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A Study of Edge-Detection Methods

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ABSTRACT: **Edge is a basic feature of an image. Edges can be defined as boundary between two different regions in an image. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. Edge detection process significantly reduces the amount of data and filters out useless information, while preserving the essential structural properties in an image. Since computer vision involves the recognition and classification of objects in an image, edge detections is a vital tool . In this paper , the main aim is to study edge detection process based on different techniques.**

Keywords: Edge-detection, Image segmentation, Canny operator, Gradient method, Zero crossing

I. INTRODUCTION

For computer vision and image processing systems to interpret an image , the separation of the image into object and background is a critical step. Segmentation partition the image into a set of disjoint regions that are visually different, uniform and meaningful with respect to some characteristics or computed properties, such as grey level, intensity, texture or colour to enable easy image analysis . A huge number of methods are available in the literature to segment images. This is a crucial work because the output of an image segmentation algorithm can be feed as input to higher-level processing tasks. Edge based method is most commonly used technique to perform image segmentation.

An edge may be regarded as boundary between two dissimilar regions in an image . The edges for an image are the significant characteristics that put forward an indication for a higher frequency. Edge detection is a terminology in image processing and computer vision , mainly in field of feature detection and feature extraction that plays an important role in segmentation of an image for identification of objects. The process of detecting edges for an image may facilitate in image segmentation, data compression, and also help for image reconstruction.

The purpose of edge detection is to mark the points in a digital image at which the luminous intensity changes sharply. In Image analysis process to interpret an image, one first must be able to detect the edges of each object in the image. Edge representation of an image significantly reduces the amount of data to be processed, yet it retains useful information about the shapes of objects in the scene. The effectiveness of many image processing and computer vision tasks depends on the perfection of detecting meaningful edges. Edge-detection has been a challenging task in low level image processing .Various approaches are available for edge detection , some are based on error minimization, maximizing an object function, neural network, fuzzy logic, wavelet approach, Bayesian approach, morphology, genetic algorithms.

This paper is organized as follow: Section I gives the Introduction of the edge-detection technique for image segmentation and its purpose .Section II provides basics of edge-detection method. Section III includes various steps of edge-detection method. Section IV describes different approaches to implement edge-detection and the last section V concludes the paper followed by the references.

II. EDGE-BASED SEGMENTATION

Edge-based segmentation techniques rely on discontinuities in image values between distinct regions, and the objective of the segmentation algorithm is to precisely distinguish the boundary separating these regions .Edge-based segmentation is the process of locating pixels in the image that match up to the boundaries of objects seen in an image .It is also assumed that since it is a boundary of a region then it is closed and that the number of interesting objects is equal

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to the number of boundaries in an image. There are an exceptionally large number of edge detection operators available, each of which are designed to be sensitive to certain edge types. Some variables that are involved in the selection of an edge detection operator include:

A. Edge orientation

The geometry of the operator determines a characteristic direction where it is most sensitive to edges. Operators can be optimized to seek horizontal, vertical, or diagonal edges

B. Noise environment:

Edge detection is complex in noisy images as both the noise and the edges contain high-frequency content. Operators used on noisy images are usually of larger range, so they can average adequate data to discount localized noisy pixels. This results in not as much of accurate localization of the detected edges.

C. Edge structure:

All edges may not involve a step change in intensity. Effects like refraction or poor focus can end result in objects with boundaries defined by a gradual change in intensity. The operator needs to be preferred to be responsive to such a gradual change in those cases. in order to distinguish newer wavelet-based techniques actually exemplify the nature of the transition for each edge.

III. EDGE-DETECTION STEPS

The basic steps involve in the edge-detection process are:

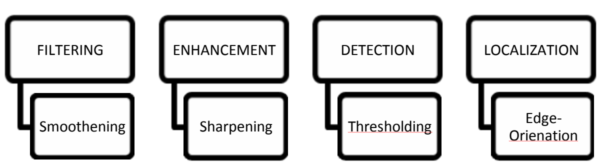


Fig. 1 Edge-detection steps

A. Filtering

Filter image to enhance performance of the edge detector concerning noise. It includes suppressing the noise as much as possible, without destroying the true edges.

B. Enhancement/Sharpening

Give emphasis to pixels having considerable change in local intensity.

C. Detection

Decisive about which edge pixels should be superfluous as noise and which should be retained.

D. Localization

Determine the accurate locations of an edge .Edge thinning and linking are generally a requisite for edge localization.

IV. EDGE-DETECTION METHODS

The edge detection algorithms can be generally classified based on the behavioural study of edges with respect to the operators. Different edge-detection approaches can be broadly classified under Classical or Gradient based edge detectors (first derivative), Zero crossing (second derivative) and Optimal edge-detector.

TABLE I
EDGE-DETECTION APPROACHES

METHODS	APPROACHES
First order derivative / Gradient methods	Roberts Operator Sobel Operator Prewitt Operator
Second order derivative / Zero crossing	Laplacian of Gaussian Difference of Gaussian
Optimal Edge Detection	Canny Edge Detector

A. *First Order Derivative Based Edge Detection (Gradient method):*

It detects the edges by seeking the maximum and minimum in the first derivative of the image. Sharpening an image provide results in the detection of fine details and also in enhancing the blurred ones. The magnitude of the gradient is the most influential technique that forms the basis for various approaches to sharpening. The gradient vector points in the direction of maximum rate of change. For a function f(a,b), the magnitude of the gradient of f at coordinates (a,b) is defined as

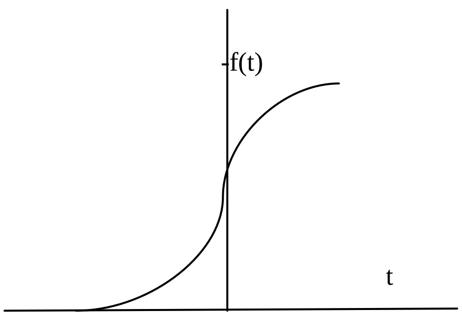
$$\nabla \boldsymbol{f}\,(a,b) = \left(\partial_x \boldsymbol{f}\,(\boldsymbol{a,b})\right)^2 + \left(\partial_y \boldsymbol{f}\,(a,b)\right)^2 \qquad (1)$$

while the gradient orientation is given by

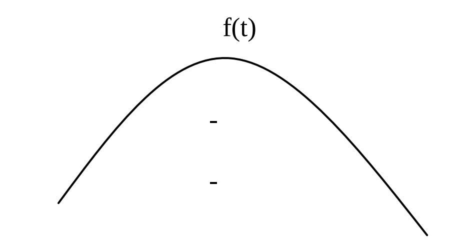
$$\angle\nabla f\,(\text{a,b}) = \boldsymbol{arctan}\big(\partial_y f\,(x,\text{a,b}) \quad \partial_x f\,(\text{a,b})\big)$$

B. *Second Order Derivative Based Edge Detection (Laplacian based Edge Detection)*

To find the edges, Laplacian method search for zero crossings in the second derivative of the image. An edge has the 1-D shape of a ramp and its location can be highlighted by calculating the derivative of the image. Suppose we have the following signal with an edge shown by the jump in intensity below:

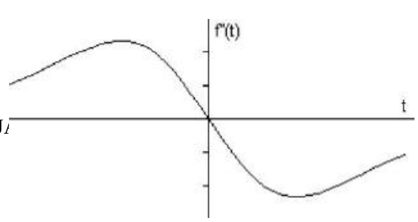


If we take the gradient of this signal we get the following:



Noticeably, the derivative shows a maximum located at the center of the edge in the original signal.

This method of locating an edge is characteristic of the **"**gradient filter**"** family of edge detection filters and includes the Sobel method. Once a threshold is set, we can compare the gradient value to the threshold value and detect an edge each time the threshold is exceeded. Moreover, when the first derivative is at a maximum, the second derivative is zero. Consequently, another option to find the location of an edge is to locate the zeros in the second derivative. The second derivative of the signal is shown below:



This approach uses the zero-crossing operator which acts by locating zeros of the second derivatives of f(a,b). The differential operator is used in the so-called zero-crossing edge detectors.

$$\nabla^2 f = \frac{\partial^2 f}{\partial a^2} + \frac{\partial^2 f}{\partial b^2} \qquad (2)$$

Thresholding allocates a range of pixel values to each object of interest. It provide good result with greyscale images that exploit the whole range of the greyscale. For the image f(a,b), the threshold image g(a,b) is defined as

$$g(x,y) = \begin{cases} 1 & \text{if } f\,(a,b) > T \\ 0 & \text{if } f\,(a,b) \le T \end{cases} \qquad (3)$$

Where T is the threshold value.

Convolution operates on images of different sizes but of the same dimensionality. For an image of M rows and JV columns, and a kernel of m rows and n columns, the convolved image will have M - m + 1 rows, and N - n + 1 columns, and the image is given by

$$O(i,j) = \sum_{k=1}^{m}\sum_{l=1}^{n} I(i+k-1,\, j+l-1)K(k,l) \qquad (4)$$

Where i runs from 1 to M - m + 1 and j runs from 1 to JV - 11 + 1.

C. *The Roberts Detection*

The Roberts Cross operator performs a simple, rapid to compute, 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. The operator is made up of a 2×2 convolution kernel as shown in figure.

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1	0
0	-1

Gx

0	1
-1	0

Gy

Fig. 2 Roberts Mask

These kernels are designed to act in response maximally to edges running at 45° to the pixel grid, one kernel for each of the two perpendicular orientations. The kernels can be applied independently to the input image, to produce separate measurements of the gradient component in each orientation (call these *Ga* and *Gb*). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient. The gradient magnitude is given by:

$$|G| = \sqrt{Ga^2 + Gb^2}$$

Although typically, an approximate magnitude is computed using:

$$|G|=|Ga|+|Gb|$$

which is much faster to compute.

The angle of orientation of the edge grows the spatial gradient (relative to the pixel grid orientation) and is given by:

$$\theta = \arctan\left(\frac{Gb}{Ga}\right) - \frac{3\pi}{4}$$

D. *The Sobel Detection*

The Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. The convolution masks of the Sobel detector are given below.

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

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

Fig. 3 Sobel Mask

The Sobel edge detection technique is similar to that of the Roberts Cross algorithm. Despite the design of Sobel and Robert are common, the main difference is the kernels that each uses to obtain the image is different. The sobel kernels are more suitable to detect edges along the horizontal and vertical axis whereas the Roberts's able to detect edges run along the vertical axis of 45° and 135°.

E. *The Prewitt Detection*

The prewitt edge detector is an appropriate way to estimate the magnitude and orientation of an edge. The prewitt operator is limited to 8 possible orientations, however most direct orientation estimates are not much more accurate.

This gradient based edge detector is estimated in the 3x3 neighbourhood for 8 directions. All the eight convolution masks are calculated. The convolution mask with the largest module is then selected. The convolution masks of the Prewitt detector are given below:

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

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

Fig. 4 Prewitt Mask

F. *Laplacian of Guassian(LoG) Operator*

It was invented by Marr and Hildreth (1980). The Gaussian filtering is combined with Laplacian to break down the image where the intensity varies to detect the edges effectively. It uses linear interpolation to determine the sub pixel location of the edge .The digital implementation of the Laplacian function is made using the mask given in below figure.

0	-1	0
-1	4	-1
0	-1	0

Fig. 5 Laplicaian of Gaussian Mask

The operator usually takes a single gray-level image as input and produces another gray-level image as output.

The Laplacian *L(a,b)* of an image with pixel intensity values *I(a.b)* is given by:

$$L(a,b) = \frac{\partial^2 I}{\partial a^2} + \frac{\partial^2 I}{\partial b^2}$$

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Since the input image is represented as a set of discrete pixels, we need to find a discrete convolution kernel that can approximate the second derivatives in the definition of the Laplacian.The disadvantage of LOG operator is that it can not find orientation of edge because of laplician filter.

G. *Canny Operator*

It is a method to find edges by isolating noise from the image without affecting the features of the edges in the image and then applying the tendency to find the edges and the critical value for threshold. The canny edge detector first smoothens the image to eliminate noise. Then it finds the image gradient to highlight regions with high spatial derivatives. After that it perform tracking along these regions and suppresses any pixel that is not at the maximum . The gradient array at this moment can further be reduced by hysteresis which is used to track along the remaining pixels that have not been suppressed. Hysteresis uses two thresholds and if the magnitude is below the first threshold, it is set to zero . If the magnitude is above the high threshold, it is made an edge. Major application of canny edge detector is for remote sensing images which are inherently noisy.

V. CONCLUSION

This paper presented a theoretical study of edge-based image segmentation methods which provide insight into most widely used edge detection techniques of Gradient-based and Laplacian based Edge Detection. We have described Robert ,Prewitt,Sobel,LoG, Canny detection methods. Different edge detection methods can be implemented as per the need of segmentation of image .An adaptive edge-detection algorithm is necessary to pro-vide a robust solution that is adaptable to the varying noise levels. The gradient-based approaches such as the Prewitt filter have a foremost downside of being very sensitive to noise. Canny edge detection algorithm is less sensitive to noise but are computationally more expensive compared to Robert's operator Sobel, and Prewitt operator . However, the Canny edge detection approach performs better than all these operators nearly under all scenarios.

REFERENCES

[1] Adnan Khashman ,"Automatic Detection, Extraction And Recognition Of Moving Objects" ,International Journal of Systems Applications, Engineering and Development, Issue 1, Volume 2,2008.

[2] Jacinto C. Nascimento, Member, IEEE, and Jorge S. Marques, "Performance Evaluation Of Object Detection Algorithms For Video Surveillance", IEEE Transactions on Multimedia, Vol. 8, no. 4, August 2006.

[3] Kinjal A Joshi, Darshak G. Thakore ,"A Survey On Moving Object Detection And Tracking In Video Surveillance System", International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-2, Issue-3, July 2012.

[4] Roshni V.S, Raju G ,"Image Segmentation Using Multiresolution Texture Gradient And Watershed Algorithm",International Journal of Computer Applications (0975 – 8887) Volume 22– No.6, May 2011.

[5] Y.Ramadevi, T.Sridevi, B.Poornima, B.Kalyani, " Segmentation And Object Recognition Using Edge Detection Techniques", International Journal of Computer Science & Information Technology (IJCSIT), Vol 2, No 6, December 2010.

[6] Kavitha Ganesan,Shanmugam Jalla,"Video Object Extraction Based On A Comparative Study Of Efficient Edge Detection Techniques",The International Arab Journal of Information Technology, Vol. 6, No. 2, April 2009.

[7] Houari Sabirin and Munchurl Kim,"Moving Object Detection And Tracking Using A Spatio-Temporal Graph In H.264/Avc Bitstreams For Video Surveillance",IEEE Transactions On Multimedia, Vol. 14, No. 3, June 2012.

[8] Lu Wang and Nelson H. C. Yung, ,"Extraction Of Moving Objects From Their Background Based On Multiple Adaptive Thresholds And Boundary Evaluation",IEEE Transactions On Intelligent Transportation Systems, Vol. 11, No. 1, March 2010.

[9] Beant Kaur, Mr.Anil Garg ," Comparative Study Of Different edge Detection Techniques",International Journal Of Engineering Science And Technology (IJEST).

[10] Bindu Bansal, Jasbir Singh Saini, Vipan Bansal, And Gurjit Kaur ,"Comparison Of Various Edge Detection Techniques", Journal Of Information And Operations Management ISSN: 0976–7754 & E-ISSN: 0976–7762 , Volume 3, Issue 1, pp-103-106, 2012.

Biography

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