Analysis of Various Edge Detection Techniques

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Abstract--- In this paper the fundamental concept of various edge detection techniques are studied. It mainly concentrates on gradient based Robert, Sobel, Prewitt and Canny edge detection operators. They are implemented using MATLAB and Simulink.

Keywords--- Gradient, Canny, Sobel, Robert, Prewitt.

I. INTRODUCTION

ONE of the fundamental problem in the area of image processing is the location of boundaries of objects within an image. A considerable number of edge detection schemes have been devised. The comparison is necessary in order to compare the various available techniques. It establishes performance limitations of each scheme under the various threshold values. The edge detection techniques studied in this paper are Sobel, Roberts, Prewitt and Canny edge detection. The figure 1 shows block diagram of different types of edge detection.

Figure 1: Block Diagram for Different Types of Edge Detection

II. TECHNIQUES USED FOR EDGE DETECTION

The different edge detection techniques studied are

1. Sobel Operator

2. Prewitt Operator
3. Robert's Cross Operator
4. Canny Operator.

A. Sobel Operator

It has a pair of 3×3 convolution kernels as shown in table 1. Other kernel is rotated by 90°.

Table 1: Masks used by Sobel Operator

-1	0	1
-2	0	2
-1	0	1

Gx

1	2	1
0	0	0
-1	-2	-1

Gy

The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (Gx and Gy). The gradient magnitude is given by:

$$|G| = \sqrt{G_x^2 + G_y^2} \quad (2.1.1)$$

An approximate magnitude is computed using:

$$|G| \approx |G_x| + |G_y| \quad (2.1.2)$$

The angle of orientation of the edge is given by:

$$\theta = \arctan(G_y/G_x) \quad (2.1.3)$$

B. Prewitt Operator

Prewitt operator is similar to the Sobel operator and is used for detecting vertical and horizontal edges in images. It uses the same equations as the Sobel operator. It has 3×3 convolution kernels as shown in table 2.

Table 2: Masks used by Prewitt Operator

-1	0	1
-1	0	1
-1	0	1

Gx

1	1	1
0	0	0
-1	-1	-1

Gy

It does not place any emphasis on pixels that are closer to the center of the masks.

C. Robert's Cross Operator

The Roberts Cross operator performs a 2-D spatial gradient measurement on an image. This operator has a pair of 2×2 convolution kernels as shown in table.3. Other kernel is rotated by 90° [3].

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Table 3: Masks used by Robert's Operator

+1	0	0	+1
0	-1	-1	0

Gx

Gy

The kernels are applied to the input image, to produce the gradient component Gx and Gy. The gradient magnitude is given by:

$$|G| = \sqrt{(Gx^2 + Gy^2)} \quad (2.3.1)$$

an approximate magnitude is computed using:

$$|G| = |Gx| + |Gy| \quad (2.3.2)$$

The angle of orientation of the edge is given by:

$$\theta = \arctan(Gy/Gx) - 3\pi/4 \quad (2.3.3)$$

D. Canny Operator

Steps involved in canny edge detection algorithm are as follows:

1. First it smoothes the image to eliminate the noise.
2. It then finds the image gradient to highlight regions with high spatial derivatives.
3. The present pixel value is compared with neighbouring pixel values. If pixel value is greater then it masks in the same direction else the value is suppressed (non-maximum suppression).
4. High threshold and low threshold values are fixed. If the pixel value is greater than the high threshold value then it is a strong edge. If the value falls in-between the double threshold values then it is a weak edge. Pixel is discarded if its value is less than low threshold value.
5. Edges are tracked by using hysteresis.

III. RESULTS

The above four technique were implemented in MATLAB and Simulink® and the results are shown in figure 3. Qualitative analysis and subjective analysis were made on the obtained results. Table 4 shows comparison canny edge detector in Matlab and Simulink. The threshold was varied between Threshold= [0.01- 0.09] to Threshold=[0.01- 0.4]. Table 5 shows the comparison of various threshold values of four edge detectors.

Figure 2: Simulink Results

Table 4: Comparison of Matlab and Simulink Results for Canny Edge Detector

Matlab	Simulink
Threshold=[0.01- 0.09]	Threshold=[0.01- 0.09]
Threshold=[0.01- 0.1]	Threshold=[0.01- 0.1]
Threshold=[0.01- 0.2]	Threshold=[0.01- 0.2]
Threshold=[0.01- 0.3]	Threshold=[0.01- 0.3]
Threshold=[0.01- 0.4]	Threshold=[0.01- 0.4]

Table 5: Comparison of Various Threshold Values of Four Edge Detectors

Sobel	Prewitt	Roberts	Canny
Threshold=0.1	Threshold=0.1	Threshold=0.1	Th=[0.01-0.09]
Threshold=0.5	Threshold=0.5	Threshold=0.5	Th=[0.01-0.3]
Threshold=2	Threshold=2	Threshold=2	Th=[0.01-0.3]
Threshold=4	Threshold=4	Threshold=4	Th=[0.01-0.4]
Threshold=12	Threshold=12	Threshold=12	Th=[0.01-0.5]

IV. CONCLUSION

Canny edge detection method is the efficient technique amongst all the available algorithms because of its noise suppression and clear edge detection.

V. FUTURE SCOPE

In the future, edge detection can be implemented in low cost hardware such as Beagle bone raspberry-pi and arduino. This can be extended to other industrial applications.

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