Comparison of Edge Detection Techniques for Brain MRI Image

A.V.Kavitha
Dept. of Computer Science
Govt. College for Women,
Guntur, India

Madhulika.Y
Dept. of Information Technology
RVR &JC College of Engineering,
Guntur, India

Siddardha Kumar .M
Dept. of Information Technology
RVR &JC College of Engineering,
Guntur, India

***Abstract*— Edge detection is an important task in any image processing application. An edge is a boundary between two disjoint regions. To recognize any unusual objects or growths automatically in medical images, medical image segmentation plays a predominant role and proper edge detection is a crucial step for efficient medical image segmentation. In this paper various algorithms based on first order derivatives and second order derivatives like Sobel algorithm, prewitt algorithm, Laplacian of Gaussian algorithms , Canny algorithm, algorithms based on mathematical morphology are studied. These algorithms are applied on brain MRI image. The investigational results are shown for detecting edges from a normal brain MRI image and on a noisy medical image. Results shows that canny edge detection technique extracts edges well from a brain MRI image, where as few algorithms of mathematical morphology perform better in case of detecting edges from noisy medical images.**

Keywords- Medical image, edge detection, mathematical morphology, noisy images.

I. INTRODUCTION

Interpretation of image contents is a significant objective in computer vision and image processing. In order to extract the outline of an object, we must identify the edges forming that object, and this detail reveals the constitutional significance of edge detection in image processing[1]. Edge detection is a process that finds the presence and location of edges formed by sharp changes in color intensity of an image. An essential property of the edge detection method is its ability to take out the exact edge line with good orientation. Many edge detection techniques are available. Generally, an edge detection method can be expressed in three stages. A noise reduction process is performed in the first stage. Image noise should be condensed as much as possible, in order to achieve better performance of edge detection. Noise reduction is usually achieved by performing a low-pass filter because the additive noise is normally a high-frequency signal.

However, the edges can possibly be removed at the same time because they are also high frequency signals. Hence, a parameter is commonly used to make the best trade-off between noise reduction and edges information preservation. In the second stage, a high-pass filter such as a differential operator is usually employed to find the edges. In the last stage, an edge localization process is performed to identify the genuine edges, which are distinguished from those similar responses caused by noise.

In this paper various edge detection techniques are studied on a brain MRI image. Sobel, Prewitt, Robert, Laplacian of Gaussian, Canny edge detection techniques are applied on brain MRI image. Along with these techniques various methods based on mathematical morphology are also applied. All these techniques are applied on normal brain MRI image and also on brain image with salt and pepper noise and the results are analyzed.

The rest of the paper is organized as follows. Section II discusses various conventional edge detection techniques. Section III describes edge detection techniques based on mathematical morphology. Section IV presents the results. Finally, Section V concludes the paper.

II. VARIOUS EDGE DETECTION TECHNIQUES:

A. *Sobel Edge Detector:*

In image processing , the Sobel Edge Detector is used particulary within edeg detection algorithms. It is a simple edge detection technique which uses the 3x3 convolution masks for detection of edges in horizontal and vertical directions. The masks are shown in the Fig(1) .Both of these masks are used to compute the gradient magnitude and direction [1],[3],[15].

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

(a)

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

(b)

Figure 1. Sobel Operator Masks

B. *Prewitt Edge Detector:*

Prewitt Edge detector works almost like Sobel operator but have the following kernals [1],[3],[15].

Identify applicable sponsor/s here. *(sponsors)*

-1	-1	-1	-1	0	+1
0	0	0	-1	0	+1
+1	+1	+1	-1	0	+1
	(a)			(b)	

Figure 2. Prewitt Operator Masks

C. Laplacian Edge Detector:

The Laplacian operator is a second order derivative operator used for edge detection. It is from the zero crossing category of the edge detection technique. It yields better edge localization when compared with first order derivative based edge detection techniques but it is sensitive to noise [1],[3],[15].

The Laplacian of an image I(x,y) is given as [1]

$$L(x,y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$

Two commonly used small kernels are shown in Fig(3).

0	-1	0	-1	-1	-1
-1	+4	-1	-1	8	-1
0	-1	0	-1	-1	-1
	(a)			(b)	

Figure 3. Laplacian Operator Masks

D. Roberts Edge Detector:

2-D spatial measurement of gradient is performed by Roberts operator on digital image. It highlights the regions of high spatial frequency which corresponds to the edges [1],[3] .The cross convolution masks are shown in Fig(4).

-1	0	0	-1
0	1	1	0
(a)		(b)	

Figure 4. Roberts Operator Masks

E. Laplacian of Gaussian Edge detector:

Laplacian of Gaussian edge detector first removes noise from the image by applying Gaussian operator and then detects edges by using Laplacian operator [1],[3],[6][15].

Kernel for the LOG operator is shown in fig(5):

0	0	-1	0	0
0	-1	-2	-1	0
-1	-2	16	-2	-1
0	-1	-2	-1	0
0	0	-1	0	0

Figure 5. Kernel of LOG operator

F. Canny Edge Detector:

J.F Canny in [14] has proposed an Computational Approach to Edge Detection which is known as optimal edge detector .The Canny's intentions were to enhance the many edge detectors already out at the time he started his work. He was very successful in achieving his goal and his ideas and methods can be found in his paper, "An Computational Approach to Edge Detection "[14].The algorithm runs in 6 separate steps:

1. Smoothing: Blurring of the image to remove noise
2. Finding gradients: The edges should be marked where the gradients of the image has magnitudes
3. Direction calculation: In this step, direction of edge should be calculated.
4. Non maximum suppression: Only local maxima should be marked as edges
5. Double thresholding: Potential edges are determined by thresholding.
6. Edge tracking by hysteresis: Finally edges are determined by suppressing all edges that are not connected to very certain (strong) edge .

III. EDGE DETECTION USING MATHEMATICAL MORPHOLOGY

A Mathematical Morphology works on the basis of a structuring element. Both image and the structuring element are treated as sets and makes use of basic set theory concepts. Basic operations of mathematical morphology are dialation and erosion. Few edge detecting algorithms are developed based on these fundamental concepts.

Structuring element:

Structuring the element is as essential part of dilation and erosion. It is a matrix consisting of only 0's and 1's that can have any random shape and size. The pixels with values of 1 define the neighborhood [1].

Size of structuring elements are generally much smaller than the image being processed [1]. The origin which is the centre pixel of structuring element , identifies the pixel being processed. The neighborhood of the structuring element is defined as the pixels in structuring element containing 1's. Three-dimensional structuring elements use 0's and 1's to define the extent of the structuring element in the x- and y-planes and add height values to define the third dimension.

The centre pixel of the structuring element, called the origin, identifies the pixel being processed. The pixels in the structuring element containing 1's define the neighborhood of the structuring element. These pixels are also considered in dilation or erosion processing. Three-dimensional structuring elements use 0's and 1's to define the extent of the structuring element in the x- and y-planes and add height values to define the third dimension.

A. Dilation residue edge operator:

Dilation is one of the two basic operators of mathematical morphology. It is generally applied to binary images and on gray scale images. The basic effect of the operator on a binary image is to gradually enlarge the boundaries of regions of foreground pixels. Thus areas of foreground pixels grow in size while holes within those regions become smaller [9].

Dilation residue edge operator, denoted by $E_d(I)$ is defined as the differnce between the dilation of I by the structuring element say 'B' and the image set 'I'.

$$E_d(I) = (I \oplus B) - I$$

B. Erosion residue edge operator:

Erosion is one of the two basic operators of mathematical morphology. The basic effect of the operator on a binary image is to erode away the boundaries of regions of foreground pixels . Thus areas of foreground pixels shrink in size, and holes within those areas enlarge[9].

Erosion residue edge operator, denoted by $E_e(I)$ is defined as the differnce between the image set I and the erosion of 'I' by the structuring element say 'B'.

$$E_e(I) = I - (I \Theta B)$$

C. Morphological gradient operator:

Morphological gradient operator [9],[11] , denoted by *G*(I) is given by

$$\mathbf{G(I)} = (I \oplus B) - (I \Theta B).$$

D. Opening top hat transformation :

The opening top-hat transformation of image I, denoted by THo (i), is defined as the difference between the image set ' I' and the opening of I by the structured element 'B' [4],[8].

$$THo(I) = I - (IoB).$$

E. Closing top hat transformation :

The closing top-hat transformation of image I, denoted by THc (I), is defined as the difference between the closing of I by the structured element 'B' and the image set ' I' [4],[8].

$$THc(I) = (I \bullet B) - I.$$

F. Edge Detection algorithm proposed by Zhao yu-quain[10]:

According to the Edge detection technique proposed by Zhao yu-quain[10] , Opening-closing operation is firstly used as pre-processing to filter noise. Then smooth the image by first closing and then dilation. The perfect image edge will be got by performing the difference between the processed image by above process and the image before dilation. The following is the novel algorithm:

$$([(I \bullet B)oB] \bullet B) \oplus B - [(I \bullet B)oB]$$

IV. RESULTS AND DISCUSSIONS

In this section , results of various edge detection techniques are compared. Fig(6) is the original brain image. Fig(7), Fig(8), Fig(9), Fig(10) ,Fig(11) are the results of brain MRI images processed with sobel, prewitt, Roberts, Laplacian of guassian and canny edge detection operators.

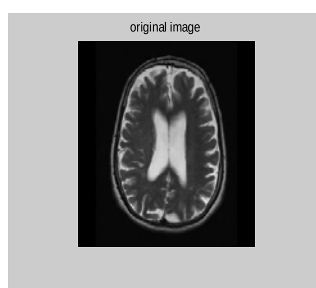

Figure 6. Original MRI Brain Image

Figure 7. Sobel Edge Detected Image

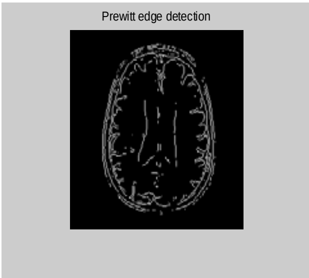

Figure 8. Prewitt Edge Detected Image

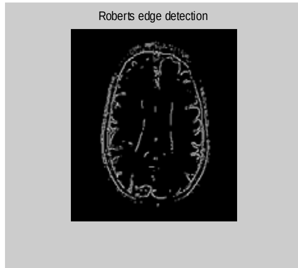

Figure 9. Roberts Edge Detected Image

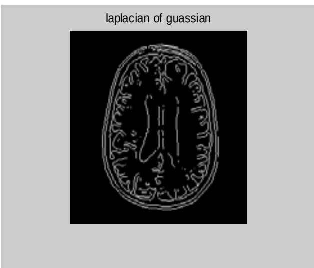

Figure 10. Log Edge Detected Image

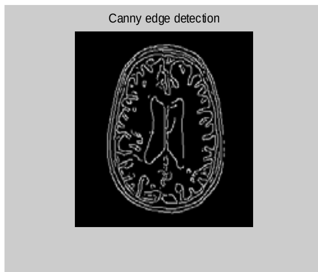

Figure 11. Canny Edge Detected Image

Based on the experimental results shown in fig(7), fig(8), fig(9), we can say that sobel , prewitt and Roberts edge detection operators are able to detect the edges, but failed to detect them properly. From fig(10), we can say Laplacian of Gaussian operator performs better than all previous three operators. Still at the corners it can't properly detect the edges. From fig(11), we can say that canny edge detection operator performs well, when compared to all the previous operators. As non-maximum suppression takes place in canny edge detection operator , it results in thin edges. Fig(12) and fig(13) are the results of images detected with morphological operators. Fig(12) shows the results of applying gradient operator on brain MRI image where as fig(13) shows the results of applying mathematical morphology method referred by[10].

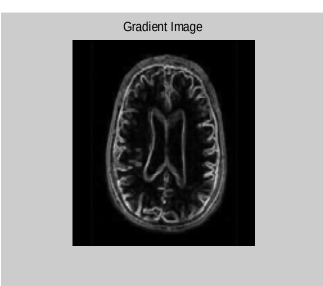

Figure12 .Gradient edge detected Image

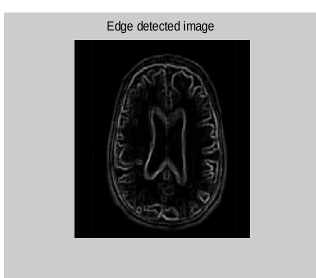

Figure 13. Edge Detected Image proposed by Zhao yu-quain[10].

As we can use different stucturing elements in mathematical morphology, edges can be clearly detected, when compared to all previous methods. Edges are more thick in gradient operated image when compared to canny edge detector.

The following are implementation screen shots of gradient and algorithem proposed by Zhao yu-quain[10].

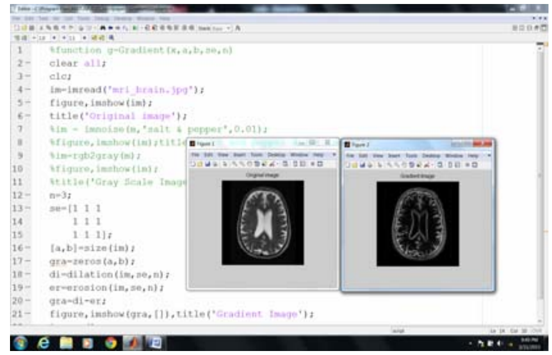

Figure 14. Implementation screen shot of gradient algorithm.

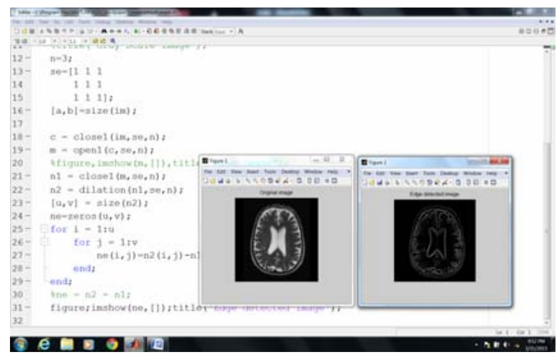

Figure 15. Implementation screen shot of Zhao yu-quain[10] algorithm

When all the methods are applied on a brain MRI image with salt and pepper noise. Fig(16) shows noisy image. Fig(17), Fig(18), Fig(19) shows that sobel, prewitt and roberts operators eliminated few of the edges instead of noise.

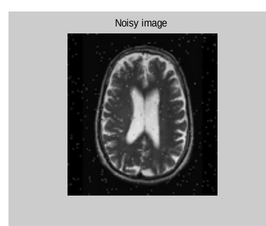

Figure 16. Noisy image
From noisy image

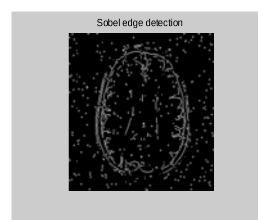

Figure 17. Sobel edge detection
From noisy image

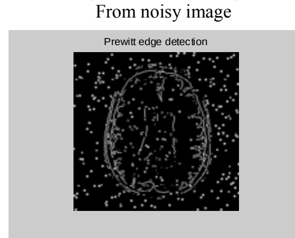

Figure 18. Prewitt edge detection
From noisy image

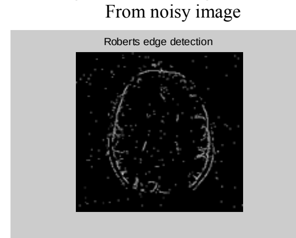

Figure 19. Robert edge detection
From noisy image

When compared to original salt and pepper noise brain MRI image , we can see that sobel and prewitt operators have enhanced the noise.

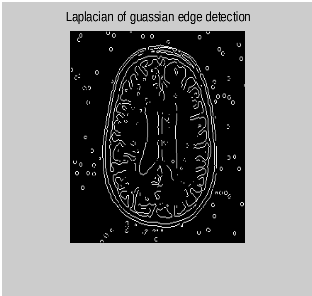

Figure 20. Laplacian of Guassian edge detection From noisy image

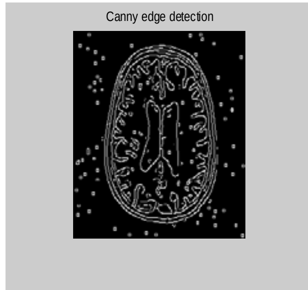

Figure 21. Canny edge detection From noisy image

Fig(20) and Fig(21) shows that Laplacian of Gaussian and Canny edge detector have detected the edges correctly but noise is not properly removed.

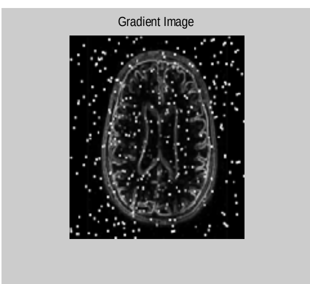

Figure 22. Gradient edge detection from noisy image

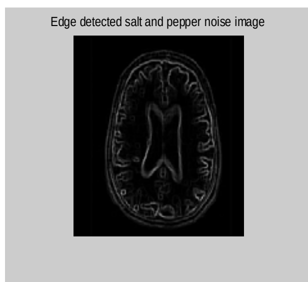

Figure 23. Edge Detection from noisy Image Proposed by Zhao yu-quain[10].

Fig(22) shows that gradient operator of mathematiacal morphology also has detected the edges but was unable to eliminate salt and pepper noise. Where as Mathematical morphological algorithm referred by Zhao yu-quain[10] has efficiently removed the noise as shown in Fig(23).

V. CONCLUSIONS

Various edge detection techniques are studied while applying them on a brain MRI image. Among 'Sobel', 'Prewitt', 'Robert', 'Laplacian of Guassian' and 'Canny' edge detector algorithms, 'Canny' algorithm performed well for a noiseless plain brain MRI image. 'Canny' algorithm has given thin and complete edges when compared to the above said other algorithms. Mathematical morphological algorithms like gradiant and Zhao yu-quain[10] algorithm also resulted in complete edge detection. The morphological edge detection works well in salt and pepper noise than the first order and second order derivative edge detection technique.

REFERENCES

[1] R.C. Gonzalez and R.E. Woods, Digital Image processing (3rd Edition).Upper Saddle River, NJ, USA: Prentice Hall, Inc 2006.

[2] E. Argyle. "Techniques for edge detection," Proc. IEEE, vol. 59, pp. 285-286, 1971

[3] Shashidhar Ram Joshi,Roshan koju," Study and Comparison of Edge Detection Algorithms", IEEE,2012.

[4] Chen T., and Wu Q.H., Rahmani-Torkaman R., Hughes J., "A pseudo top-hat mathematical morphological approach to edge detection in dark regions," *Pattern Recognition*, vol. 35, pp. 199-210, 2002

[5] H. Tang, E.X. Wu, Q.Y. Ma, D. Gallagher, G.M. Perera, and T. Zhuang, "MRI brain image segmentation by multi-resolution edge detection and region selection," *Computerized Medical Imaging and Graphics*, vol 24, pp. 349–357, 2000

[6] Huertas, A. and Medioni, G., "Detection of intensity changes with sub pixel accuracy using Laplacian-Gaussian masks," *IEEE Trans. On Pattern Analysis and Machine Intelligence,* PAMI, vol. 8, pp. 651–664, 1986.

[7] Jing Xiao-jun, Yu Nong, and Shang Yong, "Image Filtering Based on Mathematical Morphology and Visual Perception Principle,"

[8] J. Serra, *Image Analysis and Mathematical Morphology*, Academic Press, New York, 1982.

[9] Lee J.S.J., Haralick R.M., and Shapiro L.G., "Morphological Edge Detection," *IEEE J. Robot. Automat*, vol. 3, pp. 142–156, February 1987.

[10] Zhao yu-qian, Gui Wei-hua, Tang Jing-tian and Li Ling-Yun, "Medical Images Edge Detection Based on Mathematical Morphology", proceedings of 2005 IEEE Engineering in medicine and Biology 27th annual conference.

[11] Maragos P., "Differential Morphology and Image Processing," *IEEE Trans Image Processing*, vol. 5, pp. 922–937, June 1996.

[12] Richard A P, "A New Algorithm for Image Noise Reduction Using Mathematical morphology," *IEEE Transaction on Image Processing*, vol. 4, pp. 554–568, March (1995).

[13] Rivest Jean, "Morphological Operators on Complex Signals," *Signal Processing*, vol. 84, pp. 133–139, January 2004.

[14] J. F. Canny. " A computational approach to edge detection" IEEE Trans. Pattern Anal. Machine Intel , vol. PAMI-8, no. 6, pp. 679-697, 1986

[15] http://www.mathworks.com/matlabcentral/fileexchange/13628-edge-detection-and segmentation

AUTHORS PROFILE

Smt. A.V.Kavitha is working as incharge of computer science department at Govt. college for women, Guntur, Andhra Pradesh, India. She completed M.Sc in Computer science from Indore University, Indore. She attended and presented papers in various national seminars and conferences. Her research interests are image processing , computer vision and data structures and algorithms.

Smt.Y.Madhulika is working as Assisstant professor in department of Information Technology, RVR & JC college of Engineering, Guntur, Andhra Pradesh. She completed Master of technology from Guru Nanak Engineering College, Hyderabad, Telangana, India. She attended various International and National Conferences and workshops. Her research interests are Data mining, Digital image processing and Data structures and algorithms.

Mr.M.Siddardha Kumar is working as Assistant Professor in department of Information Technology, RVR & JC College of Engineering , Guntur, Andhra Pradesh, India. He completed Master of technology from GITAM University, Visakapatnam, Andhra Pradesh, India. He attended various International, National Conferences and workshops. His research interests are Digital Image Processing, Computer Networks, Data Structures and Algorithms.