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Application of COM-SOBEL Operator for Edge Detection of Images

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Abstract

In this paper, an improved edge detection method that computes image edges using the concept of Center of Mass with Sobel Operator (COM-SOBEL) is presented. The proposed method can be used as template for multi-scale edge detectors. Here the edge detection by COM with Sobel operator is compared with simply COM method.

Keywords*: Edge detection, COM-SOBEL operator, multi-scale edge detector.*

1. Introduction

Edges are representation of changes in intensity functions of an image. Image intensity variations such as steps, lines and junctions [1].Edge detection as a fundamental image processing method.The edge detection methods detect edges by finding local maxima of first-order derivative function or zero-crossing of second-order derivative function of the intensity profile of given image .

Edge detection of an image reduces significantly the amount of data and filters out information that may be regarded as less relevant, preserving the important structural properties of an image. The state-of-the-art gradient-based edge detectors lack scalability in the filter size. Small-scaled filters are sensitive to edge signals but also prone to noise, whereas large-scaled filters are robust to noise but can filter out fine details [2].A small step in this direction has been accomplished by using multiple detectors and multiple scales. [5].

The characterization of signals from multi-scale edges has been studied extensively in the literature [4]. Multi-scale edge detection face a runtime issue that when scale increases there will be a linear or quadratic increase of time consumption [7]. The general idea of edge detection is to first convolve the input image with a filter to obtain gradient. The complexity of this operation per pixel is usually $O(n)$ or $O(n2)$, where n is the filter width. For example, Sobel edge detector which runs in $O(n)$ time takes 45 ms on 512×512 image with filter size of 31×31. This is not applicable for real-time algorithms. COM edge detector uses integral image to compute center of mass in constant time $O(1)$.

There are different traditional operators such as Sobel Operator, Prewitt Operator, LOG Operator, Canny Operator and Robert Operator which are used for edge detection of images [11].

2. COM Method

The definition of edges is abrupt changes in intensity functions of an image. If we calculate a local COM of non-edge locations within a region of certain size, the center of mass will be very close to the center of that region.The distance between COM and center of region can indicate the change of intensity function. This allows the possibility of using COM to design a new edge detector. The location of COM is given by the equation:

$$X_{COM}= \Sigma m_i x_i / \Sigma m_i$$

This is a vector equation that represents each of the three object dimensions in the physical world. We first try to estimate the gradient of image intensity by the distance between COM and the region center:

$$Gx' = c(XCOM - xc)$$

where c is a constant parameter and x_c is region center.

The gradient estimated by COM reflects step changes of image intensity. However, the local maxima of gradient are not accurately located on the step edge.

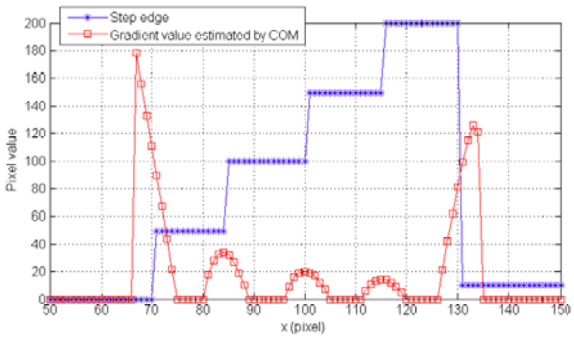

Fig 1. Gradient estimation of 1D case

COM based method can be applied to a 2D image. Digital image is discrete object where each pixel as a particle has its own mass. In image processing, such mass is referred as intensity. Directional gradient of an image is calculated as:

$$Gx=a(\Sigma I(x,y)x\Sigma I(x,y)-xc)\Sigma I(x,y)$$
$$Gy=a(\Sigma I(x,y)y\Sigma I(x,y)-yc)\Sigma I(x,y)$$

where $I(x,y)$ is image intensity, (x_c, y_c) is the center of the region (called kernel in conventional edge detection method), Σf all denotes $\Sigma f_{x<x\leq x\,,\,y<y\leq y}$, x_1, x_2, y_1, y_2 are the boundary of calculated region. Pixel intensity of a gray scale image can obtain a range of values from 0 to 255. Brighter pixels have heavier mass, i.e. they are heavier. Therefore, COM is closer to brighter area. Inheriting from conventional edge detection method [8] image gradient and gradient direction are calculated as:

$$G=\sqrt{(Gx2+Gy2)}$$
$$\theta=arctan\,(G_y/G_x)$$

3. Sobel Operator

The Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image.

In theory at least, the operator consists of a pair of 3×3 convolution kernels. One kernel is simply the other rotated by 90°.

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

Gx

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

Gy

Fig.2. Sobel Operator Mask

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 (call these *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:

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

Typically, an approximate magnitude is computed using:

$$\mathbf{G} = |\mathbf{G}_x| + |\mathbf{G}_y|$$

This is much faster to compute.

The angle of orientation of the edge giving rise to the spatial gradient is given by:

$$\theta = \tan^{-1}\left(\frac{G_y}{G_x}\right)$$

In this case, orientation θ is taken to mean that the direction of maximum contrast from black to white runs from left to right on the image, and other angles are measured anti-clockwise from this.

4. Experimental Result

Fig 3. Original Image

Fig 4. Result Using COM Method

Fig 5. Result Using COM-SOBEL Method

5. Conclusion

In this paper, the COM method and COM-SOBEL method had been implemented to find the edges associated with an image. From the experimental result, it is concluded that the COM-SOBEL method provides better result.

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