SEGMENTING DIGITAL IMAGES USING EDGE DETECTION

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ABSTRACT

Image segmentation is an active topic of research for last many years. Edge detection in images significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image. In this paper, the two most commonly used edge detection methods (Laplacian and Sobel edge detectors) are discussed. It is found that Sobel edge detection algorithms perform better than Laplacian algorithms; however, the false edges are high in both cases for blurred or low resolution images. Therefore, a new algorithm and set of filters (kernels) is proposed and its results are compared with the Sobel and Laplacian filters for three images. From the results obtained it is found that the proposed algorithm performs better than in terms of less false edges than the Sobel and Laplacian filters.

Keywords: Edge Detection, Noise, Digital Image Processing

1.INTRODUCTION

Analytically, a digital image (composed of elements called pixels), is defined as a two dimensional function $f(x, y)$, where x and y are spatial (plane) co-ordinates. The value of 'f' at any pair of co-ordinate (x, y) is called the intensity 'or' gray level of the image at that point**.** The processing of digital images is called digital image processing. The most common digital image processing tasks include: resizing, zooming, image segmentation, edge detection and color enhancement. Among these techniques, this paper focused on image segmentation of digital images. Image segmentation separates an image into its component parts or objects. This process of image segmentation is usually done using edge detection techniques, which are basically   2-D filters and detects the edges depending upon the level of the intensity difference of pixels and the level of discontinuity [1-2]. Segmentation algorithms based on discontinuity approach partitions an image based on abrupt changes in intensity and those on similarity approach are based on partitioning an image into regions that are similar according to a set of predefined criteria [3-5]. Thus, the choice of image segmentation technique depends on the quality of detecting edges. In particularly, this depends on detecting intensity discontinuities in a digital image. Traditional methods of edge detection involve convolving the image through an operator/filter, which is constructed to be perceptive to large gradients in the image, although returning values of zero in uniform regions [6-7]. A large number of edge detection techniques are available, with mainly each technique designed to be perceptive to certain types of edges. Variables concerned in the selection of an edge detection operator consist of edge orientation, edge structure and noise environment. The geometry of the operator establishes a characteristic direction in which it is most perceptive to edges. Operators can be optimized to look for vertical, horizontal, or diagonal edges [6-8]. Edge detection is a difficult task in noisy images, as both the edges and noise hold high-frequency content. Efforts to reduce the noise result in unclear and distorted edges. This results in less perfect localization of the detected edges; and results in problems of fake edge detection, edge localization, and missing true edges [7-10].

2.SYSTEM MODEL

As discussed above, image segmentation is the process of partitioning a digital image into multiple regions or sets of pixels. This can be done by (i) finding boundaries between regions based on discontinuities in intensity levels, (ii) thresholds based on the distribution of pixel properties, such as intensity values, and (iii) finding the regions directly [6-11]. There are many image segmentation techniques utilizing these approaches. The choice of a particular image segmentation technique depends on the problem being considered. For example, region based methods are based on continuity. These techniques divide the entire image into sub regions depending on some rules like all the pixels in one region must have the same gray level. Region-based techniques rely on common patterns in intensity values within a cluster of neighboring pixels. Thresholding is another simplest way of segmentation [11-12]. Using thresholding technique, regions can be classified on the basis range values, which are applied to the intensity values of the image pixels. Thresholding is the transformation of an input image to an output that is segmentated binary image. Segmentation methods based on finding the regions directly find for abrupt changes in the intensity value. These

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methods are called as Edge or Boundary based methods. Edge detection techniques are generally used for finding discontinuities in gray level images. Edge detection is an active area of research as it facilitates higher level image analysis. There are three different types of discontinuities in the grey level like point, line and edges. Spatial masks can be used to detect all the three types of discontinuities in an image. The most commonly used discontinuity based edge detection techniques are Laplacian based edge detection, Roberts edge detection, Sobel Edge Detection, Prewitt edge detection, Kirsh edge detection, Robinson edge detection, Marr-Hildreth edge detection, LoG edge detection and Laplacian based edge detection. Among these techniques, Sobel and Laplacian edge detection is very famous. This paper focuses on Sobel Edge detection and proposes a new filter to overcome its shortcomings. These are discussed below.

Laplacian based edge detection:
The Laplacian method searches for zero crossings in the second derivative of the image to find edges. An edge has the one-dimensional shape of a ramp and calculating the derivative of the image can highlight its location. This method of locating an edge is characteristic of the "gradient filter" family of edge detection filters and also includes the Sobel method. A pixel location is declared an edge location, if the value of the gradient exceeds some threshold. As mentioned before, edges have higher pixel intensity values than those surrounding it. So once a threshold is set, the gradient value to the threshold value can be compared and an edge can be detected whenever the threshold is exceeded. Furthermore, when the first derivative is at a maximum, the second derivative is zero. As a result, another alternative to finding the location of an edge is to locate zeros in the second derivative. This method is known as the Laplacian edge detection. A very popular Laplacian based edge detection technique is the Marr-Hildreth edge detector. It is a gradient based operator which uses the Laplacian to take the second derivative of an image. The idea is that if there is a step difference in the intensity of the image, it will be represented by the second derivative by a zero crossing. The general algorithm for the Marr-Hildreth edge detector is:
a) Smoothing image using a Gaussian filter to reduce the amount of error found due to noise.
b) Applying a two dimensional Laplacian to the image

$$r^2 f = \frac{\partial^2 x}{\partial x^2} + \frac{\partial^2 y}{\partial y^2} \qquad (1)$$

This Laplacian will be rotation invariant and is often called the "Mexican Hat operator". It is because of its shape as shown in Figure 1. This operation is the equivalent of taking the second derivative of the image.
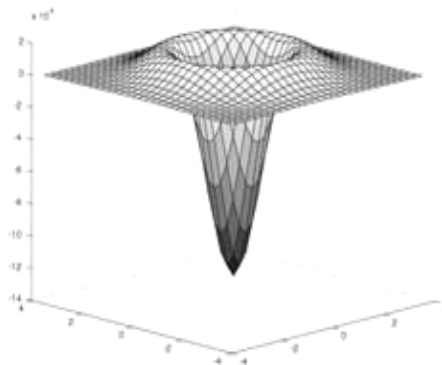

Figure 1: Mexican Hat [1].

c) Loop through every pixel in the Laplacian of the smoothed image and look for sign changes. If there is a sign change and the slope across this sign change is greater than some threshold, mark this pixel as an edge. Alternatively, these changes could be run in slope through a hysteresis rather than using a simple threshold.

Sobel operator: The Sobel edge detection method is introduced by Sobel in 1970. The Sobel method of edge detection for image segmentation finds edges using the Sobel approximation to the derivative. It precedes the edges at those points where the gradient is highest. The Sobel technique performs a 2-D spatial gradient quantity on an image and so highlights regions of high spatial frequency that correspond to edges. In general it is used to find the estimated absolute gradient magnitude at each point in n input grayscale image. The Sobel operator consists of a pair of 3×3 convolution kernels as shown in Table 1. One kernel is simply the other rotated by 90°.

Table 1: Masks used by Sobel operator.

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

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	Gx			**Gy**	

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 (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:

$$|G| = \sqrt{Gx^2 + Gy^2} \qquad (2)$$

Typically, an approximate magnitude is computed using:

$$|G| = |Gx| + |Gy| \qquad (3)$$

Equation (3) is much faster to compute. The above mentioned Sobel filter is reported to shown poor performances with low resolution images and does not consider high frequency content of images. Therefore, another filter is proposed as below.

Proposed method:

Similar to Sobel operator, the proposed method and operator shown in Table 2 performs a 2-D spatial gradient quantity on an image and highlight regions of high spatial frequency corresponding to edges. The kernels are designed to respond maximally to edges running diagonally in addition to vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations. The proposed operator consists of a pair of 3×3 convolution kernels as shown in Table 2.

Table 2: Masks used by the proposed operator.

-1	-2	-1		+1	0	-1
0	0	0		+2	0	-2
1	+2	1		+1	0	-1
	Gx				**Gy**	

i-2, j		i, j		i-2, j	i-1, j	i, j
i-2, j-1		i, j-1				
i-2, j-2		i, j-2		i-2, j-2	i-1, j-2	i, j-2
	Gx				**Gy**	

The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (Gx and Gy), as given by:

$$Gx = (f(i,j-2) + f(i,j-1) + f(i,j)) - (f(i-2,j-2) + f(i-2,j-1) + f(i-2,j)) \qquad (4)$$

And,

$$Gy = (f(i-2,j) + f(i-1,j) + f(i,j)) - (f(i-2,j-2) + f(i-1,j-2) + f(i,j-2)) \qquad (5)$$

These are then combined together to find the absolute magnitude of the gradient at each point, as given by:

$$|G| = \sqrt{Gx^2 + Gy^2} \qquad (6)$$

The above mentioned Sobel filter is reported to shown poor performances with low resolution images and does not consider high frequency content of images. However, the above mentioned filter considers both the low and high frequency content of images. The results obtained for the same filter are discussed below.

3. RESULTS & DISCUSSION

This section presents the results of the proposed filter in comparison to Sobel filter and the Laplacian filter. The edge detection techniques were implemented using Matlab, and tested for many images. However, the results obtained for

pictures of house, lena and butterfly are reported in Figures 2, 3 & 4 respectively in this paper. The edge maps are produced by extracting the principal edge features of the image, using the above edge detection techniques.
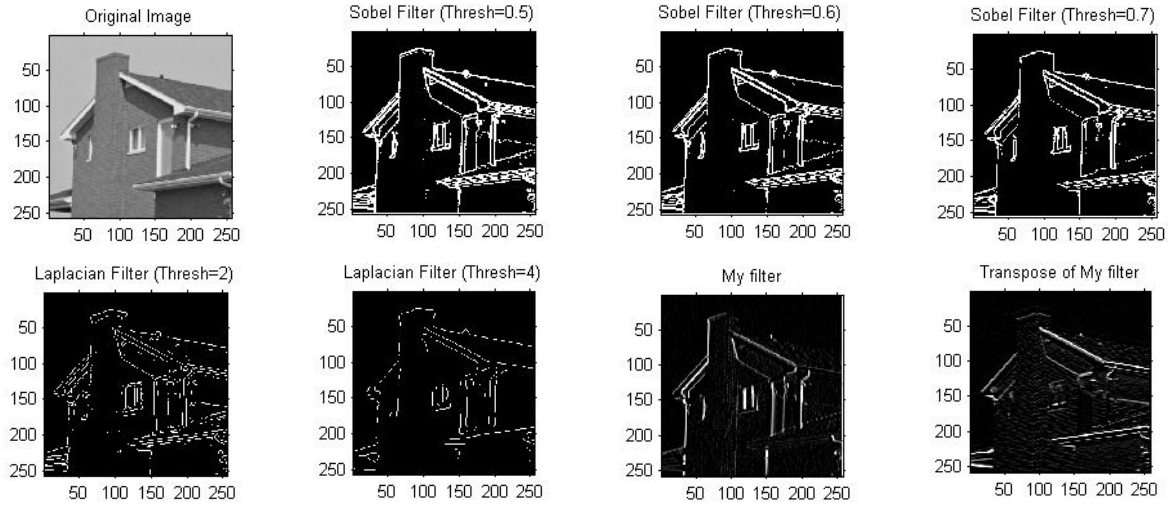

Figure 2: Original image of house with the result of Sobel edge detector (Threshold=0.5, 0.6 & 0.7) and Laplacian filter (Threshold=2 & 4) and the proposed filter. It can be seen that there are less false edges in the proposed filter.
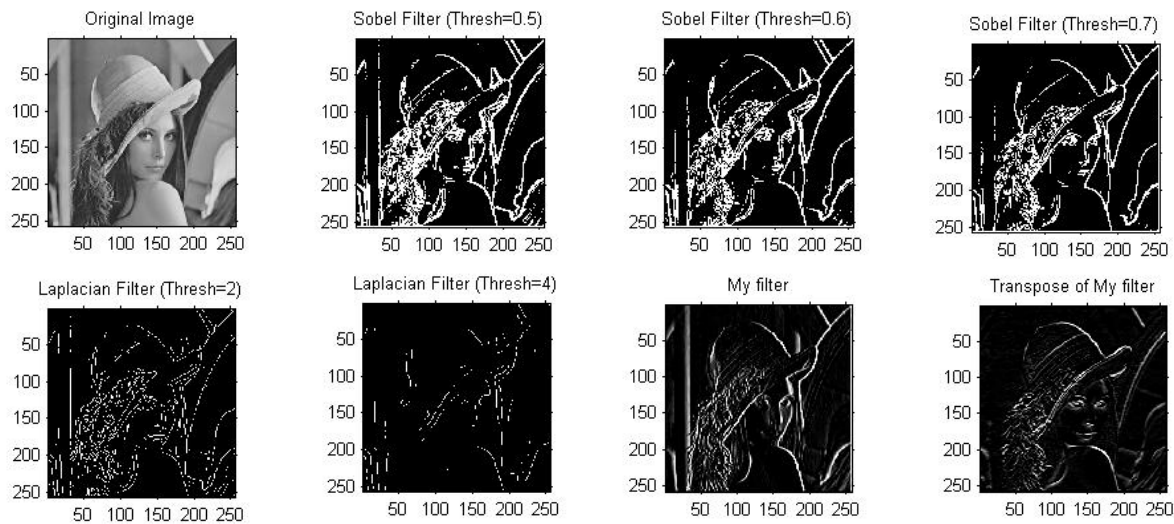

Figure 3: Original image of Lena with the result of Sobel edge detector (Threshold=0.5, 0.6 & 0.7) and Laplacian filter (Threshold=2 & 4) and the proposed filter.
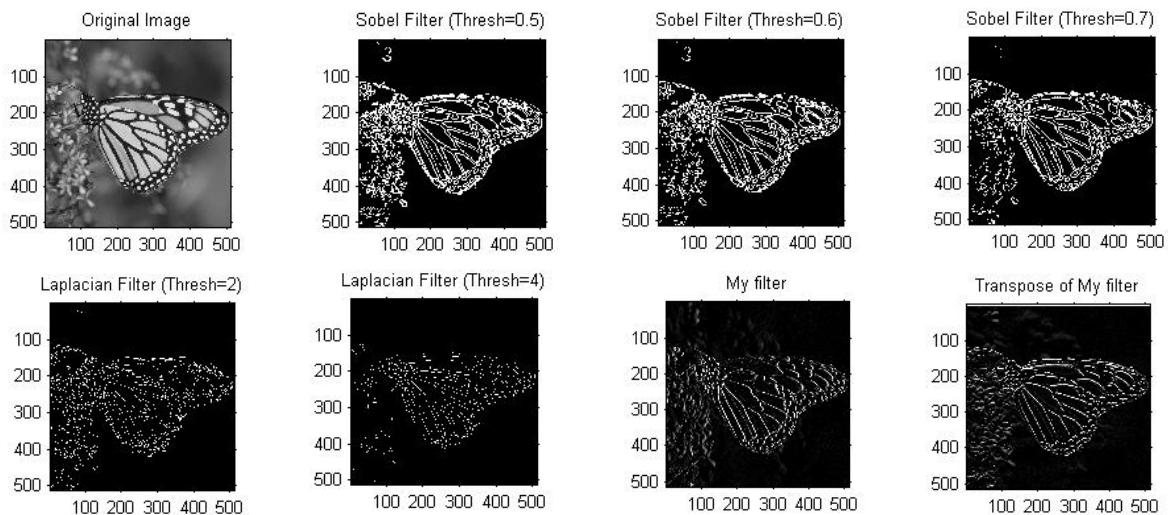
Figure 4: Original image of butterfuly with the result of Sobel edge detector (Threshold=0.5, 0.6 & 0.7) and Laplacian filter (Threshold=2 & 4) and the proposed filter.

4. CONCLUSIONS

The evaluations and comparisons made in this paper are made through visual observations only and may vary with the individual. From the results obtained, it can be concluded that the proposed filter proved to be very effective for edge enhancement purposes. It is observed that for the three images used, there are less false edges in the proposed filter. From the results, it is concluded that results obtained from the newly designed filter are the best in comparison to Sobel and Laplacian 2D FIR filters used for different threshold limits. The results obtained by this filter are better in terms of intensity of edges than the Sobel and Laplacian 2D FIR filters.

REFERENCES

[1.] S. Lakshmi & V.Sankaranarayanan (2010) "A Study of edge detection techniques for segmentation computing approaches", Computer Aided Soft Computing Techniques for Imaging and Biomedical Applications, 35-41.
[2.] P. Thakare (2011) "A Study of Image Segmentation and Edge Detection Techniques", International Journal on Computer Science and Engineering, Vol 3, No.2, 899-904.
[3.] N. Senthilkumaran & R. Rajesh (2009) "Edge Detection Techniques for Image Segmentation – A Survey of Soft Computing Approaches", International Journal of Recent Trends in Engineering, Vol. 1, No. 2, 250-254.
[4.] B. Sowmya & B. Sheelarani (2009) "Colour Image Segmentation Using Soft Computing Techniques", International Journal of Soft Computing Applications, Issue 4**,** 69-80.
[5.] U. Sehgal (2011) "Edge detection techniques in digital image processing using Fuzzy Logic", International Journal of Research in IT and Management, Vol.1, Issue 3, 61-66.
[6.] K. J. Pithadiya, C. K. Modi & J. D. Chauhan (2011), "Selecting the Most Favourable Edge Detection Technique for Liquid Level Inspection in Bottles" International Journal of Computer Information Systems and Industrial Management Applications (IJCISIM) ISSN: 2150-7988 Vol.3, pp.034-044, 2011.
[7.] S. Jeong You & N. I. Choet (2011), "A New Image Denoising Method Based On The Wavelet Domain Nonlocal Means Filtering", International Conference on Acoustics, Speech and Signal Processing (ICASSP), pp. 1141-1144.
[8.] Z. Zhang & G. Zhao (2011), "Butterworth filter and Sobel edge detection to image", International Conference on Multimedia Technology (ICMT), pp. 254-256.
[9.] C. Deng, W. Ma & Y. Yin (2011), "An Edge Detection Approach of Image Fusion Based on Improved Sobel Operator" 4th International Congress on Image and Signal Processing, pp. 1189-1193.
[10.]Zhang Jin-Yu, Chen Yan, Huang Xian-Xiang (2009), "Edge Detection of Images Based on Improved Sobel Operator and Genetic Algorithms", International Conference on Image Analysis and Signal Processing (ICASP),pp. 31-35.
[11.]T. Zaveri & M. Zaveri (2009), "A Novel Region based Image Fusion Method using High boost Filtering" International Conference on Systems, Man, and Cybernetics, pp. 966-971.
[12.]Z. Zhang & G. Zhao (2011), "Butterworth filter and Sobel edge detection to image", International Conference on Multimedia Technology (ICMT), pp. 254-256.