Image Geometry Based Concretecrack Quantification

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Abstract: Cracks in the concrete are the common defects in buildings and structures. Many computer vision-based methods are used to identify the concrete structures.This paper is developed to analyze and measure different parameters of crack in concrete structures. Three different types of cracks are available in structures such as longitudinal, transverse and diagonal. The main reasons of crack depend on the crack appeared in a beam, column or any structural wall. Crack in a beam is usually due to tension, crack in a column occur due to eccentric loading, structural cracks are formed due to moisture change or thermal movement.The proposed method initially deals with crack segmentation and secondly the image geometry-based parameters are employed for crack quantification.

I. INTRODUCTION

Analysing crack ensure the safety, durability and service of concrete structure. The reason is when crack is developed in concrete structure there will be increase of stress and there will be failure of concrete structure as crack will increase due to stress. Cracks create very harmful environment when it penetrates to the structures. Now-a-days,manual inspectionis the key way to assess any concrete structures like pavements, bridges, roads subways, tunnels[1-3] and pipelines.Butthis method is expensive, dangerous and little bit inaccurate, which would cause further damage to the structure. Whereas high accuracy is needed to effectively repair the crack, to avoid imperfection[4-7]. Many computer vision-based methods are proposed in the last decades for the crack detection in the structures. Crack detection, classification and quantification are the main streams of the automation methods. Recently,Nhat-Duc Hoang [8] proposed a method for crack detection in building structures with the help of otsu adaptive threshold.

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Min-Max to GrayLevel Description(M2GLD) is used for the image enhancement in [8]. The accurate detection of cracks are made in this literature. Yusuke fujita et al [9] proposed a method for crack detection on concrete structure in which new pre-processing method is gauged by region of convergence analysis.Gajanank et al [10] proposed a paper for crack detection in concrete structure. Fuzzy logic and artificial neural network are used to find the concrete cracks. Initially edge detection methods are adopted to find the features from the input image.

Bang yeon lee et al [11] used image processing for quantification of crack in the surface of concrete structure. Measurement of cracks are estimated via crack width, crack length, crack direction.The unit pixel length is determined in [11]. It applies morphological techniques for shading correction and to improve the efficiency of crack detection system. The image binarization and filtering operations are used initially to perform pre-processing steps. Packing density is used to distinguish cracks from other object like noise.

Mohammad R jahanshahi et al [12] proposed a new contactless crack measurement method. It is also a automation method to find the cracks. Ito et al [13] attempted to separate single cracks on the basis of identification of the nodes after skeletonizing the crack pattern, the nodes were mainly used for tracing and labelling the cracks. Paul dare et al [14] provides the review of feature extraction methods which are essential for concrete crack detection. Andrushia et al [15] reviewed the various edge detection methods for crack detection.

Even though many literatures are proposed in the automatic crack detection and quantification, the image geometry-based methods are still in infancy. The proposed method initially deals with crack segmentation and secondly the image geometry-based parameters are taken for crack quantification.

II. EXPERIMENTAL MATERIAL

The input images are collected from concrete structures with cracks. The normal digital camera is used. The image properties are 2340*4160 pixel and focal length of 4.225mm. To maintain the computation time, every image of 2340*4160 pixels is compressed to 400*300 pixels. In this experiment, 50 concrete crackimages were taken for analysis. Real time images are collected along with the database images.

III. METHODOLOGY

Figure 1 shows the proposed methodology flow diagram and the sample crack image is given in figure 2. The crack image which is mentioned in figure 2 involves three type of cracks. As an initial step, crack images are converted to gray scale image. The noises are removed from the gray scale image. The image skeleton is taken for the further steps.Weighted median filter and otsu threshold are used to find the end points of crack.Starting point and end points are given by numerical representation. The branch point is indicated by ‘1’ in the adjunct matrix, otherwise the point is not branched.

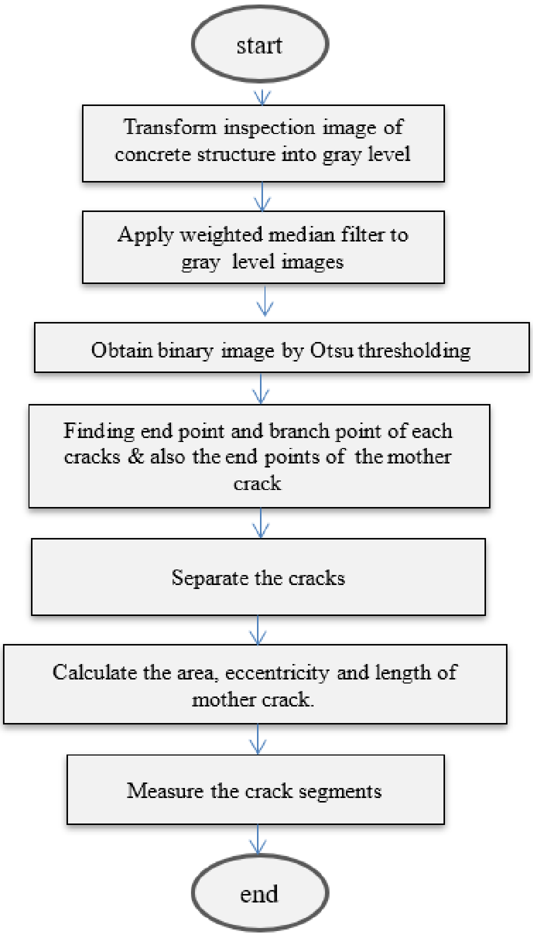

Fig. 1. Flow Chart of crack detection and quantification**.**

The entries in the matrix is defined as ‘0’. The mother crack is then obtained. The image geometrical features of mother crack is obtained via length, width, area and eccentricity.

A. Image Reading and Binarization

The RGB image is given as input to the system and it is converted as gray scale image by using define threshold.

Fig 2. Gray scale image.

B. Removal of unwanted noises

The noises in the image are removed by the weighted median filter in fig.3. Median filter helps to remove environmental noises which areexisting in the crack image.

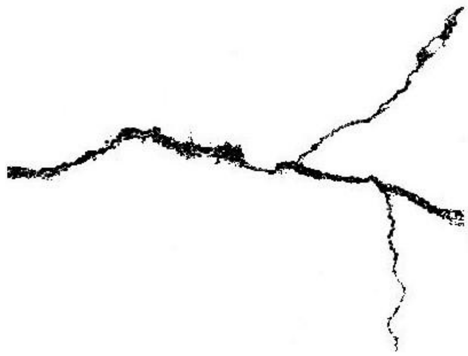

Fig. 3. Binarized image with noise removal

It is one of the flatten filters, although it removes the required textures in the image too, to avoid this problem Weighted median filter is used, it does not change any image textures which are useful for quantification purpose.

C. OTSU Thresholding

OTSU Thresholding method is adopted in this method which uses adaptive threshold concepts. It converts gray scale images to binary images. The process contains images with two classes of pixels and a suitable threshold value dividing both the classes. OTSU’s method is known to be limited by the low size of the images. Thresholding is the common and basic method for various applications like image segmentation, compression, image understanding [16-18]

D. Find the branch points and end points

Morphological operators are used for the identification of end points and branch points on the variouscrack skeletons. It is found that single crack, quantification is essential to find the crack details about the extension of crack path.

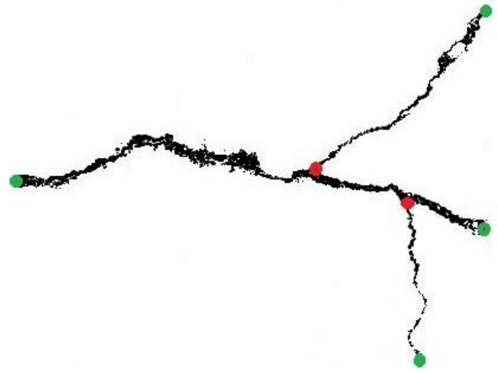

Fig. 4. Detecting specific points (branch and end point)

Each skeleton of cracks are given with starting and ending points. Nearest point to the origin is taken as starting point and other point is taken as end point. Result is shown in fig.4. in which starting point, branch point and end point are indicated by red and green points [19].

E. Separation of cracks into each segment

As shown in fig.5, each crack starting point and ending points are represented by numbers. The branch points which separate each segment of cracks.

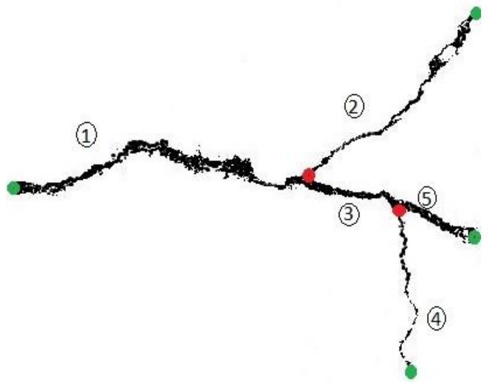

Fig.5. Numbered branch points and end points

For breaking up the collector segment branch point and the 3*3 neighbourhood points are detachedin figure 4.

F. Construction of adjacent matrix

Adjacent matrix is used to denote the crack and non-crack points. It is a square matrix. The 'one' indicates nodes of the crack and the "zero" denotes the non-availability of branches in the particular crack.

IV. QUANTIFICATION OF CRACKS

A. Area

Let 'm' denotes the pixel in each segment. The total area of the crack is calculated by the total area of each segment. The total area of the crack is calculated by the equation (1)

$$Total\ area\ of\ cracks = \sum Area\ of\ segments \quad (1)$$

The area is measured for each segment and the result is shown in the below table 1.

Table 1: Evaluation of crack area

Segmented Region	Area (pixel)
Point 1	943
Point 2	510
Point 3	365
Point 4	253
Point 5	307

B. Eccentricity

Eccentricity is one of the region properties of an image. It is defined as the ratio between major axis length and foci. It is given in the equation 2

$$e = \frac{c}{k} \qquad (2)$$

Let 'e' denotes eccentricity, c and k represent foci and major axis length. So, the eccentricity of the taken crack image is 10.

C. Length

The crack length is derived by the equation (3)

$$L = \sqrt{(l-a)^2 + (m-b)^2} \ (3)$$

The crack segment length is given as 'L'.

(l, m) is the coordinate of starting point and (a, b) is the end point of crack.The length of each crack segment is shown in table 2.So, the length of main mother crack will be:

Length of mother crack = Length of the first segment

+ Length of the third segment

+ Length of the fifth segment

The length of the mother crack is calculated as 316 pixels for the fig 5.

Table 2: Evaluation of crack length

Segmented Region	Length (pixel)
Point 1	188
Point 2	175
Point 3	75
Point 4	113
Point 5	37

The cracks in the type of longitudinal, transverse and diagonal are evaluated in terms of area, eccentricity and length.

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V. CONCLUSION

Concrete cracks are one of the life agitating issues in concrete structures. This research work focusses on the quantification of cracks in terms of image geometry. Initiallyotsu threshold and filtering concepts are used to perform the pre-processing steps. The cracks are segmented by considering the start point, end points and branch points. The crack parameters are calculated for each segment. Crack length, crack area and eccentricity are calculated from mother crack and other sub cracks. This experiment is done for longitudinal, diagonal and transversal cracks. In the near future, many crack parameters will be calculated from the crack images.

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