Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 2, Issue. 7, July 2013, pg.86 – 92

RESEARCH ARTICLE

A Review and Research of Edge Detection Techniques for Image Segmentation

Poonam Dhankhar[1], Neha Sahu[2]
[1]Student, ITM University, Gurgaon-Haryana, India
[2]Faculty of CSE, ITM University, Gurgaon-Haryana, India

Abstract*— Interpretation of image contents is one of the main objectives in computer vision. The purpose of Image segmentation is to partition an image into meaningful regions with respect to a particular application. Image segmentation is a method of separating the image from the background and read the contents. Edge is a basic and important feature of an image. Image is a combination of edges. Detecting edges is one of the most important aspects in image segmentation. Edge detection is a vital step as it is a process of identifying and locating sharp discontinuities in an image. In this paper through study has been done on most commonly used edge detection techniques such as Sobel, Prewitt, Roberts, Canny, Laplacian Guassian(LoG).

Key Terms: - Image Segmentation; MATLAB; Edge; Edge Detection; Canny

I. Introduction

Segmentation is a process of distinguishing objects from the background. Hence, Image segmentation is distinguishing or partitioning the image from its background. The four main approaches used for image segmentation are: threshold techniques, edge detection techniques, region-based techniques, and connectivity-preserving relaxation methods. Most widely and important amongst these four techniques is “edge detection”. The level of the subdivision has to stop when the object or image of interest have been partitioned. Picking up an appropriate technique for “good” segmentation is a challenging task. Edge being such an essential part in an image, its study becomes important. Some important features can be extracted from an edge of any image (e.g.: corners, lines, curves).

Edge detection is a technique in which the points where image brightness changes sharply or formally are identified. These points are organized under line segments called edges. Edge detection also aims to classify and place discontinuities in an image [1]. Noise and image both have high frequency, hence edge detection becomes difficult. The main objective of studying various edge detection techniques and analyzing their performance is due to problems such as fake edge detection, noisy images, missing edges etc.

II. Edge Detection Techniques

Edge: The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges. The edges extracted from a two-dimensional image of a three-dimensional scene can be classified as either viewpoint dependent or viewpoint independent. A viewpoint independent edge typically reflects inherent properties of the three-dimensional objects, such as surface markings and surface shape. A viewpoint dependent edge may change as the viewpoint changes, and typically reflects the geometry of the scene, such as objects occluding one another. A typical edge might for instance be the border between a block of red color and a block of yellow. In contrast a line can be a small number of pixels of a different color on an otherwise unchanging background. For a line, there may therefore usually be one edge on each side of the line.

2.1 Edge Components:

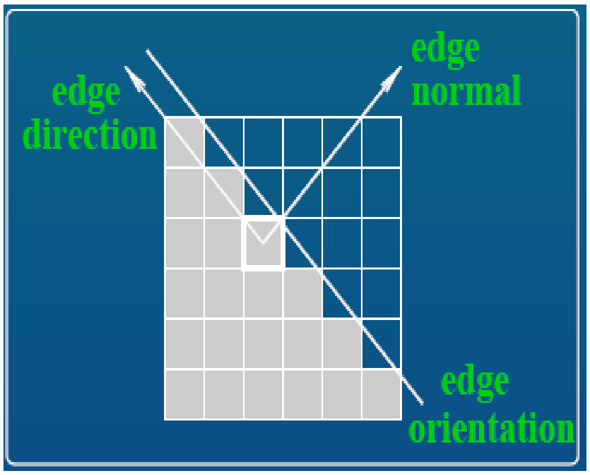
A. Edge normal: unit vector in direction of maximum intensity change.

$$e_{o(i,j)} = atan\frac{J_x}{J_y}$$ [3].

(Where: i & j are the image co-ordinates.)

B. Edge direction: unit vector perpendicular to the edge normal.
C. Edge position or center: position of image where edge is located.
D. Edge strength: local image contrast along the normal.

$$e_{s\,(i,j)} = \sqrt{J_x^2(i,j) + J_y^2(i,j)}$$ [3].



Edge detection is a fundamental tool for image segmentation. It partitions a digital image into multiple regions or pixels. There are various techniques for edge detection based on error minimization, fuzzy logic, genetic algorithms, neural networks etc. [2].

Edge: it is a sign of lack of continuity in an image. Any point where discontinuity occurs in an image is a edge. They occur due to significant change in the intensity.

2.2 Steps in Edge detection:

A. Filtration: Every image is associated with some intensity values, random change in these values can result in noise. Some common noise is: salt and pepper noise, impulse noise etc. Noise can result in difficulties in effective edge detection; hence image has to be filtered in order to reduce the noise content that leads to loss of edge strength [2]. It is also termed as Smoothening.
B. Enhancement: Improving the quality of image is termed as enhancement. It aims to produce an image which is better and more suitable than original. A filter is applied in order to enhance the quality of edge in image.
C. Detection: Several methods are adopted to determine which points are edge points and which a edge pixels should be discarded as noise.

These steps should be followed carefully in order to detect the edges effectively, as the next steps are solely dependent on edges detected.

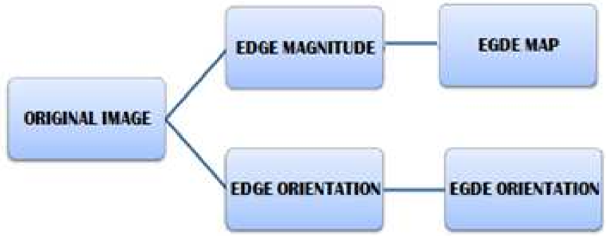
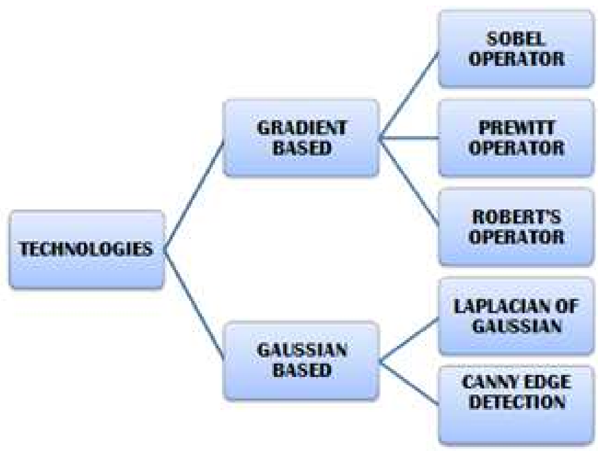


Figure:1

2.3 Various techniques:



A. Gradient Based Techniques:

1. Sobel Operator: It is 3x3 convolution kernels. One kernel is simply the other rotated by 90^0. It is a row-edge detector.

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

Gx

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

Gy

G_X and G_Y are the common masks used in Sobel Operator.

This figure shows the masks used by Sobel operator.

The kernel can be applied separately to input image for obtaining gradient component in each orientation i.e. G_X and G_Y.

The magnitude is given by:

$|G|=\sqrt{G_X^2 + G_Y^2}$

And its approximation is done by:

$|G|=|G_X| + |G_Y|$.

The orientation of angle is given by:

$\Theta = \arctan(G_X/G_Y)$. [4]

2. Prewitt Operator: It is similar [4] to the Sobel Operator and is used to detect vertical and horizontal edges in an image.
3. Robert's cross Operator: This is somewhat similar to Sobel and Prewitt Operator. It is a 2-D spatial gradient measurement of an image. The pixel value represents the absolute magnitude of spatial gradient of input at that point. Operator has 2x2 convolution kernel. Kernel responds to maximize edges running at 45^0 to each pixel grid. For each of the perpendicular orientations there is one corresponding kernel.

The magnitude is given by the same formula as of the Sobel but the orientation of the angle is given by:

$$O = \arctan(G_X/G_Y) - 3\pi / 4.$$

B. Gaussian Based Techniques:

1. Laplacian of Gaussian(LoG)

It was proposed by Marr(1982). The LoG of an image f(x,y) is a second derivative defined as

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$ [1].

It first smoothes the image and then computes the Laplacian. This yields in double edge image; hence for finding the edge the zero crossing between the double edges is taken.

The Laplacian of an image with the pixel intensity value L(x,y) is given by:

$$L(x,y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$

The commonly used discrete approximations to Laplacian filter are:

1	1	1
1	-8	1
1	1	1

L_X

-1	2	-1
2	-4	2
-1	2	-1

L_Y

The Gaussian filtering is combined with Laplacian to break down the image where the intensity varies to detect the edges effectively [2].

2. Canny Edge Detection

Canny edge detector is one of the most commonly used image processing tools. It detects edges in a very robust manner.

Unlike Roberts Cross and Sobel, the canny operation is not very susceptible to noise. It takes less time than Roberts cross. It is one of the most important methods to find the edges by separating noise from input image. The algorithm is adaptable to various environments.

It is a better method because it extracts the features in an image without disturbing its features. There are certain criteria to improve current methods of edge detection. The first and most obvious is low error rate. It is important that edges occurring in images should not be missed. The second criterion is that the edge points be well localized i.e. the distance between the edge pixels as found by the detector and the actual edge should be minimum. A third criterion is to have only one response to a single edge [4].

2.1 Importance of Canny

Despite of number of edge detection techniques available canny algorithm is considered because it contains a number of adjustable parameters which can affect the computation time and effectiveness of the algorithm.

a) The size of the Gaussian filter: The smoothing filter used in the first stage directly affects the results of the detection of small, sharp lines. A larger filter causes more blurring, smearing out the value of an given pixel over a larger area of image.
b) The use of two thresholds with hysteresis allows more flexibility than in a single-threshold. A threshold set too high can miss important information. On the other hand, a threshold set too low will falsely identify irrelevant information (such as noise) as important.

The edge detection in this technique is optimized with regard to the following criteria [6].

a) Maximizing the signal-to-noise ratio of the gradient.
b) Edge localization for ensuring the accuracy of edge.
c) Minimizing multiple responses to a single edge.

2.2 The steps are as follows:

a) Smoothing: Blurring of given image to remove noise. It is done by convolving the image with Gaussian filter. A suitable mask is calculated and Gaussian smoothing can be performed using standard convolution methods.

Convolve image f(r,c) with a Gaussian function
F^ (r,c)=f(r,c)*G(r,c)
Where G(r,c) is the Gaussian function [1].

b) Finding Gradients: After smoothing the image next step is to find the strength of edge by taking the gradient of the image. Sobel operator is used to perform 2-D spatial gradient measure on an image. The edges should be marked where the gradients of the image has large magnitudes, finding the gradient of the image by feeding the smoothed image through a convolution operation with the derivative of the Gaussian in both the vertical and horizontal direction.

c) Non-maximum suppression: Only local maxima should be marked as edges. Finds the local maxima in the direction of the gradient, and suppresses all others, minimizing false edges.

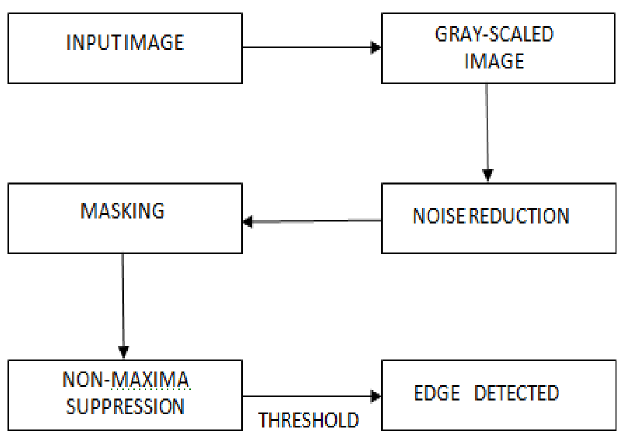
A. The "non-maximal suppression" step keeps only those pixels on an edge with the highest gradient magnitude. These maximal magnitudes should occur right at the edge boundary, and the gradient magnitude should fall off with distance from the edge.

d) Double Thresholding: Potential edges are determined by thresholding, Instead of using a single static threshold value for the entire image, the Canny algorithm introduced hysteresis thresholding, which has some adaptively to the local content of the image. There are two threshold levels, th , high and tl, low where th > tl. Pixel values above the th value are immediately classified as edges [6].

e) Edge tracking by hysteresis: Final edges are determined by suppressing all edges that are not connected to a very strong edge.

A simple threshold may actually remove valid parts of a connected edge, leaving a disconnected final edge image. This happens in regions where the edge's gradient magnitude fluctuates between just above and just below the threshold. Eliminating pixels whose gradient magnitude D falls below some threshold removes problem, but it introduces a new problem. Hysteresis is one way of solving this problem. Instead of choosing a single threshold, two thresholds t_{high} and t_{low} are used. Pixels with a gradient magnitude $D<t_{low}$ are discarded immediately. However, pixels with $t_{low} \leq D < t_{high}$ are only kept if they form a continuous edge line with pixels with high gradient magnitude (i.e.,above t_{high}).

Hysteresis uses 2 thresholds, a high and a low. Any pixel in the image that has a value greater than T1 is presumed to be an edge pixel, and is marked as such immediately. Then, any pixels that are connected to this edge pixel and that have a value greater than T2 are also selected as edge pixels. If you think of following an edge, you need a gradient of T2 to start but you don't stop till you hit a gradient below T1 [4].

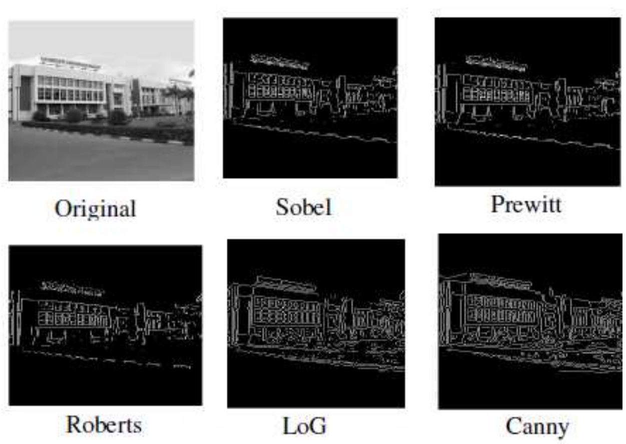


III. ADVANTAGES AND DISADVANTAGES [4]

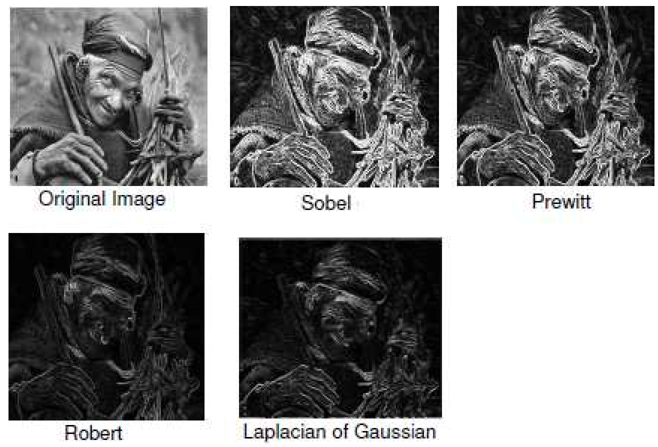
Technique	Advantage	Disadvantage
Gradient Based Techniques	1. Simple, easy and quick to compute.	1. These are more sensitive to noise.
	2. Edges are detected along with their orientation.	Detection of edges is inaccurate at times. Thus less reliable.
Gaussian Based Techniques		
A) LoG	1. The cross operation detection of edges and their orientation is simple due to approximation of gradient magnitude is simple.	1. The magnitude of edges degrades as noise increases due to detection of edges and their orientation.
	2. The characteristics are fixed in all directions.	2. Malfunctioning at the corners, curves and where the gray level intensity function varies.
	3. Testing wide area around the pixel is possible.	
b) Canny Edge Detection	1. Improved signal to noise ratio.	1. Complex and time consuming computations.
	2. Better detection in noise conditions.	2. False zero crossing.
		3. It is difficult to give a generic threshold that works well on all images.

IV. EXPERIMENTAL EXAMPLES

Various edge detection techniques were applied on the two samples of images based on the steps each one of them describes. The main point of attention was the results were best in case of CANNY EDGE DETECTION, though the LAPLASSIAN of GAUSSION shows the similar results but with less defined edges.



Roberts, Sobel and Prewitt results actually deviated from the others. LoG and Canny produce almost same edge map. It is observed from the figure, Canny result is superior by far to the other results.



Edge detection of all four types was performed and Canny yielded the best results. 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 thresholding.

V. CONCLUSION

The purpose of this paper is to present a review of various approaches for image segmentation based on edge detection techniques. The study of different Edge detection techniques and their experimental results shows that canny yield best results. In this paper an attempt is made to review the edge detection techniques which based on discontinuity intensity levels. The relative performance of various edge detection techniques is carried out with an image by using MATLAB software. It is observed from the results LoG and Canny edge detectors produce almost same edge map. Canny result is superior one when compared to all for a selected image since different edge detections work better under different conditions. Despite of so many edges detection techniques are available in the literature, since it is a challenging task to the research communities to detect the exact image without noise from the original image.

REFERENCES

[1] Muthukrishnan.R and M.Radha "Edge Detection Techniques for image Segmentation" International Journal of Computer Science & Information Technology (IJCSIT) Vol3, No 6, Dec 2011

[2] S.Lakshmi and Dr.V.Sankaranarayanan "A study of Edge Detection Techniques for Segmentation Computing Approaches" IJCA Special Issue on Imaging and Biomedical Applications" CASCT, 2010.

[3] Edge Detection by Trucco,Chapter 4 and Jain ct al.,Chapter 5.

[4] Raman Maini and Dr. Himanshu Aggarwal "Study and Comparison of various Image Edge Detection Techniques" International Journal of Image Processing(IJIP),Vol3:Issue(1).

[5] G.T Srivanshan and Dr. C. Chandrasekar "A Comparison of Various Edge Detection Techniques used in Image Processing" International Journal of Computer Science & I.T (IJCSIT),Vol9,No 1,Sep 2012.

[6] Jamil A. M. Saif, Ali Abdo Mohammed Al-kubati, Abdultawab Saif Hazaa and Mohammed Al Moraish "Image Segmentation using Edge Detection and Threshold" The 13th International Arab Conference on Information Technology (ACIT),2012 Dec 10-13 ISSN:1812-0857.

