MEASUREMENT OF CRACK DETECTION IN CONCRETE IMAGE USING IMAGE PROCESSING TECHNIQUES

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Abstract: The cracks arriving in the concrete surface due to atmospheric effects such as stains, climate etc. The aim of crack detection is to be monitored and identify the crack to prevent damage very effectively. The image can be processed and displayed by using image processing techniques.

The crack detection is useful for predicting the level of damages on concrete surfaces. Conventional crack detection can be performed by manually sketches the pattern of cracks; however, such detecting algorithms had higher cost in nature. Then the automated detection of cracks techniques have been introduced to optimize the resources using image processing methods which concentrates on to maintain accuracy of the detected cracks as well as the time required for computation that is more useful for practical purpose of digital image. The boundaries of crack image on a concrete structure are detected by involving various easier algorithms used for image processing that includes the Pre-processing i.e. by using a simple filters to remove an unwanted noise and equalization is done through Histogram technique. Thus the proposed method is not much complex to execute and maintain the accuracy that implies the detection of crack on the concrete structure is very simple in practical life.

Index Terms - Crack image, Segmentation, Conventional crack detection, automated crack detection, Pre-processing, Histogram equalization

I. INTRODUCTION

The cracks arriving on the concrete structure due to stains, stress, climate etc that reduces the stiffness and cause material discontinuity. Thus the crack on the concrete structure image can be detected using some simpler image processing algorithms/ techniques. Image acquisition is the first step in image processing to convert the analog image into digital by sampling and quantization processes. Pre-processing has been done next to remove noise and degradations in a concrete structure image. Colour image processing and image resolution can be presented by a graphic display with quality and accuracy detail. In segmentation the image is partitioned into several non-overlapping regions which are used to extract the crack characteristics from the concrete structure and background regions. Surfaces of crack boundary can be extracted, modelled, manipulated, measured and visualized based on the partitioning results. Therefore, to develop reliable image segmentation methods for crack on concrete structure has the priority by the other research groups. The crack boundary can be analyzed and detected using computers as a first step. In the literature, the performance of segmentation becomes complicated and does not provide sufficient information when the magnitude of the image gradient is used. Thus, to improve the quality of the image segmentation the proposed histogram equalization technique is used rather than the gradient magnitude.

Edge detection is done on the concrete structure images to segment the image from the background images. Linking and boundary detection procedures are the algorithms plays a vital role in edge detection. The edges in an image are detected by implementing first and second order digital derivatives.

Edge is defined as the boundary between two regions which are relatively distinct gray-level properties and an edge is a set of connected pixels between two regions that lie on the boundary. The concrete structure image complexity is reduced by detecting the edges of the crack and they can be used to measure parameters related to length, width and depth of the crack images.

Thus edge detection is done using first-order derivative and the sobel and prewitt algorithms. In this paper, the crack on the concrete structure image is detected using the proposed algorithm which involves the Pre-processing step, segmentation and post-processing step. Median filtering is useful in eliminating the intensity spikes i.e. the noise is removed while it preserves the edges in a best way. The image is stretched or compressed by Histogram equalization which is used to detect the edges of a crack in the concrete structure.

II. EXISITNG METHOD

A multi-stage algorithm to detect a wide range of edges of the crack in the concrete structure images by the following stages of the Edge Detection algorithm by Canny.

a) Noise Reduction

Median filter is a filter that removes only noise and retains the entire structures of an image in the neighborhoods pixel values edge smoothing filter, because no filter can discriminate image content where the level is set to the median of the pixel.

Median (P_0, P_1,…..,P_{k-1}, P_k,……,P_{2k-1}) = P_{k-1} + P_k/2

Where

P_0, P_1,……, P_{k-1}, P_k,……., P_{2k-1} is the sorted sequence

b) Gradient Operator

This algorithm used to detect the edges of the crack in the blurred image by four filters. An edge in the image points variety of directions, horizontal and vertical edges are detected. It can be done by calculating the gradient of the pixel which is relative to its neighborhood.

For the 2-dimesional column vector function f (x, y), the gradient f at co-ordinate (x, y) is defined as

$$\Delta f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \partial f / \partial x \\ \partial f / \partial y \end{bmatrix}$$

$$\Delta f = mag(\Delta f) = \left[G_x^2 + G_y^2\right]^{1/2}$$

$$= \left[(\partial f / \partial x)^2 + (\partial f / \partial y)^2\right]^{1/2}$$

$$\cong |Gx| + |Gy|$$

If α (x,y) represent the direction angle of the vector ∇f at (x,y), then, α (x,y) = $\tan^{-1}$(Gy/Gx)

The gradient direction is, $\alpha = \tan^{-1}\left(\frac{G_x}{G_y}\right)$

Hence the direction angle of edge is rounded to one of the four angles such as vertical, horizontal and the two diagonals (0, 45, 90 and 135 degrees).

c) Non – maximum suppression

The edges of the crack are colored to indicate direction. When the image gradient is determined by the magnitude of the gradient assumes gradient direction as local maximum. It is impossible to specify the threshold when it is traced through the image and hysteresis hence Canny method is used. The edges are traced along with the continuous curves in an image that allows to a faint section of a line and to discard the noisy pixels. Each pixel from the binary image is marked as either an edge pixel or a non- edge pixel.

III. PROPOSED METHOD

The new algorithm is proposed to make the dissimilarities by using the image processing technique, as shown in the flow chart.

Algorithm for the proposed method:

Step 1: Load an acquired concrete structure image, display in the matrix form, where the pixel value of each images are ranges from 0-255.

Step 2: Image of Gray scale is obtained by converting RGB image and the Median filters are applied to degrade noise from an image.

Step 3: For the given input image Histogram equalization is taken and if the blur or noise present in the image could be restored by using Wiener filter.

Step 4: Sobel edge detectors are applied to identify edges in the image and repeat the above process again.

Step 5: Thresholding method is applied to the concrete structure image to obtain the binary image that is 0 or 1.

Step 6: To detect the concrete structure edge from an image and also the components of the image is extracted using morphological technique

Fig 1.1 shows that the acquired crack image as input, then the noise removed by Median filters in preprocessed step and the histogram of concrete structure crack that is extracted from the background.

Again, the Gray scale image is obtained by converting RGB image and Thresholding method is suitable for the concrete structure image to obtain the binary image. Finally, the edges of the concrete structure image and also the components of the image is extracted using morphological technique.

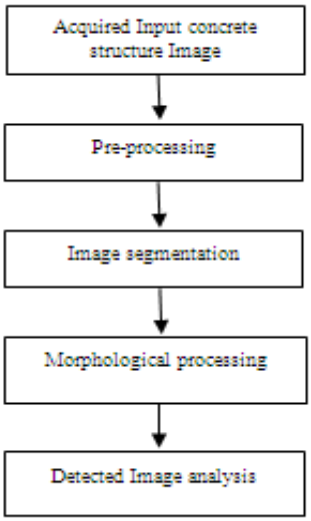


Figure 1 flow diagram of proposed method

Thus, the edges of the crack from the given concrete structure image is detected by the above shown algorithm.

a) Image Enhancement

The goal of enhancement method is to emphasize certain features in a crack for image display and for a particular application where the outcome is comparatively same as that of input image.

Image enhancement is used to sharpening of more useful image features such as edges, boundaries that gives a graphical display and analysis.

Histogram represents the number of times a particular grey level has occurred in an image. Histogram of an image is defined as

$$H(r_k) = n_k , \quad k = 0,1,\ldots\ldots\ldots\ldots,L-1$$

Where

$r_k = k^{th}$ grey level

n_k = number of birds grey level values as r_k

For n various image processing applications it provides a useful image statistics as well as it is the variation of an object's grey level average and surroundings.

Histogram equalization is that overlaps a desired image onto the actual image which used for contrast enhancement. Assume the intervals [0, 1], where 0 represents black and 1 represents white.

$$S = T(r) \text{ when } 0 \leq r \leq 1$$

Where T (r) is a single valued function (one to one relationship)

b) Image Restoration

The images are corrupted with noise because of channel interference, lightening and other disturbances in wireless network. Wiener filter restores the image when blur or noise present in the image.

$$H_R(u, v) = (H^*(u, v)\, S_{ff}(u, v)) / |H(u, v)|^2 S_{ff}(u, v) + S_{nn}(u, v)$$

Where

H (u, v) is the degradation function

$|H(u, v)| = H(u, v) * H^*(u, v)$

$S_{ff}(u, v)$ is the power spectral density of undegraded image,

$S_{nn}(u, v)$ is the power spectral density of noise

The objective of wiener filter is to minimize the Mean Square Error (MSE)

Error

$$e(m, n) = f(m, n) - \hat{f}(m, n)$$

where,

f (m, n) - input value

$\hat{f}$ (m, n) - output value

c) Edge Detection

The first derivative magnitude and the second derivative are used for detecting the boundary of a concrete structure image is detected. Edge detection is not simple because edges are corrupted by noise and blurring but it can be made simple by specify a threshold value that decides if an edge exists between the neighboring pixels. Diagonal edges are detected by rotating the mask by 45^0 counter clockwise by sobel mask. Thus it provides both a derivative and a smoothing effect that has noise suppression characteristics in a crack image.

d) Morphological Processing

Morphological processing is used as a tool for extracting image components used in representation and description of region/ shape.

Algorithm for morphological operation are given below

1. Read image
2. Grey scale conversion
3. Create structure element
4. Perform opening and closing operation
5. Display output

e) Crack Measurement

The area and perimeter of the crack is measured for the analysis of the image that is to find the level of crack and the shape of the crack occurred.

$$\text{Area} = a \times b$$
$$\text{Perimeter} = 2 \times (a + b)$$

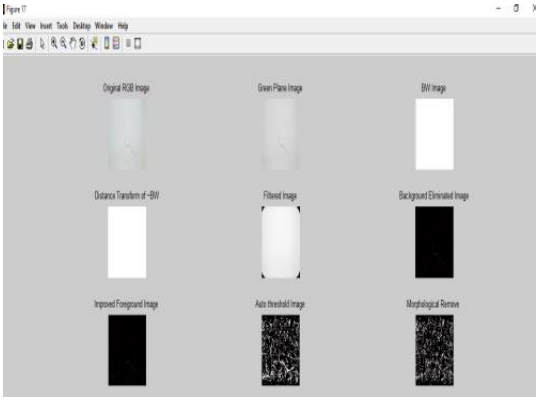
Where a – length of crack

b – Width of crack

IV. RESULTS

Nearly 10 Concrete structure images were taken and tested out in that four images are shown in Figure 2 for the detection of edge of crack on concrete structure. The size of each image had 356x356 pixels and 72 dpi for both the vertical and the horizontal resolution. With the help of MATLAB 7.12.0 on a Pentium IV PC the algorithm was tested successfully.

Figure 2 Input Concrete Structure Image



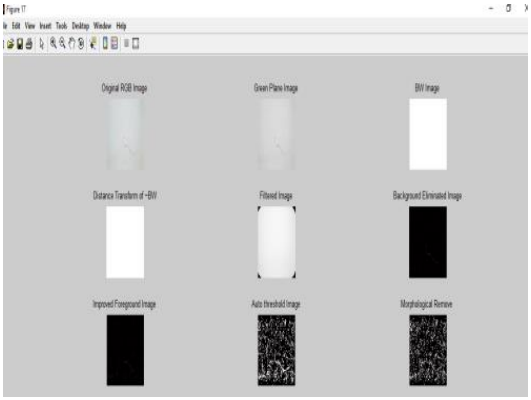
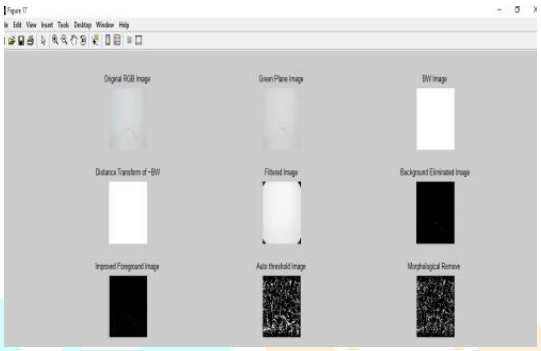


Figure 3 Pre-processed output of the Concrete Structure Image1, Figure 4 Pre-processed output of the Concrete Structure Image2



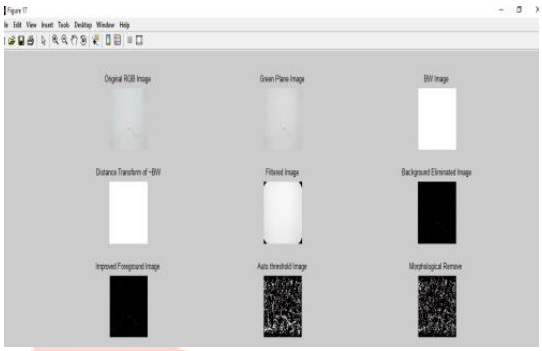
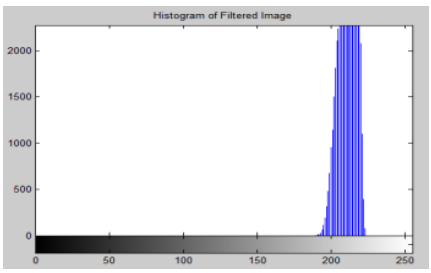


Figure 5 Pre-processed output of the Concrete Structure Image3, Figure 6 Pre-processed output of the Concrete Structure Image4

Fig 2 - 5 represents the outcome of Concrete Structure's images edge detection based on preprocessing algorithms. The various steps to find the boundaries of the crack from the acquired concrete structure images are by the following techniques. Fig 6 represents the given input concrete structure images histogram output. Fig 7 as well as Fig 8 represents the output of the histogram equalization of the input image and also its histogram output. At last Fig 9 represents the edge or boundary of the crack from the input concrete structure image using the edge detection algorithms such as edge detection based on segmentation and thresholding and morphological operation.

Finally the results shows that the edges of the crack on the concrete structure detected by edge detection techniques is more effective when compared to other edge detection algorithms such as canny, laplacian.. From all the figures anyone can easily predict that the proposed algorithm can detect more complete edges with good contrast of the crack on the concrete structure. Thus the outcome proves that the proposed method reduces the cost of computation and time.



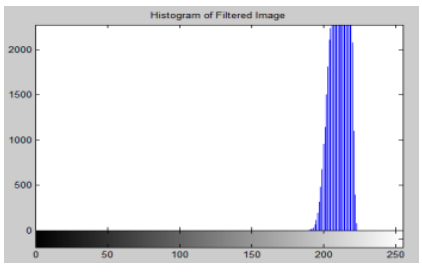


Figure 7 Input image's Histogram output, Figure 8 Histogram equalization of input image

Figure 9 Edge detected Concrete Structure Image

Table 1 Measurements of detected crack image

Area	Dia	Britns	Skew	Mean	Std	Var	Circty	Eccent	Smooth	Compact
736	30.61	199	0.00	199.00	4.54	29690.79	2.62	0.92	15.31	1.00

V. CONCLUSION

In the image processing technique, the proposed edge detection methods are used to detect the edge of the crack from the input Concrete Structure's images. This edge detection technique is compared with canny edge detection, very simple or easy methods are embedded to get the boundaries of crack by segment the edges of concrete structure's images in an accurate manner is implemented. Thus the result shows that the crack detection technique is efficient to detect the edges of crack. To detect the parameters and characteristics of damages in a Concrete Structure's images will be the further work in future by including more simple techniques as that of the previous techniques with accuracy.

VI. ACKNOWLEDGMENT

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