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Design and Fundamentals of Sobel Edge Detection of an Image

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***Abstract*— This research is in the field of digital image processing and communication engineering, which are considered as fields of wide application. The work aims to reveal the edges of the digital image, in order to determine the largest perimeter of the image. The research focuses on using the MATLAB program to solve the problem of image edge detection. In the application, we used the calculation of the absolute value and the square root with the adoption of threshold values (5, 10, 15, 20, 25, 30, 35, 40, 45, and 50) to determine the desired points in the digital image. The results gave sharp changes in the brightness of the edges of the image, and these points of sharp brightness represent the edges or borders of the image.**

***Keywords*— Edge detection; Sobel filter; Kernel; Gradient magnitude; Threshold.**

I. INTRODUCTION

Sobel filter is used in digital image processing and computer vision, and in selection in edge detection algorithms to obtain edge-confirming images. The candidate is named after Irwin Sobel and Gary Feldman, colleagues at the Stanford Artificial Intelligence Laboratory (SAIL), where they presented the idea of the isotropic 3×3 image gradient factor in 1968 [1]. The basis of the Sobel filter is based on linking the image to a small detachable filter and an integer in the horizontal and vertical directions, and this process is easy in terms of calculations. The Sobel filter works by calculating the gradient of the image's intensity at each pixel within the image, and thus how likely that pixel is to represent an edge. There are two types of edge detection filters (Fig. 1):

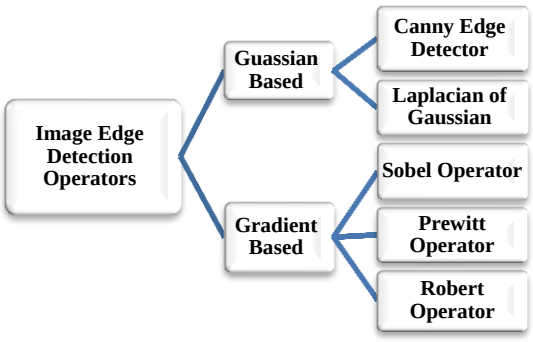


Fig. 1. Edge detection operator's types

1. The first type adopts a color gamut that calculates the first-order derivative of the digital image, such as an operator (Sobel, Prewitt, and Robert).

2. The second type is called Gaussian and depends in its calculations on the second-order derivative in the digital image such as, Canny detector, and Laplacian of Gaussian detector.

A feature of the Sobel operator is its simplicity and the provision of approximate values for the gradient amount, and its ability to detect edges and direction. In the field of digital image processing, a convolution matrix or mask is a small matrix used for edge detection, which is achieved by convolution between the kernel and the image [1, 2].

II. SOBEL FILTER METHOD

The Sobel filter works with a gradient-based method that searches for strong changes in the value of the first derivative of the image, where the detector uses a pair of 3 x 3 convolution masks (Fig. 2); one computes the gradient in the x direction and the other computes the gradient in the y direction.

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

G_x

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

G_y

Fig. 2. The Sobel edge detector of 3×3 convolution masks

As previously mentioned, the Sobel operator measures the 2D spatial gradient on the image, and in turn emphasizes regions of higher spatial frequency that align with the edges. The filter is often used to find the approximate absolute amount of gradation in all points of an input grayscale image [3-5]. Kernel represents a two-dimensional matrix. The term filter represents a three-dimensional structure of multiple cores stacked on each other. In the case of a 2D filter, the filter is the same as the kernel. In the case of a 3D filter, the filter is an array of kernels. Reducing the number of operands limits the number of possible irrelevant features, and thus is applied to a machine learning algorithm that is concerned with learning common features, so the most comprehensive choice is to keep the kernel size at 3 x 3 or 5 x 5.

III. G_x AND G_y COMPUTATIONAL

The mechanism of calculating Gx and Gy can be summarized in the process of moving an appropriate window over the input image, after which the value is calculated for one pixel and then one pixel is shifted to the right direction. When the end of the row is reached, it moves to the beginning of the next row. The example below shows the calculation of the value of Gx (Fig. 3):

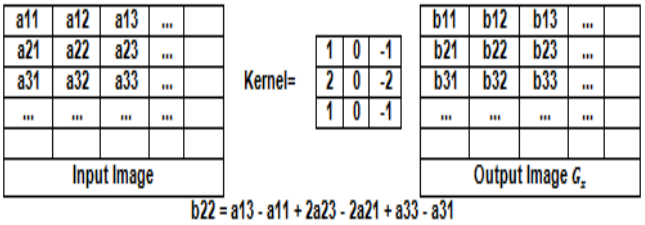


Fig. 3. Calculation of a value of Gx

The kernels contain positive coefficients and negative coefficients [6, 7]. Therefore, the resulting image will contain both positive and negative values. Therefore, for presentation purposes:
1. The regression of zero is plotted to a half-grey level. Thus, the negative gradient appears dark, and the positive gradient appears bright.
2. Adopt the absolute value of the gradient (for values between 0 and 255).
3. The highly positive and negative gradients appear bright and the kernel is sensitive to horizontal transitions and vertical transitions.
From the calculation of Gx and Gy it is possible to easily measure the edges, which are the amplitude and the angle.

The gradient estimates given by Gx and Gy are combined for each pixel in the image, and when merging we get the gradient size using:

$G = \sqrt{G_x^2 + G_y^2}$. As for the direction of the gradient, it is calculated using: $\theta = arctan\left(\frac{G_y}{G_x}\right)$.

A θ value of 0 indicates a vertical dark edge on the left side [8-11].

IV. RESULTS AND DISCUSSION

The main steps in edge detection using masks are:

1. Read the input image data and convert the data to gray.
2. Find the first derivative Sobel operators.
3. Smooth in one direction, differentiate in the other.
4. Apply Sobel mask for x-direction and y-direction.
5. Defined a threshold value, threshold (as mask) and dilate the threshold image.
6. Compute the absolutes value and the arctan= gradient direction.
7. Compute the gradient of the image and save the result.

The edge detection techniques were implemented using MATLAB. The objective is to produce a clean edge map by extracting the principal edge features of the image. The masks of the Sobel edge detection are extended from 3×3 to 5×5 dimensions, are constructed in this paper.

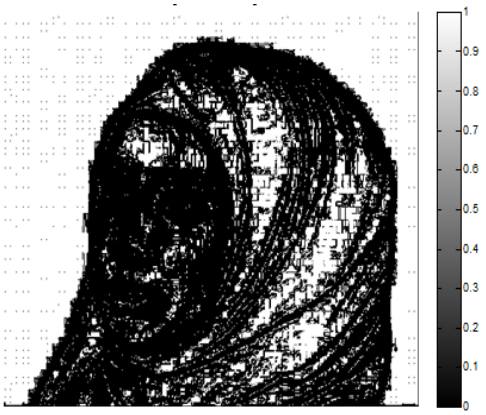
The original image and the Sobel gradient image are shown in figures 4 below.

(a) Original Image

(b) Sobel Gradient Image

Figs. 4. The original image and the Sobel Gradient Image

The image obtained by using different threshold Sobel edge detection technique are shown in Figs. 5 below, it gives the binary image with discrete point at the edges and where the intensity level changes. Points are present on everywhere, including the edges.
To clear the edges, other points should be minimizing. To minimize the point, the threshold value is kept to 50 (Fig. 5 a10).



(a1) Absolute edge detected image with threshold value= 5

(b1) Square root edge detected image with threshold value= 5

(a2) Absolute edge detected image with threshold value= 10

(b2) Square root edge detected image with threshold value= 10

(a3) Absolute edge detected image with threshold value= 15

(b3) Square root edge detected image with threshold value= 15

(a4) Absolute edge detected image with threshold value= 20

(b4) Square root edge detected image with threshold value= 20

(a5) Absolute edge detected image with threshold value= 25

(b5) Square root edge detected image with threshold value= 25

(a6) Absolute edge detected image with threshold value= 30

(b6) Square root edge detected image with threshold value= 30

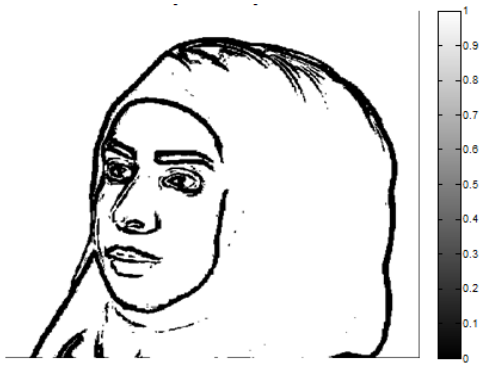
(a7) Absolute edge detected image with threshold value= 35

(b7) Square root edge detected image with threshold value= 35

(a8) Absolute edge detected image with threshold value= 40

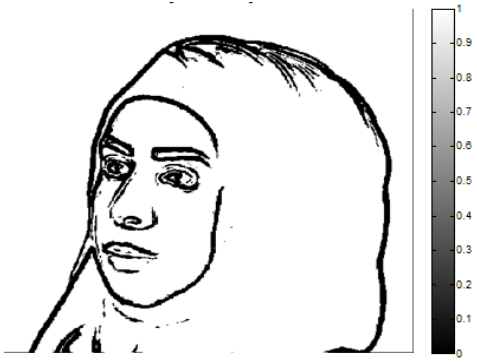
(b8) Square root edge detected image with threshold value= 40

(a9) Absolute edge detected image with threshold value= 45



(b9) Square root edge detected image with threshold value= 45

(a10) Absolute edge detected image with threshold value= 50



(b10) Square root edge detected image with threshold value= 50

Figs. 5. The original image and the image obtained by using different threshold Sobel edge detection technique

V. CONCIUSION

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g.” Avoid the stilted expression “one of us (R. B. G.) thanks .”.Instead, try “R. B. G. thanks.”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

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BIOGRAPHIES

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