morphological features provided by Google Earth software, combined with GPS high-precision fixed-point acquisition data, and the point data collected contains fracture and crack information. Wang Bo and Wang Xia et al. proposed the aerial imagery method According to the characteristics of high efficiency and large field view of UAV ground-based exploration, it can collect aerial images containing complete road surface information and conveniently complete the image collection. For image acquisition, different digital camera modes can be used according to the different needs of the study.

3. Pre-processing – Denoising

In the process of capturing an image, random signals could interfere with the real signal which would lead to image noises. These noises seriously hamper the extraction of image information. Therefore, the image must be preprocessed before the image recognition to eliminate irrelevant information and enhance(restore) useful real information. It can greatly simplify the data and improve the reliability of feature extraction, image segmentation, and recognition.

Li Lihua et al. proposed a composite image enhancement method, which integrates spatial domain, frequency domain, and time domain information, and it avoids the shortcoming of using single domain information. Li Jicheng et al. proposed the image enhancement method based on curvelet transform the method makes the classification of focal points clearer and effectively enhances useful information. In order to improve the quality of medical images, an enhanced algorithm based on shear wave domain and improved Gamma correction has provided by Zhou Fei and Jia Zhenhong et al. This algorithm successfully removes image noise and highlights detailed texture information. In fingerprint recognition, Luo Xiping and Tian Jie estimated the field of fingerprint direction to perform image enhancement. Qiu Liping proposed a new dynamic filtering image enhancement algorithm using two complementary filtering methods (Gabor filtering and directional filtering). In the aerospace field, Wang Ning et al. have developed an image preprocessing method based on statistical analysis and pixel channels. Zhao Yutian and Du Hongji improved the Pal-King algorithm which used the fuzzy mathematical model algorithm, making the improved algorithm more suitable for power line gray image recognition. Fuzzy mathematics algorithm also has a certain influence on image processing.

Shen Sasha utilizes Gaussian fuzzy algorithm to denoise and applies fuzzy sets to the gray-scale transformation, which highlighted the desired contents and removed the unimportant part. In the traffic images recognition area, by using the traditional Retinex algorithm, Wang Fengping et al. introduced filter smoothing and fractional integrals. This method effectively suppresses noise, at the same time also enhancing the details of the image.

The image preprocessing methods introduced above could fall into two categories: frequency domain method and space domain method. The former one is good for enhancing the high-frequency signals such as edges, and the latter one is more suitable for removing or reducing the noises. The frequency domain method includes low-pass filtering, high-pass filtering, homomorphic filtering, and etc.; the space domain method mainly uses histogram equalization, grayscale stretching, median filtering, and nonlinear transformation and etc.

4. Image Segmentation

Image segmentation is the key step in crack recognition. After image preprocessing, image segmentation can distinguish useful to useless information. The useful information is the part which consists characteristic information. There are many methods for image segmentation, e.g., threshold method, region growing method, edge detection method, neural network method and etc.

4.1. Threshold Segmentation

Threshold segmentation is a widely used method in image segmentation. The key of threshold segmentation lies in the determination of the threshold value. The selection of threshold value determines the quality of the image segmentation, the more appropriate the threshold value is selected, the more accurate the image is segmented. The principle of threshold segmentation is comparing the threshold to the grayscale value of the pixel and simultaneously performing pixel segmentation. The basic threshold segmentation includes three parameters: global thresholds, adaptive thresholds, and optimal thresholds. The global threshold is determined by applying the peak-to-valley method (or the minimum error method, Ostu segmentation method, etc.) to the image grayscale histogram. The artificial ant colony intelligence algorithm proposed by Karaboga has been used for image segmentation. Combining with Otsu method, threshold segmentation algorithms have been proposed.

4.2. Edge Detection

The idea of edge detection is to identify the area where the grayscale value changes significantly. Edge detection methods can be roughly divided into two categories: searching (first derivative) and zero crossing (second derivative). Common first-order detection operators are Roberts Cross operator, Prewitt operator, Sobel operator, Kirsch operator, and compass operator. And second-order detection operators include Canny operator, Laplacian operator and etc. The canny operator has relatively better performance, so we will mainly introduce it.

The Canny operator is a commonly used for edge detection. It was proposed by John F. Canny in 1986. The Canny edge detection algorithm is: firstly, the noise is removed through the Gaussian filter, and then searching for the grayscale level gradient of the image. Finally, the edge is detected using the hysteresis thresholds—high and low thresholds. Some researchers have proposed an improved Canny algorithm to detect and connect boundaries based on dual thresholds. Nan Kailai and Fu Chaobin used real-time FPGA detection based on dual thresholds, and real-time segmentation results could be obtained. Zhao Jing and Yang Huachao also proposed an algorithm that combines the detection results of the Canny operator with the wavelet modulus maxima method, which improves the edge detection effect of a single Canny operator.

5. Image Feature Extraction and Analysis

Extracting image features is a key step in pattern recognition, so the selection of image features is crucial. The selection of features should be representative, unique and recognizable. Common image feature description methods are color features, texture features, and geometric shapes, etc. The process

of feature extraction is to reduce the dimension of information in high-dimensional space by mapping or transformation.

Add batteries and photovoltaic devices based on the basic equipment with the function of electric energy feedback. Considering the power consumption and comfort, the objective of optimization control is to minimize the power consumption and the cost of comfort. Iteration process is shown in Figure 2.
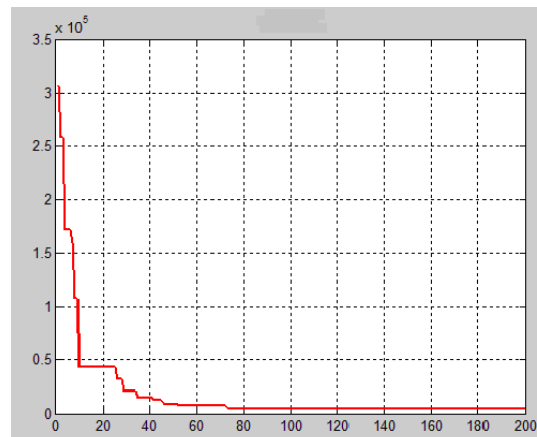
Figure 2. Iteration process

Simulation result of the interactive energy of family and grid is shown in Figure 6, the cost of power consumption: 18.4123 yuan.
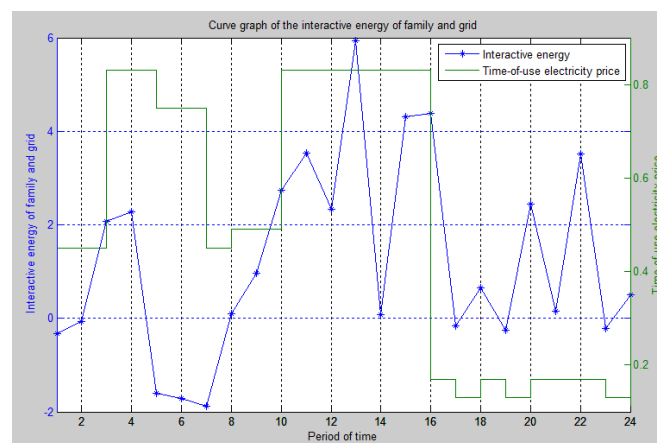
Figure 3. The interactive energy of Family and grid

Cracks formed in walls and pavements after the collected images are transformed to grayscale, most of them have the same commonalities:

(1) The non-negative feature: that is, the background area pixels' gray value is greater than the crack area pixels'.

(2) Contrast characteristics: there is a difference in contrast between the cracked area and the pixels in the background area.

(3) Gray-level co-occurrence matrix features: the pixels in a small window area are geometrically continuous and gray values are similar. This feature is described as a co-occurrence matrix feature based on the similarity distribution of gray values.

For other forms of cracks, their characteristics are not necessarily the same, and the analyzing method is different. For cracks, according to the above three characteristics, the mean, standard deviation, and high-order moment features can be used as selection features, and the image segmentation algorithms can be adapted for feature extraction. For the analysis of the characteristics of fractures produced by oilfield logging, etc., fracture development can be judged by analyzing the occurrence of fractures-horizontal and vertical, and fracture density. In general, the crack image analysis is based on crack characteristics. Therefore, the characteristics of the cracks must be identified. Then appropriate extraction method should be chosen; Finally, image analysis is performed.

6. Conclusion
This paper describes the basic principle and developments of digital image cracks recognition technique. With the improvement of the algorithm, digital image crack recognition technology is getting faster with better accuracy. Therefore, how to apply the technology to crack structure identification in different fields has practical significances. And the applications will definitely motivate the improvement of the algorithm.

Acknowledgements

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