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Computer Vision Survey

Title:- Edge Detection Techniques: Innovations and Comparisons

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Introduction

Image processing is a method of analyzing and manipulating the digital images with the computer using mathematical operators. An image comprises various information like contour of the object, its orientation, size and color, so as to find the shape information of the object , the edges involved in that object must be identified. Edge detection is a method to detect the occurrence of edge and its locality which is created by sharp and abrupt variation in intensity of an image. The edge detection in an image is based on intensity, illumination, objects, noise, blur.

In this survey various techniques of edge detection are studied and compared. Edge detection is a process to locate the edge that has good orientation and it is an essential tool of image segmentation. Edge detection method transforms the original image into edge image with the help of operators.In the process of edge detection, the image is inputted first and converts that image into a grayscale image. Classical methods of edge detection involve convolving the image with an operators a(2D-D filter), which is constructed to be sensitive to large gradient in the image while returning values of zero in uniform regions.

An edge detector accepts discrete, digitized images as input and produces an edge map as output. The edge map of some detectors include explicit information about the position and strength of edges, their orientation and the scale. During the history of image processing a variety of edge detectors have been devised which differ in their purpose and in their mathematical and algorithmic properties. The most commonly proposed scheme for edge detection(both autonomous and contextual detection) include three operations: differentiation, smoothing and labeling. Differentiation consists in evaluating the desired derivative of the image. Smoothing consists in reducing noise in the image and regularizing the numerical differentiation. Labeling involves localizing edges and increasing the signal to noise ratio of the edge image by suppressing false edges.

a.

b.

: *a) Original image, b) Position information provided by an edge detector.*

Edge detection Algorithms

1, Roberts Cross Operators

The Robert edge detection operator was discovered in 1963 and has a fast and simple structure. It has 2x2 convolution kernels as shown in figure 1 these two convolution kernels are rotated 90 to each other.

These kernels are designed to respond maximally to edges running at 45 to the pixel grid, one kernel for each of the two perpendicular orientations. In the kernels we produce separate measurements of the gradient components in each orientation. Then combine together to find the absolute magnitude of the gradient at each point.

|G|=|Gx|+|Gy|

+1	0
0	-1

Gx

0	+1
-1	0

Gy

It takes the input image as a gray scale image and produces edges involved in that image. The main disadvantage is it can't detect the type of edges which are multiples of 45 degree and it is not symmetric. This operator produces the position of edge more accurately, but it has the short support of filters which cause vulnerability to noise. 3

2, Sobel Operators

Irwin Sobel proposed the Sobel edge detection techniques in 1970. The sobel kernel depends on the central difference, but while averaging it gives more weight to the central pixel. This edge detection method contains a pair of 3x3 convolution masks. One mask is just to the other rotated by 90 degrees. This mask can deal with the edges which are running 45 degrees to the pixel grid.

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

Gx

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

Gy

3, Prewitt's operator

Prewitt operator(prewitt, 1970) is similar to the sobel operator with constant c=1 and is used for detecting vertical and horizontal edges in images.It has two kernels and their size is 3x3. It is a gradient based edge detection operator and it has gradient features. Compared to the success of edge detection in complex image, success of prewitt operator is greater than robert operator.

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

Gx

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

Gy

4, Laplacian of Gaussian(LOG) Edge detection

Marr has introduced the laplacian of Gaussian(LOG) technique in (1982). LOG smoothes the image first then calculates Laplacian. This process produces the double edge image. It locates edges then searches for the zero crossing between the double edges.

+1	+1	+1
+1	-8	+1
+1	+1	+1

G_x

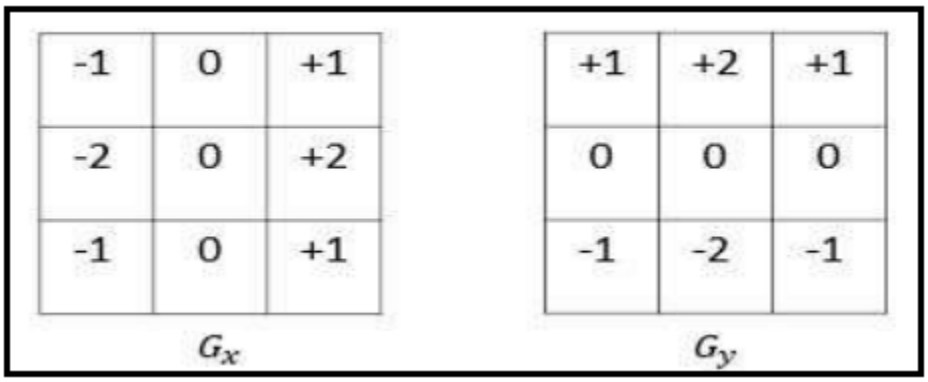
-1	+2	-1
+2	-4	+2
-1	+2	-1

G_y

Because these kernels are approximating a second derivative measurement on the image they are very sensitive to noise. To counter this the image is often gaussian smoothed before applying the Laplacian filter. This preprocessing step reduce the high frequency noise components prior to the differentiation.

5, Canny Edge Detection

John Canny introduced the canny edge detection technique at MIT in 1983. It is the standard, powerful and usually used edge detection method. It separates the noise from the image before extracting edges. Canny is a better method for extracting the edges than other existing methods and produces good results. The canny operator can control a number of details of edge image and can suppress the noise efficiently.
The following steps are used.
Step1: Smooth the image with a Gausian Filter
Step2: Compute the gradient magnitude and orientation using finite- difference approximation for the partial derivatives.
Step3: Apply non maxima suppression to the gradient magnitude, use the double thresholding algorithm to detect and link edges.



6, Marr- Hildreth

Marr-Hildreth uses the Gaussian smoothing operator to improve the response to noise, which is differentiated by the Laplacian of Gaussian is called the LOG operator. Edges are at the 'zero Crossings' of the LoG, where there is a change in gradient. The main advantage of Marr-Hildreth is tested and established among the wider area around the pixels. The disadvantage is that it reduces the accuracy in finding out the orientation of edges and malfunctioning at the corners, curves, where the gray level intensity function variations.

Comparison of the various edge detector

As edge detection is a fundamental step in computer vision, it is necessary to point out the true edges to get the best result from the matching process.

I. Classical (sobel, prewitt)
   Advantage - simplicity, detecting edges and their orientations.
   DisAdvantage- Sensitivity to the noise in the detection of the edge and their orientations.
   - Inaccuracy as the gradient magnitude of the edge decreases.

II. Zero crossing(Laplacian)
   Advantage- Detecting edge and their orientations
   - Fixed characteristics in all directions

   DisAdvantage-Sensitive to noise
   - The operation gets refracted by some of the existing edges in the noisy image.

III. Gaussian(Gobar Filter)
   Advantage-Gabor function which is a good fit to the receptive field weight functions.
   DisAdvantage-

IV. Gaussian (Canny)'

Advantage-Smoothing concept

- Improving the signal with respect to the noise ratio and this is established by Non Maxima suppression method as it results in one pixel wide ridges as the output.
- Better detection of edges especially in noise state with the help of thresholding method.

DisAdvantage-Time consumption because of complex computation

V. Marr-Hildreth

Advantage- Tested and established among the wider area around the pixel

DisAdvantage-it reduces the accuracy in finding out the orientation of edges

- Malfunctioning at the corners, curves, where the gray level intensity function variations.

Reference

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