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SIMULATION AND IMPLEMENTATION OF EDGE DETECTION ALGORITHM

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Abstract- In this paper, we present the software implementation of a modified version of canny edge detection algorithm, which result in significantly increased edge detection performance. The results of various gradient based filters: Roberts, Sobel and Prewitt are also observed. The edge tracking step in the canny edge detection algorithm is replaced by considering the horizontal and vertical components of the image, resulting in improved performance of the detection algorithm. The implementation of the detection algorithm is done by using MATLAB tool. The results show the effectiveness of the proposed approach.

Keywords – Canny edge detection, Roberts, Prewitt, and Sobel

INTRODUCTION

In present scenario, edge detection is widely used in various applications. Edge detection is most common approach for detecting meaningful discontinuities in gray level of an image. The basic purpose of edge detection is to minimize the amount of data to be processed by simplifying the image data.

Different types of edge detection operators are-

1. Roberts
2. Prewitt
3. Sobel

The principle of edge detection is by determining the presence of an edge or line in an image and outlining them in a proper way.

EDGE DETECTION OPERATORS

A. *Roberts Operator*

It is a 2x2 gradient operator consisting of two kernels in x-direction (X) and in y-direction (Y).

$$X = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

$$Y = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$$

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The kernels can be applied to the input image separately, to produce separate components in each direction. These can be combined together to calculate the magnitude of the gradient and the orientation of that gradient at each point.

The disadvantage of this operator is that it has no fix center, as it consists of 2x2 mask and it is more prone to noise.

B. Prewitt Operator

It is a 3x3 gradient operator. Prewitt operator provides us two masks one for detecting edges in horizontal direction and another for detecting edges in the vertical direction.

$$V = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

$$H = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

Where, V and H are the vertical and horizontal masks respectively.

When we apply vertical mask (V), the output image will contain vertical edges and if horizontal mask (H) is applied, the resultant image will contain horizontal edges.

Although it has good noise reduction capacity as compared to Roberts but it does not have any special effect around the center pixel.

C. Sobel Operator

The Sobel operator consists of 3x3 convolution kernels. It only considers two orientations which are 0 and 90. One kernel is simply the other rotated by 90^0.

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

$$G_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

It is used to find the approximate absolute gradient magnitude at each point in an input gray scale image.

Its advantage is that it is the differential of two rows or two columns, so the edge on both sides can be enhanced and the edges will be thick and bright.

CANNY EDGE DETECTION ALGORITHM

Canny edge detection algorithm is most widely used and its purpose in general is to significantly reduce the amount of data in an image, while preserving the structural properties to be used for further image processing. The algorithm runs in several steps.

A. Smoothing

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Every image contains some amount of noise that is inevitable and this noise must be reduced so that it is not mistaken for edges. Hence smoothing is done in which Gaussian filter is applied. The performance of this algorithm depends largely on adjustable parameter σ. The kernel of a Gaussian filter has a standard deviation is equal to 1.4 (σ = 1.4).

The bigger the value for σ, the larger the size of the Gaussian filter becomes. This implies more blurring, necessary for noisy images, as well as detecting larger edges.

$$K = \frac{1}{159}\begin{pmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{pmatrix}$$

B. Finding Gradients

The Canny algorithm finds edges where the grayscale intensity of the image changes the most. These areas are determined by finding the gradients of the image. Gradients at each pixel are determined by applying Sobel operator.

The edge strengths also known as gradient magnitudes are determined by Euclidean distance measured by applying Pythagoras theorem.

$$|G| = \sqrt{G_x^2 + G_y^2}$$

Where, G_x and G_y are the gradients in x- and y- directions respectively.

The direction of edges are determined by-

$$\Theta = \arctan\left(\frac{|G_y|}{|G_x|}\right)$$

C. Non-maximum suppression

Blurred edges are converted into sharp edges in non-maximum suppression. It is done by preserving all local maxima in the gradient image. The algorithm is for each pixel in the gradient image.

1. Round the direction of gradient Θ to nearest 45^0, corresponding to an 8-connected neighbourhood.

2. Comparing the gradient magnitudes with the values in positive and negative gradient direction.

3. If the gradient magnitude of the current pixel is largest, preserve the value, otherwise remove the value

D. Double thresholding

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Thresholding is used so that only the edges stronger than a certain value would be preserved and rest would be discarded. Canny edge detection algorithm uses double thresholding. The edge pixels stronger than the high threshold are marked as strong; edge pixels weaker than the low threshold are suppressed and edge pixels between the two thresholds are marked as weak. Here we have considered the upper threshold and lower threshold as 100 and 20 respectively.

EDGE TRACKING

Edges are located by Canny edge detector. A direction on edge pixels is determined based on horizontal and vertical derivatives.

For edge pixel P(i,j), computing horizontal and vertical components H(i,j) and V(i,j) as

$$H(i,j) = [P(i-1,j-1)-P(i-1,j+1)]/4 + [P(i,j-1)-P(i,j+1)]/2 + [P(i+1,j-1)-P(i+1,j+1)]/4$$

And

$$V(i,j) = [P(i-1,j-1)-P(i+1,j-1)]/4 + [P(i-1,j)-P(i+1,j)]/2 + [P(i-1,j+1)-P(i+1,j+1)]/4$$

If $H(i,j) \geq V(i,j)$, the edge direction is horizontal and the neighbourhood pixels are modified as

$$P(i,j-1) = [P(i,j-1)+P(i,j-2)]/2$$

$$P(i,j+1) = [P(i,j+1)+P(i,j+2)]/2$$

And if $H(i,j) \leq V(i,j)$, the edge direction is vertical and the neighborhood pixels are modified as

$$P(i-1,j) = [P(i-1,j)+P(i-2,j)]/2$$

$$P(i+1,j) = [P(i+1,j)+P(i+2,j)]/2$$

SIMULATION RESULTS

A. Operator Results

Figure 1. Input image

Figure 2. Output of Roberts operator

Figure 3. Output of Prewitt operator

Figure 4. Output of Sobel operator

B. Canny Results

Figure 5. Input image

Figure 6. Gaussian image

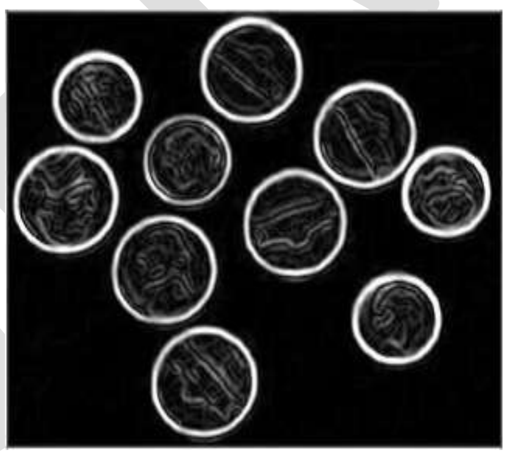

Figure 7. Magnitude of gradient

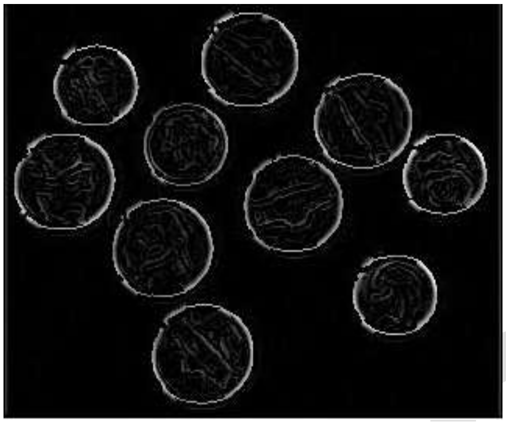

Figure 8. Non-maximum suppression

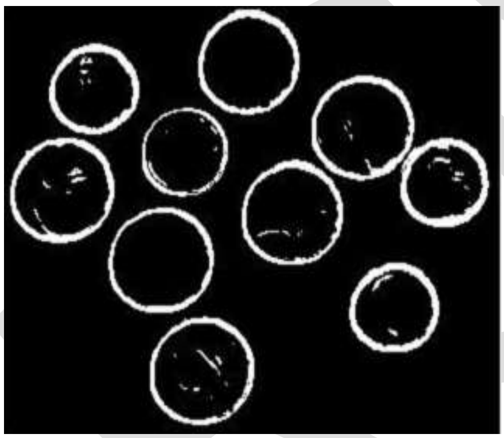

Figure 9. Double thresholding

C. Edge tracking Results

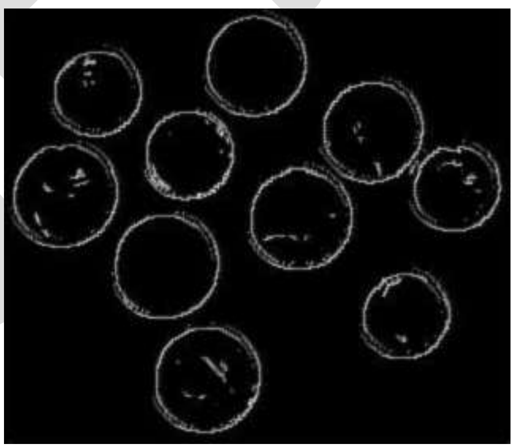

Figure 10. Edge tracking output

CONCLUSION

Edge detection algorithms are used in image processing in order to reduce the data to be processed. These algorithms are widely used in various fields such as military, medical, etc. And they require more research in the coming years for improvements in various

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technologies. The developed algorithm takes advantages from the use of neighborhood structure as well as the simple formulation of the edge detection operations.

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