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Image Segmentation Using Various Edge Detection Operators: A Comparative Study

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ABSTRACT: Computer vision concerns the identification and classification of objects in an image, edge detection is an essential tool for digital image processing. Edge detection is one of the crucial operations in image analysis. In interpretation of images the division of the image into subsets like object and background is an important step for processing purpose. An edge discriminates the boundary between an object and the background, and indicates the boundary between overlapping objects. In this paper an attempt is made to study the performance of most commonly used edge detection techniques for image segmentation.

KEYWORDS: Image Segmentation, Edge detection, MATLAB.

I. INTRODUCTION

Edge detection is the very important part of the image segmentation. A set of connected pixels that form a boundary between two disjoint regions called an edge i.e. it describes the sharp changes in the intensity function. Edges can be represented in the form of discontinuities of the scene intensity function. The process of edge detection is done by the derivative approach. This derivative approach is based on the local derivative operator. Edge is the boundary between objects and background. So it separates the object from the background. To the detection of the image there may be the threshold value, if the given pixel is not according to the threshold value then that given pixel is discarded. To plot a derivative image we have to take a magnitude of the given edge. The first derivative at any point in an image is obtained by using the magnitude of the gradient at that point. For detection of the edge we use the different masks. And this mask convolves over the given image and after applying this process we get the required result. In every edge detection techniques this mask are different. So process of edge detection is same for most of the edge detection operators, only masks are differ from each other.

The Edge detection technique is very useful in the area of the machine vision, computer vision, pattern recognition, image analysis and image processing field. It is also useful in the biomedical field. There are various edge detection techniques. In our paper we studied commonly used edge detection techniques, that are Gradient Edge detection, Roberts Edge detection, Sobel Edge detection, Prewitt Edge detection, Log edge detection, Robinson Edge detection, Kirsch Edge detection, Canny edge detection techniques etc.

II. EDGE DETECTION TECHNIQUE

Since isolated points and lines of unitary pixelthickness are infrequent in most practical application. Edge detection is the most common approach in graylevel discontinuity segmentation. An edge can be defined as a set of connected pixels that form a boundary between two disjoint regions. An edge is a boundary between two regions having distinct intensity level. It is very useful in detecting of discontinuity in an image. The changes of intensity in an image can be estimated using first-order derivative and second-orderderivative.

2.1 First order derivatives:

First order derivatives responds whenever there is discontinuity in intensity level and value remain positive at leading edge and negative at the trailing edge. Let output function of two variables, f(x,y). In the two variable case x and y are the variables.

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$$\frac{\partial f}{\partial y}=\lim_{h\to 0}\frac{f(x+h,y)-f(x,y)}{h}$$

Here $\frac{\partial f}{\partial x}$ is the rate of change of f with respect to x keeping y fixed.

Similarly

$$\frac{\partial f}{\partial y}=\lim_{k\to 0}\frac{f(x,y+k)-f(x,y)}{k}$$

Here $\frac{\partial f}{\partial y}$ is the rate of change of f with respect to y keeping x fixed.

Hence the final gradient is

$$\nabla F = \hat{\imath}\frac{\partial f}{\partial x} + \hat{\jmath}\frac{\partial f}{\partial y}$$

$$F=\begin{bmatrix}G_x\\G_y\end{bmatrix}=\begin{bmatrix}\frac{\partial f}{\partial x}\\\frac{\partial f}{\partial y}\end{bmatrix}$$

2.1.1 Robets Edge Detection:-

For the edge detection, in 1945 Robert L.G. published a paper in which he stated that better result can be obtained if cross differences is used instead of the straight difference. And the mask that is used by the Roberts are 2×2.

-1	0
0	+1

G_x

0	-1
+1	0

G_y

2.1.2 Prewitt Edge Detection:-

The mask finds the horizontal edges is equivalent to gradient in the vertical direction and the mask compute the vertical edges is equivalent to gradient in the horizontal direction. Using these two masks passing to the intensity image, we can find out and component at different location in an image. So,we can find out the strength and direction of edge at that particular location (x, y).

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

Gx

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

Gy

2.1.3 Sobel Edge Detection:-

In 1973, Duda R.O. and Hart P.E. published a paper "Classification and Scene Analysis" in which they used a new operator known as the Sobel Operator. In Sobel Operator higher weights are assigned to the pixels that are close to the candidate pixels.

$$\nabla F \approx |(Z_7 + 2Z_8 + Z_9) - (Z_1 + 2Z_2 + Z_3)| + |(Z_3 + 2Z_6 + Z_9) - (Z_1 + 2Z_4 + Z_7)|$$

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

Gx

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

Gy

2.2 LoG Edge Detection:-

LoG edge detection is the abbreviation of the Laplacian of Gaussian. In 1986, it is used by the Marr. The Laplacian of Gaussian is also called the Marr-Hildreth Operator. Second derivative of an LoG image f(x,y) is defined as:-

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

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There are two processes in the LoG edge detection, first it smooth the image and second it perform the Laplacian which contains a double edge image and look for zero crossing. So LoG edge detection combines filtering with the Laplacian for edge detection. And points of edge in the image are obtained by the zero crossing of the 2nd derivative of image intensity. Since 2nd derivative is high sensitive to the noise. So Gaussian filter can be used to reduce the noise in the LoG edge detection.

2.3 Kirsch Edge Detection:-

Kirsch edge detector is named on the computer scientist Russell A. Kirsch. Kirsch operator has single kernel mask and it rotates in 45 degree increments through eight directions. These directions are N, NW, W, SW, S, SE, E and NE. It is the non-linear edge detector. It finds the maximum edge strength in a few fore determined directions.

$$E = \overset{k_0}{\begin{bmatrix} -3 & -3 & 5 \\ -3 & 0 & 5 \\ -3 & -3 & 5 \end{bmatrix}} \quad NE = \overset{k_1}{\begin{bmatrix} -3 & 5 & 5 \\ -3 & 0 & 5 \\ -3 & -3 & -3 \end{bmatrix}} \quad N = \overset{k_2}{\begin{bmatrix} 5 & 5 & 5 \\ -3 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix}} \quad NW = \overset{k_3}{\begin{bmatrix} 5 & 5 & -3 \\ 5 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix}}$$

$$W = \overset{k_4}{\begin{bmatrix} 5 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & -3 & -3 \end{bmatrix}} \quad SW = \overset{k_5}{\begin{bmatrix} -3 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & 5 & -3 \end{bmatrix}} \quad S = \overset{k_6}{\begin{bmatrix} -3 & -3 & -3 \\ -3 & 0 & -3 \\ 5 & 5 & 5 \end{bmatrix}} \quad SE = \overset{k_7}{\begin{bmatrix} -3 & -3 & 5 \\ -3 & 0 & 5 \\ -3 & 5 & 5 \end{bmatrix}}$$

Magnitude of the edge can be defined as the maximum value obtained by convolution of each mask over the image. Mask defines the direction that produces the maximum magnitude. Example, mask k0 corresponds to a vertical edge, while mask k5 corresponds to a diagonal edge. Notice that the last four masks are actually the same as the first four, but flipped about a central axis**.**

2.4 Canny Edge Detection:-

In 1986, Canny Edge operator is developed by the John F. Canny. This is very good edge detection technique. It detects a broader range of edges in images by using a multi-stage algorithm. Canny edge detection algorithm is based on the following steps:-

- Smoothing the image $\hat{f}(r,c)$

$$\hat{f}(r,c) = f(r,c) * G(r,c,6)$$

- Compute the Gradient of image for magnitude and direction
- Non-maximum suppression as per gradient magnitude
- Thresholding for non-maximal suppression of image unlike Roberts and Sobel.

2.5 Robinson Edge Detection

The Robinson Edge Detection method (Robinson 1977) is similar to Kirsch masks but is easier to implement because they rely only on coefficients of 0, 1 and 2. The masks are symmetrical about their directional axis, the axis with the zeros. One needonly to compute the result on four masks and the result from other four can be obtained by negating the result from thefirst four. The masks are as follows:

r_0

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

r_1

0	1	2
-1	0	1
2	1	0

r_2

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

r_3

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

r_4

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

r_5

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

r_6

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

r_7

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

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III. RESULTS AND SIMULATION

In this section we simulate different type of images for relative performance of the various edge detection techniques like Roberts Operator, Prewitt Operator,Sobel Operator, Kirsch Operator, Robinson Operator, Marr- Hildreth operator, LoG operator and Canny Edge Operator. We have compared different type of edge operators on building and baboon images as shown in Fig.1 and Fig.2. In the said comparison we found that Kirsch and Robinson edge operators work fairly good in comparison to other operators. From Fig.1 it is clear that Canny and LoG operator have noise in comparison to Kirsch and Robinson image. And from Fig.2 we can detect the baboon face edges using Kirsch and Robinson and other operators are very susceptible to noise. Hence we can reduce that Kirsch and Robinson operator works fairly well in comparison to other edge operators.

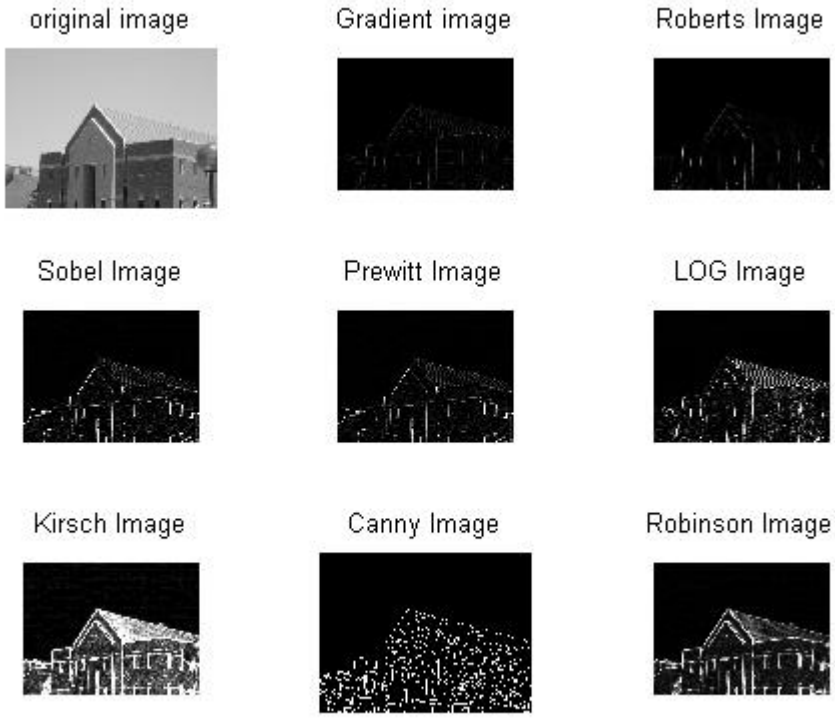

Fig.1 Edge Detection operations performed on Building Image

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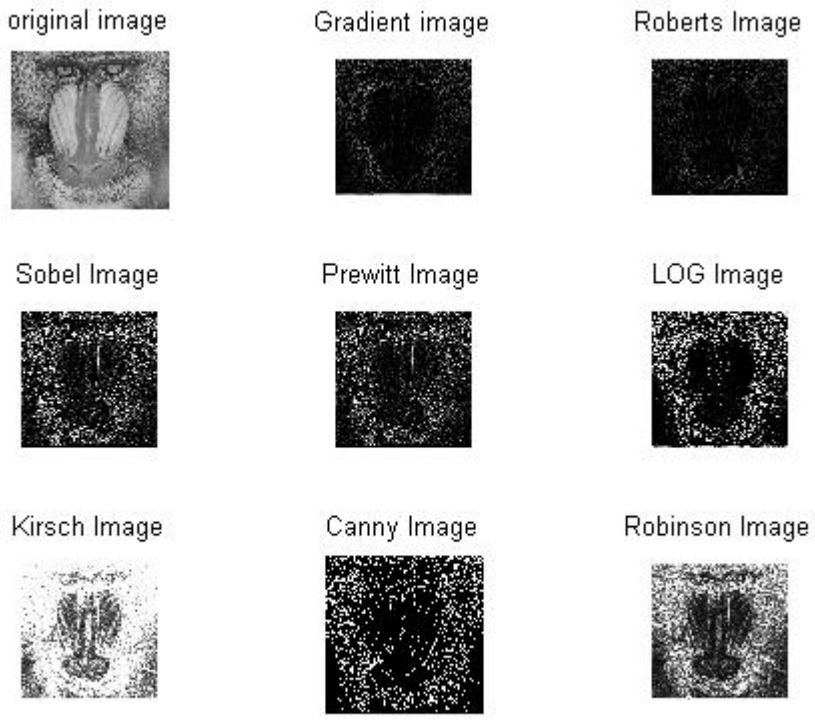

Fig.2 Edge Detection operations performed on Baboon Image

IV. CONCLUSION

The field of image processing is a rapidly growing field for ICT. Its development has been keyed up by technological advances in processing of digital imaging, computer processors and multimedia storage devices. In this paper we make an attempt to compare the existing edge detection techniques which are based on discontinuity intensity levels by using MATLAB software. It is observed from the results for edge detection provides a fairly comparable result in case of Kirsch and Robinson edge
Operator, and gives good results in comparison to other operator for edge detection.

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