DETECTION OF CRACKS IN CONCRETE STRUCTURES USING COLOR IMAGE PROCESSING

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1. Introduction

Current practice of inspection and monitoring of concrete infrastructures usually involve manual visual inspection of the structure by field personnel. This is often dangerous, labor-intensive, tedious, and involves high degree of variability among personnel. Considerable interest therefore exists in developing an automated system that will improve safety and efficiency of the data collection, reliability, consistency and uniformity of data and data quality.

The use of color image processing to the inspection and monitoring of concrete infrastructures, in particular for crack detection, is now being studied due to the limitations of present conventional methods of inspection. Color image processing involves the acquisition of a colored digital image of the concrete structural element and subjecting this image to a series of image processing procedures such as filtering, enhancement and segmentation to detect the cracks. The presence of cracks or "edges" is indicated by the discontinuity in intensity from one region to another[1]. The following sections describe how color image processing is used for crack detection, the results obtained and the future works to be done.

2. Color Image Processing

Fig. 1 is a block diagram describing how color image processing is used for crack detection. Matlab is the software used for image processing. A color image of a portion of a railway pier is acquired using a digital camera. This is shown in Fig. 2. After the color image is digitized and stored within the computer as an m-by-n-by-3 data array that defines the red, green, and blue color components for each individual pixel, the color image or "RGB image" is transformed to one of the color spaces (color models). Two cases were considered, the RGB to HSV (Hue, Saturation, Value) transformation and the RGB to YIQ (Luminance, In-phase, Quadrature) transformation. A detailed discussion of these color models can be found in the literature[2,3]. Transformation of the RGB image to another color space is performed to obtain the luminance or intensity component. Grayscale processing techniques such as filtering, enhancement and edge detection is then applied to the luminance or intensity image to detect the cracks.

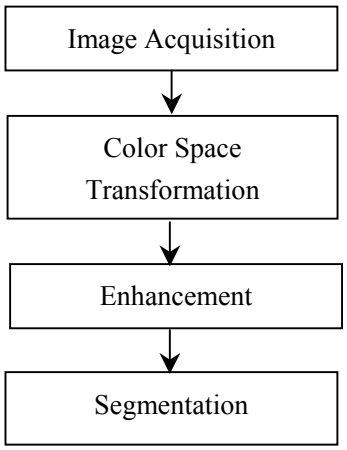

Fig. 1 Color Image Processing

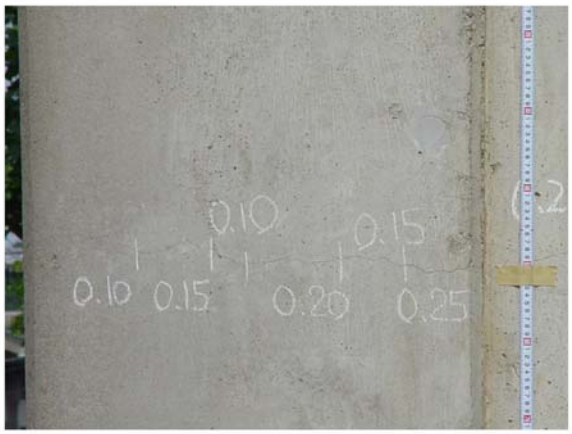

Fig. 2 Color Image of a Portion of Pier

Keywords: Color image processing, crack detection, concrete structures
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The luminance component of the RGB to HSV transformation was enhanced to improve the perceived brightness and contrast of the image. Filtering was also applied to sharpen the edges of the cracks. Gradient edge operators such as the Sobel, Prewitt and Laplacian edge operators were each applied to the luminance component to determine which edge operator works best in detecting the cracks. Fig. 3 shows the Prewitt edge detection of HSV luminance component. Likewise, the same image processing techniques were applied to the luminance component of the RGB to YIQ transformation. Fig. 4 shows the Prewitt edge detection of YIQ luminance component.

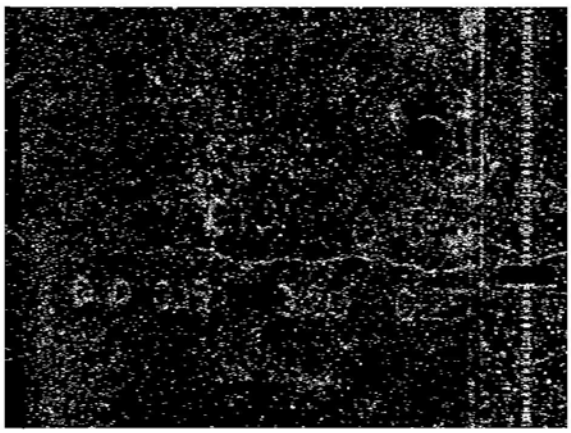

Fig. 3 Prewitt Edge Detection of HSV Luminance Component

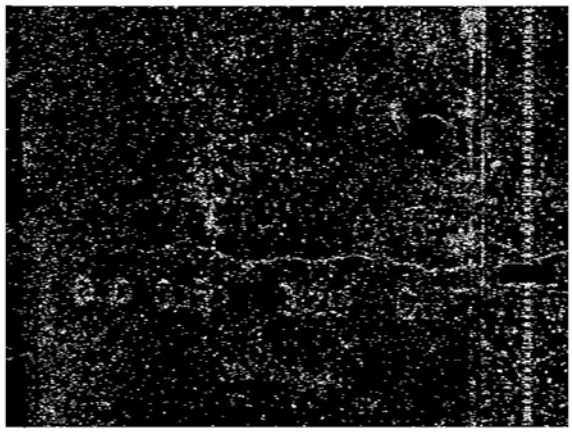

Fig. 4 Prewitt Edge Detection of YIQ Luminance Component

3. Results and Discussion

Result of the edge detection was able to discern the horizontal crack in the luminance component image but both the processed images were very noisy. The original image has very low contrast or variation in color such that some concrete pores have relatively the same color as the crack. The concrete pores emphasized during the enhancement and edge detection process made the image noisy hampering recognition of the horizontal crack in the image. The Prewitt edge-detected HSV image was noisier compared to the Prewitt edge-detected YIQ luminance image. Among the edge detectors applied, the Prewitt operator performed well compared to the Sobel and the Laplacian operators.

4. Conclusions and Future Directions

Detection of cracks in concrete structures using color image processing was investigated. In color image processing, only the luminance or intensity component is processed and filtering, enhancement and edge detection is then applied to the luminance or intensity image to detect the cracks. Based on these procedures, cracks were detected using grayscale edge-detection techniques. Further application of post-processing techniques such as noise removal and crack segment linking may further improve the detection of cracks.

In the transformation of the RGB image to another color space, only the luminance component is processed thus the hue and saturation, representing the color information, is not used to advantage for edge detection purposes. Techniques that use luminance and color information will therefore be investigated and applied for crack detection. One such method is cluster analysis that use global color information to guide local gradient computation[4].

5. References

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