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A NOVEL SURVEY ON IMAGE EDGE DETECTOR

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ABSTRACT

Edge detection is a terminology in image processing and computer vision, particularly in the areas of feature detection and feature extraction, to refer to algorithms which aim at identifying points in a digital image at which the image brightness changes sharply or more formally has discontinuities. The extraction of edges or contours from a two dimensional array of pixels (a gray-scale image) is a critical step in many image processing techniques. A variety of computations are available which determine the magnitude of contrast changes and their orientation. In this paper we discuss the comparison and analysis edge detection method in digital image processing.

KEYWORDS
Canny, LOG, Prewitt, Roberts, Sobel.

I. INTRODUCTION

There are two goals for image processing: one is to obtain the image that more suitable for human Observing and understanding, the other one is to recognize the image automatically by computer. The key step is to decompose a large and complex image into small image with independent feature.

The edge is the basic characteristic of image. It is a collection of pixels whose surrounding pixels havea grayscale step-like changes or changes in the roof. The edge widely exists between objects and background, objects and primitives. It contains rich information, step property, shape etc, which is able to describe the target object. There are two types of edge detection: one is step change edge whose pixels grayscale of two side's have significantly difference; the other one is roof edge that is the turning point from increase to decrease of gray value.

Edge is basically the symbol and reflection of discreteness of partial image [1]. It symbolizes the end of one area and the beginning of the other area. The detected edge may become wide or discrete with the existence of noisy and ambiguity. So what we have to do for edge obtaining is to detect the discreteness of partial image and then eliminate breaking points of edges. Complete edge is combined by these edge pixels.

The organization of this papers as follows. In section II we have discussed Principles of EDGE Detection with some expressions. In section III we have described EDGE detection algorithms. In section IV we give some Advantages and Disadvantages of EDGE Detector. In section V compare the results of different EDGE detection algorithm. Finally in section VI conclude and future work.

II. PRINCIPLE F EDGE DETECTION

Edge detection operator is a mutation in the nature of the image edge to test the edge. There are two main types[2]: one is the first derivative-based edge detection operator to detect image edges by computing the image gradient values, such as Roberts operator, Sobel operator, Prewitt operator; the other one is the second derivative-based edge detection operator, by seeking in the second derivative zero-crossing to edge detection, such as LOG operator, Canny operator.

A. Based on the First Order Derivative of Edge Detection

Gradient is a measure of the function changes. And it is also the first order derivative of the image corresponds to two-dimensional function. An image can be seen as a continuous derivative of image intensity of sampling points group. Gradient [3] is a type of two-dimensional equivalent of the first derivative. So it can be defined as a vector.

$$G(x, y) = \begin{bmatrix} Gx \\ Gy \end{bmatrix} = \begin{bmatrix} \partial f/\partial x \\ \partial f/\partial y \end{bmatrix} \quad (1)$$

There are two important properties. First, the vector G (x, y) direction is same as the direction of the maximum rate of change of increasing function f(x, y) (eg. formula (2)); Second, the gradient amplitude (eg.formula (3));

$$|G(x, y)| = \sqrt{Gx^2 + Gy^2} \quad (2)$$

$$\propto(x, y) = \arctan(G_x/G_y) \quad (3)$$

For digital images, partial derivative of the edge is almost same as differences. So the edge often lies on the differential value of the maximum, minimum, or zero.

$$Gx = f[x+1, y] - f[x, y]$$
$$Gy = f[x, y+1] - f[x, y] \quad (4)$$

When we calculate the gradient, the same location (x, y) of real partial derivatives is essential in computing space. Gradient approximation is not in the same location using the above formula.

So the 2x2 first order differential template is used to calculate partial derivatives in x and y direction of the interpolation points[x +1 / 2, y +1 / 2], then G_x and G_y can be expressed as:

$$Gx = \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix}$$
$$Gy = \begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix} \quad (5)$$

The first order derivative method described above uses a boundary point. This method may lead to the edge points to detect excessive data storage. Theoretically more effective way is to determine the point with maximum value in ladder and these points are to be considered as edge point.

III. ALGORITHMS OF EDGE DETECTION

A. Sobel Operator

The operator consists of a pair of 3×3 convolution kernels as shown in Figure 1. One kernel is simply the other rotated by 90°.

These kernels are designed to respond maximally to edges running vertically and horizontally relative 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 (called *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:

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

Typically, an approximate magnitude is computed using:

$$|G| = |G_x| + |G_x|$$

This is much faster to compute. The angle of orientation of the edge (relative to the pixel grid) giving rise to the spatial gradient is given by:

$\theta = \arctan(G_y/G_x)$

B. 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.

FIG. 1: CONVOLUTION KERNEL FOR SOBEL OPERATOR

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

Gx

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

Gy

The operator consists of a pair of 2×2 convolution kernels as shown in Figure 2. One kernel is simply the other rotated by 90°.
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 (called *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:

$|G| = |G_x| + |G_x|$

This is also much faster to compute. The angle of orientation of the edge giving rise to the spatial gradient (relative to the pixel grid orientation) is given by:

$\theta = \arctan(G_y/G_x) - 3\pi/4$

C. Prewitt's operator:

Prewitt operator is similar to the Sobel operator and is used for detecting vertical and horizontal edges in images. 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

FIG. 2: CONVOLUTION KERNEL FOR ROBERT'S CROSS OPERATOR

+1	0
0	-1

Gx

0	+1
-1	0

Gy

D. Canny's Edge Detection Algorithm

The Canny edge detection algorithm is known to many as the optimal edge detector. Canny's intentions were to enhance the many edge detectors already out at the time he started his work. He was very successful in achieving his goal and his ideas and methods can be found in his paper, "A Computational Approach to Edge Detection".
In his paper, he followed a list of criteria to improve current methods of edge detection. The first and most obvious is low error rate. It is important that edges occurring in images should not be missed and that there be NO responses to non-edges. The second criterion is that the edge points be well localized. In other words, the distance between the edge pixels as found by the detector and the actual edge is to be at a minimum. A third criterion is to have only one response to a single edge. This was implemented because the first 2 were not substantial enough to completely eliminate the possibility of multiple responses to an edge.
Based on these criteria, the canny edge detector first smoothes the image to eliminate and noise. It then finds the image gradient to highlight regions with high spatial derivatives. The algorithm then tracks along these regions and suppresses any pixel that is not at the maximum (non maximum suppression). The gradient array is now further reduced by hysteresis. Hysteresis 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 (made a non edge). If the magnitude is above the high threshold, it is made an edge. And if the magnitude is between the 2 thresholds, then it is set to zero unless there is a path from this pixel to a pixel with a gradient above T2.

E. The Marrs-Hildreth edge detector

The Marr–Hildreth algorithm is a method of detecting edges in digital images, i.e. continuous curves where there are strong and rapid variations in image brightness. The Marr–Hildreth edge detection method is simple and operates by convolving the image with the Laplacian of the Gaussian function, or, as a fast approximation by Difference of Gaussians. Then, zero crossings are detected in the filtered result to obtain the edges.
The Laplacian-of-Gaussian image operator is sometimes also referred to as the Mexican hat wavelet due to its visual shape when turned upside-down. The Marr–Hildreth operator, however, suffers from two main limitations. It generates responses that do not correspond to edges, so-called "false edges", and the localization error may be severe at curved edges. Today, there are much better edge detection methods, such as the Canny edge detector based on the search for local directional maxima in the gradient magnitude, or the differential approach based on the search for zero crossings of the differential expression that corresponds to the second-order derivative in the gradient direction.

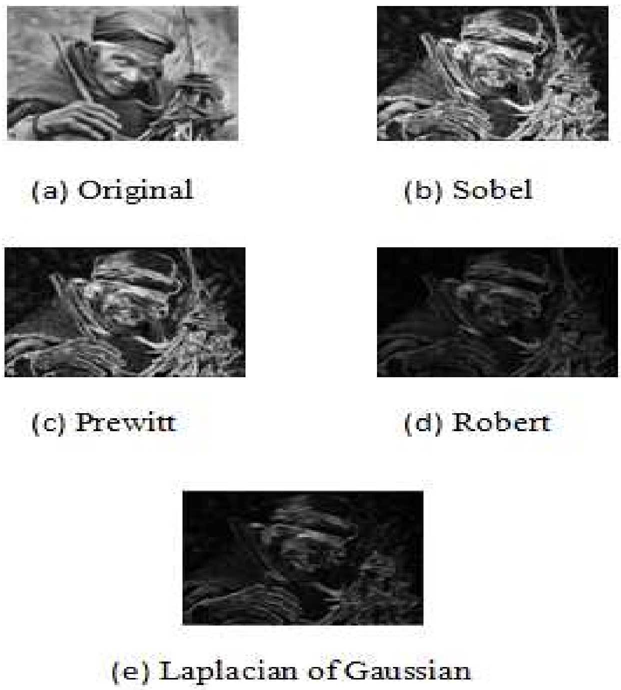
IV. ADVANTAGES AND DISADVANTAGES OF EDGE DETECTOR

TABLE 1: ADVANTAGES AND DISADVANTAGES OF EDGE DETECTOR

Operator	Advantages	Disadvantages
Classical (Sobel, prewitt, Kirsch…)	Simplicity, Detection of edges and their orientations	Sensitivity tonoise, Inaccurate
ZeroCrossing(Laplacian, Second directionalderivative)	Detection of edges and their orientations. Having fixedcharacteristics inall directions	Responding tosome of theexisting edges, Sensitivity tonoise
Laplacian ofGaussian(LoG)(Marr-Hildreth)	Finding the correct places of edges, Testing wider areaaround the pixel	Malfunctioningat the corners,curves andwhere the graylevel intensity function varies. Not finding theorientation ofedge because ofusing theLaplacian filter
Gaussian(Canny,Shen-Castan)	Using probability for finding error rate, Localization and response. Improving signalto noise ratio, Better detectionspecially in noise conditions	ComplexComputations,False zerocrossing, Timeconsuming

V. COMPARISON RESULT OF EDGE DETECTION ALGORITHMS

FIG.3: COMPARISON RESULTS OF EDGE DETECTION ALGORITHMS



VI. CONCLUSION AND FUTURE

Since edge detection is the initial step in object boundary extraction and object recognition, it is important to know the differences between different edge detection operators. In this paper an attempt is made to review the edge detection techniques which are based on discontinuity intensity levels. The relative performance of various edge detection techniques is carried out with two images by using MATLAB software. It have been observed that that the Canny edge detector produces higher accuracy in detection of object edges with higher entropy and execution time compared with Sobel, Roberts, Prewitt, Zero crossing and LOG.

VII. ACKNOWLEDGMENT

We would like to acknowledge the support and input from my family and Mr. Noor Mohmad, Asst. Professor, Shekhawati Engineering College, Dundlod, Mr.Niranjan Lal, Asst. Professor, MITS University, Sikar and Mrs. Uma Choudhary, Head of the Department, Shekhawati Engineering College, Dundlod and my other colleagues at Shekhawati Engineering College, Dundlod.

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