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High-order image processing technique for concrete automatic crack recognition

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ABSTRACT

Application of artificial intelligence in concrete technology is expanded significantly especially identify the crack location and propagation mechanism which it has a direct role in damaging concrete. Structural health monitoring techniques are used to image based automatic crack detection where successfully applied on crack detection in concrete. Presented study attempted to use the image processing technique to identify the crack status in concrete bodies which is used as alternative procedures for conventional crack detection methods where provide the accurate detection method by Python programming languages.

1. Introduction

Concrete cracking is a common phenomenon in concrete based structures where get under different loading conditions. Cracking is the earliest indications of degradation, failure, raptures and deficiency in concrete structures. Creating and propagation of cracks in concrete body represent the over loading, cyclic loading existence or concrete deterioration and weathering conditions which must be identified and improved (Dorafshan et al., 2018). This step is presented as most important step during the concrete structures inspection. Crack detection in conventional methods was performed by experienced engineer or worker (inspectors) who sketch crack patterns manually and attempted to provide the pattern of crack propagation in concrete. As a view, conventional methods are always time consuming and costly, which is a serious issue for them (Arena et al., 2014). So, application of structural health monitoring techniques like image processing can be modified the evaluation process, reduce the costs and times and increase the accuracy of the evaluations. Recently, some crack detection algorithms and tools have been developed as utility software which is used as distanced based photogrammetry to provide the appropriate edge detection and pattern recognition to develop the crack mechanism and propagation system in concrete (Bagheri Shendi and Azarafza, 2018). The common denominator of all image-based processing methods is reduction of dependence on hardware equipment and the increase of reliance on instantaneous software analysis.

Image processing or digital image processing is one of the artificial intelligence techniques which uses of digital computer to digital process through an algorithm were has many advantages over analog image processing. It allows a much wider range of algorithms to be applied on input data and can avoid problems such as the build-up of noise and distortion during processing. Image processing was developed in the 1960s, at Bell Laboratories and some other research facilities which primarily applied on satellite imagery to provide main features and image enhancement (Azarafza et al., 2019). However, application of the image processing in geotechnical engineering and concrete technology is grower fast which is reported many contributions by several scholars (Gonzalez et al., 2010). In image processing operations, first an image (usually two-dimensional) of the surface or object is prepared and enters the software evaluation process. In this regard, the image taken by appropriate camera or

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camera based devises. In capturing the image, try to avoid creating shadows and noise as much as possible. For this purpose, the image is usually taken during the day and usually at noon (for field investigators). The camera is then placed vertically on the shooting surface to avoid shadows. In laboratory conditions, artificial type and lights are usually used which in this circumstances, the light should be shining directly on the surface and the light should not be colored (Yamaguchi and Hashimoto, 2010). After preparing the appropriate image (which is named as 'basic image', 'original image' or 'input image'), the image is entered in processing stages were can be classified as pre-processing, main processing and past-processing. Each step is divided in several separate steps that are performed sequentially. In pre-processing step, the input image prepared for main processing stage which must be modified, remove noises, cut the shadows, sharpen and improve the quality of image. These tasks were applied based on pre-processing filters. After improving the image in the pre-processing stage, the image enters the main processing stage. In the main processing stage, using filters and techniques such as edge detection and pixel change algorithms tires to extract the proper features of the image. The extracted features are used to preparing the data-set of image processing utilization. Past-processing is application several filters to reduce the errors and modified the results (Gonzalez et al., 2010). Presented study used these steps to detect the crack in concrete body for structural health monitoring of concrete durability. In this regard, the image processing technique was used to proved the results and extract the crack properties in concrete by Python OpenCV library.

2. Material and Methods

Concrete is a composite material were composed of fine to coarse aggregate bonded together with a fluid cement that hardens over time. In this past over time theoretically concrete get stronger, but due to the environmental changes and loading conditions Concrete usually begins to wear out after a while. The first factor in showing this is cracking. From the engineering point of view, cracking begins when the adhesive strength of concrete is lower than the ambient stress, in other words, cracks indicate a decrease in strength and threshold of concrete destruction. Therefore, identifying cracks and evaluating their development in the concrete body can always prevent the occurrence of concrete ruptures and consequently the instability of the structure (Dorafshan et al., 2018). Digital image processing is the effective method for indentifying the crack condition and recognizes the pattern of crack propagation in concrete. Generally, to provide accurate results the image processing required time for crack detections which is depends on the image size, quality, resolution, etc. Although these features increase processing time, but due to the finer detail of image form concrete surface, more cracks can be detected. The presented study used the high resolution digital camera to provide the input image for used methodology. After preparation of the input image, the image was used to crack detection by image processing algorithm were implemented by Python programming language. The processing flowchart for simulation and crack detection is presented in Fig. 1.

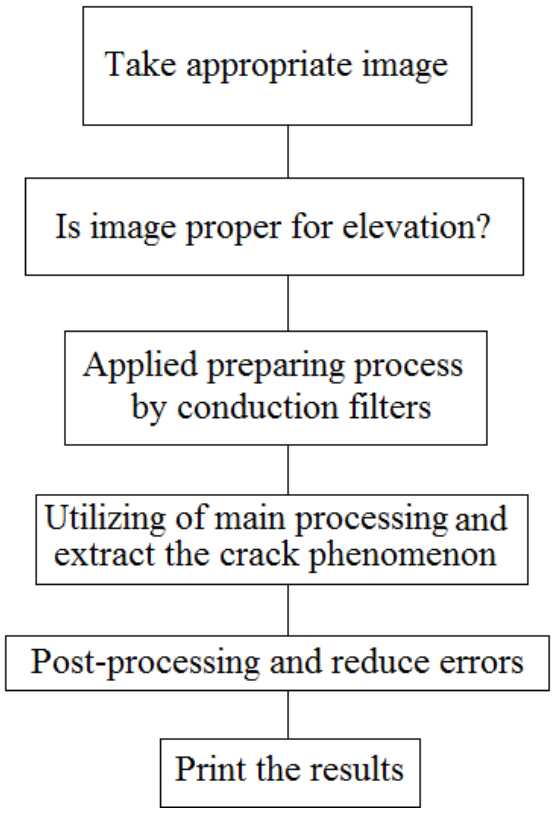

Figure 1. Flowchart of the studied process

3. Results and Discussions

After providing the input image was presented in Fig. 2 is used to extract the crack status in concrete. In this regard, the input image by performing three stages of image processing including pre-processing, main processing and post-processing attempted to extract the crack traces. Figs. 3 to 5 are presented the results of the preprocessing procedures based on image processing techniques for crack identification on concrete. According to the evaluation process, utilized processing methods capable to covered the uncertainties and provide the appropriate results.

Figure 2. View of concrete surface

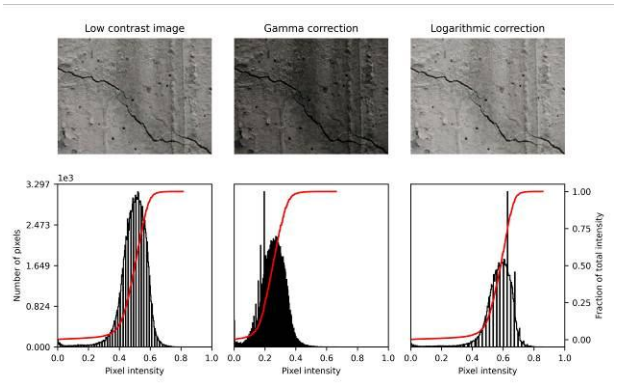

Figure 3. Pre-processing filters for crack identification

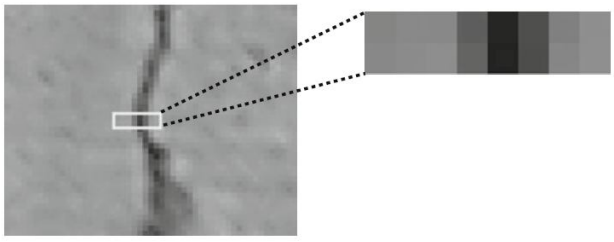

Figure 4. Image data extraction for images

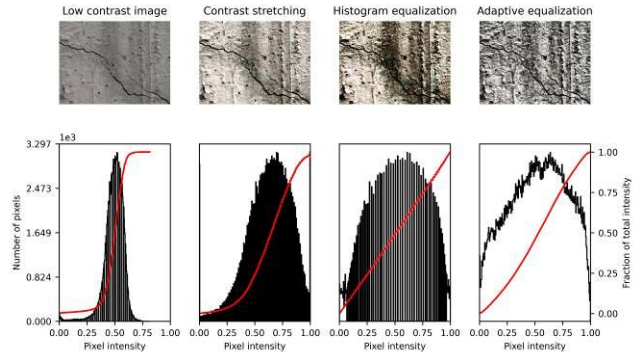

Figure 5. Crack feature extraction for studied image (step 1)

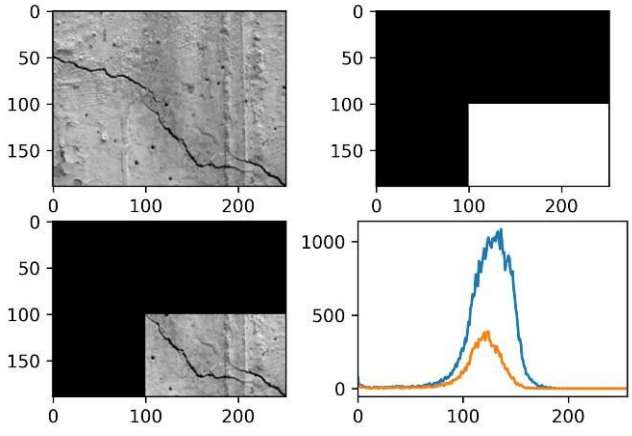

Figure 6. Crack feature extraction for studied image (step 2)

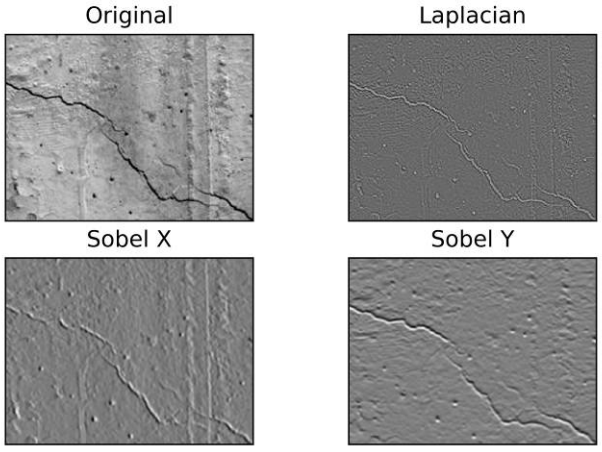

Figure 7. Crack feature extraction for studied image (step 3)

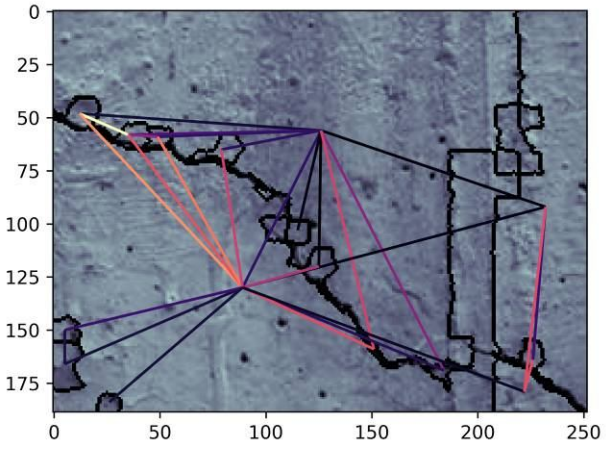

Figure 8. Crack feature extraction for studied image

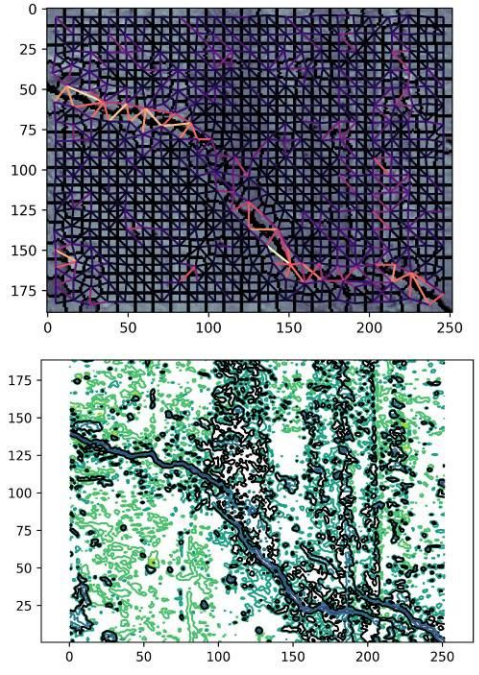

Figure 9. Crack feature extraction for studied image

As seen in these figures, the trace of the crack in concrete surface was perfectly determinate by algorithm. Figure 10 is presented the results of crack recognition in this work.

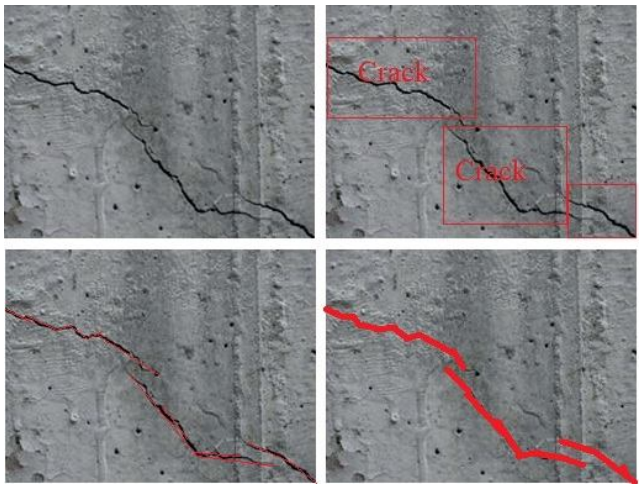

Figure 10. Results of the crack recognition in concrete

4. Conclusion

In this study, we tried to use the artificial intelligence techniques and image processing method for extract crack pattern and crack propagation in concrete surface. The crack in concrete indicated the failure condition in concrete body. From the engineering point of view, cracking begins when the adhesive strength of concrete is lower than the ambient stress, in other words, cracks indicate a decrease in strength and threshold of concrete destruction. Therefore, identifying cracks and evaluating their development in the concrete body can always prevent the occurrence of concrete ruptures and consequently the instability of the structure. In this regard, the image processing technique was used to proved the results and extract the crack properties in concrete by Python OpenCV library. The input image by performing three stages of image processing including pre-processing, main processing and post-processing attempted to extract the crack traces. As results, the trace of the crack in concrete surface was perfectly determinate by algorithm.

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