Review on Effective Edge Detection Techniques

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Abstract -Edge detection includes a variety of mathematical methods that aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges. The same problem of finding discontinuities in one-dimensional signals is known as step detection and the problem of finding signal discontinuities over time is known as change detection. Edge detection is a fundamental tool in image processing, machine vision and computer vision, particularly in the areas of feature detection and feature extraction.[13].The evidence for the best detector type is judged by studying the edge maps relative to each other through statistical evaluation. Upon this evaluation, an edge detection method can be employed to characterize edges to represent the image for further analysis and implementation. It has been shown that the Canny's edge detection algorithm performs better than all these operators under almost all scenarios.

Index terms: MATLAB, Dilation , Edge detection technique, Thresholding, Hole filling command.

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1 INTRODUCTION

Metallic surfaces/objects gets corroded with age, usage and surrounding environment. Therefore, their condition assessment is necessary. The metallic surfaces/objects can vary in shape, size and usage, so their corrosion will vary and can be very difficult to assess. For example, larger boiler tanker, other metallic surface of larger ship body parts which is inside the water . There are many example in present day life for the corroded metallic object that takes a lot of time to do measure how much part of the metallic surface is fine and how much part is corroded. Seeing this difficulties, I and my respected sir are willing to do a work on solving this problem . Therefore, the research to be done will focus on using image processing for identifying the corroded and non-corroded regions of metallic objects for the purpose of condition assessment. Small surfaces can be easily monitored visually; but for large surface it is very difficult and time consuming to do condition assessment visually. But it is easier to take the image of a large surface, so the research will be done to develop an image processing based algorithm for doing condition assessment of corroded metallic surfaces/objects. The algorithm will use the edge detection for detecting the corroded region and hole filling to determine the area for doing condition assessment.

2 EDGE AND EDGE DETECTION IN DIGITAL IMAGES

Edge is a part of an image that contains significant variation. Edges are those places in an image that correspond to object boundaries. Edges are pixels where image brightness changes. Physical edges are produced by variation in the reflectance, illumination, orientation, and depth of scene surfaces. The most common edge types are steps, lines and junctions. An Edge in an image is a significant local change in the image intensity, usually associated with a discontinuity in either the image intensity or the first derivative of the image intensity.[1] An edge is the boundary between an object and the background. The edge representation of an image significantly reduces the quantity of data to be processed, yet it retains essential information regarding the shapes of objects in the scene. The various types of edge of images are

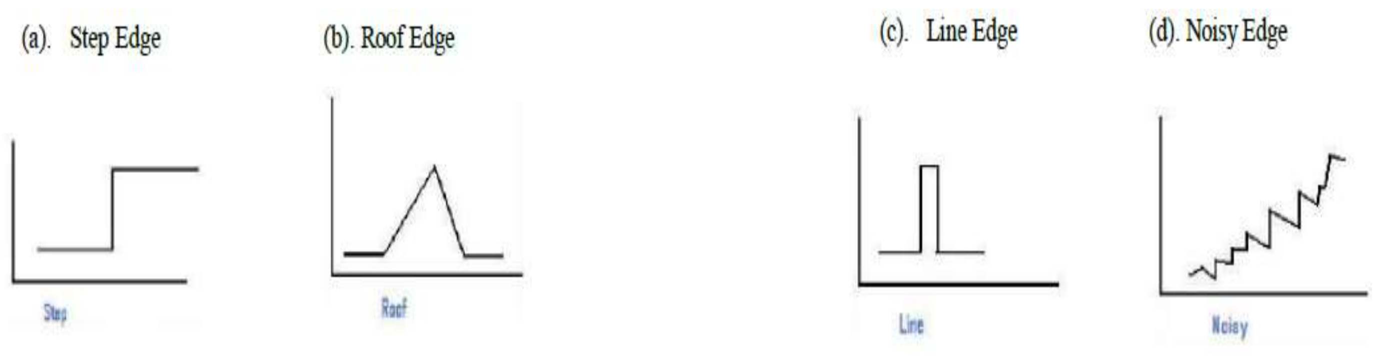

Figure 1:-Different types of edges.[4]

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. So, edge detection is a vital step in image analysis and it is the key of solving many complex problems. Edge detection is a fundamental tool used in most image processing applications to obtain information from the frames as a precursor step to feature extraction and object segmentation.

The edge detection have been used by object recognition, target tracking, segmentation, data compression ,and also help for well matching, such as image reconstruction and so on.

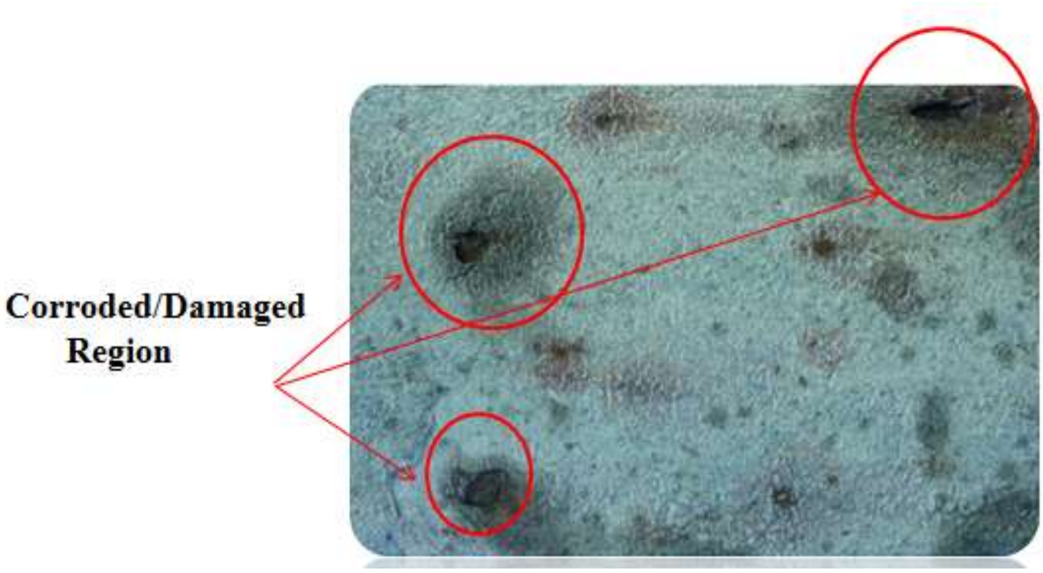

Figure 2:- Small corroded surfaces or damage region.

The result of applying an edge detector to an image may lead to a set of connected curves that indicate the boundaries of objects, the boundaries of surface markings as well as curves that correspond to discontinuities in surface orientation in the below diagram.

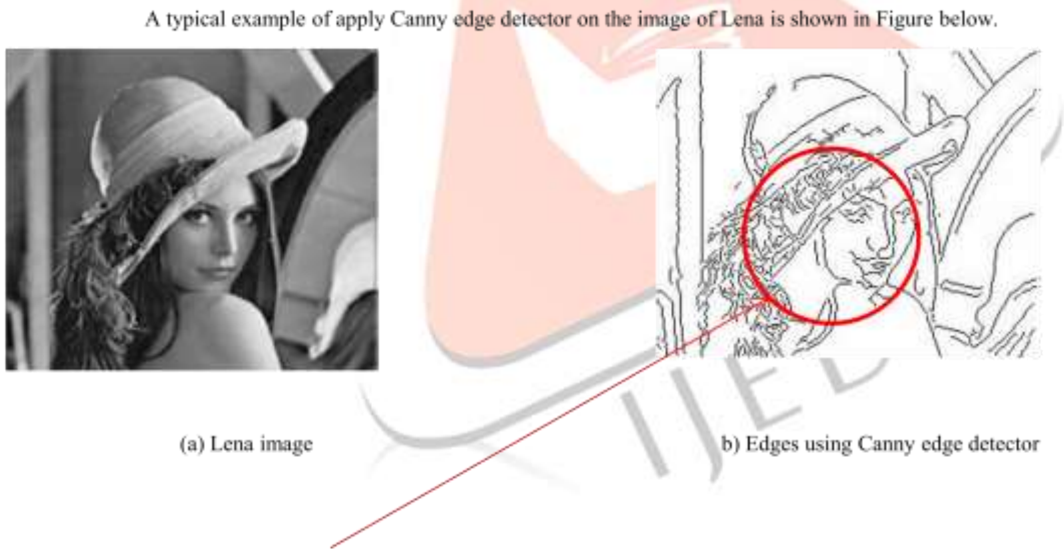

Figure 3:- The result of applying an edge detector to an image

When we are talking about the portion which have been marked by arrow with circle .The marked circle boundary is not connected . So it is very difficult to find its areas. So We will minimize/remove the discontinuities and apply hole filling concept to convert discontinuous broken edge or boundaries into continuous boundaries. Same concept can be applied on the corroded surface and measured out about how much area is corroded and finest area and that will be verified by taking a test image of known area.

There are many types of edge detection algorithms developed. In point of technical view, the edge detection methods can be grouped into two categories: search-based and zero-crossing based[2]. The search-based methods detect the edges by first computing a measure of edge strength, such as magnitude of gradient of the image intensity function, and then searching for local maxima in a direction that matches with the edge profile, such as the gradient direction. The first-order derivative is regularly used to express the gradient. The zero-crossing based methods search for zero crossings in a second-order derivative expression computed from the image in order to find edges, such as the Laplacian or a non-linear differential expression.

3 STEPS IN EDGE DETECTION:

i Filtering: Some major classical edge detectors work fine with high quality pictures, but often are not good enough for noisy pictures because they cannot distinguish edges of different significance. Noise is unpredictable contamination on the original image. There are various kinds of noise, but the most widely studied two kinds are white noise and "salt and pepper" noise. In salt and pepper noise, pixels in the image are very different in color or intensity from their surrounding pixels

ii. Enhancement: Digital image enhancement techniques are concerned with improving the quality of the digital image. The principal objective of enhancement techniques is to produce an image which is better and more suitable than the original image for a specific application. Linear filters have been used to solve many image enhancement problems. Throughout the history of image processing, linear operators have been the dominating filter class.

iii. Detection: Some methods should be used to determine which points are edge points or not.

4 APPLYING DIFFERENT EDGE DETECTION TECHNIQUES TO DETECT CORRODED SURFACE BOUNDARY WITH THRESHOLD :-

4.1 Sobel operator:- The Sobel operator consists of a pair of 3×3 convolution masks shown below in Table 1. One kernel is remain constant and the other s irotated by 90°. The kernels can be applied separately to the input image to produce separate gradient component measurement in each orientation (Gx and Gy). Magnitude is given by the Mathematical equation [9]. Gx is horizontal mask and Gy is vertical mask

Gx		
-1	0	+1
-2	0	+2
-1	0	+1

Gy		
+1	+2	+1
0	0	0
-1	-2	-1

$$|G|=\sqrt[2]{Gx^2 + Gy^2} \qquad |G| = |Gx| + |Gy| \qquad (1)$$

The Sobel edge detection method is introduced by Sobel in 1970. The Sobel method of edge detection for image segmentation finds edges using the Sobel approximation to the derivative. It precedes the edges at those points where the gradient is highest. The Sobel technique performs a 2-D spatial gradient quantity on an image and so highlights regions of high spatial frequency that correspond to edges. This is very similar to the Roberts Cross operator.[3]

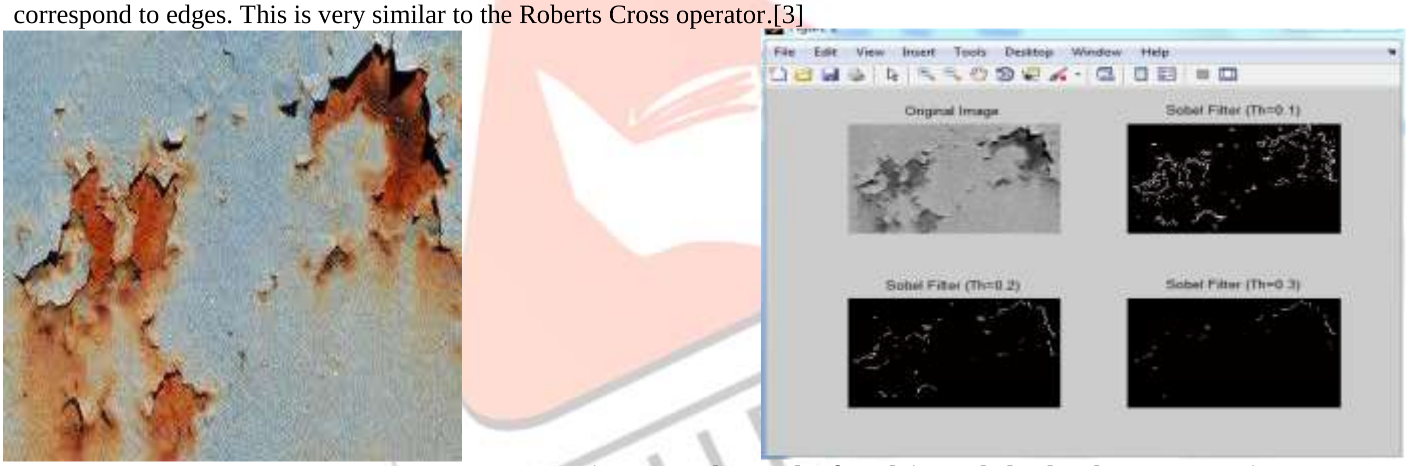

Figure 4:- The result of applying Sobel edge detector to an image

4.2 Perwitt operator:- Like Sobel operator , Perwitt edge detection technique consists of co a pair of 3×3 convolution kernels . One kernel is simply the other rotated by 90°. These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid. this operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical.

$$\text{Edge Magnitude} = \sqrt{P_1^2 + P_2^2} \qquad \text{Edge Direction} = \tan^{-1}\left[\frac{P_1}{P_2}\right] \qquad (2)$$

The Prewitt edge detection is proposed by Prewitt in 1970. Prewitt operator edge detection masks are the one of the oldest and best understood methods of detecting edges in images. The Prewitt edge detector is an appropriate way to estimate the magnitude and orientation of an edge. The Prewitt operator measures two components. The vertical edge component is calculated with kernel Gx and the horizontal edge component is calculated with kernel Gy. | on the opposite sides of the center point of the mask. These masks are then convolved with the original image to Gx| + |Gy| give an indication of the intensity of the gradient in the current pixel. The operator uses two 3x3 size masks which gives more information regarding the direction of the edges as they consider the nature of data obtain the approximations of derivatives for the horizontal and vertical edge changes, separately.

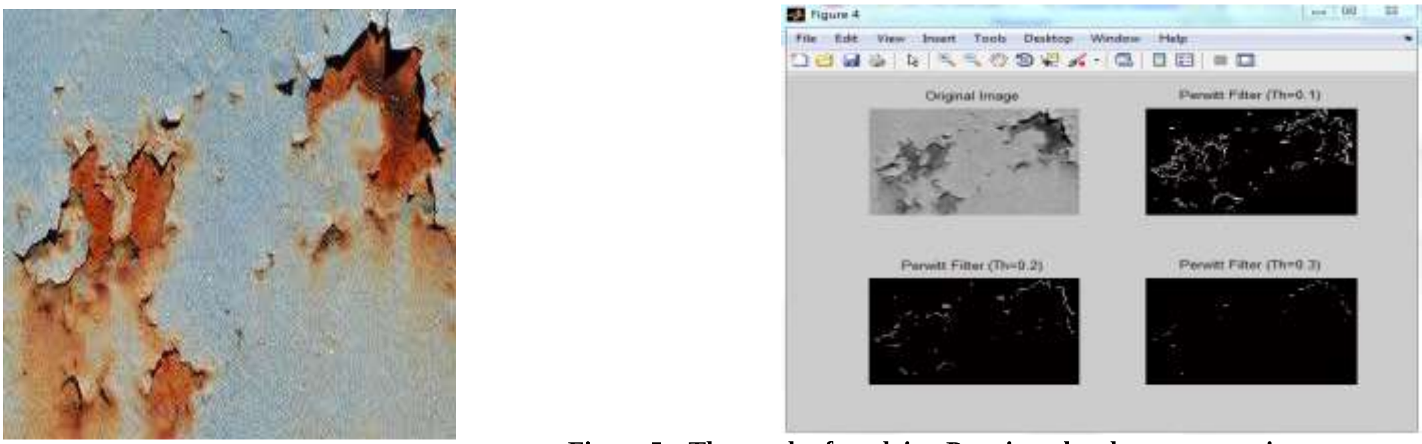

Figure 5:- The result of applying Perwitt edge detector to an image

4.3 Robert operator:- The operator consists of a pair of 2×2 convolution kernels . One kernel is simply the other rotated by 90°. This is very similar to the Sobel operator. These kernels are designed to respond maximally to edges running at 45° to the pixel grid, one kernel for each of the two perpendicular orientations. The Roberts cross operator provide a simple approximation to the gradient magnitude[8].

$$G[f[i,j]] = |f[i,j] - f[i+1,j+1]| + |f[i+1,j] - f[i,j+ \quad (3)$$

Using convolution masks, this becomes:

$$G[f[i,j]] = |G_x| + |G_y| \quad (4)$$

Where Gx and Gy are calculated using the following

$$G_x = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} \qquad G_y = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \qquad |G| = \sqrt{G_x^2 + G_y^2} \quad (5)$$

As 2 x 2 gradient operator, the differences are computed at the interpolated point [i + 1/2, j + 1/2]. The Roberts operator is an approximation to the continuous gradient at the interpolated point and not at the point [i, j] as it might be expected.

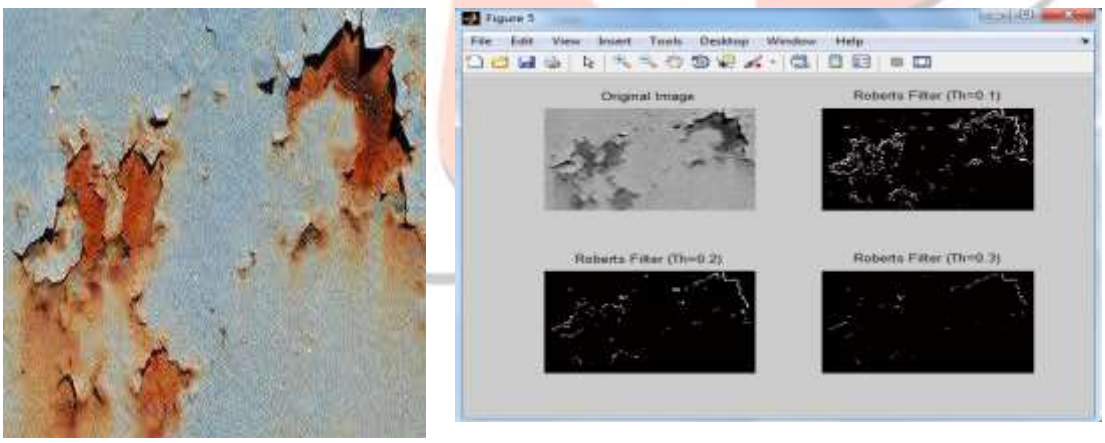

Figure 6:- The result of applying Robert edge detector on an image

4.4 Canny filter:- This method was proposed by John F. Canny in 1986. Even though this method is quite old but is still used because of its precision in edge detection. The main advantage of this method is elimination of multiple responses to a single edge. It also have a good localization property, means the detected edges are much closer to the real edges. This method is not easily disturbed by noise and can keep the good balance between noise and edge detection. It can detect the true weak edge. **Properties**: good localization ,low error rate , uniqueness of the multiple responces.

Steps in Canny edge detector:-The Canny Edge Detection Algorithm has the following Steps:

Step 1: Smooth the image with a Gaussian filter. **Step 2:** Compute the gradient magnitude and orientation using finite-difference approximations for the partial derivatives. **Step 3:** Apply non maxima suppression to the gradient magnitude, Use the double thresholding algorithm to detect and link edges. Canny edge detector approximates the operator that optimizes the product of signal-to-noise ratio and localization. It is generally the first derivative of a Gaussian.

The Smoothing is computed as *I[i,j]* to denote the image. *G[i,j,□]* has to be a Gaussian smoothing filter where □ is the spread of the Gaussian and controls the degree of smoothing[7]. The result of convolution of *I[i,j]* with *G[i,j,□]* gives an array of smoothed data as:

$$S[i,j] = G[i,j,\sigma] * I[i,j] \qquad (6)$$

Firstly, the Gradient is calibrated for the smoothed array *S[i,j]* is used to produce the x and y partial derivatives *P[i,j]* and *Q[i,j]* respectively as[5]:

$$P[i,j] \approx (S[i,j+1] - S[i,j] + S[i+1,j+1] - S[i+1 \qquad (7)$$

$$Q[i,j] \approx (S[i,j] - S[i+1,j] + S[i,j+1] - S[i+1,j+ \qquad (8)$$

The x and y partial derivatives are computed with averaging the finite differences over the 2x2 square. From the standard formulas for rectangular-to-polar conversion, the magnitude and orientation of gradient

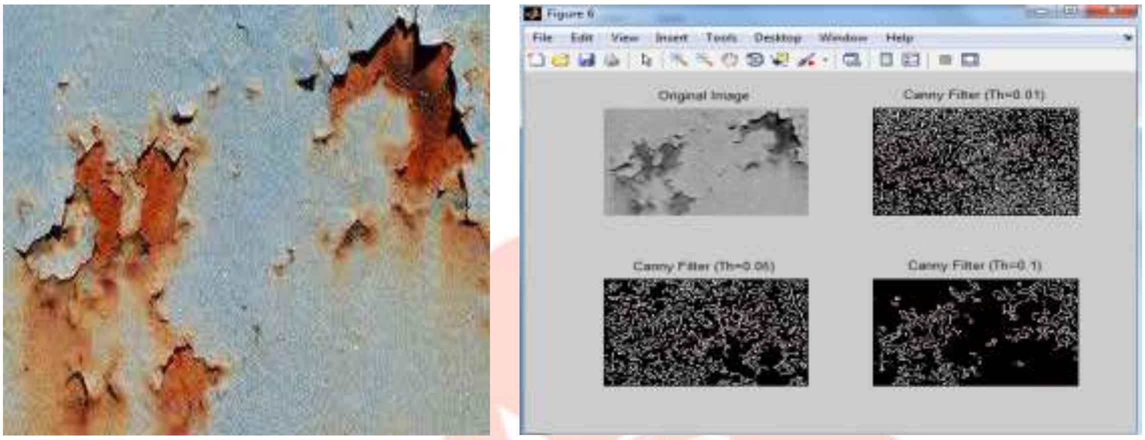

Figure 7:- The result of applying Canny edge detector to an image

$$M[i,j] = \sqrt{P[i,j]^2 + Q[i,j]^2} \qquad (9)$$

$$\theta[i,j] = \arctan(Q[i,j], P[i,j]) \qquad (10)$$

Here the arctan(x, y) function takes two arguments and generates an angle. The Non maxima Suppression is evaluated using the magnitude image array.

5 COMPARISON OF VARIOUS EDGE DETECTION TECHNIQUES:

We used different natural images to experiment using Robert, Sobel, Prewitt,and canny Edge Detection techniques. Different edge detection techniques work better under different conditions. There are some differences between various Edge Detection Techniques for natural image segmentation as below [6]

1) The Roberts, Sobel and Prewitt operators use the first derivative, while LoG uses Second derivative.

2) The Roberts, Sobel and Prewitt operators/Edge detections have very simple calculation to detect edges and their orientation but they have inaccurate detection sensitivity in case of noise because the subjective evaluation of edge detection result images show that under noisy condition Roberts, Prewitt and Sobel operator have poor quality.

3) The Roberts operator use 2×2 masks, while Sobel, Prewitt and LoG use 3×3 masks.

4) LOG can finding the correct places of edges and test wider area around the pixel but malfunctioning at corners, curves and where the gray level intensity function varies and it do not find the orientation of edge.

5) Prewitt is very similar to sobel but difference is that Sobel edge detector marks a lot of number of pixels while the Prewitt edge detector marks a few number of pixels.

6) From the above experiment the Canny has better performance than other edge detection techniques.

7) Sobel and Prewitt methods are very effectively providing good edge maps.

8) Roberts and Laplacian methods are not very good as expected.

9) Canny detector detect the strong as well as weak edge also.

10)All edge detectors were implemented using MATLAB. For the Sobel edge detector, it was possible to set the slope threshold, the sigma of the Gaussian, and the size of the Gaussian.

11) For the Canny edge detector and Color Canny edge detector, it was possible to set the high threshold and low threshold, the sigma for the Gaussian, and size of the Gaussian.

6 RESULT AND CONCLUSION:-

We have reviewed the Different edge detection techniques and literature , paying special attention to all those methods of edge detection which detect the finest boundary. Our methodology would be extended by using Comparison of the binary edge images obtained by the Sobel, Canny ,Robert and Perwitt methods from my algorithm will develop in next .. We have also found that Canny detector are best edge detector having advantage of good localization , low error rate and uniqueness of the multiple responces. method . More importantly, we have also seen that the Sobel method advantages with other well-known techniques . Here, we studied the most commonly used four Edge detection techniques and they are Robert, Sobel, Prewitt, and Canny Edge Detection. The performance of various edge detection techniques is carried out with different images by using MATLAB software. Different Edge detection techniques work better under different conditions. The Canny has better performance than other Edge Detection Techniques.

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