Performance Analysis for Image Segmentation of Various EDGE detection techniques

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ABSTRACT:

In modern day, many applications need large number of images for solving problems. Digital image processing can used an image as an input, analyze it and gives an output as in meaningful way. Image segmentation is an important method through which we can analyze the image. An image is contains one or more objects with background through these objects we can identify and divide them. In image segmentation we do not only concentrate and identify the objects of the image but also concentrate on interested part of the image. This research paper has been done for to analyze various edge detection image segmentation techniques. In this paper, mainly eight numbers of edge detection techniques are simulated in MATLAB and compared its results with evaluation parameters like FRR (false rejection rate), FAR (false acceptance rate), RR (Recognition rate), Receiver Operating Characteristics Area (ROCA) and Simulation time for performance analysis of an image.

Keywords: **Image Segmentation, Edge detection, MATLAB.**

I. INTRODUCTION

Image segmentation is an essential step in image analysis. Segmentation separates an image into its objects and background. The level to which the separation is carried depends on the problem being solved. When the objects of interest in an application have been inaccessible the segmentation must stop. Segmentation algorithms for images generally based on the discontinuity and similarity of image intensity values. Discontinuity approach is to partition an image based on abrupt changes in intensity and similarity is based on partitioning an image into regions that are similar according to a set of predefined criteria. Thus the choice of image segmentation technique is depends on the problem being considered. Edge detection is a part of image segmentation. The effectiveness of many image processing also computer vision tasks depends on the perfection of detecting meaningful edges. It is one of the techniques for detecting intensity discontinuities in a digital image.

II. EDGE DETECTION TECHNIQUES

Edge detection is one of most commonly used approach for detection of discontinuities of an image. Edge is nothing but a boundary between two regions having distinct intensity level or having distinct gray levels.

A. Robert Edge Detection

2-D spatial gradient measurement of an image is the Robert edge detection; it is very simple computation technique which is introduced by Lawrence Roberts (1965) [3]. Here high spatial frequency region is corresponds to edges. Take an input image as a gray level image which is same to the output for the most common usage for this technique. 2-D mask for Robert edge detection is shown as below mention Fig.1.

$$\begin{array}{|c|c|}\hline -1 & 0 \\ \hline 0 & 1 \\ \hline \end{array} \quad \begin{array}{|c|c|}\hline 0 & -1 \\ \hline 1 & 0 \\ \hline \end{array}$$

Roberts

Fig.1. Robert Edge detection

Here the output represents pixels of every point which estimated complete magnitude of spatial gradient of the image at that point.

B. ***Sobel Edge Detection***

The sobel edge detection mask which is also the first derivative mask called as sobel operator [3]. Here two different masks as shown in Fig.2. In which one mask is responsible computation for the horizontal edges & other mask

−1	−2	−1
0	0	0
1	2	1

−1	0	1
−2	0	2
−1	0	1

Sobel

Horizontal Vertical

Fig.2. Sobel Edge detection

is responsible for vertical edges and compute the sobel edge operator. The sobel edge operator gives an averaging effect over the image.

C. ***Prewitt Edge Detection***

First derivative operators can be implemented & here we shown some mask as below mention Fig.3 in which we use to compute image gradient [3].

−1	−1	−1
0	0	0
1	1	1

−1	0	1
−1	0	1
−1	0	1

Prewitt

Fig.3. Prewitt Edge detection

Mask are called prewitt edge operator, first mask we have identify as a horizontal edges and the other mask identify as a vertical edge operator. So the mask finds out the horizontal edges equivalent to having the gradient in vertical direction and the mask which is compute the vertical edges is equivalent to taking the gradient in to horizontal direction. So using these two masks by passing these two masks over the intensity image we can find the Gx & Gy component at different location in the image & once we compute Gx & Gy then we can find out what is the strength of image at that particular location as well as what is the direction of an image at that particular location.

D. ***Laplacian Of Gaussian Edge Detection***

The Laplacian of Gaussian Operator is second derivative operator for edge detection operation but it is very sensitive to noise and its gives double edges these are the reasons for second derivative normally not preferred for edge detection operation [3]. It use the extract the secondary information and it looking the polarity of second derivative output we can determine whether a point lies on the darker side of edge or point lies the brighter side of edge and the other information that we can obtain from the second derivative operator is from the zero crossing between the positive side and negative side and zero crossing points accurately determine the location of an edge whenever an edge is the smooth edge.

The second derivative operator called the laplacian operator, it is use for enhancement of image details. The laplacian operator of function f is given by

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

$$\nabla^2 f = [f(x+1,y) + f(x-1,y) + f(x,y+1) + f(x,y-1) - 4f(x,y)]$$

Now reduce the noise the effect in second derivative operation, image will first smooth using the Gaussian operator and these two operators can be used together to have operator something likes which is called a laplacian of Gaussian or LOG operator and Gaussian can represent by

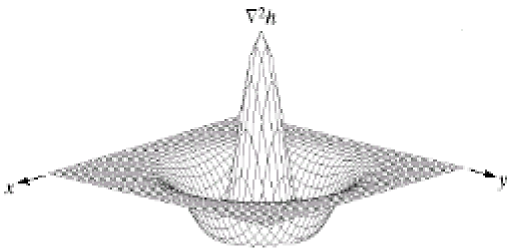
$$h(r) = -e^{-\frac{r^2}{2\sigma^2}}$$

Where $r^2 = x^2+y^2$, and σ is the standard deviation Now laplacian of edge can be resent as in the as follow.

$$\nabla^2 h(r) = -\left[\frac{r^2-\sigma^2}{\sigma^4}\right] e^{-\frac{r^2}{2\sigma^2}}$$

First operation smooth the image using the Gaussian operator and this image using by the laplacian operator, these two operations are done after another then these reduces the effect of the noise present in the image, however these operations to combined to have laplacian & Gaussian operation that means we operate the image with the laplacian of Gaussian operationthat gives equivalent results.

Now in below mention Fig.4 laplacian of Gaussian, this LOG can again be represent in form of a mask which called a LOG mask and if present of two dimension of mask



0	−1	0
−1	4	−1
0	−1	0

−1	−1	−1
−1	8	−1
−1	−1	−1

Fig.4. LOG operator

present of two dimension of mask will appears as above mention Fig.4 it will shown by two numbers of 3x3 mask. If we compare these LOG masks with LOG operator we find that if X = 0 LOG is positive then it comes to maximum negative then try to moves towards a value zero and the same is obtain using above masks that at the centre the maximum positive value which are 4 and 8 then it is goes towards zero that is becomes -1.

E. Krisch Edge Detection

Krisch edge detection is introduced by Krisch (1971) [6]. The Mask for this technique is defined by considering a single mask which is rotating it to eight main compass directions like North, Northwest, West, Southwest, South, Southeast, East and Northeast. The masks are distinct as follows shown in Fig.5.

$$E=\begin{bmatrix}-3&-3&5\\-3&0&5\\-3&-3&5\end{bmatrix} NE=\begin{bmatrix}-3&5&5\\-3&0&5\\-3&-3&-3\end{bmatrix} N=\begin{bmatrix}5&5&5\\-3&0&-3\\-3&-3&-3\end{bmatrix} NW=\begin{bmatrix}5&5&-3\\5&0&-3\\-3&-3&-3\end{bmatrix}$$

$$W=\begin{bmatrix}5&-3&-3\\5&0&-3\\5&-3&-3\end{bmatrix} SW=\begin{bmatrix}-3&-3&-3\\5&0&-3\\5&5&-3\end{bmatrix} S=\begin{bmatrix}-3&-3&-3\\-3&0&-3\\5&5&5\end{bmatrix} SE=\begin{bmatrix}-3&-3&5\\-3&0&5\\-3&5&5\end{bmatrix}$$

Fig.5. Krisch Edge detection

The Magnitude of the gradient value is the maximum value gained and from applying all eight masks to the pixel neighbourhood, the angle of the gradient can be approximated as the angle of line of zeroes in the mask

F Robinson Edge detection

The Robinson edge detection method is introduced by Robinson (1977) [3]. This method is similar to Krisch edge detection but it is easier to implement because of the relay on coefficient of 0, 1, 2. The Masks are symmetrical on their directional axis, the axis with the zeros. One need only to compute the result on four masks and the result from the other four can be obtained by negating the result from the first four. The masks are as follows in Fig.6.

$$E=\begin{bmatrix}-1&0&1\\-2&0&2\\-1&0&1\end{bmatrix} NE=\begin{bmatrix}0&1&2\\-1&0&1\\-2&-1&0\end{bmatrix} N=\begin{bmatrix}1&2&1\\0&0&0\\-1&-2&-1\end{bmatrix} NW=\begin{bmatrix}2&1&0\\1&0&-1\\0&-1&-2\end{bmatrix}$$

$$W=\begin{bmatrix}1&0&-1\\2&0&-2\\1&0&-1\end{bmatrix} SW=\begin{bmatrix}0&-1&-2\\1&0&-1\\2&1&0\end{bmatrix} S=\begin{bmatrix}-1&-2&-1\\0&0&0\\1&2&1\end{bmatrix} SE=\begin{bmatrix}-2&-1&0\\-1&0&1\\0&1&2\end{bmatrix}$$

Fig.6. Robinson Edge detection

The Magnitude of the gradient is the maximum value gained from applying all eight masks to the pixel neighbourhood, and the angle of the angle of the gradient can be approximated as the angle of line of zeroes in the mask yielding the maximum response.

G. Marr-Hildreth Edge detection

The Marr-Hildreth (1980) technique is a method of detecting edges in digital image[7] that continuous curves are well-built and fast variations in the image brightness. It is easy to implement and by convolving the image with the LoG function it can operate, or as a quick approximation by DoGs. Subsequently the zero crossing is discovered to find the edges in the filtered result. Algorithm for Marr-Hildreth is:

- Smooth the image by using a Gaussian.
- Apply a 2-D laplacian operation to the smoothed image.
- Loop through the result and look for sign changes. If there is a sign change plus the slope across the sign change is greater than some threshold.
- To get better results alike to Canny's edge detection, it is possible to run the results of the Laplacian through a hysteresis.

H. Canny Edge Detection

The Canny Edge detection is introduced by John Canny (1983) [5]. Canny edge detection technique is one of the standard edge detection techniques. It is used many of the newer algorithms that have been developed. Through this technique use for find edges by separating noise from the image before find the edge of image. Canny edge detection is a better method without disturbing the features of edges in the image afterward it applying the tendency to find the edges and serious value for threshold. The algorithmic steps as follows:

Convolution apply to image f(r,c) with a Gaussian fuction to get smooth image f^(r,c). f^(r,c)= f(r,c)*G(r,c,6) .

- Apply first difference gradient operator to compute edge strength then magnitude and direction are obtain as before.
- Apply non-maximal or critical suppression to the gradient magnitude.
- Apply threshold to the non-maximal suppression image.

III. Edge Detection Evaluations

There are numbers of ways of evaluation for edge detection techniques. While some of them follow the visual method of edge detection, where edge map is shown to people and various people rate the edge map on the basis of number of edges being detected. They have also used the Receiver operating characteristics (ROC) curves for evaluating the performance of edge detection techniques [1].
Kevin Bowyer has used the edge map and the ground truth of the image where the statistical measure gives the true positive, true negative, undetected and false alarm [1].
First image has determining the correct edges in the given database. Performance evaluation of edge detectors have always been a biggest point of concern.
Some of the key measurement in evaluation the efficiency of edge detectors includes:

- The False Acceptance Rate (FAR) and
- The False Rejection Rate (FRR)

The FAR is also known as a False Match Rate which describes number of times the edges are inaccurately positively matched.

$$\text{False Acceptance Rate (FAR)} = \frac{\text{Incidences of False Acceptance}}{\text{Total Number of Sample}} \times 100$$

The FRR is also known as a False Non-match Rate which describes the number of times an edge should be identified positively is instead rejected.

$$\text{False Rejection Rate (FRR)} = \frac{\text{Incidences of False Rejections}}{\text{Total Number of Sample}} \times 100$$

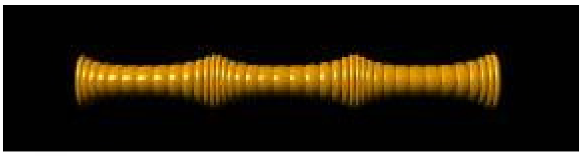
The combination of the FAR and FRR can help to determine which edge detection is more useful for a particular type of an image. The performance of edge detection system may also be summarized using the measures based on Receiver Operating Characteristics (ROC) which known as Receiver Operating Characteristics Area (ROCA). The lower ROCA value gives better results of the output image. ROCA can be calculated by mapping FAR and FRR of particular edge detection of an image, here better Recognition rate becomes higher with lowest value of ROCA which is to be considering as a best result.

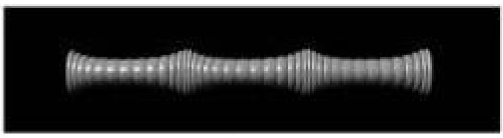
$$\text{Rcognition Rate (RR)} = \frac{\text{Incidences of True Identificaton}}{\text{Total Number of Sample}} \times 100$$

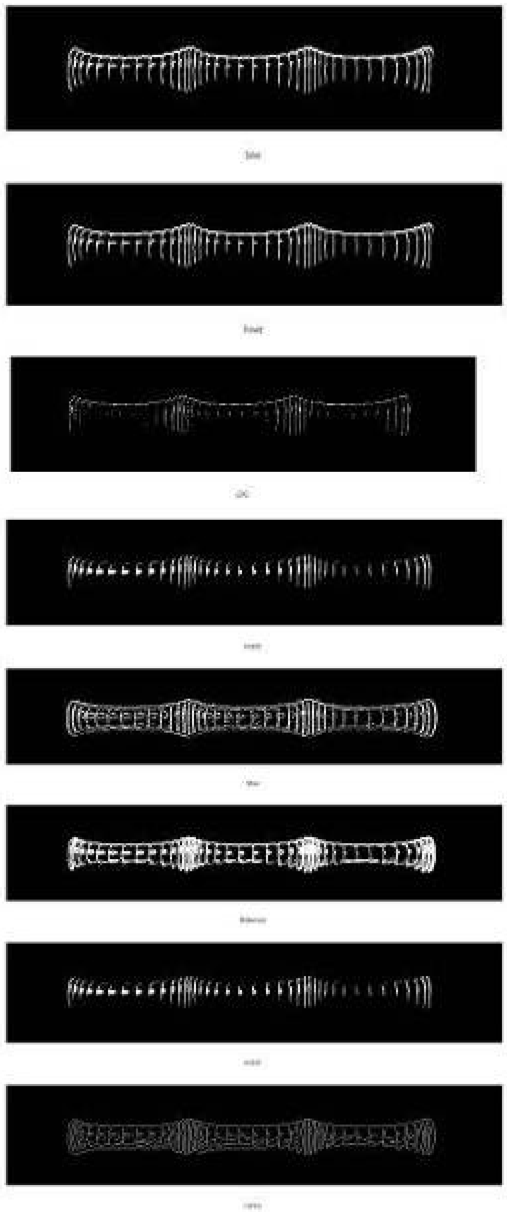
Simulation time can help to determine result with timing parameter during simulation of particular edge detection technique for the purpose of in minimum time get better result.

IV. EXPERIMENT RESULTS

The edge detection techniques are implemented using MATLAB 7.9 (R2009b) tested with arrow image, Mid image and fruit image and got the output as below mention figures.
Here we have taken an arrow image as a original image first convert it in grey level then this grey image applied to various edge detection techniques and the Result as follows:-







Parameter	FAR	FRR	RR	ROCA	Time
Robert	2.0933	1.313	51.8273	2.095	00:01.1
Sobel	2.8696	0.9131	56.5419	1.6973	00:01.1
Prewitt	2.3975	0.9399	55.2638	1.7028	00:01.1
LOG	0.604	1.6016	23.7741	1.9459	00:01.1
Krisch	1.6787	1.3579	35.3707	2.0018	00:11.9
Robinson	6.8296	0.2583	87.7063	1.6855	00:09.7
Mar-hilberth	5.8301	1.8208	13.3395	2.002	00:01.1
Canny	0.3447	0.2349	91.383	0.16355	00:08.9

V. CONCLUSION

This Paper present the various Edge detection techniques which are Robert, Sobel, Prewitt, LOG, Krisch, Robinson, Marr-Hildreth and Canny Edge detection techniques. All these techniques are applied in MATLAB for a mid image, in which Canny edge detection is gives the best results than rest of the edge detection techniques. so we have taken canny edge detection result as a ground truth image because of its output result is much better that rest of the edge detection techniques results then this ground truth image is compare with the rest of the edge detection techniques results and verify with the parameters like FAR, FRR, RR, ROCA and Time.

we have conclude that from Table 1, got better value of RR and lower value of ROCA in Canny Edge detection technique and Robinson edge detection technique [2] as well as got better ROCA value for Sobel edge detection but RR is much lower as compare to Robinson edge detection technique . In Robinson Edge detection and Marr-hildreth edge detection techniques FAR is higher as compare to other techniques but FRR is much higher in marr-hildreth technique as compare with Robinson edge detection technique so that Marr-hildreth result is not give much better result like Robinson. In these all edge detection techniques kirsch edge detection computation time is much higher and the next one is Robinson and canny edge detection techniques.

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