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Crack Detection and Parameter Estimation on Road Images Using Prewitt Operator and Hough Transformation

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Abstract: This paper shows the results on road images by detecting the edges of cracks on it with the help of prewitt and then calculates the parameter associated with the cracks because roads play an important role in everybody's life to reach their destination. Due to constant use of roads crack comes on the roads and detecting these cracks manually is very difficult tasks. To eliminate this difficulty computerized systems are developed. The proposed system detects the cracks and then calculates the some parameters associated with it. For detection of cracks, an image is acquired and filtered with the help of median filter. After that enhancement is done with the help of histogram contrast stretching and prewitt edge detection method is used to detect the edges of the cracks. Moreover mathematical formulae are used for calculating the parameters. Hough transformation is used to calculate the shape of the cracks. The PSNR, SNR and MSE values are calculated for the output image, for comparing the different edge detection operator and result shows that prewitt operator is better than all other operator. For measuring the performance of the system recall and precision is also calculated and system has recall=97.56% and precision=98% (approx.) has performance=97.49%. All these work is performed in MATLAB R2011b.

Keywords: detection, deteriorate, classification, PSNR.MSE, SNR, cracks

I. INTRODUCTION

As the technology is increasing day by day, most of the daily work of people is done with the help of technology. Human Beings depend upon the technology for their small to small work. So this technology also helps the people in detecting the cracks in the things. If someone wants to detect the cracks on the road and they will do it manually, then it takes a lot of efforts and time. But if we detect these cracks with the help of computerized system, then it will be done with less efforts and time. The roads play an important role for our society. People use these roads to reach their destination. So roads are the main medium for Human Beings to reach their destination. So the roads are constantly used by people. Hence, cracks come on the surface of the roads. Cracks can come on the roads due to some environmental factors also.

The proposed system helps in detecting the cracks with the help of prewitt edge detection techniques of digital image processing technique. Some of the other edge detection techniques are:

A. Sobel Operator

The Sobel operator helps in extracting all the edges of an image without considering its direction. Sobel operator provides smoothing and differencing effect. It has a pair of 3×3 convolution kernels. One kernel is about 90 degree rotated from other kernel. [15]

B. Robert's Cross Operator

Robert Cross operator is similar to Sobel operator but it consists of 2x2 convolution kernels. [15]

C. Prewitt Operator

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 and Gy to estimate absolute orientation and magnitude of the gradient at each pixel. [15]

D. Laplacian based Edge Detection

The Laplacian based Edge Detection is based on detecting the edges by finding second order derivative of an image. It highlights the region of rapid change in intensities of an image. For applying laplacian edge detection method an image is firstly smoothed with the help of Gaussian filter to remove noise from an image. [15]

E. Canny Edge Detection Method

The Canny Edge Detection Operator was developed by John Canny in 1983 at MIT during his master's thesis. This method sets two thresholding. These are high and low thresholding. 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. [15]

For calculating the shape of the cracks the proposed system uses Hough Transformation. Hough Transformation is the feature extraction method which is used in digital image processing, image analysis and computer vision. It is the technique which is used to estimate the shape of an object with the help of its boundaries. It was firstly introduced by Paul Hough in 1962 and after that it was developed by the Peter Hart and Richard Duda in 1972. This technique is very easy to implement and accurate as compared with other techniques.

II. METHODOLOGY

The following are the steps which our system is going to perform for detecting cracks in an image and calculating the parameters associated with it.

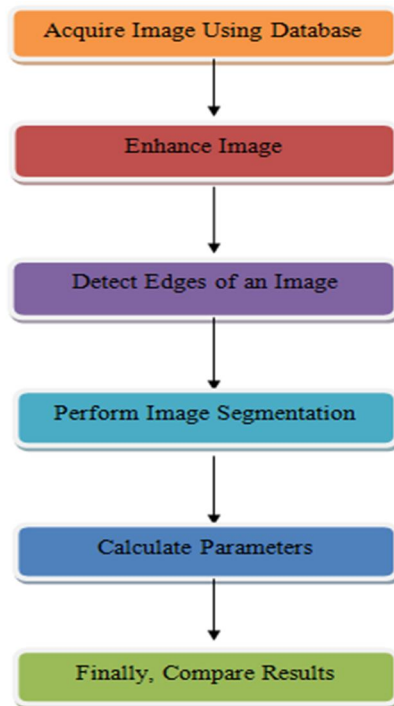


Fig. 1: Flowchart of Crack Detection and Parameter Estimation

A. Image Acquisition

The first step is Image Acquisition. The images are acquired with the help of CanStock image database.

B. Image Enhancement

The second step of this system is Image Enhancement. The enhancement is done to enhance the images for removing the noise in images. Moreover enhancement is done to clearly understand the details of an image. It is also called preprocessing of an image. The enhancement is done by using histogram enhancement by contrast stretching technique for this system.

C. Image Edge Detection

The next step is the Image Edge detection. In this step, the edge detection operator is used to detect the edges of the things present in an image. There are number of edge detection operator but for this system edge detection is done by using the prewitt edge detection method.

D. Image Segmentation

The next step is Image Segmentation. In this step, the segmentation is done so that we can get the region in an image which we need. Segmentation for this system is done by using thresholding.

E. Calculations

The last step performed by the system is to calculate the parameters associated with the cracks. This is calculated using mathematical formulae and for calculating shape Hough transformation is used.

III. RESULTS

The proposed system Crack Detection and Parameter Estimation on road images using Prewitt Edge Detection operator and Hough Transformation is tested by taking 40 images from different databases. For achieving the goals the proposed system is build in MATLAB R2011b. For detecting the cracks, the image is firstly acquired from the database and morphological technique is applied on it to clean an image, then the image is enhanced with the help of histogram contrast stretching technique, after that the edges of the cracks are detected with the help of Prewitt edge detection technique. In the last the parameters are calculated with the help of mathematical formulae. Moreover for finding the shape of the cracks Hough Transformation is used.

The result given by the system is shown in the Figure 3.1 to Figure 3.4

Step 1: Acquiring an Image

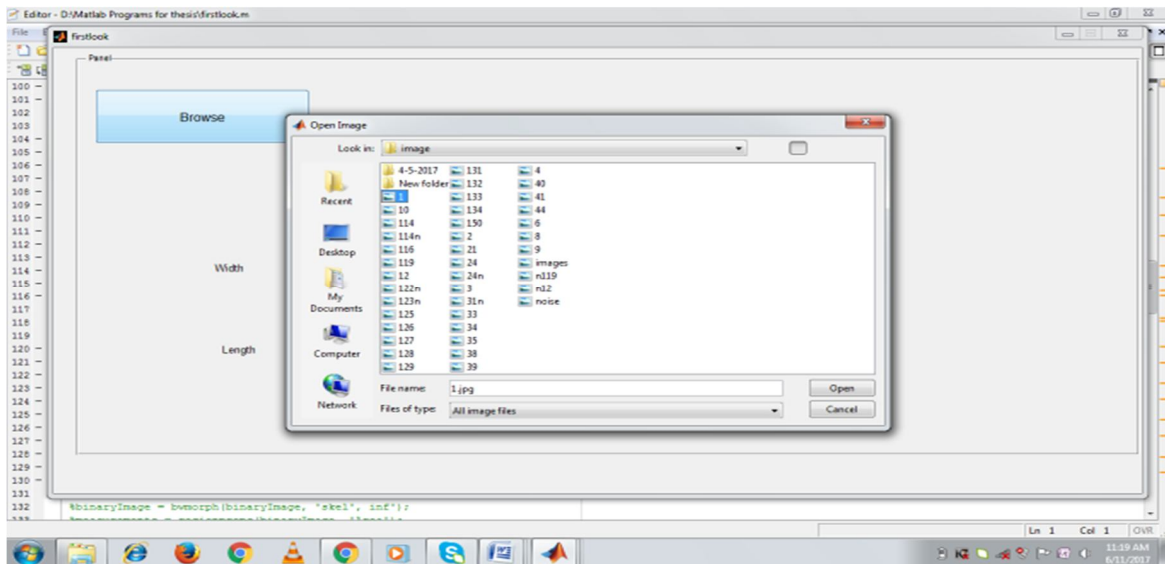


Fig. 2: Image is acquired by the system.

Step 2: Enhanced Image by Histogram Contrast Stretching

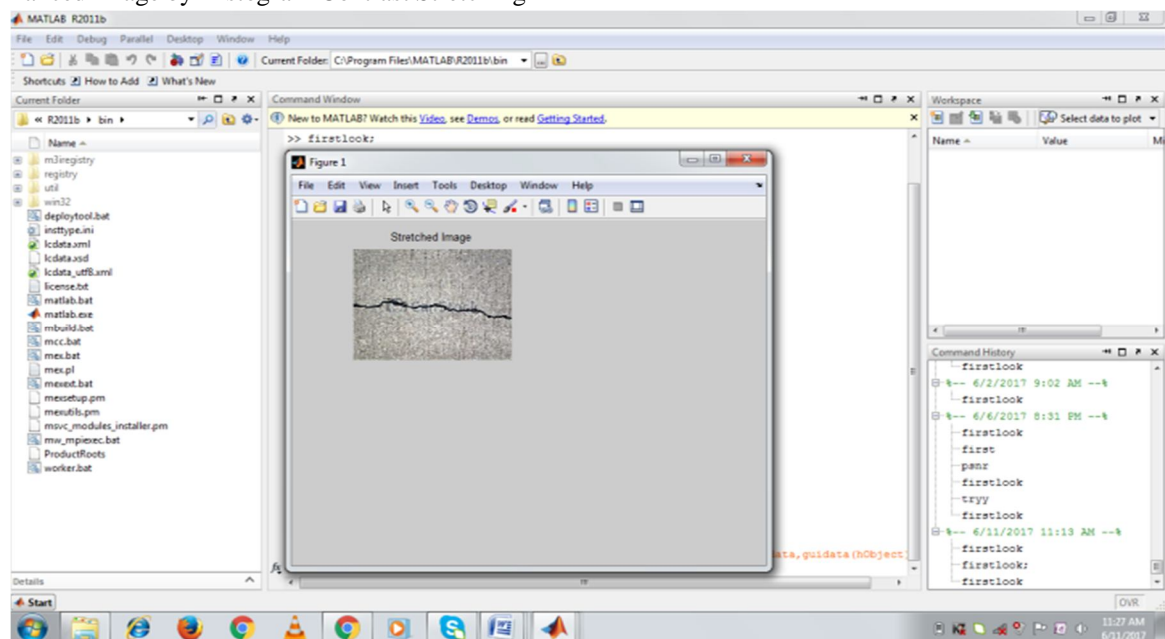


Fig. 3: Stretched Image by using Histogram Contrast Stretching

Step 3: Detect Edge

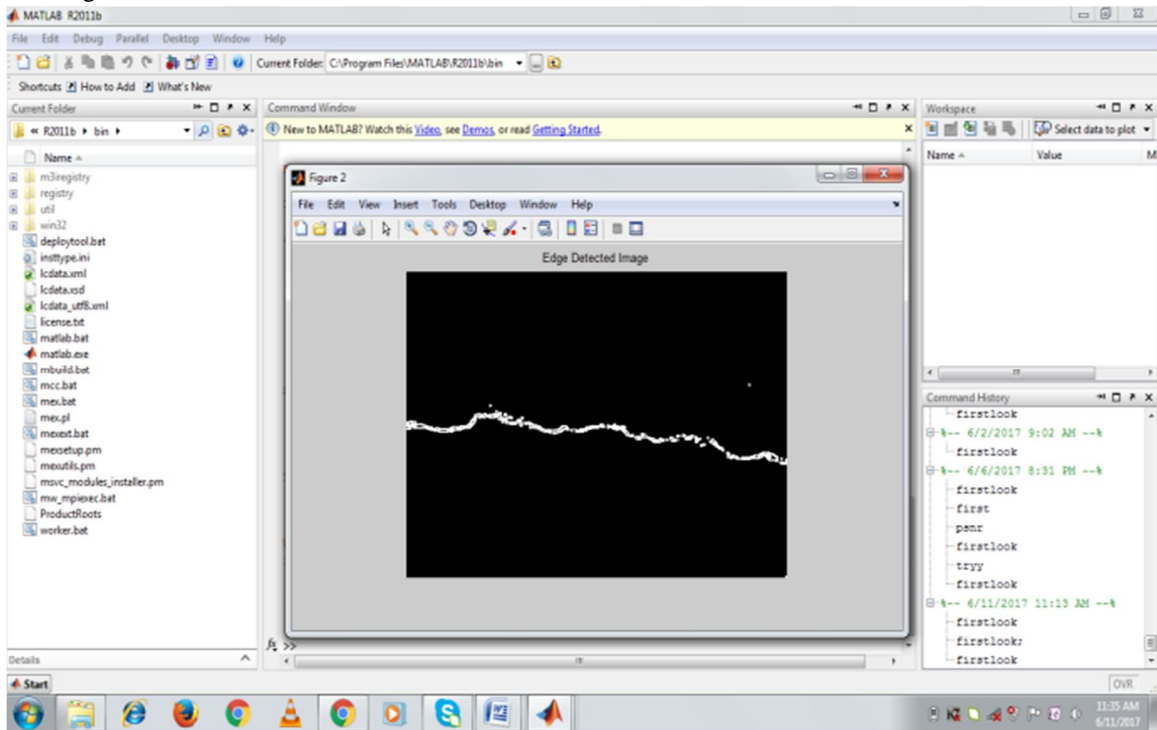


Fig. 4: Edge Detected Image

Step 4: Edge Detected Image with parameters calculated on it.



Fig. 5: Road Image with detected edge and parameters calculated on it.

This system also calculates PSNR, MSE and SNR values for the output image. The following table shows PSNR, MSE and SNR values for the output image whose result is shown above in Fig. 3.4.

Table 1: PSNR, SNR, MSE values for Prewitt Edge Operator

Performance Measure	Values
PSNR	32.4760
SNR	20.8005
MSE	0.2884

The above Table 1 shows result for Prewitt Edge Detection Operator. PSNR value for prewitt is 32.4760. SNR value is 20.8005. MSE is 0.2884. If we compare prewitt operator with our operator, it shows better results than others.


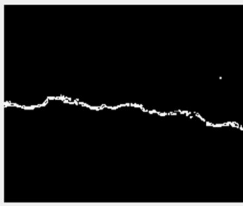

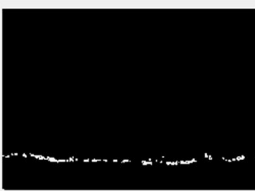


Table 2: Table of Comparison of prewitt operator with other edge detected operators.


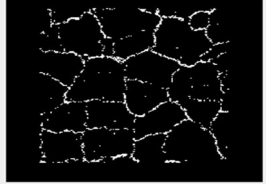

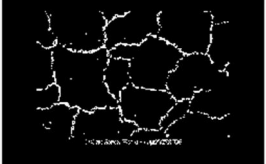



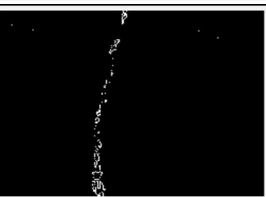
Method	PSNR	SNR	MSE
Prewitt	32.4760	20.8005	0.2884
Sobel	31.0727	21.0043	0.3984
Canny	32.1775	10.2037	0.3089

For better results, PSNR and SNR values should be higher but MSE value should be low. Hence from above table it is clear that prewitt is the best.

The results shown by the system with different cases are shown in the following table number Table 3. The table has five columns showing original image, edge detected image, length, width, shape of different images.

Table 3: Results shown by the system with different test cases.

S. No.	Original Image	Crack Detected	Width	Length	Shape
1			204	449	Line
2.			62	449	Line
3.			117	164	Line

4.			451	451	Square
5.			318	451	Rectangle
6.			299	451	Rectangle
7.			767	968	Line

measure the performance of the system recall and precision are calculated. As compared with existing method [1], the proposed system has recall= 97.56% and precision= 98% (approx.) and has performance =97.49%.

IV. CONCLUSION AND FUTURE SCOPE

Roads are used for various purposes. As a result, its maintenance is very important. The proposed system is tested on 40 two dimensional images. But existing system [1], conferred their experimental results on 20 images. The proposed system detects the edge of the cracks on two dimensional images and calculates the parameter like length, width and shape of the cracks. It uses the prewitt edge detection method to detect the edge and mathematical formula for calculating the length and width. Moreover, Hough transformation is used to calculate the shape of the crack. For handling noisy image, median filter is used. For comparing various edge detection methods, MSE, PSNR, SNR values are calculated. And results shows that prewitt method is very efficient than other edge detection method.

By comparing the proposed system with earlier existing system [1], the proposed system has approximately 98% precision and 97.56% recall and performance=97.49%. The proposed system works only on two dimensional images. In future, this system is extended to work for three dimensional images. This system is implemented on vehicles so that driver of the vehicle able to judge the cracks and also able to know the length, width and shape of the cracks. Moreover, in future, intensity and depth of the cracks can also be calculated.

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