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Edge Detection Techniques for Image Segmentation

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ABSTRACT: Edge detection is one of the identified most commonly used operations in image analysis, and there are probably more algorithms in the literature for enhancing and detecting edges than any other single subject. The reason for this is that edges form the outline of an object, in the generic sense. Objects are subjects of interest in image analysis and vision systems. An edge is the boundary between an object and the background, and indicates the boundary between overlapping objects. Since computer vision involves the identification and classification of objects in an image, edge detection is an essential tool. In image interpretation the partition of the image into object and background is a severe step. Segmentation separates an image into its component regions or objects. Image segmentation needs to segment the object from the background to read the image properly and identify the content of the image carefully. In this context, edge detection is a fundamental tool for image segmentation. 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

Image segmentation is an essential step in image analysis. Segmentation separates an image into its component parts or objects. 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 depends on the problem being considered. Edge detection is a part of image segmentation. The effectiveness of many image processing and 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 [1].

The process of classifying and placing sharp discontinuities in an image is called the edge detection. The discontinuities are immediate changes in pixel concentration which distinguish boundaries of objects in a scene. Classical methods of edge detection engage convolving the image through an operator, which is constructed to be perceptive to large gradients in the image although returning values of zero in uniform regions. There is a very large amount of edge detection techniques available, each technique designed to be perceptive to certain types of edges. Variables concerned in the selection of an edge detection operator consist of Edge orientation, Edge structure and Noise environment. The geometry of the operator establishes a characteristic direction in which it is most perceptive to edges. Operators can be optimized to look for vertical, horizontal or diagonal edges.

Edge detection is a difficult task in noisy images, since both the edges and noise hold high- frequency content. Efforts to reduce the noise result in unclear and distorted edges. Techniques used on noisy images are typically larger in scope; therefore they can common enough data to discount localized noisy pixels. This results in less perfect localization of the detected edges. Not all edges involve a step change in intensity. Things such as refraction or reduced focus can result in objects through boundaries defined by a regular change in intensity. The method wants to be chosen

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to be receptive to such a regular change in those cases. So, there are some problems of fake edge detection, edge localization, missing true edges, problems due to noise and high computational time etc. Hence, the objective is to do the comparison of a variety of edge detections and analyze the performance of the different techniques in various conditions.

A. Image Segmentation

In computer vision, image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels).The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Region based methods are based on continuity. These techniques divide the entire image into sub regions depending on some rules like all the pixels in one region must have the same gray level. Region-based techniques rely on common patterns in intensity values within a cluster of neighboring pixels. The cluster is referred to as the region in addition to group the regions according to their anatomical or functional roles are the goal of the image segmentation [1,2]

Threshold is the simplest way of segmentation. Using thresholding technique regions can be classified on the basis range values, which is applied to the intensity values of the image pixels. Thresholding is the transformation of an input image to an output that is segmented binary image [2]. 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 methods. Edge detection is the problem of fundamental importance in image analysis. Edge detection techniques are generally used for finding discontinuities in gray level images. To detect consequential discontinuities in the gray level image is the important common approach in edge detection. Image segmentation methods for detecting discontinuities are boundary base methods.

B. Edge detection

Edge detection is one of the most commonly used operations in image analysis, an edge is the boundary between an object and the background, and indicates the boundary between overlapping objects. Edge detection techniques transform images to edge images benefiting from the changes of grey tones in the images. Edges are the sign of lack of continuity, and ending. As a result of this transformation, edge image is obtained without encountering any changes in physical qualities of the main image. Objects consist of numerous parts of different color levels [1,2,3].

Edges are local changes in the image intensity. Edges typically occur on the boundary between two regions. The main features can be extracted from the edges of an image. Edge detection has major feature for image analysis. These features are used by advanced computer vision algorithms. Edge detection is used for object detection which serves various applications like medical image processing, biometrics etc.

Edge detection is an active area of research as it facilitates higher level image analysis. There are three different types of discontinuities in the grey level like point, line and edges. Spatial masks can be used to detect all the three types of discontinuities in an image. There are many edge detection techniques in the literature for image segmentation.

The most commonly used discontinuity based edge detection techniques are reviewed in this section. Those techniques are Roberts edge detection, Sobel Edge Detection, Prewitt edge detection, Kirsh edge detection, Marr-Hildreth edge detection, LoG edge detection and Canny Edge Detection.

C. Steps in Edge Detection

Edge detection contain three steps namely Filtering, Enhancement and Detection. The overview of the steps in edge detection are as follows.

1) Filtering: Images are often corrupted by random variations in intensity values, called noise. Some common types of noise are salt and pepper noise, impulse noise and Gaussian noise. Salt and pepper noise contains random occurrences of both black and white intensity values. However, there is a trade-off between edge strength and noise reduction. More filtering to reduce noise results in a loss of edge strength [4,5,6].

2) Enhancement: In order to facilitate the detection of edges, it is essential to determine changes in intensity in the neighborhood of a point. Enhancement emphasizes pixels where there is a significant change in local intensity values and is usually performed by computing the gradient magnitude.

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3) Detection: Many points in an image have a nonzero value for the gradient, and not all of these points are edges for a particular application. Therefore, some method should be used to determine which points are edge points. Frequently, thresholding provides the criterion used for detection.

II. EDGE DETECTION METHODS

Three most frequently used edge detection methods are used for comparison. These are (1) Roberts Edge Detection, (2) Sobel Edge Detection, (3) Prewitt edge detection (4) Kirsch Edge Detection (5) LoG edge detection , (6) Canny Edge Detection and (7) Marr-Hildreth Edge Detection.

A. Roberts Edge Detection

The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. It thus highlights regions of high spatial frequency which often correspond to edges. In its most common usage, the input to the operator is a grayscale image, as is the output. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point [1].

-1	0
0	+1

G_x

0	-1
+1	0

G_y

B. Sobel Edge Detection

The Sobel edge detection method is introduced by Sobel in 1970. The Sobel method of edge detection for image segmentation finds edges using the Sobel approximation to the derivative. It precedes the edges at those points where the gradient is highest. The Sobel technique performs a 2-D spatial gradient quantity on an image and so highlights regions of high spatial frequency that correspond to edges. In general it is used to find the estimated absolute gradient magnitude at each point in n input grayscale image. In conjecture at least the operator consists of a pair of 3x3 complication kernels as given away in under table. One kernel is simply the other rotated by 90 degrees. This is very alike to the Roberts Cross operator [1,4,5,6].

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

G_x

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

G_y

C. Prewitt edge detection

The Prewitt edge detection is proposed by Prewitt in 1970 [1]. To estimate the magnitude and orientation of an edge Prewitt is a correct way. Even though different gradient edge detection wants a quiet time consuming calculation to estimate the direction from the magnitudes in the x and y-directions, the compass edge detection obtains the direction directly from the kernel with the highest response. It is limited to 8 possible directions; however knowledge shows that most direct direction estimates are not much more perfect. This gradient based edge detector is estimated in the 3x3 neighborhood for eight directions. All the eight convolution masks are calculated. One complication mask is then selected, namely with the purpose of the largest module. Prewitt detection is slightly simpler to implement computationally than the Sobel detection, but it tends to produce somewhat noisier results [1,2].

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

G_x

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

G_y

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D. Kirsch Edge Detection

Kirsch edge detection is introduced by Kirsch (1971). The masks of this Kirsch technique are defined by considering a single mask and rotating it to eight main compass directions: North, Northwest, West, Southwest, South, Southeast, East and Northeast. The masks are distinct as follows:

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

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

The edge magnitude is defined as the maximum value found by convolution of each mask with the image. The direction is defined by mask 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.

E. LoG edge detection

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

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

It has two effects, it smoothers the image and it computes the Laplacian, which yields a double edge image. Locating edges then consists of finding the zero crossings between the double edges. The digital implementation of the Laplacian function is usually made through the mask below,

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

G_x

-1	-1	-1
-1	8	-1
-1	-1	-1

G_y

F. Canny Edge Detection.

In industry, the Canny edge detection technique is one of the standard edge detection techniques. It was first created by John Canny for his Master's thesis at MIT in 1983, and still outperforms many of the newer algorithms that have been developed. To find edges by separating noise from the image before find edges of image the Canny is a very important method. Canny method is a better method without disturbing the features of the edges in the image afterwards it applying the tendency to find the edges and the serious value for threshold [3,4].

G. Marr-Hildreth Edge Detection

The Marr-Hildreth (1980) technique is a method of detecting edges in digital images that is continuous curves wherever there are well-built and fast variations in image brightness. It is an easy and it operates by convolving the image with the LoG function, or, as a quick approximation by DoGs. Subsequently the zero-crossings are discovered in the filtered result to find the edges. The LoG method is sometimes as well referred to as the Mexican hat wavelet due to its image shape while turned up-side-down.

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The different edge detection methods was compared to a given image and following results were obtained (Table 1) [2].

Table 1. Comparison of different Edge Techniques

Methods	Results
Roberts Edge Detection	Deviated from the original Image
Sobel Edge Detection	Deviated from the original Image
Prewitt edge detection	Deviated from the original Image
Kirsch Edge Detection	Almost same as original Image
LoG edge detection	Almost same as original Image
Canny Edge Detection	Almost same as original Image
Marr-Hildreth Edge Detection	Almost same as original Image

III. CONCLUSION AND FUTURE WORK

In the discipline of computer vision, image processing is a quickly moving field. Its growth has been fueled by technological advances in digital imaging, computer processors and mass storage devices. In this paper an attempt is made to review the edge detection techniques which are based on discontinuity intensity levels. Though, so many edge detection techniques are available in the literature, it is a challenging task to the research communities to detect the exact image without noise from the original image. In our future work, we plan to implement all the edge detection methods reviewed in this paper and do a comparative study on the same.

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