International Journal of Computer Applications (0975 – 8887)
Volume 9– No.10, November 2010

A New Edge Detection Method based on Additions and Divisions

Sabina Priyadarshini
Department of Information Technology
Birla Institute of Technology
Mesra, Ranchi

Gadadhar Sahoo
Department of Information Technology
Birla Institute of Technology
Mesra, Ranchi

ABSTRACT
Edge is an important feature of an image and is required for image understanding. It provides important image information that can be used for image interpretation. Many techniques of edge detection have been developed. This paper proposes a new technique of edge detection that requires much lesser computation than Sobel's method and performs better than Sobel's method. The technique is based on additions and divisions. It makes use of a threshold value that is automatically computed by the program that implements this technique. The computation of the threshold value is very simple too.

General Terms
Edge detection, Digital Image Processing, Image segmentation.

Keywords
New edge detection method, arithmetic operations, computationally efficient, simpler computations.

1. INTRODUCTION
Edge detection is a technique to find out the edges of an image which are very important features of an image. Edge points are those points in an image which have a different intensity from the neighboring points. The points at which intensity changes forms the edge points. Many techniques of edge detection have been used in the past like discrete gradients, Laplacian operators, Marr-Hildreth Laplacian of Gaussian, Morphological gradient and Laplacian. Gradient methods work by finding maximum and minimum in the first derivative of the image. Laplacian method searches for zero crossings in second derivative of the image to find edges.

The gradient method of edge detection calculates the gradient magnitude as follows[1]:

$$G(x,y)= (\Delta x^2 + \Delta y^2)^{½}$$

and the direction is calculated as $\theta(x,y) = \tan(\Delta y/ \Delta x)$

where $\Delta x= f(x+n,y)-f(x-n,y)$

$\Delta y=f(x,y+n) - f(x,y-n)$

and n is a small integer, usually unity.

Different gradient operators are used like Prewitt, Roberts, Sobel, etc [1]. The Sobel operator is a discrete differentiation operator that computes an approximate gradient of the image intensity function. At each point of the image, the Sobel operator is either the corresponding gradient or the norm of this vector. The Sobel method convolves an image with a small, separable and integer valued filter in horizontal and vertical direction. It produces a gradient approximation that is crude especially for high frequency variations in the image. Sobel uses 3x3 kernels, which are convolved with the original image to calculate the approximate of the derivatives. The kernels G_x and G_y are given as follows:

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

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

and $|G| =|G_x| + |G_y|$

Sobel operator represents a rather inaccurate approximation of the image gradient, but is still of sufficient quality to be of practical use in many applications. It may prove to be inaccurate in the presence of noise.

2. LITERATURE REVIEW
Hou and Kuo [2] have presented a new edge detection method that gives better edge detection accuracy than 4-connected , 8-connected and Sobel techniques. It is based upon simple arithmetic and logic operations, consisting of three procedures: image binarization, image contraction and image subtraction. The algorithm works for automatic visual inspection. It makes use of no threshold. It can be used for both binary and grey scale images. According to this method, the grey scale images are first converted into binary images. This procedure can be eliminated for a binary image. Then, the image is contracted to get the

contents of the inspected region. Finally, the contents are subtracted from the inspected region to yield the boundary. Otsu's method of thresholding [1] has been used for image binarization. The image contraction is done by dividing the image by 9. Then, the whole image is shifted in 8 directions and eight shifted images are added to the unshifted image. Next, 8 is subtracted from the grey levels of the image obtained in the previous step. If the subtraction gets a negative value, then, the intensity of that pixel is set to zero. The objective of this procedure is to obtain results whose intensity values are one at this stage. Finally, the result is multiplied by 9 to get the content having the same grey levels as that of the original binary image. The proposed algorithm is easier to implement since it involves only arithmetic and logical operations.

Jiang and Bunke[3] have presented a novel method of edge detection based on scan line approximation. It provides edge strength measures that have a straightforward geometric interpretation. Their algorithm is superior to many region based algorithms in terms of segmentation quality and computational efficiency.

Genming et al [4] use a 5x 5 mask that reduces noise efficiently but does not increase width of the detected edge which always happens in case of 5x5 window edge detection. In order to handle the problem that the contrast decreases in the dark regions caused by underexposure, this detector uses a self-adjusting threshold, so that it can detect the edge in regions of different grey background correctly.

Qixiang Ye et al. [5] have proposed to find main edges meanwhile filter edges within texture regions. They have computed pixel similarity degree around a pixel, have computed a new gradient, and applied a Canny like operator to detect and locate edges. This method also gives very fine results.

Caragea [6] detects the difference between pairs of pixel around a pixel and uses the highest value from the difference of four pairs of pixels that can be used to form a line through the middle pixel.

Rital et. al [7] present a two stage paradigm of edge detection. Image is represented into Image Adaptive Neighborhood Hypergraph model. Local information of the given image is exploited. The hyper-edges of the image are classified as noise, edge or region based on combinatorial definitions. The researchers consider that local homogeneity characterizes edges, global homogeneity characterizes regions and no homogeneity characterizes noise.

Fesharaki and Hellestrand [8] apply a student –t test to compare the distribution functions of the intensities in the neighborhood of a given pixel and the pixel can be accurately classified as edge pixel or region pixel. Using a 5x5 window, the method works well for both synthetic and natural images.

In this paper, we propose a method that employs simple additions and divisions and finds out fine edges. It makes use of a threshold that is computed automatically during the edge detection process and is very simple to compute. The proposed method can be applied to simple images and when the images are very complex, it may not be used.

3. THE PROPOSED METHOD

The steps of the proposed algorithm are given below:

Step 1: The pixels in the image are scanned row by row from top left to bottom right and the pixel values are stored in a one dimensional array called Image- pixel array.

Step 2: Starting from the first element of the array, two consecutive pixel values from the Image- pixel array are taken at a time and added together and divided by 2. The resulting values are stored successively in another one dimensional array called Averages array.

Step 3: Similarly, starting from the first element, two consecutive values from the Averages array are taken at a time and added together and divided by 6. The resulting values are successively stored in a third array called One- sixth array.

Step 4: In a similar manner, starting from the first element of the One-Sixth array, two consecutive pixels are taken at a time from the One-Sixth array and added together and the results are successively placed in another array called Final-array.

Step 5: The highest value of the Final- array is taken and divided by the value 6. This value acts as the threshold value. The value 6 has been obtained by extensive experimentation.

Step 6: The original image pixels are retrieved row wise starting from top left and two consecutive pixels are taken at a time and if the absolute value of the difference of the two is greater than the threshold, then, the former pixel value is set to 1, otherwise, it is set to 0. This process goes on row wise from top left to bottom right end, till the end of image is reached, and the pixel values are set accordingly.

The resulting image is displayed and it gives fine edges that are better than those achieved by application of Sobel's method.

4. EXPERIMENTS AND RESULTS

The proposed method has been applied using Java on the images of an apple, a bride, the cameraman, and Lenna. The results for these images can be seen in Figure 1(b), Figure 2 (b),Figure 3(b) and Figure 4(b) respectively. The results of application of Sobel's method to these same images are shown in Figure 1 (c), Figure 2(c), Figure 3(c) and Figure 4 (c) respectively. It can be seen from the results that the proposed method is able to find out thinner, clearer and cleaner edges than those found out by Sobel's method.


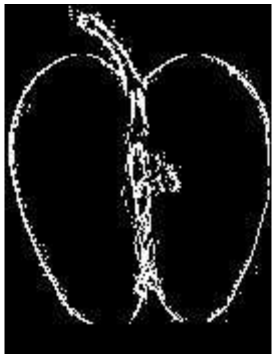

Figure 1 (a) Apple **Figure 1(b) The proposed Algorithm's result**

Figure 1(c) Sobel's Results


Figure 2(a)Bride **Figure 2 (b) The proposed Algorithm result**

Figure 2(c) Sobel's Result


Figure 3 (a) Cameraman **Figure 3 (b) Proposed algorithm Result**

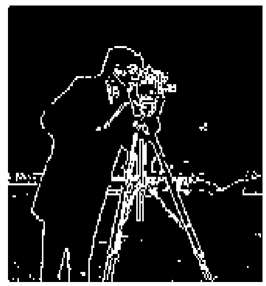

Figure 3(c) Sobel's Result


Figure 4(a) Lenna **Figure 4(b) Proposed algorithm**

Figure 4(c) Sobel result

5. COMPUTATIONAL EFFICIENCY

Computationally efficient techniques are much needed these days since computationally simpler techniques require less time and effort. Also, the image databases are very large. Extracting edges for all images is a time taking task. So, the computationally simpler technique would prove better for application on a large database than a more cumbersome technique that would take more time and resources and which would be more difficult to implement.

From the proposed algorithm, it can be shown that the proposed method of edge detection requires 15376 additions+ 15376 divisions +15375 additions +15375 divisions + 15374 additions + 1 division= 76877 operations for a 124 x124 image. Sobel method takes about 322896 operations to give results for the same image. Therefore, it can be said that the proposed method is computationally very much more efficient.

6. ADVANTAGES OF THE METHOD

The following are the advantages of the proposed method.

1. It involves only one scan line at a time instead of three scan lines that are required by Sobel masks.
2. It is computationally simpler.
3. It involves lesser number of computations when compared with Sobel's edge detection method.
4. It makes use of a threshold value that is computed by the program automatically.

7. CONCLUSION

Edge detection is a very important step for extracting features of an image which may be used for image identification. The proposed method is a computationally simpler and more efficient method for computation of edges and proves to be useful in finding edges with much less computations and is simple to implement. It proves to give results that are as good as and even better than Sobel's edge detection method based on gradient and 3x3 masks. This method can effectively be used in the areas of image processing, especially in very large databases.

8. REFERENCES

[1] Gonzalez and Woods, 2008. Digital Image Processing, Third Edition, Pearson Education.

[2]Hou, T. H. and Kuo, W.L., 1997. "A New Edge Detection method for Automatic Visual Inspection", International Journal of Advanced Manufacturing Technology, (1997) 13:407412 © 1997 Springer-Verlag London Limited.

[3] Jiang, X. and Bunke, H. 1998. "Edge Detection in Range Images based on Scan Line Approximation", Computer Vision and Image Understanding ,Vol. 73, No. 2, February, pp. 183–199, 1999 Article ID cviu.1998.0715, available online at http://www.idealibrary.com.

[4]Genming, C. and Bouzong, Y., 1989. "A New Edge Detector with Thinning and Noise resisting Abilities" , Journal of Electronics, China, Volume 6, No. 4, 314-319, DOI: 10.10071BF02778914.

[5] Qixiang, Ye, Wen, G., Weiqquiang, W. 2003. "A New Texture Insensitive Edge Detection Method",Institute of Computing Technology, Chinese Academy of Sciences ,China, ICICS-PCM 2003, 15-18 Dec 2003, Singapore.

[6] Caragea S. 2008. Fondater, Administrator and Chief Editor, IntelliProject, "Difference Edge Detection", Licensed under IntelliProject open License, Romania, http://www.intelliproject.net.

[7]Rital, S., Bretto A., Cherifi, H., Aboutajdine, D. 2002. "A combinatorial edge detection Algorithm on Noisy images", VIPromCom-2002, 4th EURASIP- IEEE Region 8 International Symposium on Video/image Processing and Multimedia Communications, 16-19 June 2002, Zadar, Croatia.

[8] Fesharaki N. Mehdi, Hellestrand Graham R. 1994. "A New Edge Detection Algorithm based on Statistical Approach", 1994 International Symposium on Speech, Image Processing and Neural Network, 13-16 April, 1994, Hong Kong.