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QUALITY ASSESSMENT OF CONCRETE STRUCTURE USING IR THERMOGRAPHY

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***Abstract*—** Crack detection is a method for detecting defects in reinforced concrete structures by using the method of IR Thermography. Infrared Thermography is one of the Non-destructive thermal method which is becoming even more popular in non destructive testing of materials and structures as well. This project is developed with an aim in detecting crack as well as length and depth. This project is implemented by using MATLAB. It is automated to increase the reliability and thus reduce the effect of human errors and wrong diagnosis. Finally Triangulation technique is implemented for cross checking the process. It is concluded that the method IR Thermography can be used for the detection and quantification of defects in reinforced concrete structures.

Keywords—Non-destructive testing,IR Thermography,Defect Identification

INTRODUCTION

In the modern communication system, Non Destructive Testing (NDT) of concrete structures is becoming increasingly important due to aging and deterioration of infrastructures. Infrared Thermography Technique (IRT) relies on the variation in the temperature caused by air packets in concrete. This method uses the infrared rays emitted by the investigated object to access it temperature gradient on the surface of the specimen. An infrared camera is used for capturing the infrared rays from the object. For the non-destructive evaluation in concrete components, the active IRT method is being used. The main goal of any non-destructive evaluation technique is to detect and locate the anomalies within an optically opaque medium through appropriate imaging technique. Advanced NDT techniques which will facilitate rapid, cost efficient and reliable condition assessment of existing infrastructure to ensure public safety

Scott et al. [1] claim that civil applications of IRT are very much limited to IRT inspections with natural excitation due to the size of the targets being evaluated and the difficulties associated with trying to actively heat such large targets with relatively small external heating sources. Sakagami and Kubo state et al [2] that the defects of 10 cm in depth cannot be detected, by their method, while considering the heating period which was used, they have set the limitation of the detectable defect depth at 5 cm. Yiyang et al [3] have proposed a crack detection algorithm based on digital image processing technology. By pre-processing, image segmentation and feature extraction, they have obtained the information about the crack image. In, Threshold method of segmentation was used after the smoothening of the accepted input image. To judge their image, they have calculated the area and perimeter of the roundness index. The exiting methods are a) Pulse Thermography : Fast inspection relying on a thermal stimulation pulse, with duration going from a few milliseconds for high thermal conductivity material inspection to a few seconds for low thermal conductivity specimens. b) Step Heating : Contrary to PT scheme for which the temperature decay is of interest, the increase of surface temperature is monitored during the application of a step heating pulse. c) Lock-in thermography: Based on thermal waves generated inside the specimen under study in the permanent regime. Here, at a frequency, the specimen is submitted to a sine modulation heating, which introduces highly attenuated a dispersive thermal waves. d) Vibrothermography: A mechanical vibration induced externally to the structure direct conversion from mechanical to thermal energy occurs and the heat is released by friction.

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INFRARED THERMOGRAPHY

Infrared thermography is equipment or method, which detects infrared energy emitted from object, converts it to temperature, and displays image of temperature distribution. In a similar way, an infrared camera creates an image by converting radiant heat energy into a signal that can be displayed on a monitor. There are two general types of infrared instruments that can be used for condition monitoring: Infrared thermometers and Infrared focal plane area (FPA).FPA is an array at the focus of a radio telescope. At optical and infrared wavelengths it can refer to a variety of imaging device types, but in common usage it refers to two-dimensional devices that are sensitive in the infrared spectrum.

TRIANGULATION

Triangulation is a powerful technique that facilitates validation of data through cross verification from two or more sources. It tests the consistency of findings obtained through different instruments and increases the chance to control, or at least assess, some of the threats or multiple cause influencing our results

BLOCK DIAGRAM

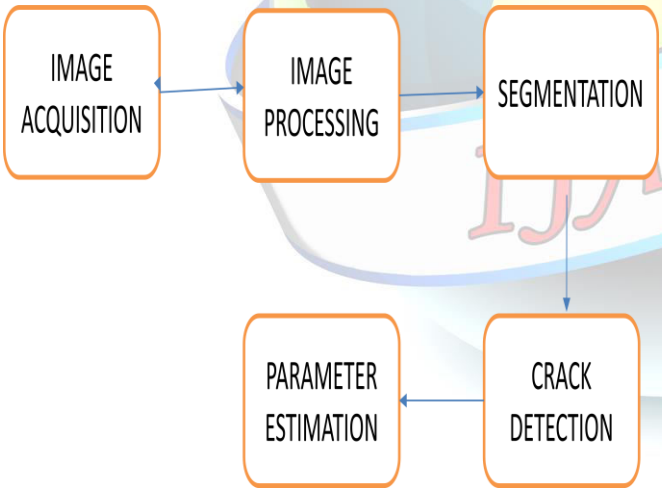


FIGURE 1 PROPOSED METHODOLOGY FOR CRACK DETECTION

ACQUSITION

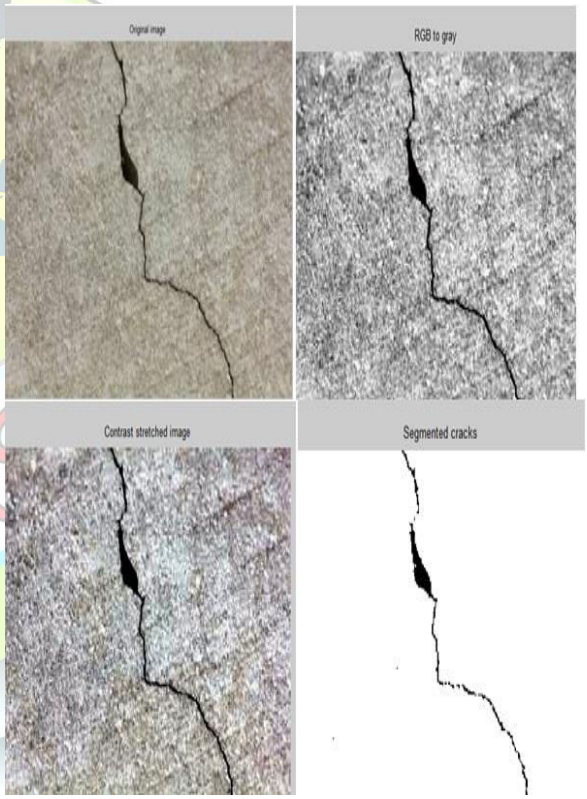
Digital imaging or digital image acquisition is the creation of digital images typically from a physical scene. The term is often assumed to imply or include the compression, storage, printing and display of such images. The most usual method is by digital photography with a digital camera but other methods are also employed

IMAGE PROCESSING

The major advantage of the image based analysis of the crack detection is that by using the image processing technique. It provides accurate result compared to conventional manual methods.

IMAGE SEGMENTATION

Image segmentation is the process of dividing an image into multiple parts. This is typically used to identify objects or other relevant information in digital images.



CRACK DETECTION

The steps of IRT data processing are the following:

- Enhancement of the signal to noise ratio, e.g., by averaging of thermograms or spatial or temporal filtering.
- Location of defect areas by visual examination of the thermograms. Contrast areas can be accentuated by edge filtering or through further steps of image

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- Transformation of geometrical parameters (size and position of measurement area, planar size and position of in homogeneities or defects) processing.

$$E= \frac{1}{N}\sum_{K=1}^{N}\left[R_k \frac{\sum_{i=1}^{W_K}\sum_{j=1}^{h_k} W_k(i,j).O_k(i,j) - T_k(i,j)}{\sum_{i=1}^{W_k}\sum_{j=1}^{h_k} W_k(i,j)\, V_{max}}\right]$$

Where,

N- No of training images in database

T_k - Target image

O_k - Output image

W_k - Weighted image

RESULT

Sample dataset of IR thermal images of crack images are shown in the figure 2.

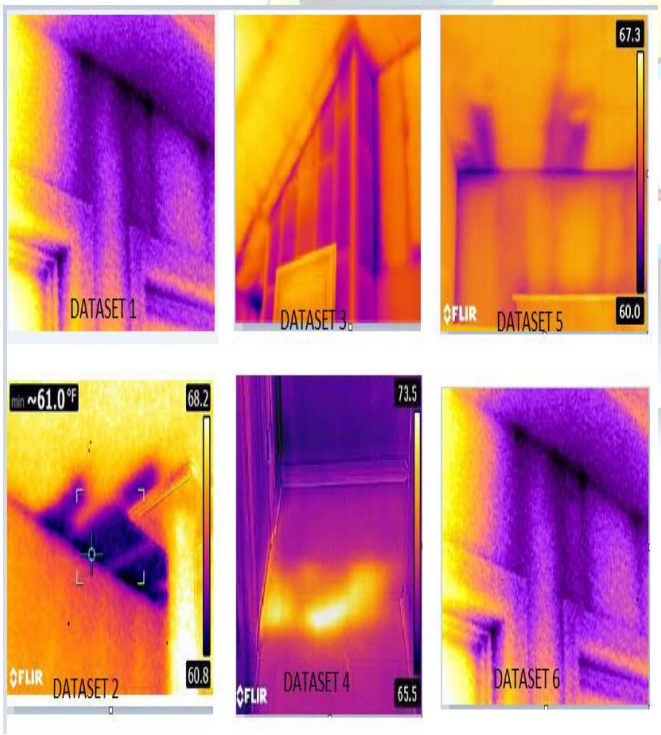

FIGURE 2 DATASET OF IR THERMAL IMAGE

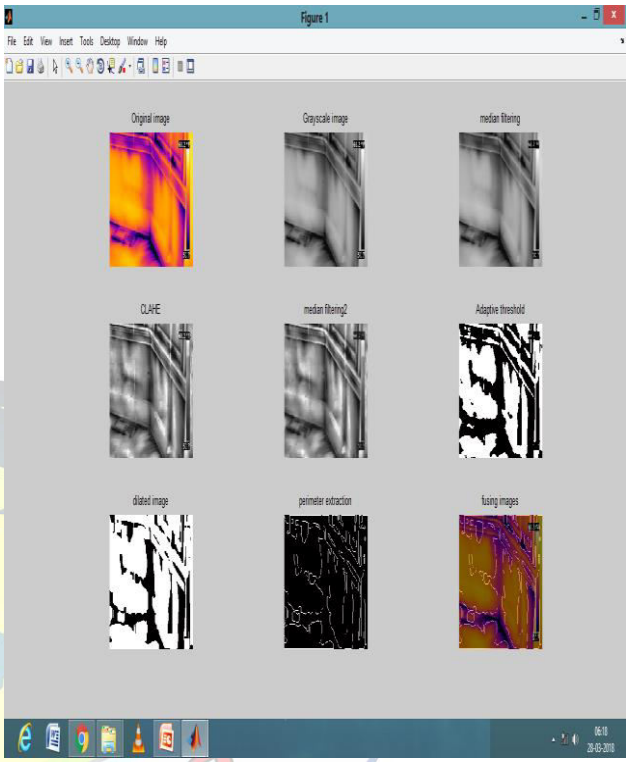

Figure 3 Identification of crack

Conversion of colour image into a grayscale image, the converted grayscale image may lose contrasts, sharpness, shadow and structure of the colour image. The median filter is a nonlinear digital filtering technique, often used to remove noise from an image or signal. A varient of adaptive histogram equalization called contrast limited adaptive histogram equalization (CLAHE). Thresholding is the simplest method of image segmentation. From a gray scale image, thresholding can be used to create binary images. Dilation is applicable to binary images. The basic effect of the operator on a binary image is to gradually enlarge the boundaries of regions of foreground pixels. A pixel is a part of perimeter if it is nonzero and connected to atleast one zero-valued pixel. Image fusing is the process of combining relevant information from two or more images into a single image is shown in the above figure 3. Finally the crack is identified with its blob size, length and depth

TABLE 1 : CALCULATION OF CRACK

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IMAGES	BLOB	AREA	WIDTH
Dataset 1	**234.00**	**45673**	**124.28**
Dataset2	**324.00**	**43524**	**116.76**
Dataset3	**433.22**	**34562**	**108.56**

The crack is identified from the thermal image and the blob size, area and width also calculated is shown in the above table 1.

CONCLUSION

In order to evaluate the safety of a concrete structure, a method to detect cracks from camera image was proposed. First, it was possible to visualize the concrete crack easily through the image processing techniques such as filtering and segmentation method. Second, the existence of cracks in many images could be automatically identified. The various optimization methods can be applied to determine optimal parameters required in the image processing. It is important in the visualization of crack and the acquisition of the exact crack information.

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