CRACK DETECTION ON CONCRETE SURFACES USING IMAGE PROCESSING

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Abstract: Due to environmental changes and poor quality of construction materials, cracks may develop in the walls of the building which is critical for maintenance as well as the continuous exposure will cause the severe damage to the environment. One of the initial signs of the degradation of a concrete surface or a material is cracks. Manual inspection has many drawbacks like invisibility of the crack, time consuming and it completely depends upon specialist's knowledge and experience. So automatic image-based crack detection is used as replacement for manual inspection which reduces the cost when compared to the manual approach. The proposed algorithm has been tested against various concrete crack images to study how effectively the algorithm is working, and how effectively it is overcoming the drawbacks of the present manual approach. The algorithm is projected to serve the purpose of various people by estimating the parameters of the crack so the bricklayer can take the necessary actions from the degradation of concrete structures.

1. INTRODUCTION

Cracks are of major concern for ensuring the safety, durability, and serviceability of structures. The reason is that when cracks are developed and propagate, they tend to cause the reduction in the effective loading area which brings about the increase of stress and subsequently failure of the concrete or other structures. Since there always exist constraints in ferro concrete structures and buildings deteriorate overtime, cracking seems unavoidable and appears altogether sorts of structures, for instance, concrete wall, beam, slab, and brick walls. Particularly for concrete elements, cracks create access to harmful and corrosive chemicals to penetrate the structure, which consequently damage their integrity as well as aesthetics. Primarily the basic question is Why Concrete Cracks? Concrete does not require much water to achieve maximum strength, however, a much of concrete used in residential pours tends to possess an excessive amount of water added to the concrete on the job site. This excess water will, however, greatly reduce the strength of the concrete. Water-Cement ratio must be in between 0.45 to 0.60 for the better concrete material, if any changes in the water to cement ratio then there will be a chance of degradation of concrete surfaces.

2. LITERATURE SURVEY

2.1 Crack Classification

Cracks can be broadly classified into two categories namely active and dormant. In active cracks, the change in direction, width or depth occurs over a measured period whereas in dormant cracks it remains unchanged. If left unrectified, both active and dormant cracks provide passage for moisture penetration, which can lead to future damage. Some of the active cracks are longitudinal crack, transverse crack, miscellaneous crack, crocodile crack and reflection crack. Dormant cracks are very fine in nature and auto healing occurs over a time period. The various types of crack based on their structure are micro crack, thin crack, sealed crack, mixed crack, line-like crack, minor crack, tiny crack, medium crack, large crack and complex crack.

2.2 Architecture

Cracks on the concrete surfaces are captured by using high resolution cameras, those images are analysed which is a field of Image Processing. There are several steps involved in the image processing which is shown in Fig (1); (1) Image Acquisition (2) Pre-Processing (3) Image Processing (4) Crack Detection (5) Parameter Estimation

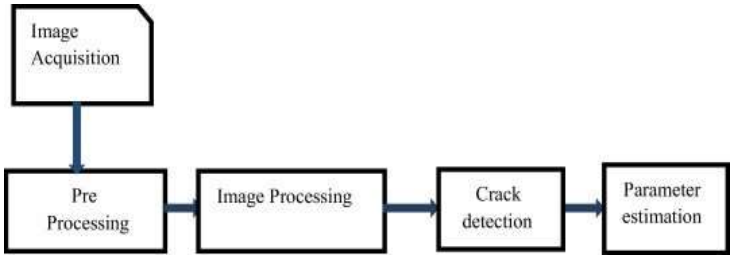


Fig (1)

2.3 Methodologies

For any edge detection algorithm, the primary process is to remove blurriness of the image or removing noise from an image which can be done by filtering algorithms. There are several filtering algorithms, but the best for any kind of the image is Gaussian Filtering. The second step after filtering algorithm is the edge detection around the image which can be done by using various algorithms such as Roberts Edge Detection, Sobel Edge Detection, Prewitt Edge Detection, Canny Edge Detection. An adaptive edge detection algorithm must provide a rough and tough solution that is adaptable to the varying noise levels. Some of the other edge detection techniques are: (1) Roberts Edge Detection: It performs 2-D spatial gradient measurement on an image which is very quick and easy to compute. This method insistence regions of high spatial frequency which often correspond to edges. The input to the operator is same as the output which is a grayscale image. (2) Sobel Edge Detection: The Sobel edge detector computes the gradient by using the discrete differences between rows and columns of a 3*3 convolution matrix. The Sobel operator is predicted on convolving the image with a small, separable, and integer valued filter. (3) Prewitt Edge Detection: A discrete differential operator is Prewitt operator which computes the approximation of the gradients. It uses 3x3 convolution mask to detect horizontal and vertical edge of an image. It combines Gx (gradient along X-axis) and Gy (gradient along Y-axis) to estimate absolute orientation and magnitude of the gradient at each pixel. (4) Canny Edge Detection: Canny edge detection is a multistage algorithm to detect a wide range of edges in images. This detector finds edges by looking for local maxima of the gradient of f (x, y). The gradient is calculated using the derivative of a Gaussian filter. If the pixel has value greater than high thresholding, then it set as edge pixel and a pixel value has a value below than low threshold value, then it does not set as edge pixel. By analysing all these algorithms for several input data Canny Edge detection algorithm provides better results for any kind of input data.

3. EXISTING ALGORITHM

This section briefs about processing techniques based on the camera image for the detection of the cracks with in the engineering structures. A work done by Yiyang et al. [1] have proposed a crack detection algorithm which is based on digital image processing. By performing the image pre-processing, image segmentation and feature extraction they derived the information the crack image. An experimental work done by Iyer et al. [2] have proposed a method for the crack detection from the high contrast images. The method detects the crack patterns in the noisy environment using curvature evaluation and mathematical morphological methodology. In the Image processing scheme different filtering techniques are adopted which alter the overall efficiency of the process; Salman et al. [3] proposed an approach that automatically distinguish cracks in digital images based on Gabor filtering. The Gabor filter is a highly potential technique for multidirectional crack detection. The images obtained from the Gabor filter function was directly related to the manual visual perception. Once filtering was completed, the cracks obtained from different directions are detected. Talab et al. [4] have presented a new approach in image processing for detecting cracks in images of concrete structures, the methodology involves three steps: (1) Change the image to a grey image using the edge of the image. (2) Use Sobel's method to develop an image using Sobel's filter for detecting cracks. (3) Using suitable threshold binary image of the pixel they are categorized into the foreground and the background image. Once again Sobel's filtering was used for the elimination of residual noise. Lee et al. [5] have proposed a system for particle detection using nearest neighbour algorithm. Based on the probability function of their corresponding location the crack features were acknowledged. Wang et al. [6] have proposed system for the image-based crack detection and to characterize the image based upon their effectiveness. According to their proposed system they have categorized the present image-based crack detection into four categories [8]. They are an integrated algorithm, morphological approach, percolation approach and practical technique. A shading correction was done using integrated algorithm [8]. The unclear crack prediction was detected using percolation method. The crack detection was done using morphological approach for the micro crack detection with the sensible method providing high- performance feature extraction. Fujita et al. [7] have proposed system for automatic crack detection on noisy concrete surface images. Their system includes two detection steps and two pre-processing steps. In pre-processing only original image is used. Using image filtering they have removed shadings. After pre-processing, they have detected the crack coarsely without noise by a probabilistic method [8]. They detected the crack more finely using an adaptive threshold algorithm.

4. PROPOSED ALGORITHM

There are four phases in our proposed algorithm:

1. Gaussian filtering
2. Canny edge detection
3. Morphological approach
4. Parameter estimation

4.1 Gaussian filtering

Gaussian filter is a linear filter which is used to blur the image or to reduce noise. If we apply Gaussian filtering and Median filtering to an image and subtract their outputs, final output can be used for unsharp masking (edge detection). The Gaussian filter alone will blur edges and reduce contrast. From the image perspective, during Gaussian filtering each individual pixel is modified with a Gaussian shaped blob with the same total weight as the original intensity value. This Gaussian is also referred as convolution kernel.

4.2 Canny Edge Detection

Canny edge detection [8] is a technique to extract useful structural information from different vision objects and dramatically reduce the quantity of data to be processed. It has been widely applied in various computer vision systems. Canny has found that the requirements for the application of edge detection on diverse vision systems are relatively similar. Thus, an edge detection solution to address these requirements can be implemented in a wide range of situations. Detection of edge with lower rate, which means that the detection should accurately catch as many edges. The Canny algorithm contains a many adjustable parameter, which can affect the computation time and effectiveness of the algorithm. Primarily the smoothing filter used in the first 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 can use small filters. But there is are some disadvantages of using large filters. They increase the amount of blurring effect in the image and value of particular pixel slights out over large area of image [9]. Larger blurring radii are more useful for detecting larger and smoother edges.

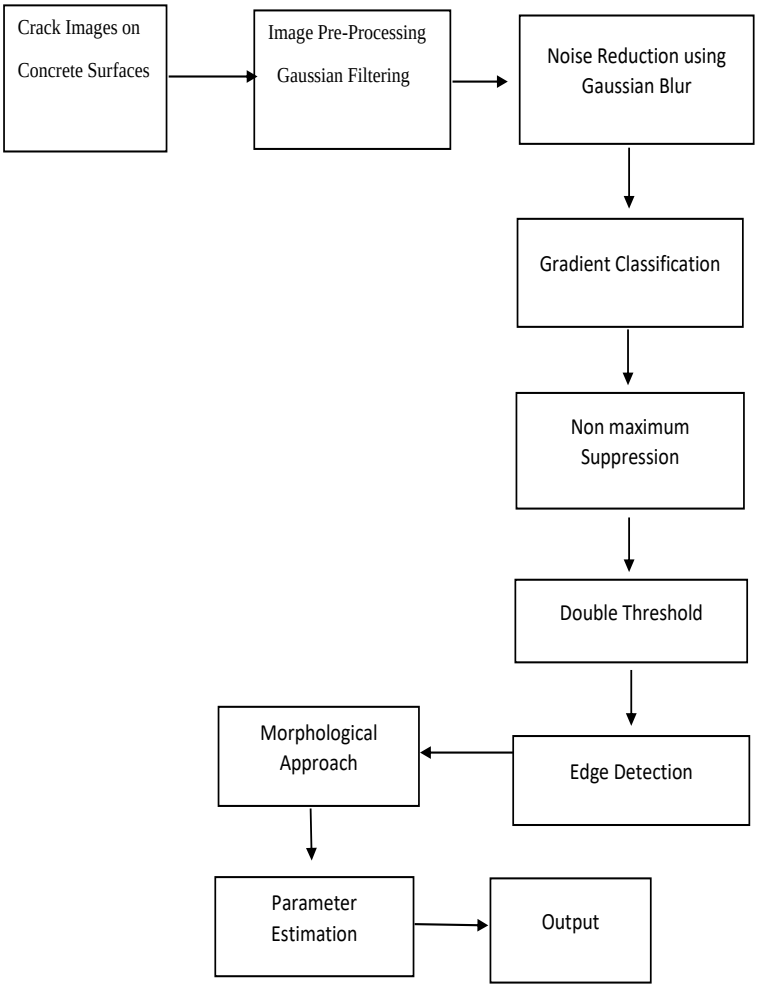
4.3 Morphological approach:

Morphological Image Processing is a collection of non-linear operation associated to the shape or morphology of features in an image. Morphological processing is capable of removing noise and has the ability to edit an image based on the size and shape of objects of interest. It is used in place of Linear Image Processing, because it sometimes distorts the geometric form of an image but in the case of Morphological approach the information of an image is not lost. In the Morphological Image Processing the original image can be reconstructed by using Dilation, Erosion, Opening and Closing operations for a finite number of times. There are basically four Morphological transformations: (1) Dilation: Dilation causes objects to dilate or grow in size. Dilation makes an object larger by adding 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 an image and eliminates thin inflammations. It is structured removal of image region boundary pixels. (4) Closing: Closing fuses narrow breaks, eliminates small holes and fills gaps in the contour. It is structured filling of image region boundary pixels. It is a powerful operator, obtained by combining Erosion and Dilation.

4.4 Parameter estimation:

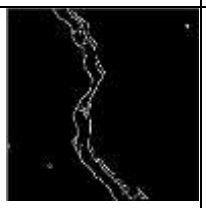
Implementing the above proposed algorithm, we will calculate the height, depth, width, direction of propagation and severity of the crack.

Steps involved in proposed algorithm are stated in the below Fig (2).


Crack Images on Concrete Surfaces
Image Pre-Processing Gaussian Filtering
Noise Reduction using Gaussian Blur
Gradient Classification
Non maximum Suppression
Double Threshold
Edge Detection
Morphological Approach
Parameter Estimation
Output

Fig(2)

5. EXPERIMENTAL RESULTS:

S. No	Original Image	Crack Image	Length (in pixels)	Width (in pixels)
1.			158	86
2.			218	97
3.			172	68
4.			168	59

6. CONCLUSION AND FUTURE WORKS:

The manual approach for the estimation of cracks in concrete surfaces is tedious. So, the proposed automatic crack detection algorithm identifies the cracks on concrete surfaces with better results compared to manual approach. In the proposed crack detection algorithm the cracks are identified using the canny edge detector algorithm which provides a better results for any kind of an image The proposed algorithm is tested with nearly 100 images and the different parameters related to crack such as length, width are measured, this can be used by various construction workers so that necessary remedies can be taken from the degradation of concrete material. Direction of Propagation and Life Span of the concrete material are measured further with different high-quality techniques.

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