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

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Abstract: ***This research paper shows the performance of different edge detection operators and Hough Transformation. The proposed system can detects the crack on the two dimensional road images taken from Crack Forest image dataset by combining canny and pewit edge detection operator and after that calculates length, width and shape of the cracks with the help of Hough Transformation. Firstly, acquired image is preprocessed with the help of histogram contrast stretching and cleaned by using morphological cleaning process. For handling noisy images, median filter is used. The performance of the system is measured by calculating the PSNR, MSE, and SNR of the crack detected images by using different edge detection operators. The result shows that combined canny-pewit edge detection operator has better result as compared to other edge detection operators.***
Keywords: edge detection operator, PSNR, MSE, SNR, cracks

I. INTRODUCTION

Most of the manpower work is replaced by computerized system because it takes less time and efforts to complete their tasks. Similarly, many computerized systems were developed to detect the cracks on the things for the purpose of maintenance of the things. The proposed system is designed to detect cracks on the road images because road is the common medium for the transport purposes. Moreover, roads play an important role in the development of the country. As roads are common medium, crack comes on the roads. Moreover, crack comes on the roads by natural calamities. To detect that cracks some system is needed so that its maintenance can be done at right time. The proposed system detects the crack with the help of combining prewitt and canny edge detection operators. The proposed system works in two steps, first step is to detect the cracks on the road image by combining prewitt and canny edge detection operator and after calculates the length, width and shape with the help of Hough Transformation.

A. The following are the some of the edge detection operators are:

1) Sobel Operator: The first type of edge detection operator is sobel operator. It is one of the kind of gradient based edge detection operator. It extracts the edges of images but does not consider its direction. Sobel operator has pair of convolution of 3x3 kernels and one kernel rotates from other kernel about 90 degrees. The gradient magnitude is given as: [1]

$$|G|=|Gx|+|Gy| \quad \text{…Equation (1.1)}$$

2) Prewitt Operator: Prewitt Operator is the differential operator which is discrete in nature and calculates approximate gradients. It is also belongs to gradient based edge detection operator.It detects horizontal and vertical edges with convolution mask of 3x3. It estimates absolute magnitude and orientation of gradient of each pixel.[15]

3) Robert's Cross Operator:Robert Cross operator has a 2x2 convolution kernel. Its working is same as that of sobel operator but difference comes in the convolution kernel. The gradient approximation magnitude is given as: [14]

$$G|=|Gx|+|Gy| \quad \text{…….Equation (1.2)}$$

4) Laplacian based Edge Detection: The Laplacian based Edge Detection uses second order derivatives to find the edges of the image. Laplacian based edge detection operator shows the areas of the rapid change in the intensities. Laplacian based edge detection operator also smoothes the image by using Gaussian filter. [15]

5) Canny Edge Detection Operator:The Canny Edge Detection Operator is different from above edge detection operator as it uses two sets of thresholding for detecting the edges. One set contains high thresholding and other set contains low thresholding. A pixel value having higher value than high thresholding is appeared as edge pixel and pixel value lower than low set value is not appeared as edge pixel. [1]

6) Mathematical Morphological based Edge Operator: The mathematical morphological edge detection operator is based on mainly four operations of set theory. These are: decay, inflate, closure and open.These operations are combined for performing

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morphological based edge detection. [15]Hough Transformation: The second step of the proposed system is to calculate length, width and shape which is done with the help of Hough Transformation. It is a technique which is used for feature extraction. This technique is mainly used in image analysis, digital image processing and computer vision. It was proposed in 1962 by Paul Hough and finds the boundaries of an object.

II. METHODOLOGY

The steps followed by the proposed system for detecting and calculating length, width and shape of the cracks in the image are as follows:

A. Image Acquisition: The first and foremost step in digital image processing is image acquisition. The proposed system uses crack forest dataset for acquisition of images.

B. Image Enhancement: After acquisition of image, the next step is the enhancement of an image. It is done to remove irregularities from an image. The proposed system uses median filter and histogram contrast stretching for enhancement.

C. Edge detection: The third step is the detection of edges of the cracks present in the image. The various edge detection operators are used for detecting the edges of an object. The proposed system uses the combination of canny-prewitt edge detection operators for detecting the edges of the cracks.

D. Calculation of parameters: The fourth step is to calculate the length, width and shape parameters of the cracks. The calculation of parameters is done with the help of Hough Transformation.

E. Comparison of Performance of different edge detection: The last step is to compare the performance of canny- prewitt edge detection operator with other operators in terms of PSNR, MSE and SNR performance measures factors.

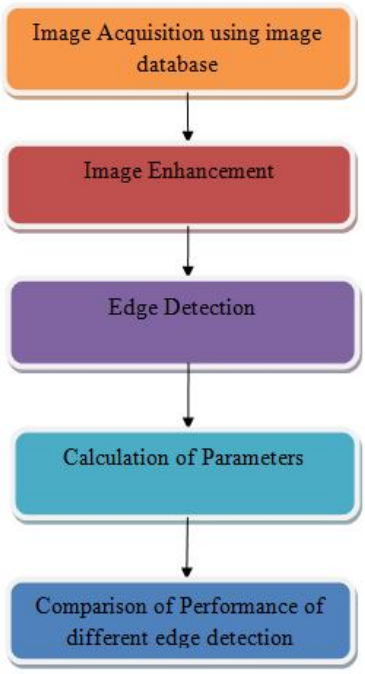

Figure 1: Methodology of Crack Detection and Parameter Estimation

III. RESULTS AND DISCUSSION

Testing of the system is done by giving the input of different road images to check whether the system is producing required output for different types of cracks. The best result is obtained from our systemas compared to other edge detection operators. The systemis testedon 40 images taken from Crack Forest dataset. The research is implemented in MATLAB R2011b.

The step wise result of research for road images is shown in Fig. 2 to Fig. 8. The system will firstly acquire image, detect the edges and calculate the length, width & shape parameters for acquired image.

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Step 1: Image is acquired from Crack Forest dataset

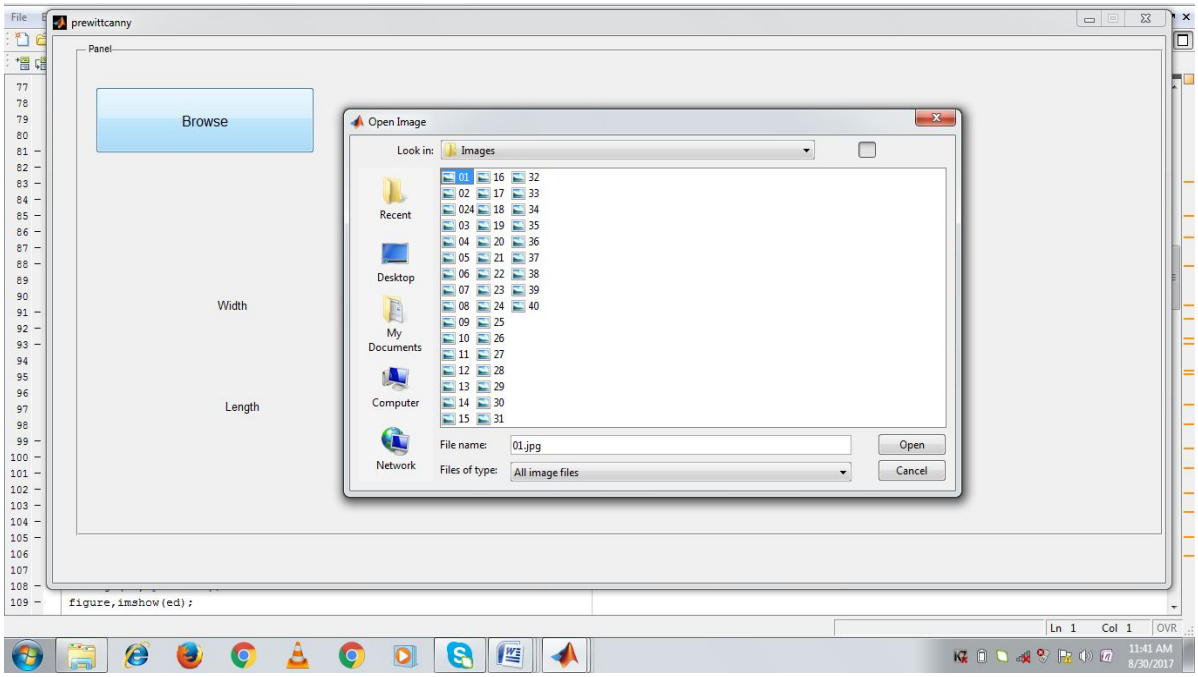

Figure 2: Acquired Image

Step 2: Get Original Image

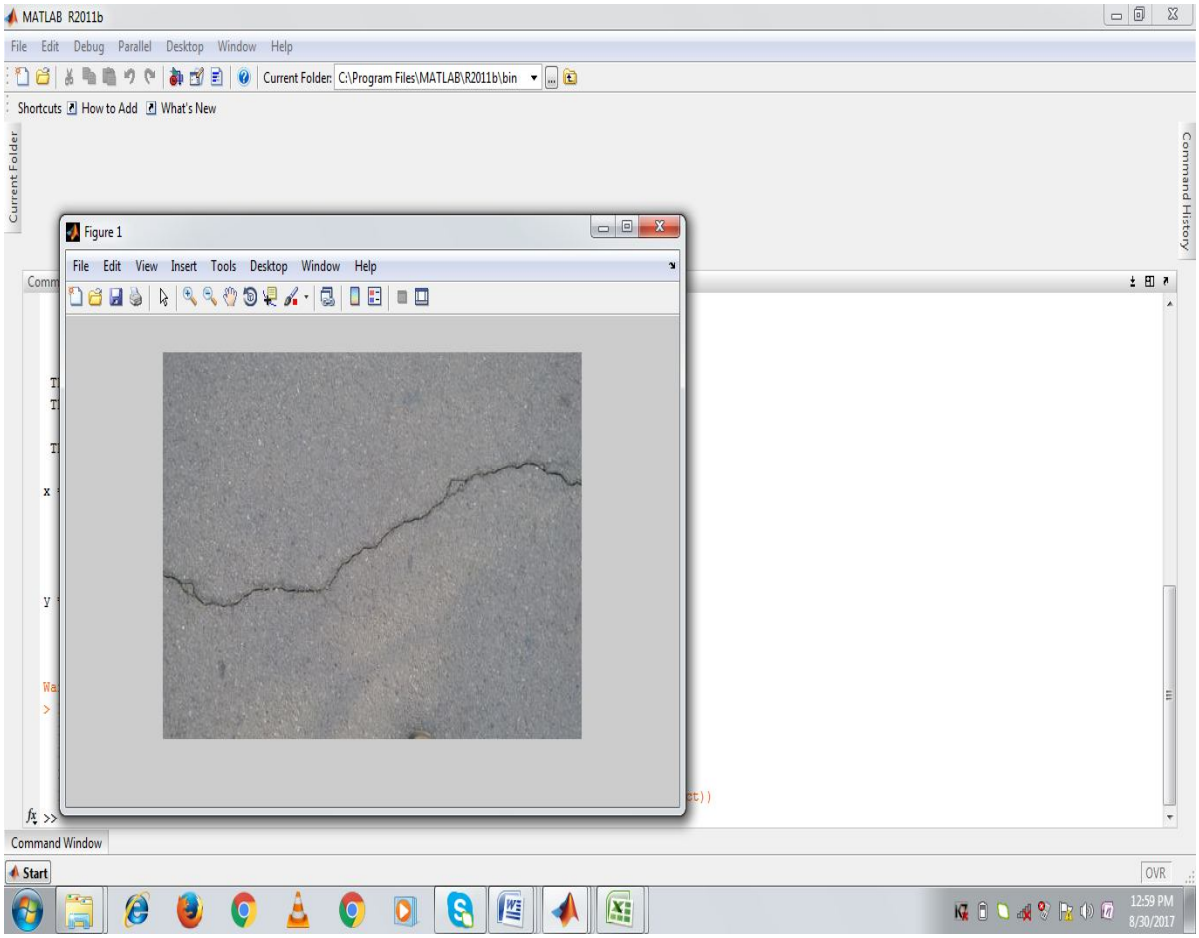

Figure 3: Original Image

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Step 3: Image is enhanced by histogram contrast stretching

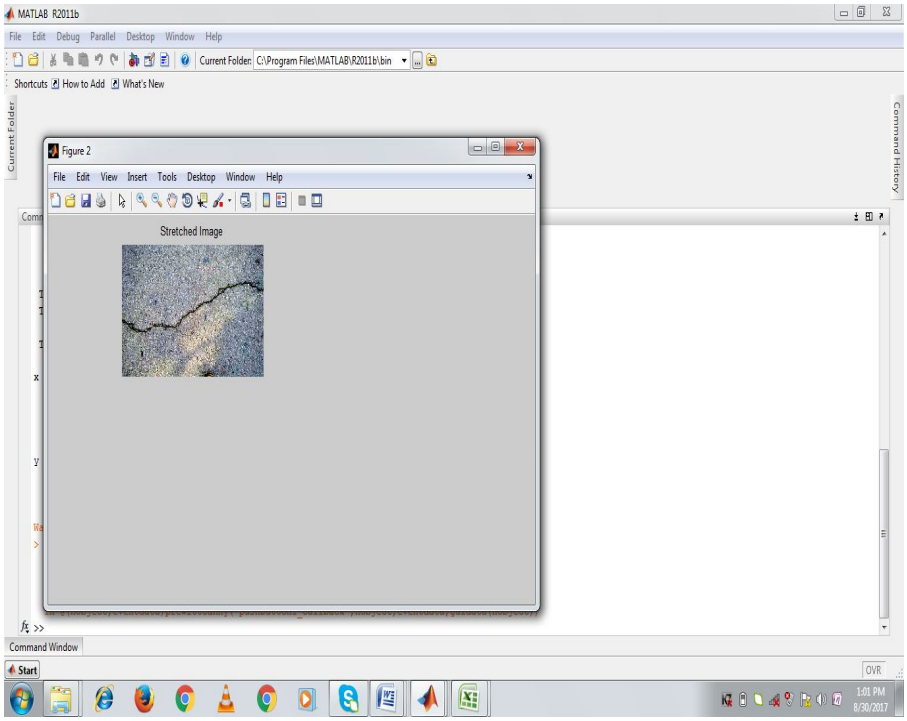

Figure 4: Enhanced Image

Step 4: Image is grayed

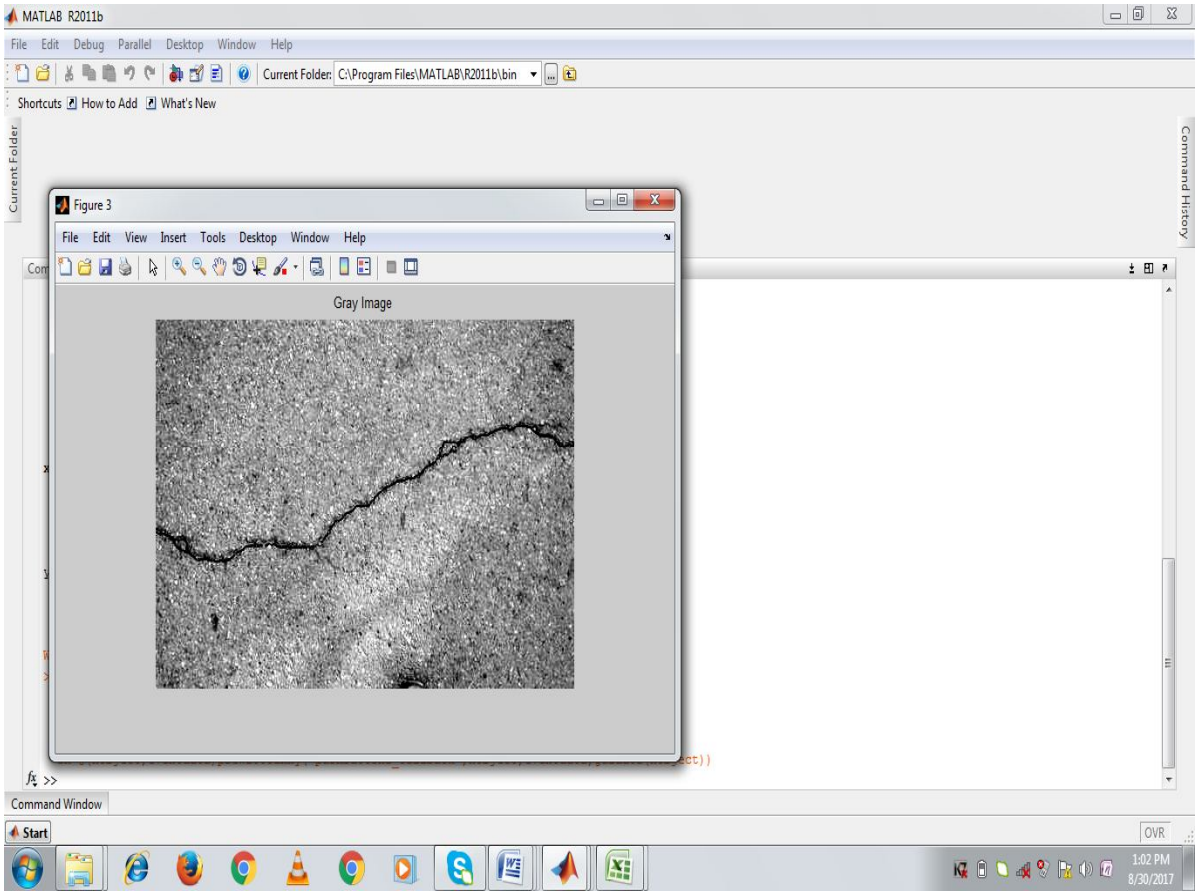

Figure 5: Gray Image

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Step 5: Image is cleaned by morphological process

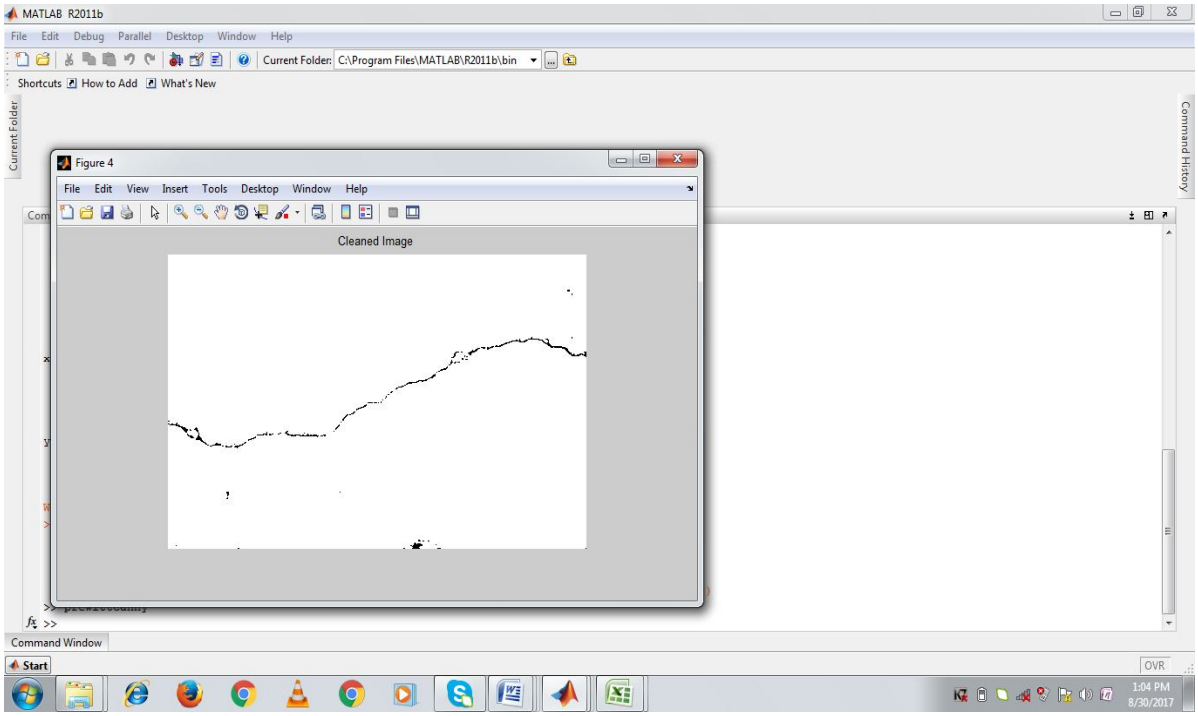

Figure 6: Cleaned Image

Step 6: Edges are detected using Prewitt-Canny operator

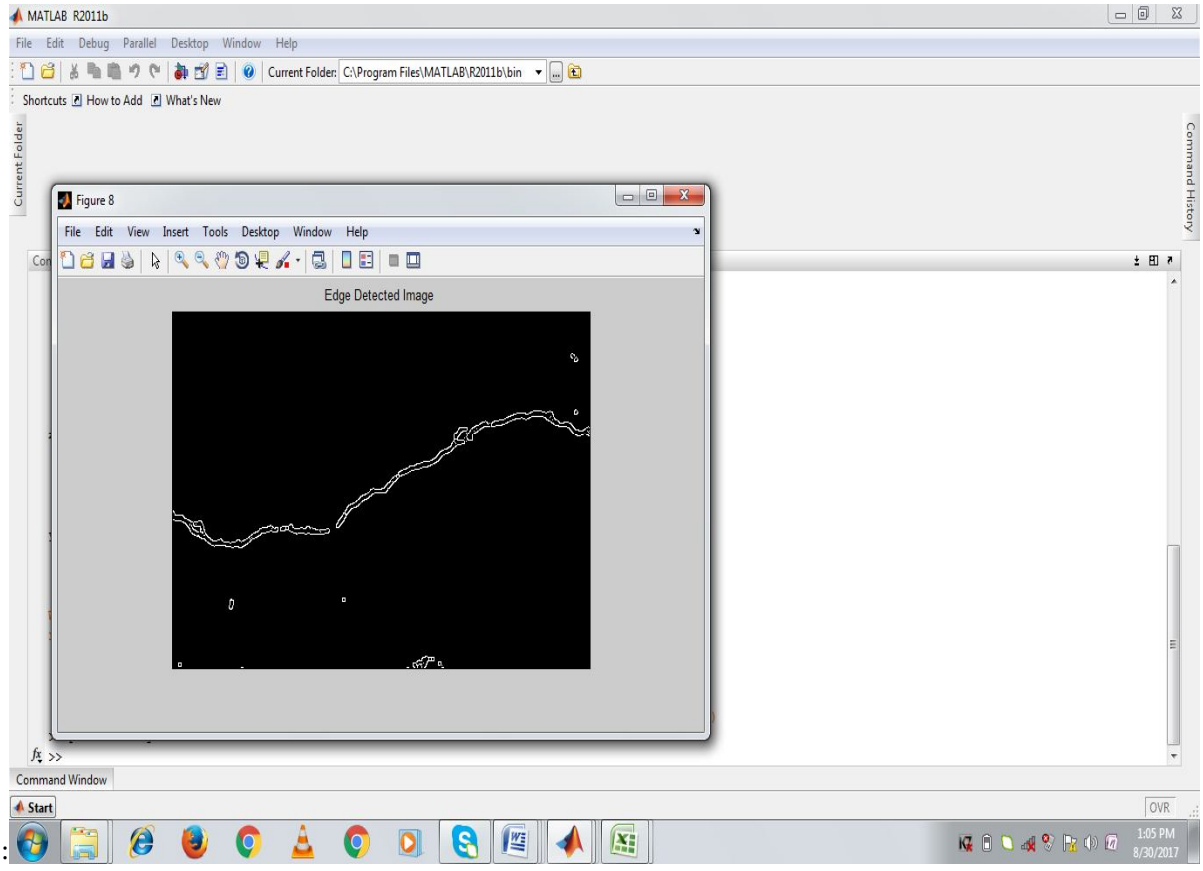

Figure 7: Edge detected Image

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Step 7: Parameters calculated on edge detected image

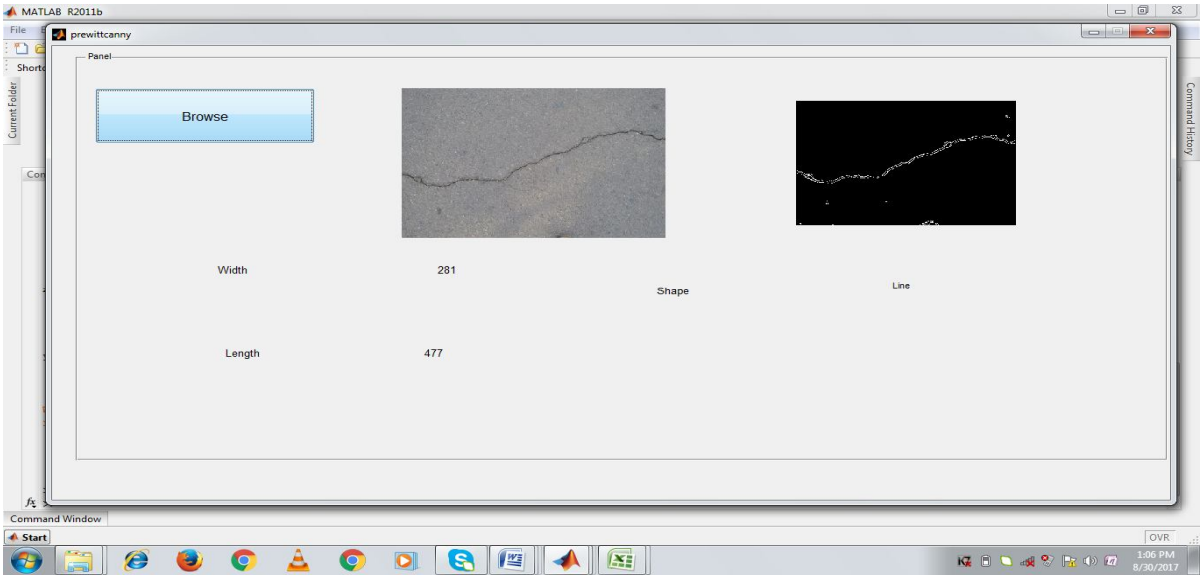

Figure 8: Parameters calculated on edge detected image

Table 1: Length, width and shape of crack for above case

Parameters	Values (in pixels)
Width	283
Length	478
Shape	Line

Table 1 shows the length, width and shape calculated by the proposed system. The width of the crack calculated by the proposed system is 283(in pixels), length is 478(in pixels) and shape is line.

Table 2: Performance Comparison of Canny-Prewitt Operator with other edge detection operators (for image shown in Figure3)

Edge detection Operators with Hough Transformation	PSNR (in decibel)	MSE	SNR (in decibel)
Sobel and Hough Transformation	31.1450	0.3918	21.1488
Prewitt and Hough Transformation	32.5427	0.284	20.9339
Canny and HoughTransformation	33.2562	0.2410	60.4918
Canny-Sobel and Hough Transformation	33.9976	0.2031	59.4218
Sobel-Prewitt and Hough Transformation	34.1654	0.1954	21.2422
Canny-Prewitt and Hough Transformation	35.4860	0.1442	59.3883

Table 2 shows the performance of the system in terms of PSNR (Peak Signal to Noise Ratio), MSE (Mean Square Error) and SNR (Signal to Noise Ratio) for image shown in Figure3. The results show that Canny-Prewitt edge detection operator shows better

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results in case of PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Ratio) because for better results the value of PSNR is high and the value of MSE is low.

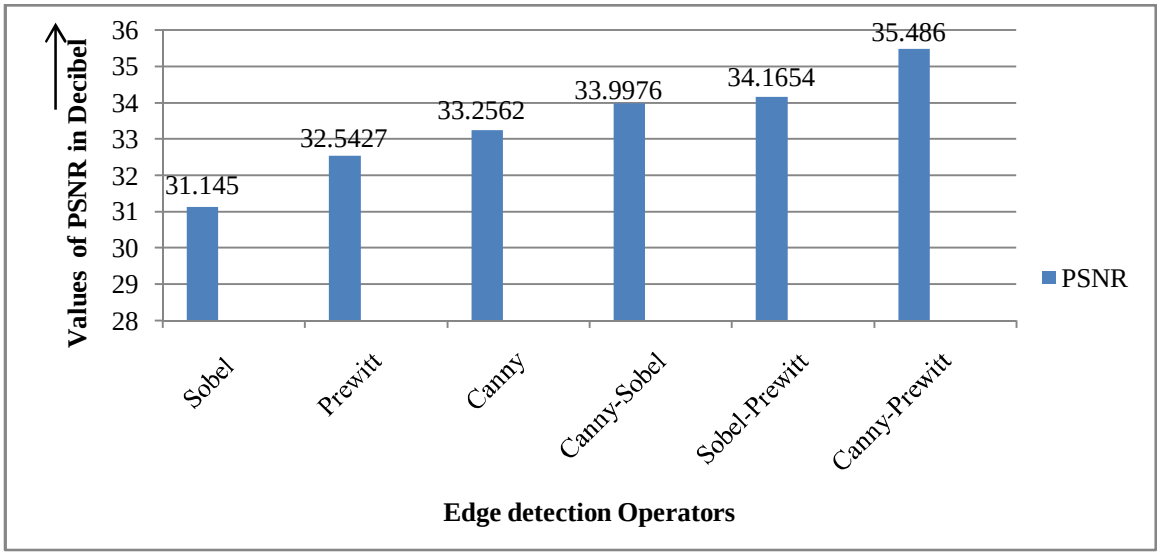

Figure 9: Graph Showing PSNR (Peak Signal to Noise Ratio)values for different edge detection operators for Table 2.

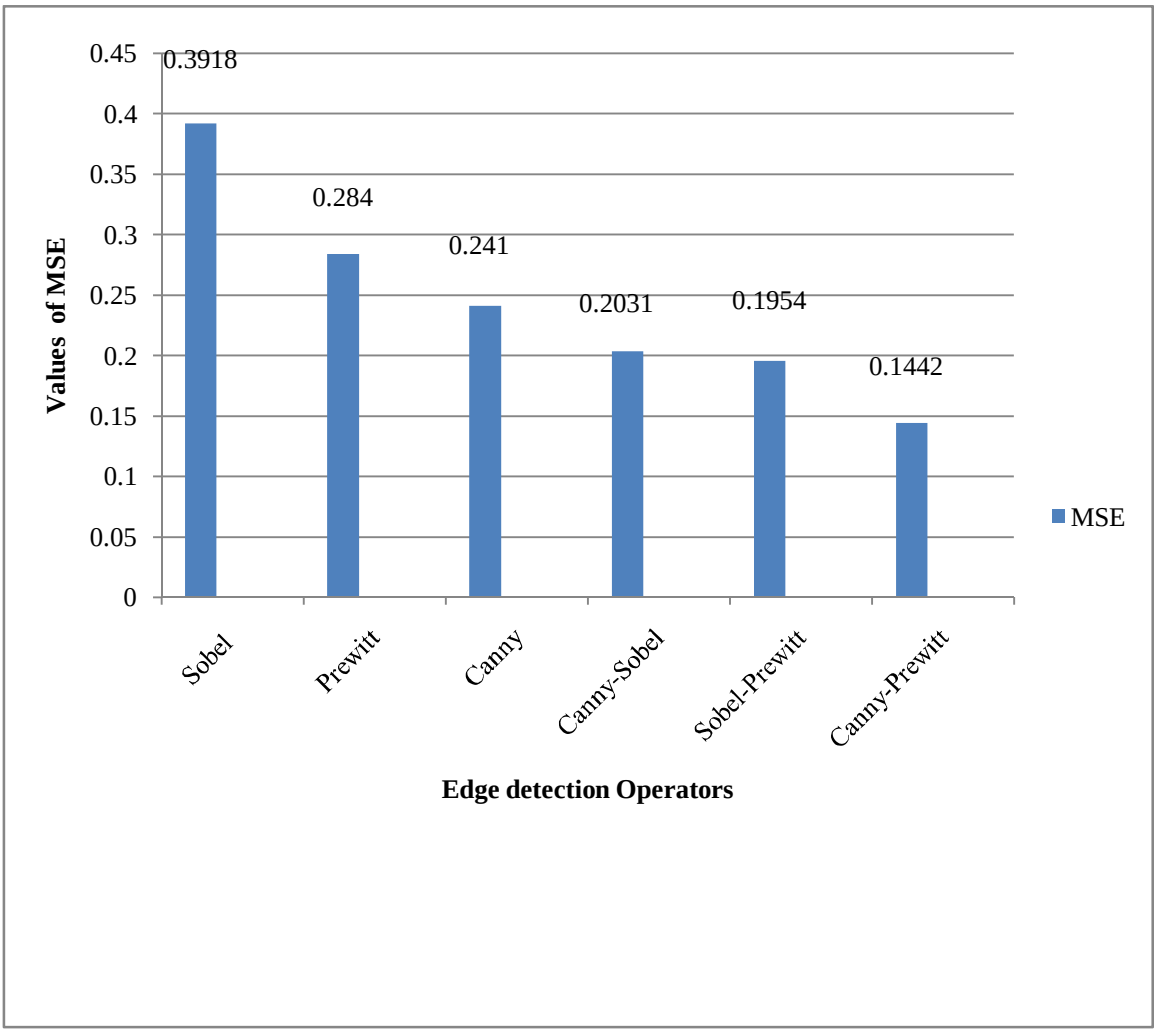

Figure 10: Graph Showing MSE (Mean Square Error) values for different edge detection operators for Table 2.

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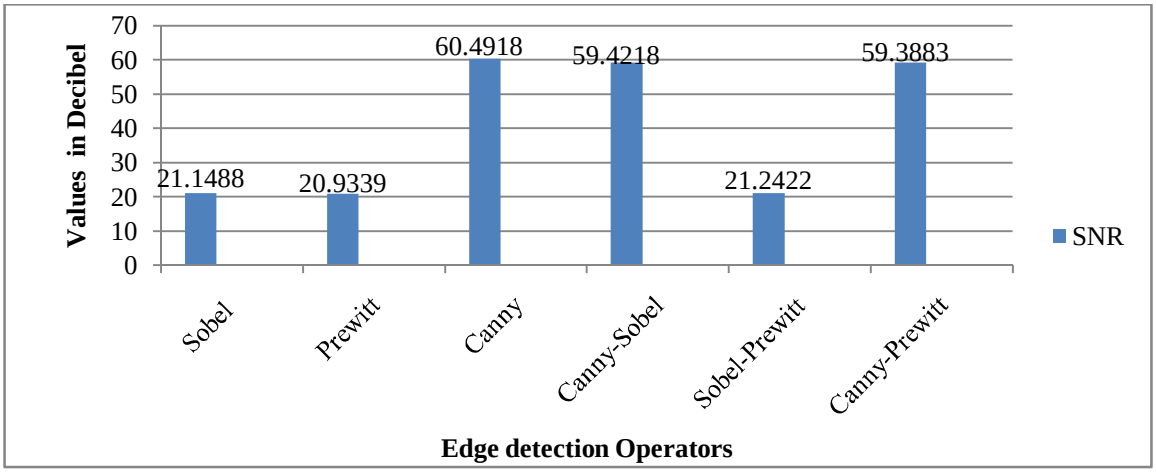

Figure 11: Graph Showing SNR (Signal to Noise Ratio) values for different edge detection operators for Table 2.

Table 3: Performance Comparison of proposed system with other edge detecting operators on 40 images

Edge detection Operators with Hough Transformation	PSNR (in decibel)	MSE	SNR (in decibel)
Sobel and Hough Transformation	31.7832	0.3409	22.4228
Prewitt and Hough Transformation	33.1762	0.2472	22.2148
Canny and HoughTransformation	33.6489	0.2208	61.2473
Canny-Sobel and Hough Transformation	34.4192	0.1848	60.2650
Sobel-Prewitt and Hough Transformation	34.5434	0.1802	21.9956
Canny-Prewitt and Hough Transformation	35.9001	0.1315	60.2121

Table 3 shows the average performance of the proposed system tested on 40 images. From Table 3, it is concluded that Canny-Prewitt Operator performs better than other edge detection operators in case of PSNR and MSE.

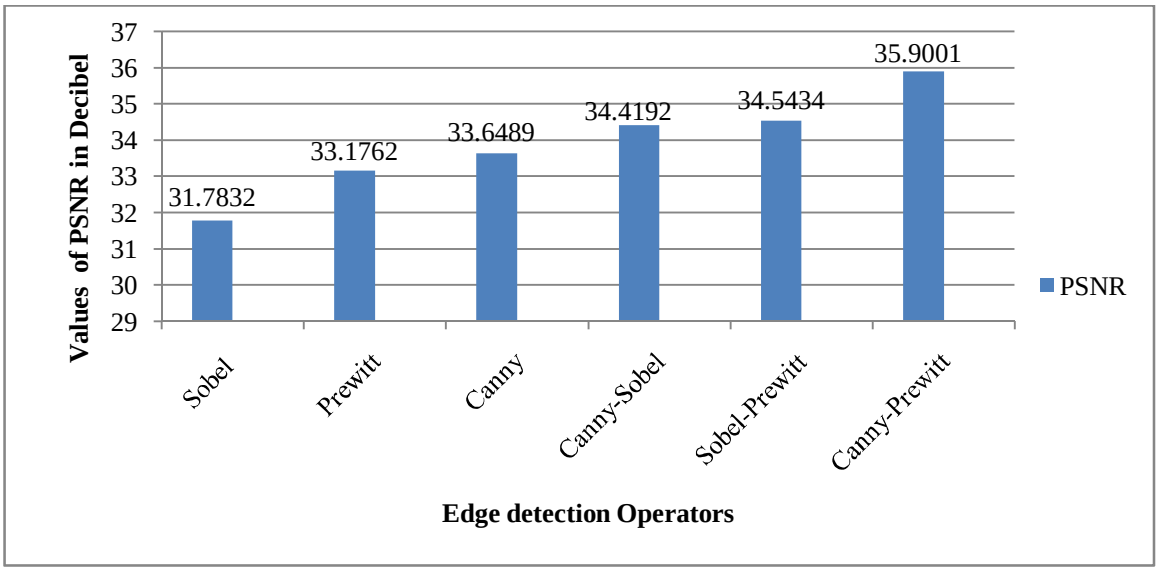

Figure 12: Graph Showing PSNR (Peak Signal to Noise Ratio) values for different edge detection operators for Table 3.

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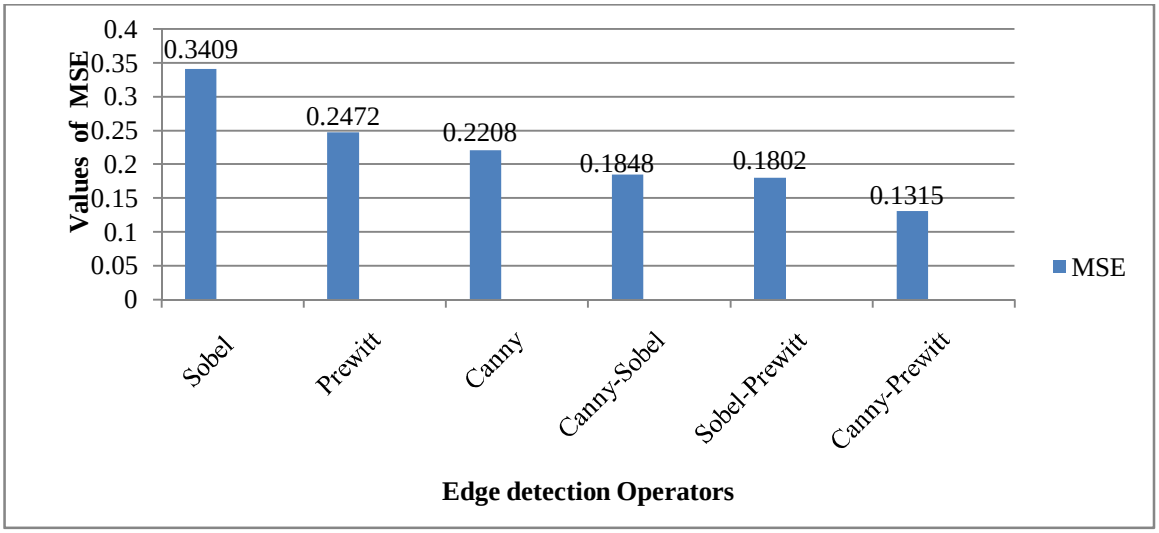

Figure 13: Graph Showing MSE (Mean Square Error) values for different edge detection operators for Table 3.

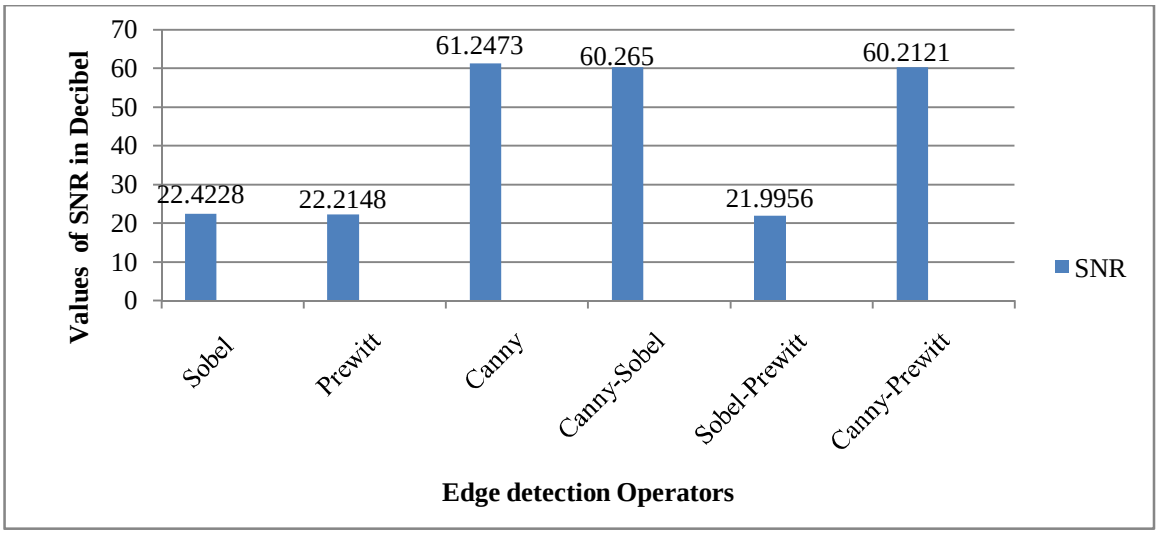

Figure 12: Graph Showing SNR (Signal to Noise Ratio) values for different edge detection operators for Table 3.

IV. CONCLUSION AND FUTURE SCOPE

There are different types of edge detection operators are available for detecting the edges. The proposed edge detection operator which is made with the help of canny-prewitt edge detection operators performs better than the available edge detection operator in terms of PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error). The research is conducted on 40 images that are taken from Crack Forest dataset shows PSNR value on using Canny-Prewitt edge detection operator is 35.9001which is highest among all and for better results its value should be high. The MSE value on using Canny-Prewitt edge detection operator is 0.1315 which is the lowest among all and for better results its value should be low.

In future, the system can be attached on the vehicles for the ease of driver. With the help of system driver will able to know that there is crack on the road. The proposed system calculates the length and width in terms of pixel and in future it will be calculated in other units like mm, cm etc.

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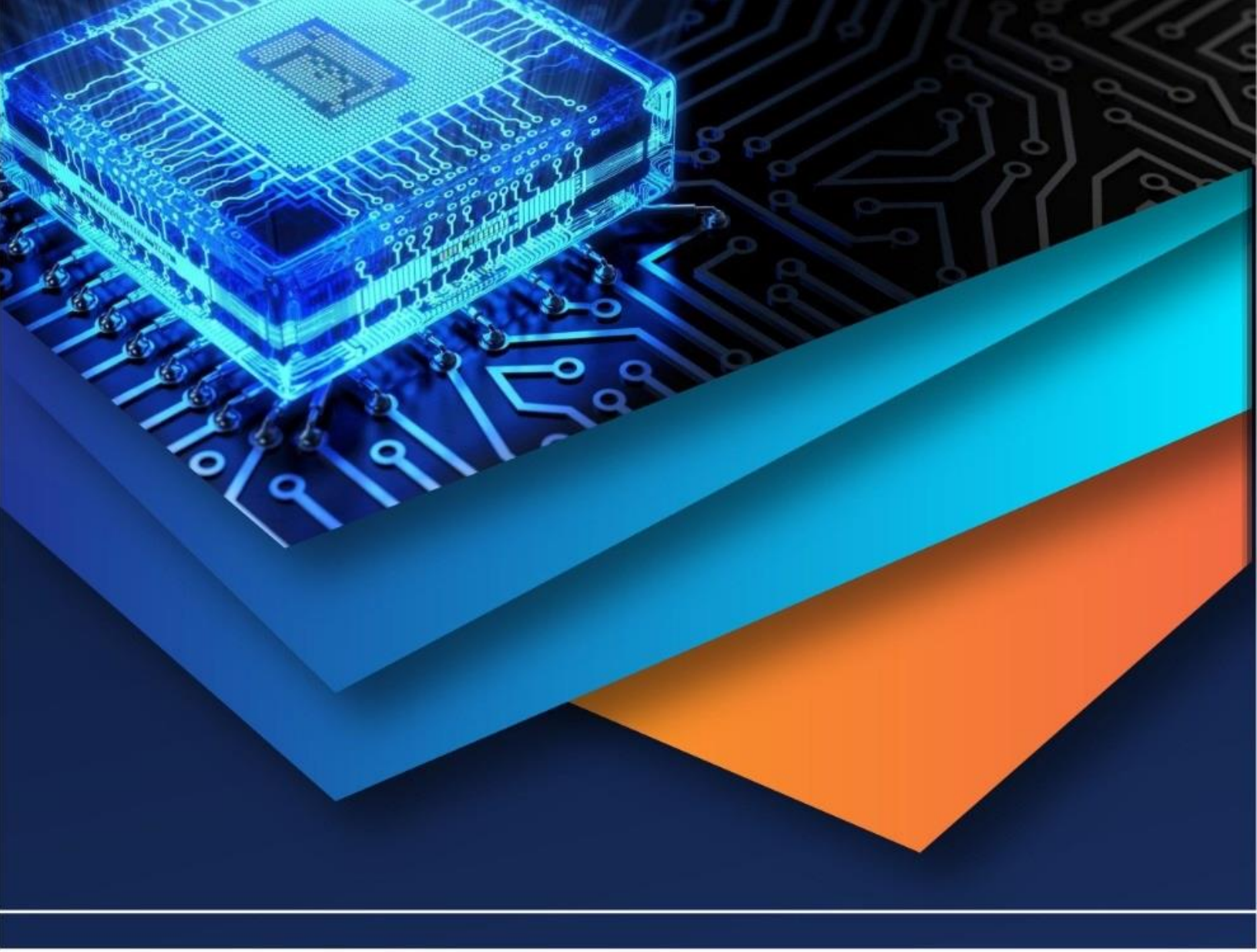

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