IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 4, April 2015.
www.ijiset.com

ISSN 2348 – 7968

An Innovative Approach for Edge Detection of Images

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Abstract

In this paper, an improved edge detection method which computes image edges using the concept of Prewitt Operator with Center Of Mass (PREWITT-COM) is presented. The proposed method can be used as framework for multi-scale edge detectors specifically in image processing. Here the edge detection by Prewitt Operator with COM technique is compared with simply COM method.

***Keywords**: Edge detection, PREWITT-COM, multi-scale edge detector, Image Processing.*

1. Introduction

Edges are representation of changes in intensity functions of an image. Image intensity variations such as steps, lines and junctions [2]. Edge detection is a fundamental image processing method. 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 [5]. 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.

There are different traditional operators such as Sobel Operator, Prewitt Operator, Gaussian Operator, Canny Operator and Robert Operator which are used for edge detection of images [18]. Multi-scale edge detection face a runtime issue that when scale increases there will be a linear or quadratic increase of time consumption [4]. The general idea of edge detection is to first convolve the input image with a filter to obtain gradient.COM edge detector uses integral image to compute center of mass in constant time $O(1)$.

2. Prewitt Operator

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.

On the other hand, the gradient approximation which it produces is relatively crude, in particular for high frequency variations in the image. The Prewitt operator is named for Judith Prewitt.

The Prewitt operator is used in image processing, particularly within edge detection algorithms. Technically, it 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 norm of this vector.

Mathematically, 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.

If we define $\mathbf{A}$ as the source image, and **Gx** and **Gy** are two images which at each point contain the horizontal and vertical derivative approximations, the latter are computed as:

$$G_X = \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} * A$$

$$G_Y = \begin{bmatrix} +1 & +1 & +1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} * A$$

.Fig. 1. Prewitt Operator Mask

Since the Prewitt kernels can be decomposed as the products of an averaging and a differentiation kernel, they compute the gradient with smoothing. For example, **Gx** can be written as

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

The *x*-coordinate is defined here as increasing in the "right"-direction, and the *y*-coordinate is defined as increasing in the "down"-direction. At each point in the image, the resulting gradient approximations can be combined to give the gradient magnitude, using:

$$\sqrt{Gx^2 + Gx^2}$$

Using this information, we can also calculate the gradient's direction:

$$\Theta = \mathrm{atan2}(\mathbf{G}_y, \mathbf{G}_x)$$

where, for example, **Θ** is 0 for a vertical edge which is darker on the right side.

3. Center Of Mass Methodology

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.

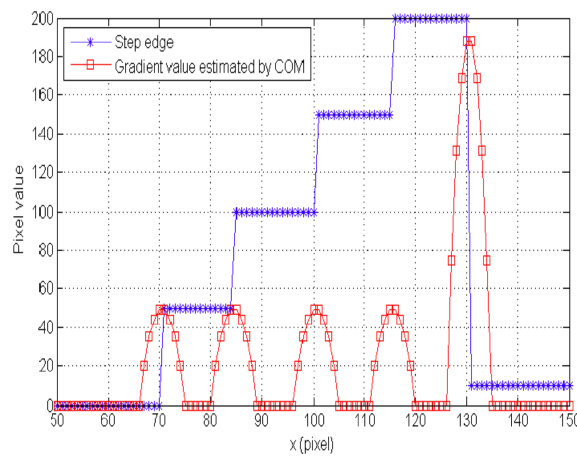

Fig 2. Step Edge- Gradient Value Estimation

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 [1].

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www.ijiset.com
ISSN 2348 – 7968

4. Pictorial Representation Of Proposed Approach

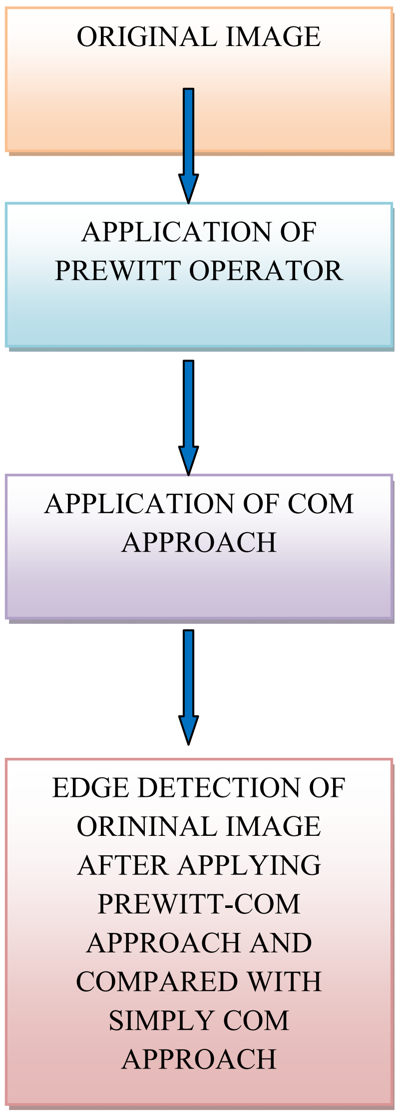

Fig. 3. Proposed Approach

5. Experimental Result And Discussion

In this section, COM Methodology is applied on the original image represented in Fig. 4 and the result image is represented in Fig. 5. Similarly, after applying the Prewitt Operator on the original image, the COM Method is applied on that intermediate image and the result image is represented in Fig. 6.

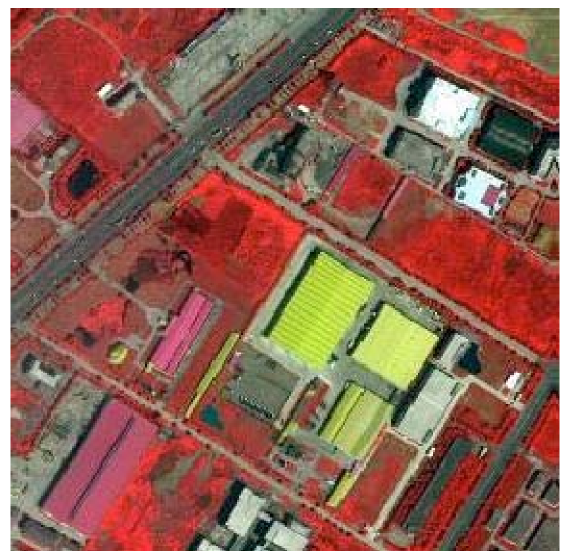

Fig. 4. Original Image

Fig. 5. Resultant Image Using COM Method

ISSN 2348 – 7968

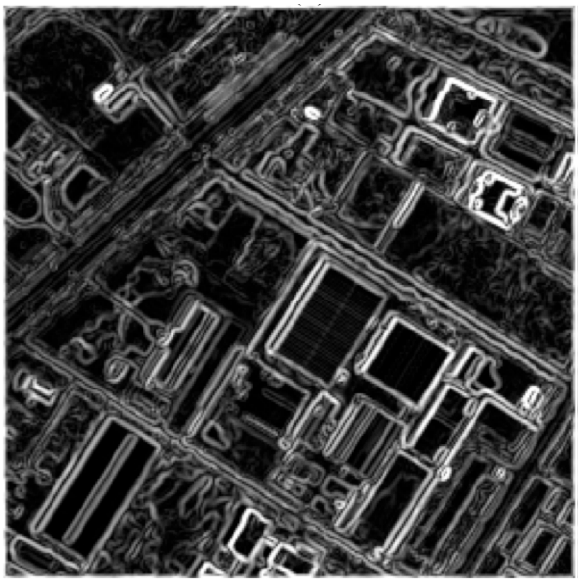

Fig. 6. Resultant Image Using PREWITT-COM Method

6. Conclusion

In this paper, Prerwitt Operator with Center of Mass and simply COM method had been implemented and compared to find the edges of an image. From the experimental result and discussion, it is concluded that the Prewitt operator with Center of Mass (PREWITT-COM) method provides better result.

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