# “Measurement of Crack Dimensions in Concrete by using Digital Image Processing”

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**Abstract:** The elements of the concrete structure are most frequently affected by cracking. Crack detection is essential to ensure safety and performance during its service life. Cracks do not have a regular shape, in order to achieve the exact dimensions of the crack; the general mathematical formulae are by no means applicable. The authors have proposed a new method which aims to measure the crack dimensions of the concrete by utilizing digital image processing technique. A new algorithm has been defined in MATLAB. The acquired data has been analyzed to obtain the most precise results. Here both the length and width of the crack are obtained from image processing by removing background noise for the accuracy of measurement. A semi-automatic methodology is adapted to measure the crack length and crack width. The applicability of the program is verified with the past literature works.

**Keywords**: Algorithm, Crack Length, Crack Width, Cracks, Digital Image Processing

## 1. Introduction

### 1.1 General

Image processing is the process of extracting significant information from digitized images by transforming them into other images using various mathematical algorithms Okan Onal et al. (2008). As for automated damage detection, many methods have been created using image processing techniques such as wavelet transforms, edge detection, and/or region-based segmentation. Abdel-Qader et al. (2003) compared various edge detection algorithms and found the Haar Wavelet method is the most reliable among them, for the purpose of crack detection. However, the performance of edge detection algorithms on noisy image data is questionable, and the same is the case with morphological operation based methods. Kabir and Rivard (2007) used Haar’s discrete wavelet transform to study the deterioration in concrete structures from the 2D image. Yamaguchi et al. (2010) used scalable local percolation-based image processing techniques, and they proved to be efficient and accurate even for large surface images. Prasanna et al. (2012) developed a histogrambased classification algorithm and used it along with Support Vector Machines to detect cracks on a concrete deck surface. The results of this algorithm on real bridge data highlighted the need for improving the accuracy. Nevertheless, training data from various locations on the bridge could be used Barkavi, T. and Natarajan, C. 12 to build the classifier and testing could be done on data from a different location of the similar structural composition. Similarly, Lattanzi and Miller (2014) developed an automatic clustering method for segmentation based on Canny and K-Means for achieving greater accuracy of crack detection under various environmental conditions at a higher speed. Li and Xuehui (2014) used a feature extraction methodology in image processing to identify segregation of the SCC mix from the photograph of the mix. Yu et al. (2006) developed a graph-based search method to extract crack properties for further assessment and used a ground-based robot for collecting images; however, this method needed the manual input of start and end points of crack. They also have used watershed segmentation algorithm to found the lower boundary of the mix and thresholding to find the upper boundary. They manually picked the boundary points and checked the vertical distance between them and have used it as the visual feature to identify segregation in the mix. The abovediscussed works are focused on crack detection alone, but it is also vital in an inspection to understand the crack properties such as width and length because condition ratings are assigned based on such properties. This type of Condition monitoring aims to obtain the signs and indicators revealing the condition of the structure. This procedure is more cost-effective than predictive or regular maintenance or repair (Mohammadi Zadeh and Yasi (2018)).

### 1.2 Semi-Automatic Crack Measurement

In this research article, a new method of semiautomation has been proposed. This system doesn’t have the provision of automatic image acquisition by external devices. Here the human intervention is needed to capture the image and feed it into the crack detecting system to compute the numerical information of crack images. So the parameters like calibration length and camera focal length are neglected while writing the algorithm. In order to compensate that, the user is instructed to select the first, end and traversing points along the crack length by using a mouse-controlled pointer. Even though it seems to be time-consuming and work-intensive, this approach will give an accurate result. Another advantage is that in case of an image with multiple/continuous cracks the user can retrieve the property of crack of interest alone.

### 1.3 Manual Measurement of Crack

The manual measurement is conducted by a technician with measuring tools such as strings, graduated scale or cracks comparator. The main problems about those measuring by comparing methods could be enumerated as low accuracy and traceability, subjectivity on reading and difficulties on recording data (Martins et al. 2013). Another instrument with better resolution applied is digital pachymeter, for which, the technician must have the knowledge to choose and insert the metallic blade in the crack opening. The conventional dimensional instruments have subjectivity on manual positioning during measurement. Another factor is the uncertainness associated with the handling of the instrument by a technician. These inconsistencies demand a higher number of repetitive measures to have more accurate values (Koch et al. 2015). With the purpose of reducing the technician workload and the generation of accurate results, the work aims to identify the crack dimensions on concrete

## Ii. Methodology

### 2.1 Digital Image Processing

Digital Image Processing is the application of various operators or filters on the image to eliminate or reduce noise, some to heal or improve the image, while others may be used to separate required information from the image. The processing methods available are from low-level processing up to high-level processing methods as illustrated in Figure

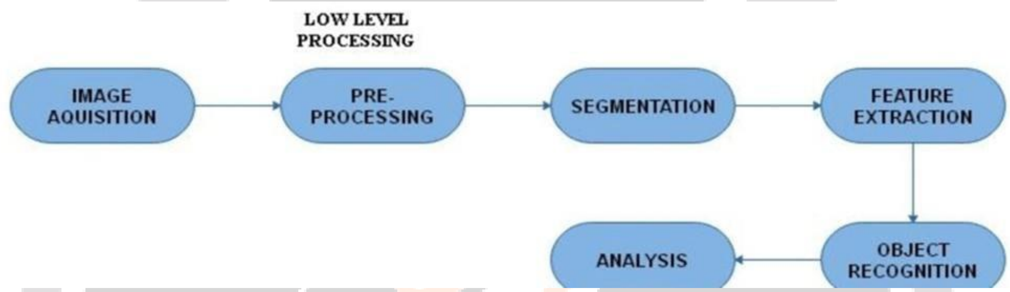



**Fig. Flow Diagram of image processing**

### 2.2 Definition of Flow Chart Term

**Image Acquisition:** This is the first step, where images of the concrete surface are captured using a digital camera or other imaging devices. Proper lighting and resolution are crucial to ensure that the cracks are clearly visible and distinguishable.

**Image Processing:** Once the images are acquired, they undergo preprocessing to enhance their quality. This may involve filtering to reduce noise, adjusting contrast and brightness, and applying edge detection algorithms to highlight the cracks.

**Segmentation**: In this step, the processed image is divided into segments to isolate the cracks from the rest of the concrete surface. Techniques such as thresholding, region growing, or clustering are used to identify and extract the crack regions from the background.

**Measurement:** After segmentation, the dimensions of the isolated cracks are measured. This involves calculating parameters such as crack width, length, and area using image analysis tools and algorithms. The measurements provide quantitative data on the extent and severity of the cracks.

### 2.2 MATLAB Code of The Proposed Algorithm

**Clearing Workspace:** clc,clear,close all; This command clears the command window, workspace variables, and closes all figure windows.
**Image Loading:** uigetfile('*.*','Choose the input image');: This opens a dialog box for the user to select an image file.
**Image Processing:**
**Image Resize**: imresize: Resizes the image to a specified size.
**Convert to Grayscale**: rgb2gray: Converts the RGB image to grayscale.
**Image Enhancement:**
**Low Pass Filtering:** Applies a low-pass filter to enhance the image.
**Blurring:** Blurs the image to further enhance it.
**Image Segmentation:** Uses Otsu's method to threshold the image and convert it into a binary image.

**Noise Removal and Connectivity Enhancement**: Iteratively dilates, connects, fills, and erodes the binary image to remove noise and connect nearby regions.
**Boundary Extraction:** Finds boundaries of connected components in the binary image (presumably cracks in this context).
**Crack Dimensions Calculation:**
Euclidean Distance Calculation: Calculates the Euclidean distance between points along the boundary of each connected component (crack).
**Conversion to Meters**: Converts the distances to meters based on the provided area of the image.
**Crack Width Calculation:** Fits a polynomial curve to each crack boundary and measures the width perpendicular to the fitted curve at multiple points.
**Displaying Results:**
Displays various stages of image processing and the final results using subplot and imshow.
Displays the crack boundaries on the original image and adds text annotations indicating crack lengths and widths.

## III. Observation

After converting the image to grayscale, the image highlights variations in intensity, which simplifies the analysis by focusing on brightness rather than colour. Enhancement techniques, such as contrast adjustment, sharpen the image, making the crack more distinct. Segmentation then isolates the crack from the background, typically using thresholding to distinguish between the crack (dark regions) and the concrete (lighter regions). Noise removal filters out irrelevant details and artifacts, ensuring that only the essential features of the crack are retained. The resulting image clearly shows the crack dimensions, ready for precise measurement and analysis.

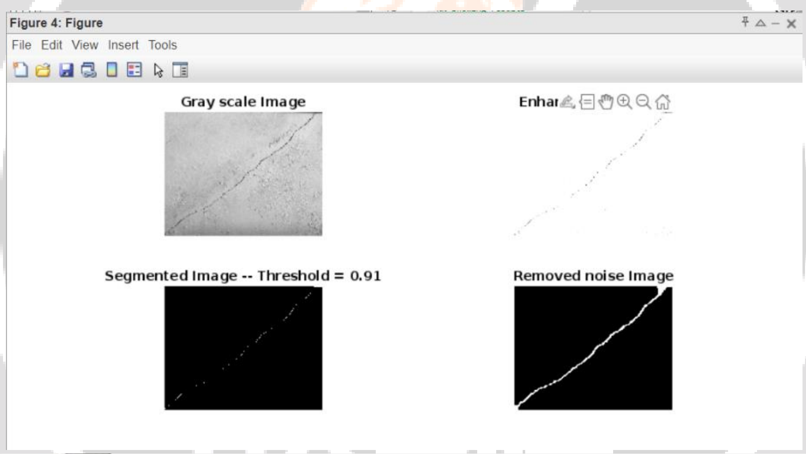



Fig. Image after /enhancement noise

Gray scale /segmentate/ removed

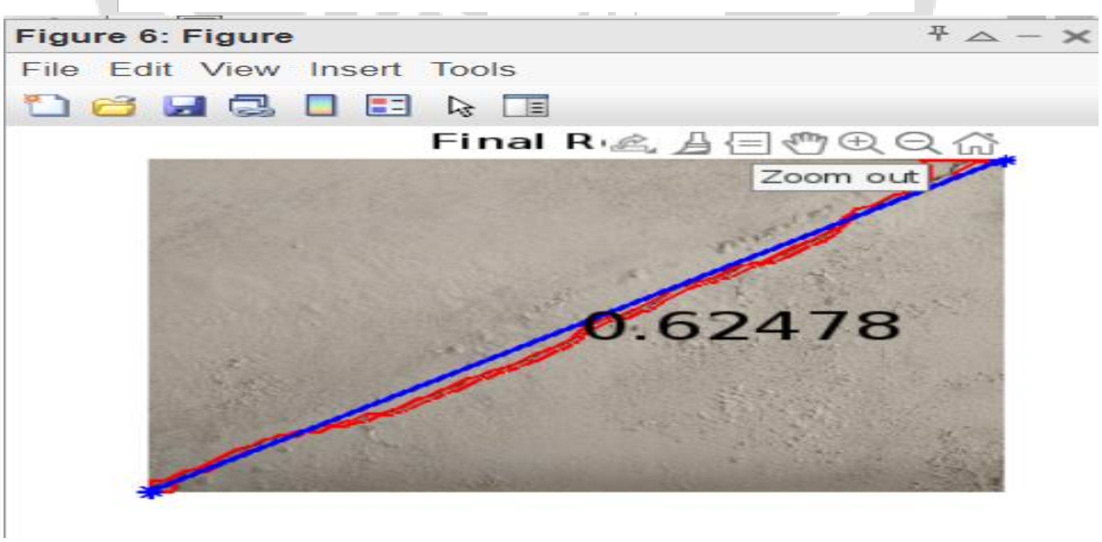



Fig. Final result with length

**Length**

processing digital images for measuring crack dimensions in concrete displays a concrete surface with identified cracks highlighted. The image typically shows these cracks marked with distinct lines or contours, and the measured length of each crack is annotated directly on the image. This visualization allows for a clear and precise understanding of the crack's dimensions, aiding in the assessment of structural integrity Further, the crack length will be measured automatically. For the concrete surface crack image, the crack length found from the proposed algorithm is 624 mm.

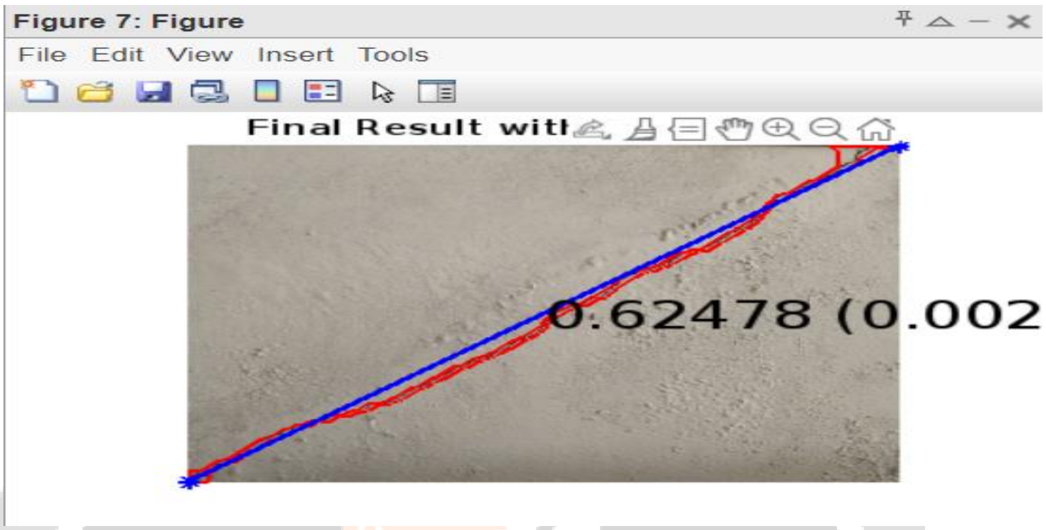


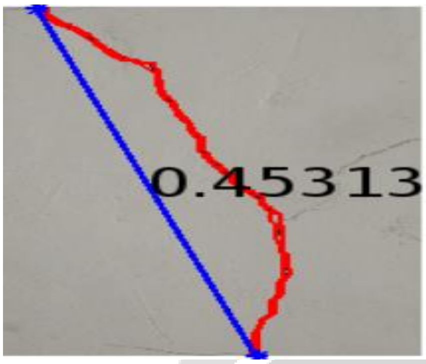
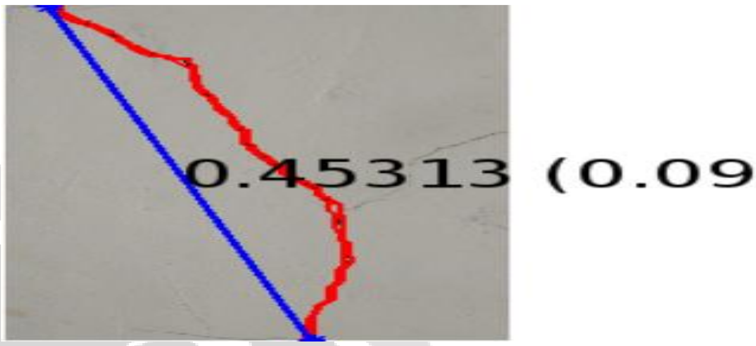

Fig. Final result with length and width

**Width**

Figure window likely presents a processed digital image of a concrete surface containing cracks, with measurements indicating the length and width of these cracks. This image is likely generated through image processing techniques that enhance the visibility of cracks and enable accurate measurement. The length and width measurements are crucial for assessing the severity and extent of damage in the concrete structure. the average crack width is found to be 2 mm

Table 1. crack length inspection

| Sr.no | Manual reading | | Software reading | | Error |
|---|---|---|---|---|---|
| | Length (mm) | width (mm) | Length (mm) | width (mm) | |
| Crack no 1 | 621 | 2 | 624 | 2 | 3 |

<table>
<tr><th>CRCK 1. Length</th><th>CRACK 2. Width</th></tr>
<tr><td>
</td><td>
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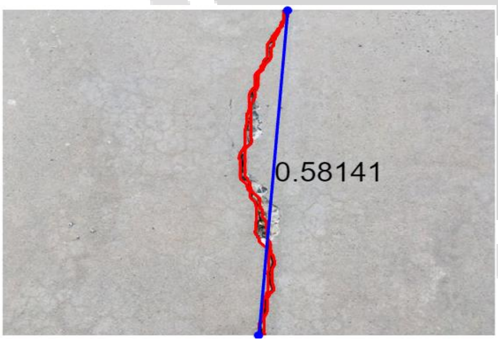
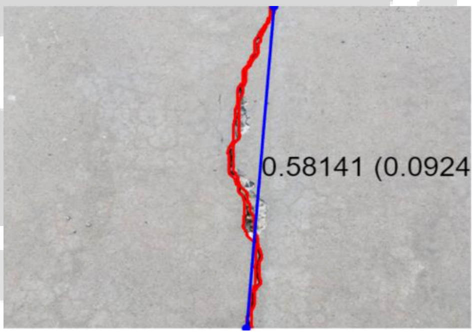
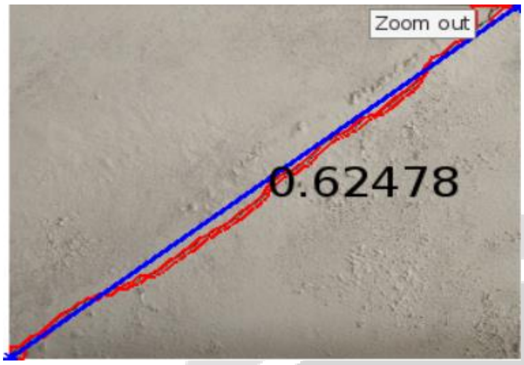
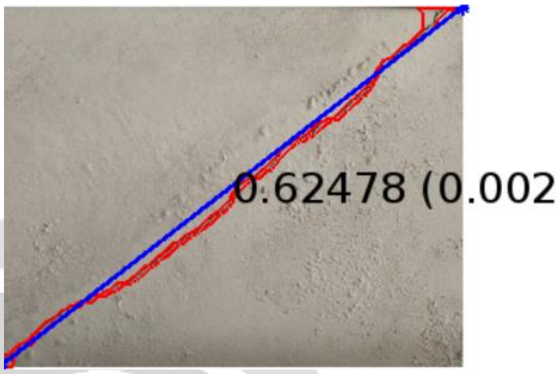
<tr><td>
</td><td>
</td></tr>
</table>

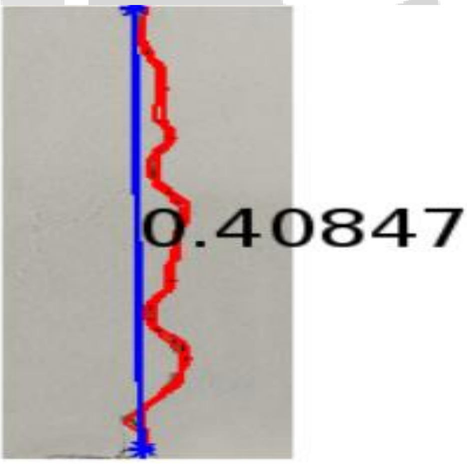
**CRCK 3. Length**



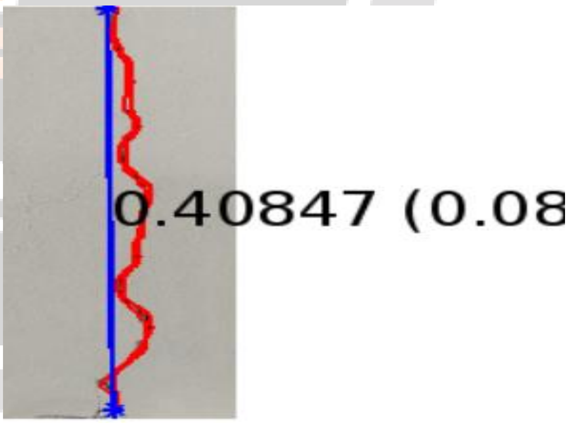

**CRACK 3. Width**




**CRCK 4. Length**



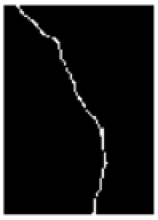
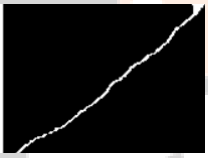
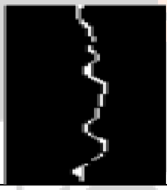

**CRACK 4. Width**




## III. Result and Discussion

The crack is then analysed by using MATLAB both length and width analysis have been done for these cracks

Table 2. Showing the properties of crack images

| Image no | Original image of crack | Image after noise reduction | Manual Measurement of crack length (mm | Crack Length provided by proposed algorithm (mm) | % error |
|---|---|---|---|---|---|
| 01 |  |  | 458 | 453 | 5 |
| 02 |  |  | 582 | 581 | 1 |
| 03 |  |  | 621 | 624 | 3 |
| 04 |  |  | 412 | 408 | 4 |

## IV. Conclusion

For measuring crack properties viz. crack length and crack width, the algorithm developed using MATLAB was presented. This algorithm after applying on the image of crack was successfully adopted. The results of the practical experiment show that a sample surface concrete cracks with a 95 mm crack length and 0.45 mm average crack width were recognized and measured properly and by means of provided algorithm the accuracy of the calculation can be highly improvised in order to decrease the error of measurement to a minimum. The widths of cracks change from place to place; hence a non-contact algorithm won't give an accurate result. Thus the research has proposed a methodology of seed point fixing along the crack line. In addition, the algorithm has analyzed totally four crack images for measurement of crack length and width. The crack width, lesser than 0.1mm is visible to naked eye, but it was unable to detect and measure with proposed algorithm. The precision of the proposed algorithm for the irregular shape of cracks with a lot of inequality and variable thickness is sufficiently satisfactory. The image with two cracks is also handled satisfactorily.

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