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Study of Edge Detection Algorithms

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Abstract: Edge detection is a very important area in the field of Computer Vision. Edges define the boundEdge detectors are local image processing methods designed to detect edge pixels in an image. Edge detection is the approach used most frequently for segmenting images based on abrupt changes in intensity. The best edge detector is the human eye.An edge represents the boundaries of an object in an image, there by representing the structural properties of the object. This paper shows the comparisons among the various edge detection algorithms. From the results it is observed that the canny edge detector performance is far superior than the Sobel, Prewitt, Roberts and Laplacian of Gaussian. (LoG).

Keywords: Edge Detection, Sobel, Prewitt, Roberts, LoG, Canny.

I. INTRODUCTION

The main goal of image processing is to identify the objects in an image. Recognizing the image using the human eye is different when compared to the automated computer. The computer is trained to identify the objects in an image. In this process, the large or complex image is segmented into smaller images.

The edge plays a vital role in any image.
Edge models are classified according to their intensity profiles.

1. A step edge involves a transition between two intensity levels occurring ideally over the distance of 1 pixel.
2. Roof edges are of lines through a region, with the base of a roof edge determined by the thickness and sharpness of the line.

Fundamental steps performed in edge detection:

- **Noise reduction**, where we try to suppress as much noise as possible, without smoothing away the meaningful edges.
- **Edge enhancement,** where we apply some kind of filter that responds strongly at edges and weakly elsewhere, so that the edges may be identified as local maxima in the filter's output. One suggestion is to use some kind of high pass filter.
- **Edge localization**, where we decide which of the local maxima output by the filter are meaningful edges and which are caused by noise

II. METHODOLOGY

One image can be represented as a surface, with height corresponding to gray level value. Brightness function depends on two variables co-ordinates in the image plane (gray level value $z = I(x,y)$)
As averaging of the pixels over a region is analogous to integration, differentiation can be expected to have the opposite effect and thus sharpen an image.

Edges are pixels where brightness function changes abruptly. We can describe changes of continuous functions using derivatives. Brightness function depends on two variables co-ordinates in the image plane and so operators describing edges are expressed using partial derivatives.

Edge Detection is done either first-order derivative or second –order derivative.
In this we use gradient method to detect the edges by looking the maximum and minimum of the first order derivative.
The gradient is calculated by considering the edges strength and direction.

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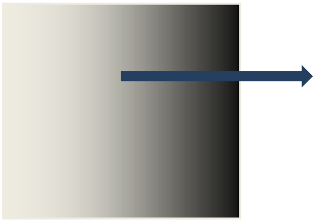
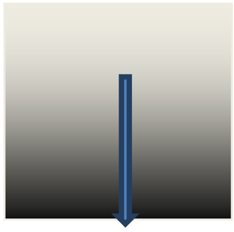
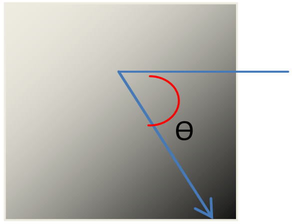
Vertical **Horizontal** **Generic**







Edge Strength:
Edge Direction

$$\|\nabla I\| = G_x \qquad \theta(x,y) = 0$$

$$\|\nabla I\| = G_y \qquad \theta(x,y) = -\frac{\pi}{2}$$

$$\|\nabla I\| = \sqrt{[G_x^2 + G_y^2]} \qquad \theta(x,y) = \tan^{-1}\left(\frac{G_y}{G_x}\right)$$

The tool of choice for finding edge strength and direction at location (x,y) of an image,I, is the gradient, denoted by ∇ I, and defined as the vector

$$\overline{\nabla I} = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial I(x,y)}{\partial x} \\ \frac{\partial I(x,y)}{\partial y} \end{bmatrix}$$

This vector has the important geometrical property that it points in the direction of the greatest rate of change of I at location (x,y). The magnitude (length) of vector ∇I, denoted as

$$\nabla I = \|\overline{\nabla I}\| = \sqrt{[G_x^2 + G_y^2]}$$

The direction of the gradient vector is given by the angle

$$\theta(x,y) = \tan^{-1}\left(\frac{G_x}{G_y}\right)$$

The gradient of an image requires computing the partial derivatives ∂ f/ ∂ x and∂ f/ ∂y at every pixel location in the image.

$$\frac{\partial f}{\partial x}[x,y] \approx f[x+1,y] - f[x,y]$$

The above two equations can be implemented for all pertinent values of x and y by filtering f(x,y) with 1-D masks.
A 3*3 matrix with its intensity values as z_i

Z_1	Z_2	Z_3
Z_4	Z_5	Z_6
Z_7	Z_8	Z_9

The Roberts operators gradients are calculated are based on the diagonal differences , their gradient are caclulated as follows:

$$G_y \approx z_8 - z_6$$

$$G_x \approx z_9 - z_5$$

The Prewitt operators are based on the row and column differences , their gradient are caclulated as follows:

$$G_x \approx (z_7 + z_8 + z_9) - (z_1 + z_2 + z_3)$$
$$G_y \approx (z_3 + z_6 + z_9) - (z_1 + z_4 + z_7)$$

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The Sobel operators are based on the row differences, their gradient are caclulated as follows:

$$G_y \approx (z_3 + 2z_6 + z_9) - (z_1 + 2z_4 + z_7)$$

$$G_x \approx (z_7 + 2z_8 + z_9) - (z_1 + 2z_2 + z_3)$$

The 2-D Laplacian of a Gaussian(LoG)expression is written as

$$\nabla^2 f(x,y) = \frac{\partial^2 f(x,y)}{\partial x^2} + \frac{\partial^2 f(x,y)}{\partial y^2}$$

The Canny operator is calculated by

$$LoG(x,y) = -\frac{1}{\pi\sigma^4}\left[1 - \frac{x^2+y^2}{2\sigma^2}\right] e^{-\frac{x^2+y^2}{2\sigma^2}}$$

A smoothed function is computed byconvolving G and f:

$$f_s(x,y)=G(x,y)*f(x,y)$$

$$g(x,y) = \left[\nabla^2 G(x,y)\right] * f(x,y)$$

and their gradient magnitude and direction is computed by

$$\nabla I = \left\|\overline{\nabla I}\right\| = \sqrt{\left[G_x^2 + G_y^2\right]} \qquad \text{and} \qquad \theta(x,y) = \tan^{-1}\begin{pmatrix} G_x \\ G_y \end{pmatrix}$$

III. EXPERIMENTAL RESULTS

As edge detection is a fundamental step in computer vision, it is necessary to point out the true edges to get the best results from the matching process.

Fig1. Original Image

The original Image is converted into grayscale using MATLAB functions.

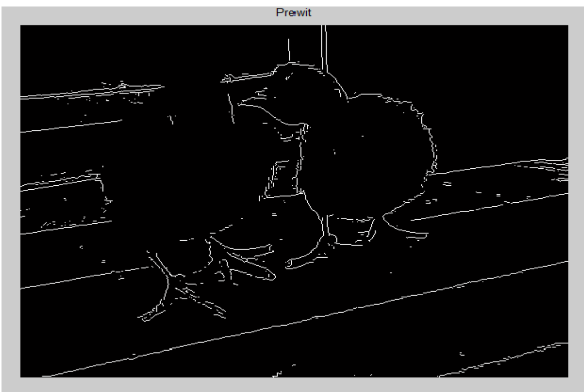

Fig2(a). Prewit Edge detector

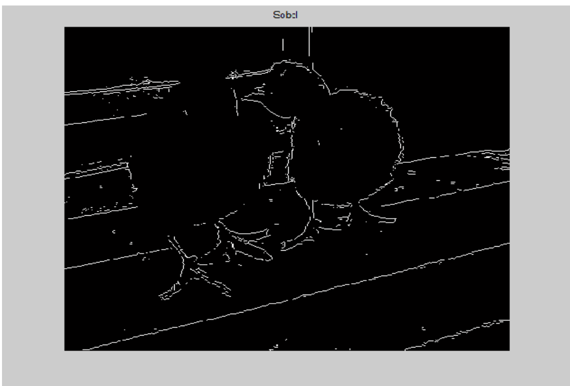

Fig2(b): Sobel Edge Detector

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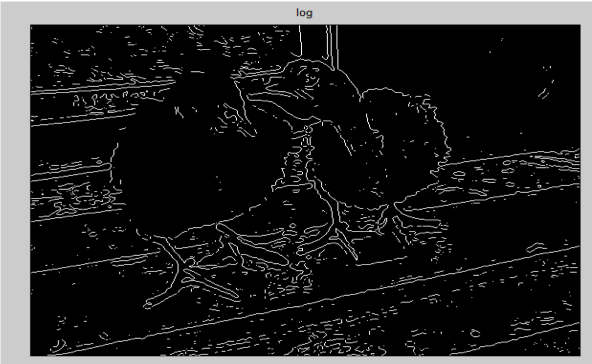

Fig2(c):Log Edge Detector

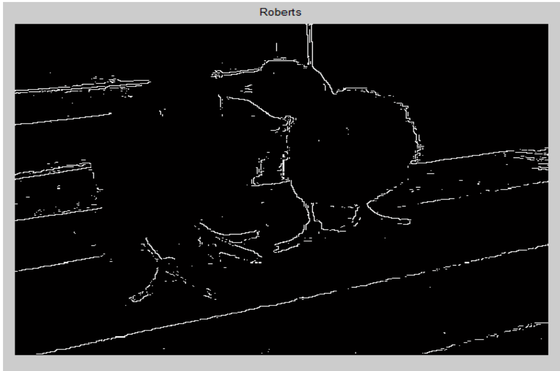

Fig 2(d): Roberts Edge Detector

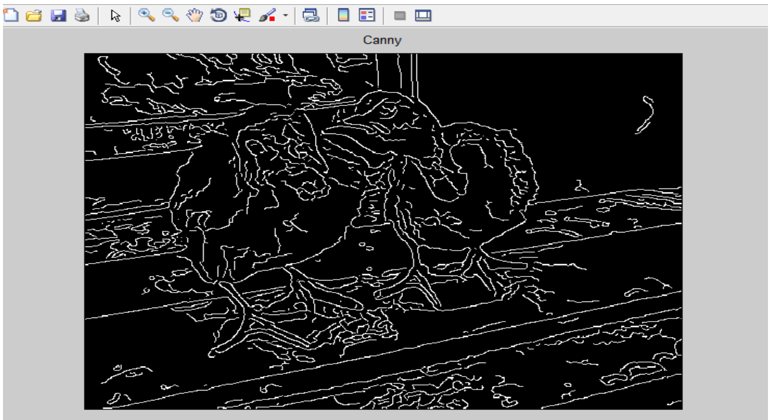

Fig2(e):Canny Edge Detector

The original image is shown in figure1. The edge detection technqiues are applied to the original image(Fig1). From the above figures we can say that Canny Edge detector gives the best result when compared to other edge detectors used.The disadvantages of these cross operators (Sobel, Prewit and Roberts) are sensitivity to the noise, in the detection of the edges and their orientations. In Laplaciandetecting the edges and their orientations are increased in the noise to the image this will eventually degrade the magnitude of the edges. This was expected as Canny edge detection accounts for regions in an image. Canny yields thin lines for its edges by using non-maximal suppression. Canny also utilizes hysteresis with threshold.

Edge Descriptors (The output of an edge detector)

1. Edge normal: The direction of the maximum intensity variation at the edge point.
2. Edge direction: The direction tangent to the edge.
3. Edge Position : The location of the edge in image
4. Edge strength: A measure of local image contrast.

IV. CONCLUSION

Since edge detection is the initial step in object recognition, it is important to know the differences between edge detection techniques. In this paper we studied the most commonly used edge detection techniques Gradient-based and Laplacian based. The performance of the Canny algorithm relies mainly on the changing parameters which are standard deviation for the Gaussian filter, and its threshold valuesCanny's edge detection algorithm is computationally more expensive compared to Sobel, Prewitt and Robert's operator. However, the Canny's edge detection algorithm performs better than all these operators under almost all scenarios.

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BIOGRAPHIES

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