# Different Techniques Of Edge Detection In Digital Image Processing

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## ABSTRACT

**Edge detection is a process that detects the presence and location of edges constituted by sharp changes in intensity of an image. Edges define the boundaries between regions in an image, which helps with segmentation and object recognition. Edge detection of an image significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image. The general method of edge detection is to study the changes of a single image pixel in an area, use the variation of the edge neighboring first order or second-order to detect the edge. In this paper after a brief introduction, overview of different edge detection techniques like differential operator method such as sobel operator,prewitt's technique,Canny technique and morphological edge detection technique are given.**

## 1.Introduction

The edge detection methods based on difference operation are used widely in image processing. It could detect the variation of gray levels, but it is sensitive to noise. Edge detection is an important task in image processing. It is a main tool in pattern recognition, image segmentation, and scene analysis. An edge detector is basically a high pass filter that can be applied to extract the edge points in an image. An edge in an image is a contour across which the brightness of the image changes abruptly. In image processing, an edge is often interpreted as one class of singularities. In a function, singularities can be characterized easily as discontinuities where the gradient approaches infinity. However, image data is discrete, so edges in an image often are defined as the local maxima of the gradient[1]-[2]. Edge widely exists between objects and backgrounds, objects and objects, primitives and primitives. The edge of an object is reflected in the discontinuity of the gray. Therefore, the general method of edge detection is to study the changes of a single image pixel in a gray area, use the variation of the edge neighboring first order or second-order to detect the edge. This method is used to refer as local operator edge detection method. Edge detection is mainly the measurement, detection and location of the changes in image gray. Image edge is the most basic features of the image. When we observe the objects, the clearest part we see firstly is edge and line. According to the composition of the edge and line, we can know the object structure. Therefore, edge extraction is an important technique in graphics processing and feature extraction. The basic idea of edge detection is as follows: First, use edge enhancement operator to highlight the local edge of the image. Then, define the pixel "edge strength" and set the threshold to extract the edge point set. However, because of the noise and the blurring image, the edge detected may not be continuous[3].

This paper discuses various techniques for Edge Detection. Edge detection detects outlines of an object and boundaries between objects and the background in the image. Edge is a boundary between two homogeneous regions. Edge detection refers to the process of identifying and locating sharp discontinuities in an image.

## 2.Different techniques of edge detection

### 2.1.Differential operator method

Differential operator can outstand grey change. There are some points where grey change is bigger. And the value calculated in those points is higher applying derivative operator . So these differential values may be regarded as relevant 'edge intensity' and gather the points set of the edge through setting thresholds for these differential values[4]. Differential operator is a classic edge detection method, which is based on the gray change of image for each pixel in their areas, using the edge close to the first-order or second order directional derivative to detect the edge. Differential operator edge detection is accomplished by the convolution. The position of first-order derivative in the image from light to dark or from dark to light has a downward or upward step, the changes of the gray value is relatively small in other locations, and the maximum of magnitude corresponds to the location of the edge. Both the theoretical of the application basis on: the feature of first-order differential operator obtains extreme in the step edge for the first-order derivative in image and will be 0 in the roof-like edge; otherwise, the second-order differential operator has the opposite values. First-order operator including: Sobel operator, Prewitt operator, Roberts operator, etc. Second order operator including: LOG operator, Canny operator, etc. First-order derivative corresponds to a gradient, first-order derivative operator is the gradient operator[5].

### 2.1.1 .Sobel Edge Detection Operator

The Sobel edge detection operation extracts all of edges in an image, regardless of direction. Sobel operation has the advantage of providing both a differencing and smoothing effect. It is implemented as the sum of two directional edge enhancement operations. The resulting image appears as an unidirectional outline of the objects in the original image. Constant brightness regions become black, while changing brightness regions become highlighted. Derivative may be implemented in digital form in several ways. However, the *Sobel operators* have the advantage of providing both a differencing and a smoothing effect. Because derivatives enhance noise, the smoothing effect is particularly attractive feature of the Sobel operators[7] .

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

Gx

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

Gy

Fig.1

The operator consists of a pair of 3×3 convolution kernels as shown in Fig. 1. One kernel is simply the other rotated by 90°. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation ( *Gx* and *Gy*) The gradient magnitude is given by:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

Typically, an approximate magnitude is computed using:

$$|G| = |Gx| + |Gy|$$

which is much faster to compute.[6]-[7]

### 2.1.2.Robert's cross operator

The Roberts Cross operator performs a simple, quick 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 consists of a pair of 2×2 convolution kernels as shown in Figure. One kernel is simply the other rotated by 90°. This is very similar to the Sobel operator.

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

Gx

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

Gy

Fig.2

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. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation ( *Gx* and *Gy*). 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:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

although typically, an approximate magnitude is computed using:

$$|G| = |Gx| + |Gy|$$

which is much faster to compute [7].

### 2.1.3.Laplacian of Gaussian

The Laplacian is a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection. The Laplacian is often applied to an image that has first been smoothed with something approximating a Gaussian Smoothing filter in order to reduce its sensitivity to noise. The operator normally takes a single gray level image as input and produces another gray level image as output. The Laplacian *L(x,y)* of an image with pixel intensity values *I(x,y)* is given by:

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

Since the input image is represented as a set of discrete pixels, we have to find a discrete convolution kernel that can approximate the second derivatives in the definition of the Laplacian. Three commonly used small kernels are shown in Fig.3.

| | | |
|---|---|---|
| 0 | 1 | 0 |
| 1 | −4 | 1 |
| 0 | 1 | 0 |

| | | |
|---|---|---|
| 1 | 1 | 1 |
| 1 | −8 | 1 |
| 1 | 1 | 1 |

| | | |
|---|---|---|
| −1 | 2 | −1 |
| 2 | −4 | 2 |
| −1 | 2 | −1 |

**Fig. 3**

Three commonly used discrete approximations to the Laplacian filter. 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 pre-processing step reduces the high frequency noise components prior to the differentiation step. In fact, since the convolution operation is associative, we can convolve the Gaussian smoothing filter with the Laplacian filter first of all, and then convolve this hybrid filter with the image to achieve the required result[7].The 2-D LoG function centered on zero and with Gaussian standard deviation as the form:

$$LoG(x,y) = -\frac{1}{\pi\sigma^4}\left[1 - \frac{x^2+y^2}{2\sigma^2}\right]e^{-\frac{x^2+y^2}{2\sigma^2}}$$

**2.1.4. Prewitt operator**

Prewitt operator is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Prewitt operator is either the corresponding gradient vector or the normal of this vector. The Prewitt operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations.

$$h_1 = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} \qquad h_3 = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

**Fig.4**

This operator is similar to Sobel operator[7].

**2.1.5 . Canny Operator**

The Canny edge detector is widely considered to be the standard edge detection method in the industry. It was first created by John Canny for his Masters thesis at MIT in 1983. Canny saw the edge detection problem as a signal processing optimization problem, so he developed an objective function to be optimized [8]. The solution to this problem was a rather complex exponential function, but Canny found several ways to approximate and optimize the edge-searching problem. The steps in the Canny edge detector are as follows:

**1.** Smooth the image with a two dimensional Gaussian. In most cases the computation of a two dimensional Gaussian is costly, so it is approximated by two one dimensional Gaussians, one in the x direction and the other in the y direction.

**2.** Take the gradient of the image. This shows changes in intensity, which indicates the presence of edges. This actually gives two results, the gradient in the x direction and the gradient in the y direction.

**3.** Non-maximal suppression- Edges will occur at points the where the gradient is at a maximum. Therefore, all points not at a maximum should be suppressed. In order to do this, the magnitude and direction of the gradient is computed at each pixel. Then for each pixel check if the magnitude of the gradient is greater at one pixel's distance away in either the positive or the negative direction perpendicular to the gradient. If the pixel is not greater than both, suppress it.

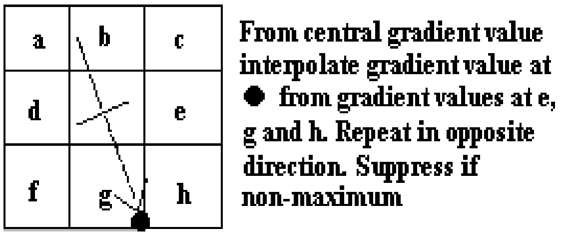


Fig.5

**4.** Edge Thresholding- The method of thresholding used by the Canny Edge Detector is referred to as "hysteresis". It makes use of both a high threshold and a low threshold. If a pixel has a value above the high threshold, it is set as an edge pixel. If a pixel has a value above the low threshold and is the neighbour of an edge pixel, it is set as an edge pixel as well. If a pixel has a value above the low threshold but is not the neighbor of an edge pixel, it is not set as an edge pixel. If a pixel has a value below the low threshold, it is never set as an edge pixel[9]-[10].

**2.2.Mathematical Morphology for Edge Detection**

The morphological basic idea is: use a certain form of structuring elements to measure and extract the image correspond shape, achieve the image analysis and identification purposes. Mathematical morphology can be used to simplify the image data, maintain the basic shape of the image features, at the same time remove the image has nothing to do with the part of the research purposes. Morphological operations could enhance contrast, eliminate noise, refinement and skeleton extraction, region filling and object extraction, boundary extraction and so on. The classical differential operator to detect the image most have a certain width , can not be directly used to measure. Morphology often used to edge detection.

The mathematical basis of mathematical morphology and language is set theory, there are four of basic operations: inflate, decay, open and closure. Based on these basic operations can also be combined into a variety of morphological methods to calculation[5].

The basic morphological operations, namely erosion, dilation, opening, closing etc. are used for detecting, modifying, manipulating the features present in the image based on their shapes. The shape and the size of SE play crucial roles in such type of processing and are therefore chosen according to the need and purpose of the associated application[11]. The key of Image edge detection based on morphology is how to combined morphological edge detection operator use the morphological structure of various basic operations, and how to select the structural elements to better solve the edge detection accuracy and the coordination of anti-noise performance[12]. Binary image of the object recognition rely on to determine whether the adjacent pixels in the image, MATLAB often use two kinds of connections: 4-connect and 8-connect. In the 4-connect agreed approach, only the vertical direction of the four adjacent Pixels are the pixels may be connected; but in the 8-connect agreed approach, users expect access to the 8 pixels adjacent pixels are the pixels may be connected[5]. Mathematical morphological method can extract much better the edge of an object than other methods.

## Conclusion

In this paper many edge detection methods like Sobel operator technique, Roberts technique ,Prewitt technique, Canny technique, and Morphology based edge detection technique are discussed. Choosing a suitable method for edge detection is based on the some environmental conditions. Each technique have its own advantages and disadvantages .But mathematical morphology is better technique than differential method. This review paper will be helpful for the researchers in understanding the concept of edge detection who are new in this field.

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