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# Detection of Cracks and Mapping System for Bridge Deck Evaluation using A Robotic System

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***Abstract*: Edge detection is very important for image processing for object detection, it is critical to have a good understanding of edge detection algorithms. This is used to detect the edges to form the shape of an object. The boundary of an object is defined as an edge and the background that indicates the boundary between overlapping objects. The edges in an image can be identified accurately, all the objects can be located (i.e.) basic property (area) can be measured. Since computer visual perception involves the identification and classification of objects in an image. In this project the crack image is taken from the database and several processing is take-out for find the crack boundary, density and specify the crack type. Here, for detecting the boundary of the cracks, the edge detection models and also using by sobel filter the exact crack will determined. This experiment is carried out using Matlab software.**

## 1. INTRODUCTION

Currently, bridge decks are inspected with very elementary methods in the form of ocular inspection by a trained engineer. The inspectors usually walk though the bridges and measure the crack sizes and locations. This physical approach has several disadvantages. First, it is susceptible to human errors. Second, it has less accuracy due to the limited visual capability of human inspectors. Third, it can't guarantee the full coverage of the whole bridge deck. This system can outperform human inspectors in several ways. First, the robotic system can achieve accuracy of crack detection if with a range finder camera. Second, the robotic system can localize itself exactly, which facilitates accurate crack localization. Finally, by using a robot, the robotic system can greatly reduce the safety risk of human inspectors. In the ROCIM system, a mobile robot is utilized to create a two-dimensional (2D) map of the bridge deck using sensor, while a camera is used to collect images of the bridge and road surface. The collected images are then processed using image processing techniques to detect the cracks. We store the crack locations in this 2D map, therefore obtaining a crack map, which can be used to measure, classify and monitor cracks periodically.

CRACK DETECTION: To detect cracks on the bridge deck using computer vision, we need to develop an effective edge detection algorithm to distinguish cracks and non cracks. The images can taken both indoor and outdoor and then image processing steps are processed to get the accurate cracks.

### *1.1 CRACK DETECTION STAGES*

Crack detection technique involves various stages:

They are image acquisition, image preprocessing, image enhancement, image restoration and image segmentation. Each stage performs meticulous operation on the image to proficiently detect cracks present in the images. The sequences of stages are discussed in detail.

*1) Image Acquisition*

Images required are obtained from various search engines like Yahoo, Google images, Bing etc. Images obtained for processing are digital images captured by means of digital camera. These acquired images are color images; comprising combination of the primary color model (RGB).The RGB color model consists of amalgamation of 8-bit generation of Red, Green and Blue.

*2) Image Preprocessing*

Images obtained for crack analysis ought to be preprocessed. Acquired images may be of different dimensions. Image resizing algorithm is applied on the images, which in turn convert them into a square image. Image resize algorithm uses various interpolation techniques to obtain an image of the desired dimension. Resizing algorithm adds the specified number of rows and columns in the given image and scales them to the required size. The algorithm by default computes the required number of rows and columns to preserve the aspect ratio of the image if the rows and columns are not specified.

*3) Image Enhancement*

For accurate crack detection, the visual appearance of the images needs to be developed. To achieve this image enhancement is done. The resized color images obtained from the preprocessing technique comprise combination of three 8-bit arrays. The 8 bit array symbolizes brightness of these colors which ranges from 0(black) to 255(white). The brightness level of the color image can be manipulated to obtain a gray scale image. Gray scale image conversion is achieved by retaining luminance and by eliminating hue and saturation. Quality of the images is not affected when true color images are gray scale converted. Gray scale images are more compatible when compared to colored images. They become compact and so, the efficiency of transmission and reception of these images increases enormously. During the acquisition or transmission of the images, unnecessary noise appends with the original image which brings down the efficiency of detecting cracks in the image.

*4) Image Restoration*

Images can be affected by noise; the noises can be categorized under two sections, periodic noise and random noise. The noise which may be appended to the original image must be removed before processing the image to detect cracks. They may affect the process reducing the efficiency of detecting cracks in the image. To remove superfluous noise, images are passed through filters. These filters remove the unwanted noise attached to the original image and retrieve the original image from the noisy image.

## 2. EXISTING SYSTEM

In this section, we review the existing works of robotic and coverage path planning. Recent years have witnessed growing research interests in structural health monitoring for bridges, buildings and other civil infrastructures [2]–[9]. Research in structure inspection using robotic devices has resulted in several prototypes. Yu *et al.* [10] presented an automated inspection system using a mobile robot that detects concrete cracks in a tunnel. An illuminator is used to help distinguish cracks from non-cracks. Sinha *et al.* [11] developed a statistical filter for crack detection in pipes. In their system, crack features from the buried pipe images are first extracted, and then the cracks among the segment candidates are detected by a cleaning and linking procedure. Tung *et al.* [12] proposed a mobile manipulator system equipped with a binocular CCD camera for bridge crack inspection. Lee *et al.* [13] and Oh *et al.* [14] proposed a bridge inspection system which consists of a specially designed car, a robotic mechanism and a control system for automatic crack detection. Sohn *et al.* [15] developed a system that monitors crack change in concrete structures. Their system focuses on quantifying the crack change from multi-temporal images during the monitoring period. Ito *et al.* [16] demonstrated an automated measurement system for concrete block inspection by means of fine crack extraction. Their proposed system uses a high-resolution camera to capture images, and the cracks are automatically extracted using an integrated image processing technique. Most of these studies classify, measure, and detect cracks. However, none of these works studies the global mapping of cracks and the optimization problem in inspection path planning. Coverage path planning for mobile robots has been investigated by many researchers. Choset *et al.* [17], [18] studied complete coverage path planning using boustrophedron motion. Their proposed algorithm allows for obstacle avoidance, and has efficient coverage paths. A neural network approach to complete coverage path planning for a vacuum cleaning robot is developed by Simon *et al.* [19]. Their algorithm is capable of planning collision-free complete coverage robot paths. Genetic algorithms are usually used to optimize the efficiency of the coverage path [20]–[22]. For example, Tu *et al.* [20] proposed a path planning method based on genetic algorithms with a variable length chromosome. Their algorithm can generate efficient collision- free paths for a mobile robot in both static and dynamic environments. Jimenez *et al.* [21] utilized a genetic algorithm to find the most efficient coverage path. Their algorithm can find a collision free path between two positions to allow a robot to sweep the whole free space environment. Muzaffer *et al.* [22] developed a genetic algorithm to generate efficient rectilinear coverage paths. They modeled the area using disks representing the sensor's coverage area. Their algorithm can find a path which runs through the center of each disk with minimal cost. Most of the above mentioned works use the robot body to cover the area of interest. In the ROCIM system, we are interested in ensuring the union of the camera field-of-view (FoV) covers the whole bridge deck area. There are challenges in the planning problem due to the configuration of the camera and the mobility of the robot. In this paper, we present a solution to this problem based on genetic algorithms. The remainder of this paper is organized as follows. In Section II, we discuss the overview of the ROCIM system. Section III presents the technique to derive the coordinate. The crack detection algorithm is described in Section IV. Section V formulates the problem of the complete coverage path planning (CCPP), and then describes the proposed algorithm for this problem. Section VI provides the experimental results. Finally, Section VII proposes some ideas for future work and gives the conclusions.

## 3. PROPOSED SYSTEM

***Block diagram for proposed system***

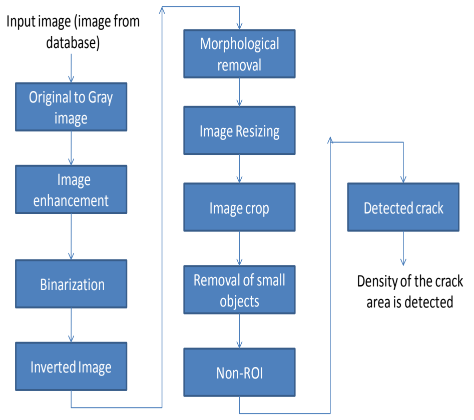


Figure 3.1 Block diagram for proposed system

*1) Image from database*

For detecting the fine crack, images are taken and get processed from the stored images in the laptop. For the particular crack image, the image processing technique is used and detects the edge of the crack.

*2) Image processing*

The segmentation and feature extraction module refers to the processing step in which each input image is analyzed and features of interest are identified and isolated from the background. Each feature is then examined to produce a set of characteristics that uniquely defines it. The set of characteristics is known as the feature vector and may include such attributes as texture, brightness or shape properties. Adjacent regions are considerably different with respect to the same individuality.

The different approaches are,

- By finding boundaries between regions based on discontinuities in intensity levels.
- Thresholds based on the distribution of pixel properties, such as intensity values.
- Based on finding the regions directly. Thus the choice of image segmentation technique is depends on the problem being considered.

Mainly in this paper used sobel filter and morphological operations for removing the small holes and noises. Hence we can detect the accurate crack.

Original to gray:

It converts the true color image RGB to the grayscale intensity image I. rgb2gray converts RGB images to grayscale by eliminating the hue and saturation information while retaining the luminance.

***Image enhancement:***

It enhances the contrast of images by transforming the values in an intensity image, or the values in the color map of an indexed image, so that the histogram of the output image approximately matches a specified histogram.

***Binarization and Inverting:***

It converts the grayscale image I to a binary image. The output image BW replaces all pixels in the input image with luminance greater than level with the value 1 (white) and replaces all other pixels with the value 0 (black). Same the converted images are again converting into black to white and white to black is known as inverting then image which is used to detect the crack easily.

***Morphological Operation:***

1) Dilation : Find local maxima in binary or intensity image
2) Erosion: Find local minima in binary or intensity images
3) Opening: Perform morphological opening on binary or intensity images
4) Closing: Perform morphological closing on binary or intensity images

***Image cropping and resizing:***

It creates an interactive Crop Image tool associated with the image displayed in the current figure, called the target image. It returns image B that is scale times the size of A. The given input image A can be a grayscale, binary image or RGB. If the scale is in between 0 and 1.0, B is smaller than A. If the scale is greater than 1.0, B is larger than A.

3) Crack map

Finally overall crack map is produced and can easily recognize the exact crack where it is placed. Through this we can reconstruct the higher density crack area in the road, bridges and in wall.

*3.2 PROJECT OVERVIEW*

The robotic system will be site to inspect the blocked half of the bridge. Once accomplished, the traffic will be switched to the completed half and the other half will be examine. During the robotic performance, we assume that the robot captures an image only when it completely stops at the pre -decided locations. There are three steps during crack inspection and mapping.1) Map building navigation: A 2D bridge deck map will be generated first, which will be used to limit the robot during the data collection step.2) Data collection: The robot will navigate on the bridge deck to collect the surface image data at predetermined locations. The raw image data will be stored in the on-board computer or transferred to a nearby laptop computer using wireless connection.3) Crack map generation: Cracks will be detected through image processing. The crack map will be created by piecing together multiple local crack maps. This step can be performed offline on the laptop computer.

## 4. RESULTS AND DISCUSSIONS

### 4.1 Sample crack images

Figure 4.1

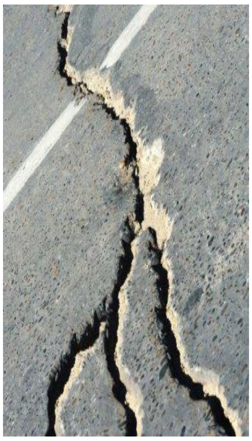

Figure 4.2

### 4.2 Simulated outputs

High density crack

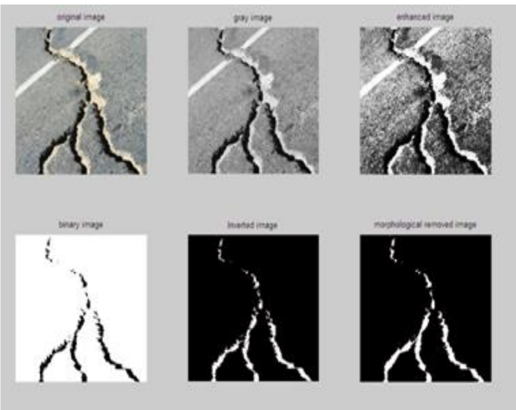


Figure 4.3

Resizing & Noise removal   Image crop & Resizing

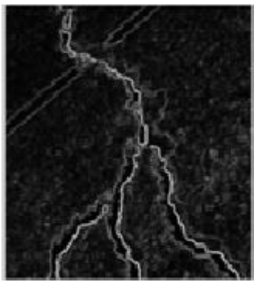

Figure 4.4

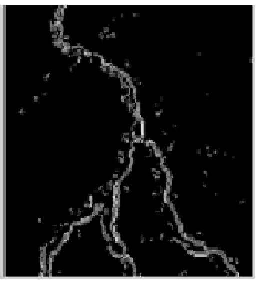

Figure 4.5

Removal of small objects

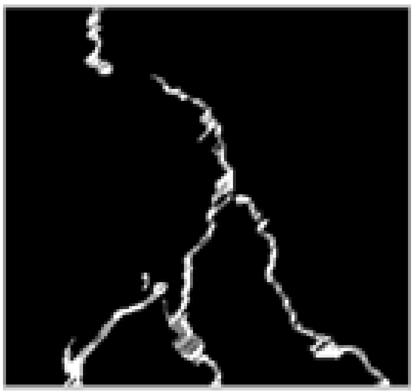

Figure 4.6

Non ROI & Detected Crack Area

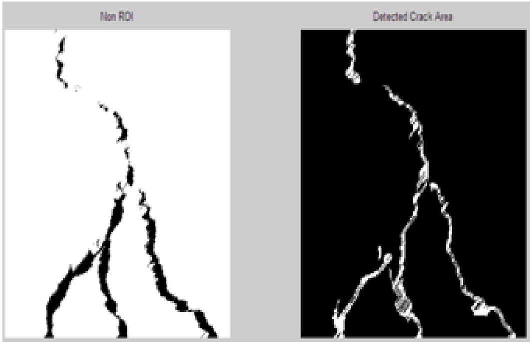


Figure 4.7

In high density crack images the counting of pixels are above 800pixels. In moderate density crack image the counting of pixels are between 500 pixels to 800 pixels. In low density crack image the counting of pixels are below 500 pixels. In the above crack image the total density of the crack area is 1500 pixel. Hence the Detected Crack has high density.

## 5. CONCLUSION AND FUTURE WORK

In this paper, we introduced a robotic crack inspection and mapping system. The robotic system provides an overall solution to bridge deck crack inspection. First, the crack detection algorithm works well for real cracks through the experiment and simulation evaluation. Second, we propose robotic inspection path planning to ensure the mobile robot collects all the images efficiently in the area of interest. Second both indoor and outdoor tests are conducted to validate the proposed robotic system. Third for detecting the crack we used the techniques like sobel filter, IMfilter and morphological operations, conducting these techniques can easily detect the exact crack In the future, we will further improve the crack detection algorithm, especially in various ambient lighting conditions. We need enhance the robustness of the crack detection algorithm in such conditions. On the other hand we will utilize Non-Destructive Evaluation (NDE) sensors such as Impact Echo and Ultrasonic Surface Wave to detect vertical cracks (crack depth) and delaminating of the bridge deck.

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