An Analysis of Edge Extraction for MRI Medical Images through Mathematical Morphological Operators Approaches

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ABSTRACT:
Medical image processing plays a major role in diagnosing of various human diseases, these images may be affected from noises i.e. unwanted signals or disturbance during acquisition thus it leads to disorder in identifying the affected human organs, in order to overcome this problem various pre-processing techniques are involved. The main objective is to segment the MRI medical image through extraction of the edges for the betterment of diagnosis process of an affected human organ. Edge extraction is done by adding the morphological operations such as erosion, dilation etc with existing edge detectors such as sobel, compass operators. This paper involves in evaluating the quality of an image and edge strength through parameters PSNR, MSE, Edge stability measures.

Keywords
Medical image, Edge detection, Morphological operators.

1. INTRODUCTION
The digital image processing techniques are broadly classified into following phases: Image acquisition, Image Enhancement, Image Restoration, Color Image processing, Wavelets, Compression, Morphological Processing, Image Segmentation, Representation and Description, Object Recognition.

Image segmentation is one of the important factors in image processing [1].It is the process of dividing a digital image into various sub-regions. The selected pixels in the sub-region have the similar properties of the color, intensity and texture [12].This type of segmentation which is referred as region-based segmentation.

The boundary based segmentation which can be done by Edge detection. It is the process of identifying and locating sharp discontinuities in an image [1], [2], and [3].Edge detection is a fundamental problem in medical images analysis. In order to obtain a clear image, removal of noise in medical image has to be done. The purpose of edge detection is to identify areas of an image where a large change in intensity occurs [4]. Several techniques for detecting gray-level discontinuities in a digital image can be done by: point, lines and edges [7].

Mathematical morphology is a pre-or post-processing tool used for extracting image components which are useful in the representation and description of region shape, such as boundaries, skeletons and convex hull [6].This paper which estimates the betterment of an edge extraction of an intensity based MRI medical image by using existing edge detectors with morphological operators, also the image quality metrics also determined.

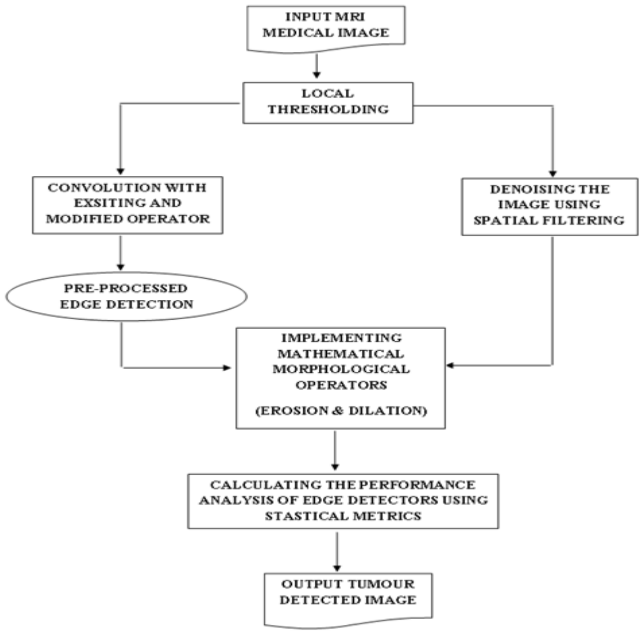


Fig 1: BLOCK DIAGRAM FOR LOCAL PRE-PROCESSED EDGE EXTRACTION

2. MRI MEDICAL IMAGE ACQUISTION
Initially the image is taken from Magnetic Resonance imaging (MRI), this image which consists of noises and with ambiguity.MRI is a technique which is to scrutinize the internal structure of the human body.MRI scanner is a device which patient is made to lie with powerful magnetic field, and thus magnetic gradient is obtained based on rotating the magnetic field. These gradient are used to examine the tumors, connective tissues and muscle etc.While comparing with CT scan, X-ray, MRI uses the non-ionizing radio frequency (RF) signals to acquire its image which is best suitable for soft tissues.

3. THRESHOLDING

Thresholding is another method which is used in image segmentation. It compares the input image into pixels of two or more values with the predefined threshold value T individually. Let f(x,y) is the gray level of point(x,y) and p(x,y) denotes some local property of this point. A threshold image g(x,y) is defined as,

$$g(x,y)=\{1 \text{ if } p(x,y) \geq T ,0 \text{ if } p(x,y)\leq T\} \tag{1}$$

When T depends only on f(x,y) then the threshold is called *global*. If T depends on both f(x,y) and p(x,y) then the threshold is called *local*.If in addition,T depends on the spatial coordinates x and y then the threshold is called *dynamic or adaptive*[6].

4. IMAGE SEGMENTATION TECHNIQUES

The most common methods which are used in image segmentation are boundary-based and region based. In boundary-based the partition of an image is based on the intensity values and in region-based the partition of an image is based on the similar properties such as color, intensity and texture. Various processes involved after segmentation are Filtering, Detection and Enhancement. Image Segmentation which determines the boundary of an object in an image and those boundaries are referred as Edges.

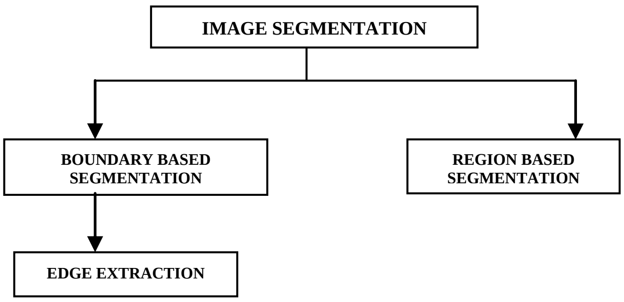


Fig 2: IMAGE SEGMENTATION METHOD

5. EDGE DETECTION TECHNIQUES

Medical image edge detection is a major task for object recognition of the human organ and it is one of the pre-processing techniques in segmentation et al [11].An edge is a set of connected pixels that lie on the boundary between two regions.The classification of the edge detection algorithms which are based on the behavioural study of edges with respect to the operators.they are (i)Classical or Gradient based edge detectors(First derivative) (ii) Zero crossing(second derivative) (iii)Laplacian of Gaussian(LoG) (iv) Gaussian edge detectors (v) colored edge detectors[12]

Three fundamental steps performed in edge detection are(i)Image smoothing for noise reduction(ii)Detection of edge points(iii)Edge localization.

Various edge detectors are used in this technique, they are as follows.

5.1 GRADIENT BASED OPERATORS

It is obtained by computing the partial derivatives ∂f/∂x and ∂f/∂y at every pixel location in image, where f(x,y) is the image with its neighborhood pixels

-1
1

$$G_X = \partial f(x,y)/\partial x = f(x+1,y) - f(x,y) \tag{2}$$
$$G_Y = \partial f(x,y)/\partial x = f(x,y+1) - f(x,y) \tag{3}$$

Equ (2) &(3) which determines 1D mask for f(x,y)

-1	1

1D mask for gradient operator

5.1.1 THE FIRST-ORDER DERIVATIVES

The Gradient of an image is given by Gx, Gy and its intensity is given by Z and the 3*3 region is given as

Z_1	Z_2	Z_3
Z_4	Z_5	Z_6
Z_7	Z_8	Z_9

The first order derivative at point x of 1D function f(x) by expanding the function **f(x+Δx)** in the Taylor series about x, is Δx=1given by

$$\partial f/\partial x = f'(x) = f(x+1)-f(x) \tag{4}$$

5.1.1.1 SOBEL OPERATOR

This operator consists of a pair of 3×3 convolution kernels as shown in Fig. One kernel is simply the other rotated by 90°. Sobel is used for better noise suppression (smoothing).The partial derivatives using 3×3 are given by,

$$G_X = \partial f/\partial x = (Z7+2Z8+Z9) - (Z1+2Z2+Z3) \tag{5}$$
$$G_Y = \partial f/\partial y = (Z3+2Z6+Z9) - (Z1+2Z4+Z7) \tag{6}$$

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

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

Fig 3: Masks used by Sobel Operator

The kernels can be applied separately such as Gx and Gy to the input image, to produce the gradient component which is given by

$$G=Gx+Gy \quad (7)$$

5.1.1.2 MODIFIED SOBEL OPERATOR

In this modified sobel operator an additional 3×3 convolution kernel by rotating along diagonal axis is created and added with existing horizontal and vertical gradient is shown in fig

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

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

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

Fig 4: Masks used by Modified Sobel Operator

$$G_X=\partial f/\partial x= (Z7+2Z8+Z9) – (Z1+2Z2+Z3)$$
$$G_Y=\partial f/\partial y= (Z3+2Z6+Z9) – (Z1+2Z4+Z7)$$
$$G_Z=\partial f/\partial z= (Z1+2Z2+Z4) – (Z6+Z8+2Z9) \quad (8)$$

The gradient component of Modified sobel operator with the kernals can be determined as

$$G_m=G_X+G_Y+G_Z \quad (9)$$

5.1.1.3 COMPASS OPERATOR

This operator which measures the gradient in a selected number of directions [14].The gradient at location(m,n) is defined as

$$g(m,n)\Delta=\max k\{|gk(m,n)|\} \quad (10)$$

1	1	1
0	0	0
-1	-1	-1

Fig 5: Rotated from 90 deg to 360 deg

3×3 arrays are mutually orthogonal and the arrays are called as *orthogonal* gradients. The gradient component of compass operator is given by

$$G_C = 45 \text{ deg } (G) \quad (11)$$

5.1.1.4 MSCWM OPERATOR

This operator which measures the compass gradient at 405 degrees and modified sobel operator also added.The gradient component of Test operator with 3×3 is given by

0	1	1
-1	0	1
-1	-1	0

G_C at 405 deg

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

+

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

+

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

$G_m=G_X+G_Y+G_Z$

The gradient component of test operator is given by

0	1	1
-1	0	1
-1	-1	0

+

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

+

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

+

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

$$GT = GC + Gm \quad (12)$$

5.1.2 THE MORPHOLOGICAL OPERATOR

Morphology in medical image processing is a tool used for extracting image components such as boundaries and skeletons. This morphing process is done on binary images. Morphology is based on reflection and translation. The reflection of set B ,denoted $\hat{B}$ is defined as

$$\hat{B} = \{\omega|\omega = -b \text{ for } b \in B\} \quad (13)$$

and the translation of set A by point Z=(Z1,Z2),denoted (A)Z is defined as

$$(A)z = \{c|c = a + z, \text{for } a \in A\} \quad (14)$$

Two principal morphological operations are dilation and erosion. Dilation which allows the objects to expand and connecting the disjoint objects whereas erosion which shrinks the object by eroding the boundaries away. These operation can be done by applying the structural element which is an interaction set. Dilation of A by B,denoted as $A \oplus B$is defined as

$$A \oplus B = \{z|(\hat{B})\ Z \cap A \neq \emptyset\}$$

which is also equivalent to

$$A \oplus B = \{z|[(\hat{B})z \cap A] \subseteq A\} \quad (15)$$

Erosion of A by B,denoted as

$$A \ominus B = \{z|(B)z \subseteq A\} \quad (16)$$

6. MORPHING TECHNIQUES

Erosion and Dilation can be combined used in filtering,the combination involves closing, opening and boundary detection.

The Boundary can be extracted by using operations such as erosion, dilation and set theoretical subtraction. This involves three properties such as[13]

$$Y = X - (X \ominus B)$$
$$Y = (X \oplus B) - X$$
$$Y = (X \oplus B) - (X \ominus B)$$

Where Y is the boundary image, operator **'(−)'** denotes erosion and operator **'(+)'**denotes dilation.'−'denotes the set theoretical subtraction.

7. QUALITY PARAMETERS

The following metrics are used for measured the quality of the denoised images like MSE and PSNR.

7.1 Mean Square Error (MSE): MSE indicates the average difference of the pixels throughout the image. Nevertheless, it is necessary to be very careful with the edges. The formula for the MSE calculation is given as:

$$MSE = \frac{1}{N} \sum_i \sum_j (Xij - Vij)^2 \quad (17)$$

Where N is the size of the image, X is the processed image, and Vis the original image.

7.2 Peak Signal-to-Noise Ratio (PSNR): It is an assessment parameter to measure the performance of the noise removal.

$$PSNR = 10 \log (255^2/MSE) \quad (18)$$

7.3 Edge Stability Mean Square Error(ESMSE): Edge stability is defined as the consistency of edge in both original and processed image.ESMSE is calculated by summing the differences distorted image at pixel position (i,j)which is denoted as $\hat{Q}(i,j)$ with undistorted image at pixel position *nd* at full resolution, denoted as $Q(i,j)$[15].The ESMSE is deliberated as

$$E = {}^{1}/_{n_d} \sum_{i,j=0}^{n_d} [Q(i,j) - \hat{Q}(i,j)]^2 \quad (19)$$

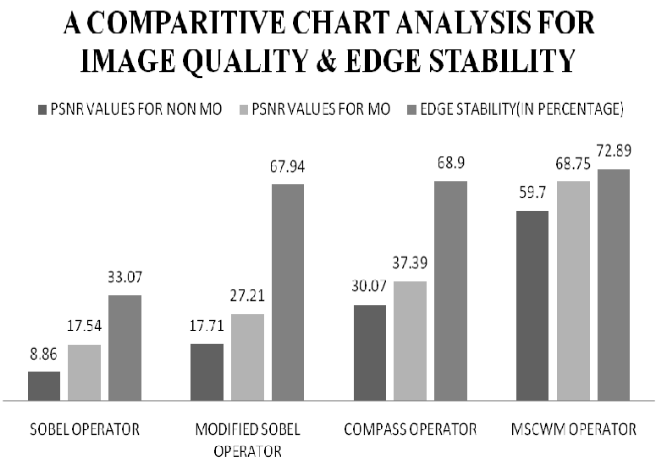
Table 1: shows the performance analysis of PSNR &MSE quality parameter for denoised MRI medical image

EDGE DETECTION TECHNIQUES BY USING MORPHOLOGICAL OPERATOR	PSNR VALUE BEFORE USING MO	PSNR VALUE AFTER USING MO
Sobel operator	8.86	17.54
Modified Sobel operator	17.71	27.21
Compass operator	30.07	37.39
MSCWM Operator	59.7	68.75

Table 2: shows the performance scrutiny of edge strength pixel displacement after Erosion and Dilation operation

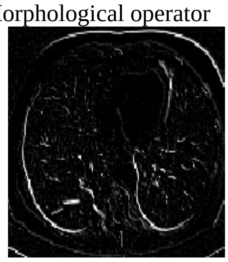
EDGE DETECTION TECHNIQUES BY USING MORPHOLOGICAL OPERATOR	EDGE STABILTY (in per)	INCREASE IN AREA OF PIXEL AFTER EROSION [pixel per inch (ppi)]	INCREASE IN AREA OF PIXEL AFTER DILATION [pixel per inch (ppi)]
Sobel operator	33.07	0.12	0.07
Modified Sobel operator	67.94	0.16	0.10
Compass operator	68.9	0.90	0.60
MSCWM Operator	**72.89**	**0.93**	**1.67**

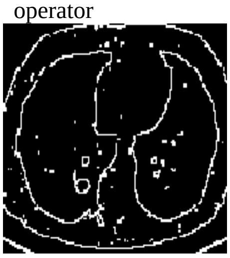
Chart1: represents Image quality and edge stability performance for various operators



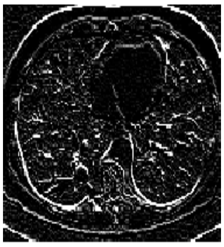
Original MRI image of an infected lung
With salt and pepper noise

Modified sobel gradient without Morphological operator | With Morphological operator





Compass gradient operator Without Morphological operator | With Morphological operator



MSCWM operator without Morphological Operator | With Morphological operator

Fig 6: Shows comparison of various gradient operators before and after adding morphological operator

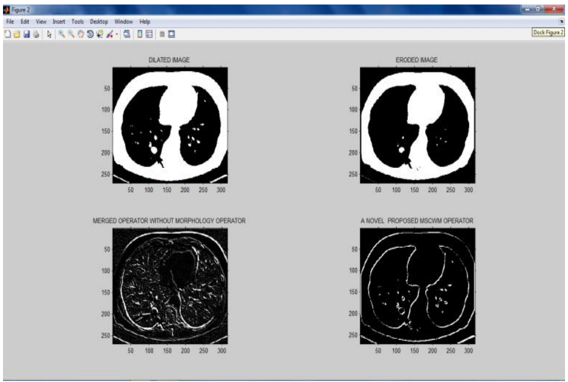


Fig7: shows a sample screen shot of proposed novel operator

8. CONCLUSION

In this paper, modified sobel operator with 3×3 convolution kernals and test operator with 3×3 convolution kernals is used implemented using MATLAB 7.12 for the boundary extraction. The morphing process is done on binary images. MSCWM operator is proposed for better extraction of the tumor also for the purpose of diagnosing and better analysis on external characteristics of lung tumors in MRI medical images which may help the specialists for further process. Thus 5×5 convolution kernals and detailed description of tumors as future enhances.

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10. REFERENCES

[1] N.Senthilkumaran1andR.Rajesh“EdgeDetectionTechniques for Image Segmentation–A Survey of Soft Computing”, International Journal of Recent Trends in Engineering,Vol.1,No.2, May2009,pp.250-254

[2] Davis,L.S.,"Edge detection techniques",Computer Graphics Image Process”(4),1995,pp.248-270.

[3] Shi,J.and Malik,J.“Normalized cuts and image segmentation”, IEEE TransPattern Anal.Mach.Intell., 22(8), 2008,pp.888–905.

[4] Mausumi Acharyya and Malay K.Kundu,“Image Segmentation Using Wavelet Packet Frames and Neuro-Fuzzy Tools”,International Journal of Computational Cognition,Vol.5,No.4,Dec.2007,pp.27- 43.

[5] J.Matthews.“An introduction to edge detection: The sobel edge detector,”

[6] R. C.Gonzalez and R. E. Woods. “Digital Image Processing”.2nd ed. Prentice Hall, 2002.

[7] R. Gonzalez and R. Woods. 1992. Digital Image Processing. Addison -Wesley, New York.

[8] N.SenthilKumaran and Rajesh,” Edge Detection Techniques for Image Segmentation-A Survey”, Proceedings of the International Conference on Managing Next Generation Software Applications(MNGSA-08),2007,pp.749-760.

[9] R. Gonzalez and R. Woods. 1992. Digital Image Processing, Third Edison, PHI Learning, New Delhi-2008.

[10] Rafael C. Gonzalez, Richard E. Woods, Steven Eddins, "Digital Image Processing Using MATLAB", Pearson Education, Inc. and Dorling Kindersley, Fourth Impression, 2008, pg no. 398 – 407.

[11] M.I.Rajab,M.S Woolfson and S.P.Morgan,”Application of region based segmentation and neural network edge detection to skin lesion,”computerized medical imaging and graphics,vol.28 pp.

[12] S.Lakshmi and Dr.V.Sankaranarayanan,”A study of Edge Detection Techniques for segmentation computing Approches”

[13] S.Jayaraman,S.Esakkirajan,T.Veerakumar,”Digital image processing”,Tata McGraw Hill.

[14] Anil.K.Jain,”Fundamentals of Digital Image Processing”

[15] Ismail Avcibas,Bulent sankur,Khalid Sayood,”Statistical evaluation of image quality metrics”