International Journal of Computer Architecture and Mobility
(ISSN 2319-9229) Volume 3 -Issue 3, May 2015

A Study of Various Edge Detection Methods

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ABSTRACT - In today's world of digital communication One of the most commonly used operations in image analysis is Edge detection . An edge is the line between an object and the background images, and it also indicates the line between overlapping objects. An Edges of an image are considered a type of crucial information that can be extracted by applying detectors with different methodology. Edge detection is a fundamental tool for image segmentation. It is play important role in digital image processing and practical aspects of our life. In this paper, we have analyzed and compared several methods and techniques for edge detection in digital image processing.

Keywords - image processing, computer vision, image segmentation, edge detection, canny detector.

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. Various 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 task but Among those all methods 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, also the data compression help for image reconstruction.

The purpose of edge detection is to mark the points in a digital image at which the luminous contrast drastically 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. The representation of edge in an image significantly decreases the amount of information to be processed, although it reserves confidential and useful information related to the shapes of objects in the picture.

The effectiveness of many digital image processing and computer vision technology work depends on the perfection of identifying useful and meaningful edges. Edge-detection has been most challenging task in all low level and high level image processing. Various methods are available for edge detection; some are based on low errors, enhancing an object function.

II. Image segmentation

Image segmentation is the process of partitioning a digital image into multiple regions or sets of pixels. Segmentation separates an image into its component regions or objects. It needs to segment the object from the background to read the image properly and indentify the content of the image carefully.

There are different types of approach used in image segmentation. Region based methods are based on the continuity. In this techniques divide the entire image into sub

regions depending on that all the pixels in one region must have the same gray level.

Segmentation methods based on finding the regions directly find for abrupt changes in the intensity value. These methods are called as edge or boundary based method.

III. Edge Detection

Edge detection may be defined as a set of connected pixels that forms a boundary between two disjoints regions. It is an integral component of image processing to enhance the clarity of edges and the type of edges. It is an image processing tech. for finding the boundaries of objects within images .It works by detecting discontinuities in brightness. The application of an edge detection method used in various areas are given below:.

A. Main steps in edge detection

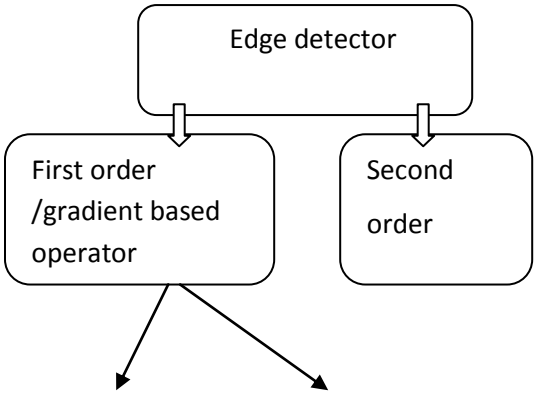
1) Smoothing: Suppress as much noise as possible without destroying true edges.

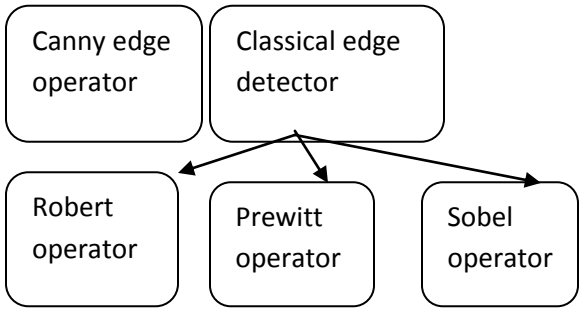
2) Enhancement: Apply differentiation to enhance the quality of edges (i.e sharpening)

3) Thresholding: Determine which edge pixels should be discarded as noise and which should be retained (i.e threshold edge magnitude.)

4) Localization: Determine the exact edge location sub pixel resoluation might be required for some applications to estimate the location of an edge to better than the spacing between pixels.

B. Different edge detection methodologies

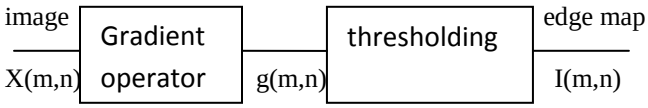




IV. Edge detection techniques

A. Gradient based edge detection

The Gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image.



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There are different type of Gradient based edge detection technique given ;

1) *Robert' s cross operator(classical edge detector):* The Robert s edge detection is introduced by Laurence robert's (1965). It is gradient based operator. It gives a simple, quick to compute,2-D spatial gradient measurement on an image. It is one of the oldest methods and is used in hardware implementation where simplicity and speed are required. It is based on that the difference on any pair of mutually perpendicular direction can be used to measure the gradient. This process the input is convolved with the default kernels of operator and gradient magnitude and directions are computed. It uses 2×2 two kernels:

$$Dx = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} \qquad Dy = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

Pixel valuses in every point in the output represent the estimated complete magnitude of the spatial gradient of the input image at that point.

2) *Sobel operator:* The sobel edge detection method is introduced by sobel in 1970. It is a discrete differentiation operator used to compute an approximation of the gradient of image intensity function for edge detection. It convolves the input image with kernel and computes the gradient magnitude and direction. It uses 3×3 two kernels.

Vertical $\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$ Horizontal $\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$

Mathematically, the operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives one for horizontal changes, and one for vertical. The differences are calculated at the center pixel of the mask. It has large kernel so it is less sensitive to noise as compared to Robert operator.

3) *Prewitt operator:* The Prewitt edge detection is proposed by Prewitt in 1970.it is used for detecting vertical and horizontal edges in images. The function of prewitt edge detector is almost same as of sobel detector but have different kernels. Basically, there are two masks, one for detecting image derivatives in X and one for detecting image derivative in Y.

To find edges, a user convolves an image with both masks, producing two derivative images (dx and dy). The Prewitt edge detector is a suitable way to estimate the magnitude and orientation of an edge. Although differential gradient edge detection needs a rather time consuming calculation to estimate the orientation from the magnitudes in the x- and y-directions, the Prewitt edge detection obtains the orientation directly from the kernel with the maximum response. The set of kernels is limited to 8 possible orientations.

Vertical $\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$ Horizontal $\begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$

Prewitt edge operator gives better performance than that of sobel operator.

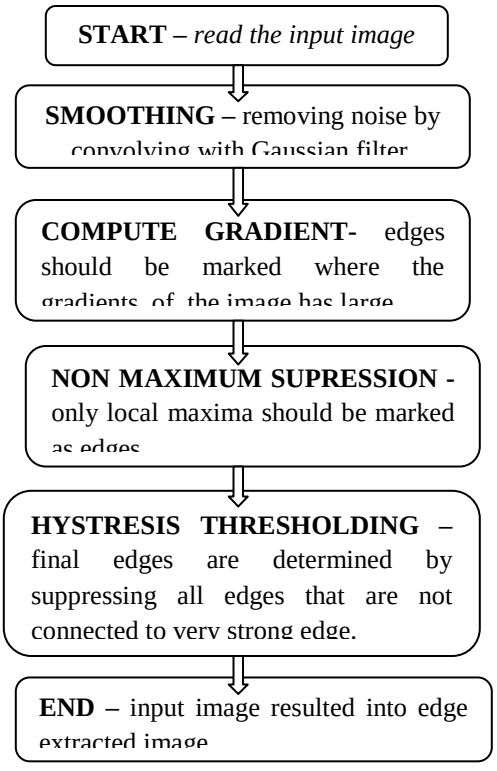
4) *Canny edge detector:* It was first created by john canny in 1983.Canny is an optimal edge detection technique as provide good detection, clear response and good localization. There are some advantage in Canny edge detector given below:

   a. *Low error rate of detection:* Well match human perception results.

   b. *Good localization of edges:* The distance between actural edges in an image and edges found by a computational algorithms should be minimum.

   c. *Single response:* The algorithm should not return multiple edges pixels when only a single one exists.

B. Flow chart of canny edge detection algorithm



C. Canny edge detection algorithm

There are some steps following in the operation of Canny edge detection algorithm given below:

1) *Noise reduction by smoothing:-* The Canny edge detector first smoothes the image to eliminate the noise .In this step the noise in image is smoothed by convolving the input image I (i, j) with Gaussian filter G. Mathematically the smooth resultant image is given by
   F(i, j) = G * I (i, j)

   Since the filter image with derivative of Gaussian.

2) *Finding gradients:-* In this step find the magnitude and orientation of gradient. When the change in gray scale intensity is maximum then an edge find. With the help of gradient of images we can find the required areas.

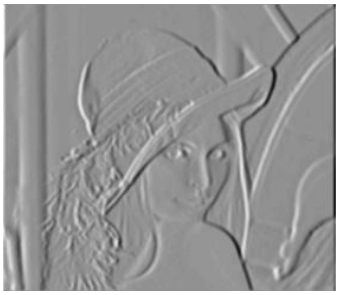
3) *Non maximum suppressions:-* In this step thin wide ridges down to single pixel width. The non maximum suppression is obtained by the preserves all local maxima in the gradient image.

4) *Hysteresis thresholding;-* In this step define the two thresholding low and high . the high threshold use to start edge carves and the low threshold to continue them. There are follow some steps in this operation given below:-

For an example a pixel M (i, j) having gradient magnitude G .

a. If G < T low than discard the edge.
b. If G >T high than keep the edge.
c. If T low < G >T high and any of its neighbors in 3×3 region around it have gradient magnitude greater than T high keep the edge.
d. Else , discard the edge.

ORIGINAL IMAGE *NORM OF GRADIENT*



VERTICAL EDGE *AFTER THRESHOLDING*

HORIZONTAL EDGE *AFTER THINING*

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, , Canny detection methods. Different edge detection methods can be implemented as per the need of segmentation of image .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 errors and 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.

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