© May 2025 | IJIRT | Volume 11 Issue 12 | ISSN: 2349-6002

Wall Crack Detection Using Python

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***Abstract*—Wall crack detection is an important activity in structural health monitoring and building maintenance. Manual inspection tends to be time-consuming, prone to errors, and not efficient for big infrastructures. This project suggests an automated wall crack detection system based on Python and image processing. Utilizing libraries like OpenCV and machine learning models like Convolutional Neural Networks (CNNs), the system can effectively detect and classify cracks from images of walls. Preprocessing operations such as grayscale, edge detection, and morphological transformation improve crack characteristics prior to classification. The method addresses enhancements in the accuracy and efficiency of crack detection, minimizing human labor, and enabling timely maintenance to avoid structural failure. The system can be scaled to real-time applications via mobile or drone-based image acquisition for wider and faster area coverage in inspection.**

I. INTRODUCTION

Using image processing techniques implemented in Python with OpenCV and Tkinter, this project presents a straightforward yet efficient crack detection. Users can upload an image to the system, process it, and use morphological operations, edge detection, contour extraction, and filters to find cracks. It shows crack properties like length, width, and type (thin/wide, short/long) and highlights cracks on both the original and a black background.

Surfaces such as walls, roads, and buildings that have cracks in them are signs of structural distress that, if ignored, could cause serious harm. For maintenance and safety, early crack identification and characterization are essential. This system offers a low-cost and user-friendly way to automatically identify, highlight, and categorize cracks using image processing.

Cracks should receive a lot of attention because they are a significant sign of damage to building structures. Finding cracks is a crucial part of keeping an eye on the condition of concrete structures. Over time, cracks can cause structural failure because they decrease the effective load-bearing surface area. Manual crack inspection takes a lot of time and is prone to inspectors' subjective opinions. Consequently, the design of a machine vision wall crack recognition system is required.

Crack detection has been researched both domestically and internationallyImage processing for crack detection efficiently analyzes and finds crack properties like width, length, and area. Therefore, automated crack detection may be a more accurate and dependable option than manual processes. A variety of technical approaches, including (i) ultrasonic testing, (ii) laser-based testing, (iii) infrared and thermal testing, and (iv) radiographic testing, can be used to perform image processing, a non-destructive testing method. Researchers' interest in creating more practical methods is growing daily as a result of image-based crack detection's ease of use and accuracy. Recent research on tall buildings, bridges, and dams has also shown that an accurate assessment of the structure's current state and service life is necessary to improve its durability. In this instance, image-based evaluation works better than conventional inspection. Despite the fact that image-based crack detection is a promising technique, its limitations—such as its inability to accurately detect the direction of crack propagation, its limited practical use, and its tendency to count surface noises as cracks—have made it difficult for researchers to develop a more appropriate and accurate method. Therefore, a thorough analysis of the current methodology is required. In order to determine the current benefits and drawbacks of this technique and assess its potential for use in the field of structural engineering, an attempt has been made to compile a number of research findings based on crack detection through image processing.

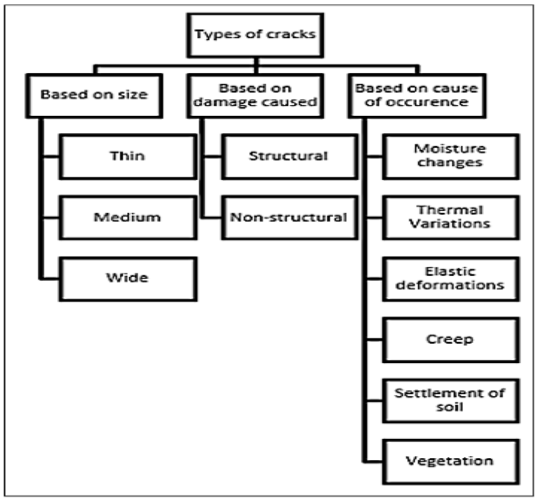


Figure 1: *Types of cracks*

II. METHODOLOGY

This project proposes a usable and accessible crack detection system intended to automate the recognition and examination of structural flaws from images. With Python, OpenCV, and Tkinter, the system merges to 47 47 solid image processing algorithms with an intuitive graphical interface so that both technical and non-technical users can assess materials or infrastructurefor cracks effectively. The user can input an image via the interface, which is subsequently processedusing a multi-stage pipeline:

Preprocessing: Noise reduction via Gaussian blurring prepares the image for analysis.

Edge Detection: The Canny edge detector isolates potential crack boundaries.

Morphological Operations: Techniques like dilation and erosion enhance crack connectivity and remove artifacts.

Contour Extraction: Crack regions are precisely identified and outlined using contour detection.

The system also visually emphasizes identified cracks by overlaying colored contours over the original image and presenting an isolated view against a black background, to provide clearness.

Quantitative analysis is supported through major metrics, such as crack length (pixel-based measurement) and width (distance transforms-derived calculation), allowing users to categorize cracks as thin/wide or short/long according to adjustable thresholds. This two-pronged approach—concatenating visual annotation with data-driven insights—supports decision-making 34 in applications structural health monitoring, quality control, or maintenance planning.

By prioritizing simplicity, accuracy, and adaptability, the system addresses challenges in real-world scenarios, such as varying lighting conditions or complex backgrounds, while remaining computationally lightweight. The integration of OpenCV for backend processing and Tkinter for the frontend ensures cross-platform compatibility, making it a versatile tool for engineers, inspectors, or researchers seeking an automated solution for crack diagnostics.

III. IMPLEMENTATION

There are four phases in our implementation.
They are
1.Gaussian Filtering
2. Canny Edge Detection
3. Morphological Approach
4. Parameter Estimation

Gaussian Filtering: Gaussian filter could be a linear filter which is employed to blur the image or to scale back noise. If we apply Gaussian filtering and Median filtering to a picture and subtract their outputs, final output are used for unsharp masking (edge detection). The Gaussian filter itself will blur the edges and also reduce the contrast. From the image perspective, during Gaussian filtering each individual pixel is modified with a Gaussian shaped blob with the identical total weight because the original intensity value. This Gaussian is additionally referred as convolution kernel.

Canny Edge Detection:

The amount of data that needs to be processed could be significantly decreased by using Canny Edge Detection to extract valuable structural information from various vision objects. It has been used in a number of computer systems. The requirements for using edge detection on various vision systems are similar, according to the Canny algorithm. Detection of edge with lower rate, which suggests that the detection should accurately catch as many edges. This algorithm contains a many adjustable parameters, which can affect the computation time and| effectiveness of an algorithm. Primarily the smoothing filter employed within the primary stage of Gaussian filter directly affects the results of the canny edge detection algorithm. to reduce blurring effect and to detect small, sharp lines we are able to apply tiny filters. However, using large filters has certain drawbacks. They decrease the value of specific pixels over a wide region of the image and increase the blurring effect within the image.

Morphological Approach: Morphological Image Processing may be a collection of non-linear operation associated to the form or morphology of features in a picture. Morphological processing is capable of removing noise and has the flexibility to edit a picture supported the scale and shape of objects of interest. it's utilized in place of Linear Image Processing, because it sometimes distorts the geometric kind of a picture but within the case of Morphological approach the knowledge of a picture isn't lost. within the Morphological Image Processing the initial image are often reconstructed by using Dilation, Erosion, Opening and shutting operations for a finite number of times. There are basically four Morphological transformations:

(1) Dilation: Dilation causes objects to dilate or grow in size. It can make an object larger by adding the pixels around its edges.

(2) Erosion: Erosion makes an object smaller by removing or eroding away the pixels on its edges and causes objects to shrink.

(3) Opening: Opening generally smoothness the outline of a picture and eliminates thin inflammations. it's structured removal of image region boundary pixels.

(4) Closing: Closing fills in the contour's gaps, closes off small holes, and fuses narrow breaks.it's structured filling of image region boundary pixels. it's a robust operator, obtained by combining Erosion and Dilation.

Parameter Estimation: Implementing the above proposed algorithm, we will calculate the height, depth, width, direction of propagation and severity of the crack.

Proposed System:

The proposed system uses a graphical user interface (GUI) for easy image selection and crack detection. Key steps include:

Converting the selected image to grayscale and applying a logarithmic transform.

Using bilateral filtering and Canny edge detection.

Applying morphological operations to enhance crack structures.

Extracting contours, calculating crack length and average width.

Classifying cracks as "Thin/Wide" and "Short/Long".

Highlighting cracks on both the original image and a black background for visualization.

Steps Required To Find Cracks In The Proposed Method:

1.The camera is used to read the original RGB.

2. The grayscale image is created from the RGB image.

3. To smooth the grayscale image's surface, a median filter is applied.

4. Sobel's edge detectors are used to make the image's edges more intense.

5. The binary image is obtained by applying Otsu's thresholding method.

6. Connected components with an area less than 200 are identified and removed .

7. Connected components with an orientation of 0, 90, and -90 degrees are identified and removed 34.

8. Morphological operation “majority”is applied to connect the objects and fill the holes in them .

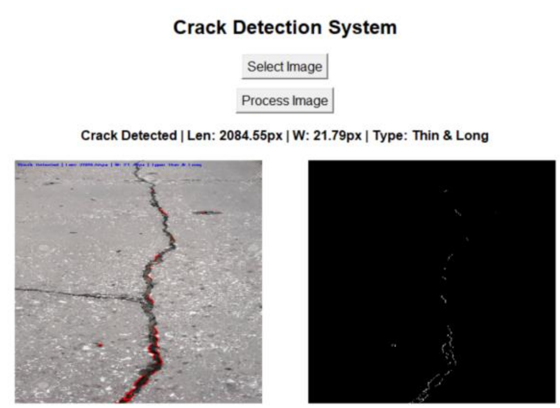
9. Objects with total pixels less than 50 are detected and removed .

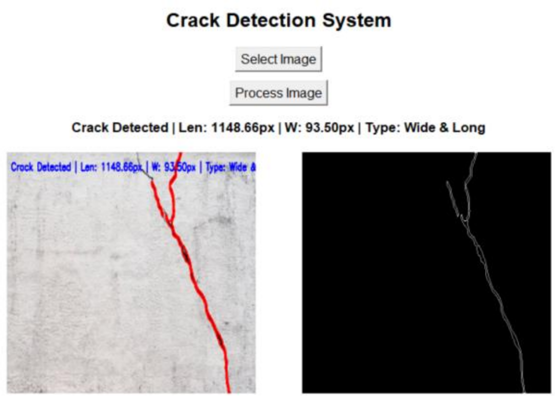
10. The original image's components in the HSV color space are computed

11. Pixels in the HSV color space that are connected to other components are retained as potential crack pixels.

12. The S values of the candidate crack are used to define a new thresholding value.

IV. RESULT





The system successfully:
Detected cracks in images with clear visibility.
Highlighted cracks accurately over the original image and separately on a black background.
Calculated meaningful crack parameters like total length and average width.
Classified cracks into "Thin/Wide" and "Short/Long" types based on measured features. The results show good performance on standard crack images but depend on image quality and environmental factors like lighting.

V. CONCLUSION

It is time-consuming to estimate cracks in concrete surfaces by hand. Therefore, when compared to a manual approach, the suggested automatic crack detection algorithm finds cracks on concrete surfaces more effectively. The clever edge detector algorithm, which yields superior results for any type of image, is used in the suggested crack detection algorithm to find the cracks. Almost 100 photos are used to test the suggested algorithm, and the various crack-related parameters—such as length and width—are measured. This allows different construction workers to use it to take the appropriate action to stop the concrete material from deteriorating. Several high-quality techniques are used to measure the concrete material's life span and direction of propagation. In this work,
A technique for measuring and detecting wall cracks based on OpenCV and cv2 is suggested. The Stitcher_create() function seamlessly stitches large multi-crack walls.
•In this paper, grayscale images are binarized using adaptive threshold segmentation. After binarization, the crack distortion is resolved using morphological operations. Lastly, the Canny algorithm extracts the crack outline.
•The primary innovation in this paper is the use of the reference object measurement method to determine the image's pixel ratio. The true value of the crack size is determined by the pixel ratio conversion, and the image visually displays the experimental results of the crack size. The width measurement error rate is up to 0.314%, and the height error rate is up to 2.9%. Hence, the system has the advantages of high efficiency and tiny error, which can satisfy the wall crack measurement requirements.

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