Edge Connectivity Techniques for Image Analysis – A Survey

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Abstract - *In medical field, there is a lot of scope for the edge detection process to analyze the medical images. It is an operation which detects the sudden transition in an image, which means the transitions are the finest variations in pixel intensities. Manual segmentation of tumor is time consuming, hence automatic disclosure of tumor region from Magnetic Resonance Imaging(MRI) images are desirable and it helps the doctors to diagnose the tumor at earliest stage[1]. In this work, the comparison among various edge operators namely Sobel, Canny, Improved Canny operators has been carried out for detecting the brain tumor region using python. The efficiency of these three detectors are estimated and compared with the factors like Mean squared error(MSE) and Peak signal to noise ratio(PSNR). Along with this edge detection, image segmentation approach called as Marker Controlled Watershed has been proposed for segmenting tumored region from MRI image. Finally from the results, it is concluded that the Improved Canny edge detection operator is an efficient algorithm for detecting the tumor region.*

***Key Words*: Canny, Sobel, Improved canny, Marker controlled Watershed, PSNR, MSE, MRI images**

1.INTRODUCTION

Edge detection is the primary concept in image processing field for detection of objects and it is the basic step in image recognition and image analysis approaches. Edge detection is generally a method of dividing an image into regions of disruptions. The disruptions in an image are due to changes in the texture of image, color etc. It reduces the data present in an image by filtering unwanted information and it preserves only the useful structural properties [2]. Edge disclosure has significant feature to find the perfect edges along with the fine orientation of the object in an image. The other important feature is, the edges can be stored with limited memory when compared to the entire image even though the edges consists of information about the object's shape and its direction[3].

Since the MRI images shows compound features, it is certainly essential to implement the image segmentation method. Image segmentation is the challenging task in automatic detection of tumor because images requires definite segmentation for improved diagnosis. Image segmentation is the technique of dividing the image into multiple regions [4]. This operation does not concentrate on entire image but it concentrates only on few regions which has identical features in it[5]. As this approach involves segregation of an image into many regions, every pixels in few region contains the similar attributes and the remaining adjoining regions will be different with respect to the attributes like brightness, gray value and colour. Hence only the user's region of interest with similar attributes will be obtained from segmentation method.

Among many image segmentation approaches, one of the fast, robust and structural method which overcome the problems of over segmentation is Marker Controlled Watershed approach and it can obtain the perfect position of objects. These striking features makes this algorithm suitable for segmenting the images. This approach uses the idea of markers which is an associated fundamental component applied to alter the gradient image .There are two kinds of markers namely internal markers and external markers. External markers are accompanied with the background and internal markers are accompanied inside an object of our interest [6]. The outcome of this transformation shows great efficiency and performs comprehensive segmentation of the images. Thus markers separate each object (foreground and background) from its neighbours.

2. METHODOLOGY

2.1 Sobel Edge Detector

It is established by convolving the image with a simple kernel or gradient in both vertical and horizontal directions. This operator uses two 3x3 kernels to convolve with the image[7]. Fig-1 shows the Sobel edge detection operation.

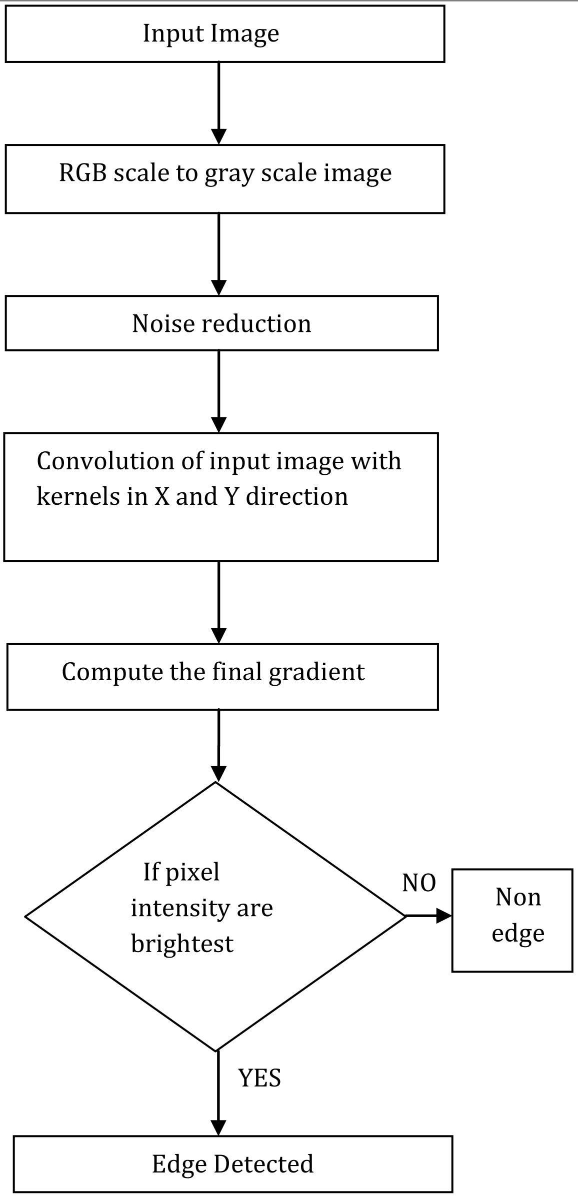

Fig - 1: Flow chart for Sobel edge detector

Step1: The input image has to be transformed from Red, Green, Blue(RGB) to grayscale image
Step2: Remove the noise using Gaussian filter
Step3: X direction kernel is shown in fig - 2 and it must be used to check across the X direction of an image to scan for large changes in the gradient.
Step4: Y direction kernel is shown in fig - 2 and it must be used to examine across the Y direction to scan for large changes in the gradient.
Step5: Once the image has been scanned across both horizontal and vertical directions, edge strength of both the X and Y gradients must be combined to form a final gradient image.
Step6: In the final image, the pixels must be checked for its brightness .The brighter pixels will be marked as edges.

X - Direction Kernel		
-1	0	1
-2	0	2
-1	0	1

Y - Direction Kernel		
-1	-2	-1
0	0	0
1	2	1

Fig – 2: Sobel Operator's Kernel

2.2 Canny Edge Detector

It is a basic method of finding the edges amidst many edge detection operators. It obtains required information from various objects. Fig- 3 shows the canny's operation.

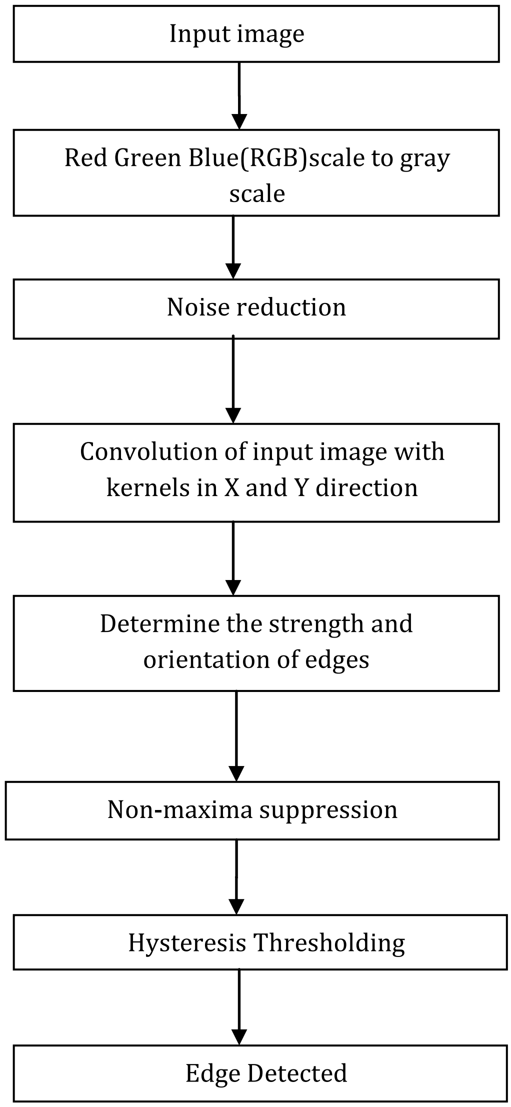

Fig - 3: Flow chart for Canny edge detector

Step1: The input image has to be converted from Red Green and blue scale(RGB) to gray scale image

Step2: Filter out the noise in an image using Gaussian filter[8]

Step3: Fig-4 shows the gradients G_x and G_y of canny . The input image must be convolved with G_x and G_y in both X and Y directions respectively to obtain the final gradient.

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

Fig - 4: Canny operator's gradient

Step4: The magnitude of edges are calculated by using the formulas as shown below

$$G = \sqrt{G_x^2 + G_y^2}$$

The edge orientation are calculated as

$$\theta = \text{atan2}(G_y, G_x)$$

atan2 is arc tangent function

G_x is gradient in X direction

G_y is gradient in Y direction

Step5: Non-maximum suppression is used to protect all brightest pixels in the gradient image and it deletes everything else which results in thin edges[9]. This basically gives the largest edge.

Step6: Hysteresis is a process used to get rid of streaking and it uses two thresholds namely low and high threshold. Streaking means it separates the edge contour generated by the operator's outcome which varies above and below the threshold.

2.3 Improved Canny Edge Detector

The main defects of the canny algorithm are briefly described below:

1. Canny edge detector makes use of Gaussian filter to smooth out the noise, but it also smooth the edges.
2. In the Canny operator, the threshold values are determined manually through experiments, and it is difficult to calculate the threshold for large number of different images.
3. The efficiency for getting responses of single edges are less means the same edges will be detected repeatedly

In order to overcome these defects, improved canny operator has been proposed here.

Fig-5 shows the Improved Cany edge detection operation.

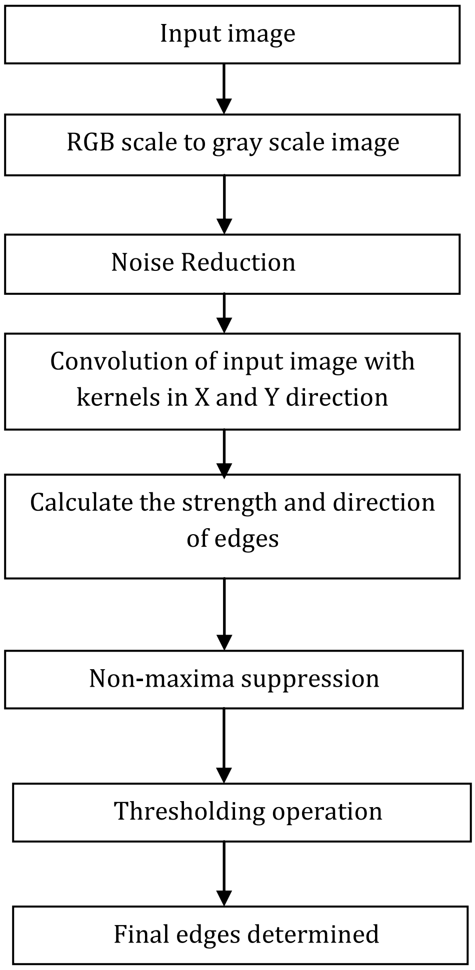

Fig - 5: Flowchart for Improved Canny operator

Step1: The input image has to be converted from Red,Green and Blue(RGB) scale to gray scale image

Step2: Bilateral filter reduces the noise and it also preserve the edges.

Step3: Fig-6 shows the gradient G_x and G_y of improved canny. The input image must be convolved with G_x and G_y to obtain the final gradient as shown in the fig-7.

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

Fig- 6: Improved Canny operator's gradient

$$G_{x,y} = \begin{bmatrix} a_0 & a_3 & a_6 \\ a_1 & a_4 & a_7 \\ a_2 & a_5 & a_8 \end{bmatrix}$$

Fig - 7: Final gradient

Step 4: The magnitude of edges are computed by the given below formula

$$G=\sqrt{P_x^2 + P_y^2}$$

where

$$p_x = \{[a_6+2a_7+a_8] - [a_0+2a_3+a_6]\}$$

$$p_y = \{[a_6+2a_7+a_8] - [a_0+a_1+a_2]\}$$

Edge orientation can be calculated as

$$\theta = \arctan\left({}^{P_x}/_{P_y}\right)$$

where θ is the angle to find direction of edges

Step5:Non maximum suppression preserves all local maxima in the gradient image and delete unwanted pixels

Step6: The high threshold(Th_H) is calculated by taking the average of pixel intensity values and low threshold (Th_L)values are calculated as $Th_L = \frac{1}{2}(Th_H)$

Given below are the three cases to detect the pixel as an edge.

i)if G $> Th_H$, then such pixels are considered as strong edges

ii) if $G < Th_H$, pixels are not marked as edges

iii)if $Th_L < G < Th_H$, then pixels are weak edges

3. PERFORMANCE EVALUATION METRICS

3.1 PSNR

It is the ratio between the permitted power of a signal and the power of corrupting noise that changes the accuracy of its depiction[10].Peak signal to noise ratio must be lesser to obtain appropriate outcomes and it is calculated as

$$PSNR=10log_{10}\left(\frac{R^2}{MSE}\right)$$

R is the changes in the input image and its value is 255.

3.2 MSE

It indicates the dissimilarity of the pixels all over the real image with edges found in the image and it measures the average squared difference between the parameter and the estimator. In case of edge detection, MSE should be high because higher the MSE there will be greater edges on the image and also it indicates the ability to find weak edges.

The MSE is calculated as

$$MSE = \frac{\sum_{M,N}[I_1(m,n) - I_2(m,n)]^2}{(M,N)}$$

I1 is the real image,

I2 is the edges found in the image,

m, n are the altitude and breadth of the image respectively

4. RESULTS

This section shows the outcome of all the three edge detection algorithms.

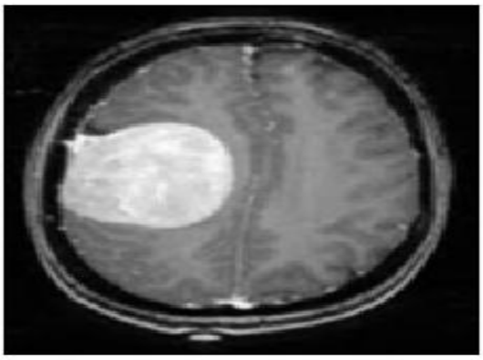

Fig-8: Input MRI image

Fig - 8 shows the input MRI image and all the edge detection algorithms are applied on this input image.

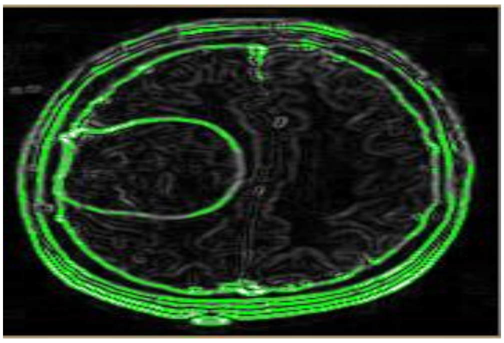

Fig-9: Sobel Edge detected image with Tumor region

Fig-9 shows the sobel edge detected image, where in the green colour highlights the tumor region and the borderline of brain .It indicates that the noise is not absolutely eliminated .This is because of its less efficiency and also due to its less processing steps.

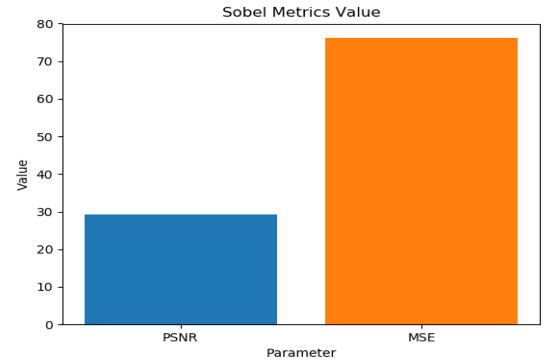

Fig-10:Graph of Sobel Edge Detector

Fig-10 display the graph of sobel operator for the MSE and PSNR parameters.

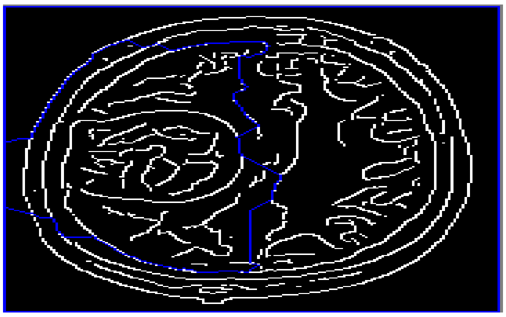

Fig-11: Canny Edge Detected image with Tumor region

Fig-11 shows the edges detected by Canny Edge Detector for original image. The edges found in this image are better than sobel detector because the noise has been removed and the edges are clearly visible .The tumor region and the boundary of MRI image are indicated with blue colour. Marker Controlled Watershed approach segments the tumor region from MRI image.

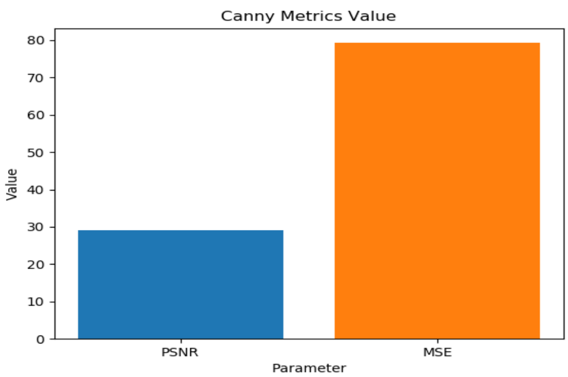

Fig – 12:Graph of Canny Edge Detector

Fig-12 shows the graph of Canny operator for the MSE and PSNR parameters.

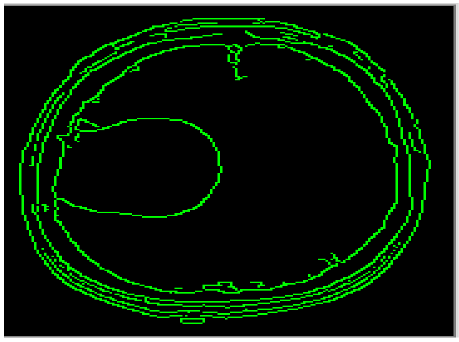

Fig-13: Improved canny Edge Detected image with tumor region

Fig-13 represent the tumor region and the borderline of brain, where both are indicated with green colour.The edges are thin in structure compared to other two operators and noise has been completely eliminated.The tumor region is clearly shown in the above image and it is extracted by using Marker Controlled Watershed approach.

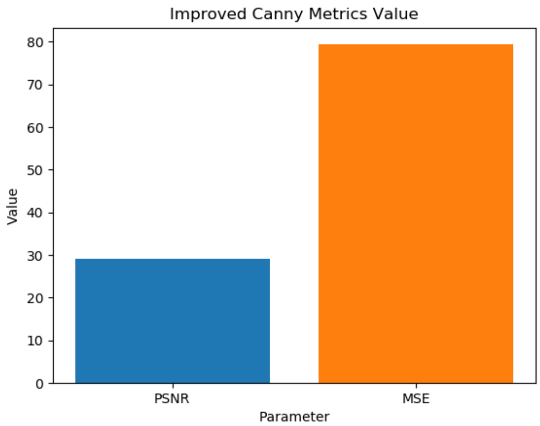

Fig-14: Graph of Improved Canny Edge Detector

Fig-14 shows the graph of improved canny operator for PSNR and MSE parameters.

Table-1: Performance Comparison of Edge Detectors

Sl.no.	Edge Detector	MSE	PSNR
1	Sobel	76.144	29.31444
2	Canny	79.2482	29.1409
3	Improved Canny	79.3655	29.13448

The performance of the Sobel,Canny and Improved Canny operators are shown in Table – 1.

4. CONCLUSION

Thus this work explained important edge detectors namely Sobel, Canny, Improved Canny operators and its performance has been compared with Mean Squared Error(MSE) and Peak Signal to Noise Ratio(PSNR) parameters. All these algorithms are specifically adapted to work with MR images of brain tumor which is collected from Kaggle.com. Among all these three algorithms, an improved Canny algorithm proved that by using bilateral filters, false edges were eliminated and only true edges were preserved. The proposed marker controlled watershed algorithm was successful in automatic segmentation of the brain tumor region from MRI images. The results have showed that the improved canny algorithm produced thin accurate edges than other operators and it successfully detected the tumor region. From the tabular column of performance comparison, the improved canny operator has less PSNR and more MSE than other operators, hence the performance of this operator is better compared to other operators.

REFERENCES

[1] Akash Kumar Bhoi , Pradeep Kumar, "Brain Tumor Detection: A Comparative Analysis of Edge Detection Techniques", International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 10 No.44 (2015)

[2] Sonam Saluja, Aradhana Kumari Singh, Sonu Agrawal, "A Study of Edge-Detection Methods", International Journal of Advanced Research in Computer and Communication EngineeringVol. 2, Issue 1,January 2013

[3] Amruta L Kabade ,Dr.V.G. Sangam, "Canny edge detection algorithm", Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)Volume 5, Issue 5, May2016

[4] Muthukrishnan R and M. Radha, "Edge detection techniques for image segmentation", International Journal of Computer Science & Information Technology (IJCSIT) Vol 3, No 6, Dec 2011

[5] Amanpreetkaur, Ashish Verma, Ssiet, Derabassi, "The Marker-Based Watershed Segmentation-A Review", International Journal of Engineering and Innovative Technology (IJEIT)Volume 3, Issue 3, September 2013

[6] Arindrajit Seal, Arunava Das, Prasad Sen, "Watershed: An Image Segmentation Approach", International Journal of Computer Science & Information Technology (IJCSIT) Vol.6(3),2015,2295-2297

[7] A. Jose K. Deepa Merlin Dixon, N. Joseph, E. S. George and V. Anjitha, "Performance study of edge detection operators," 2014 International Conference on Embedded Systems (ICES), Coimbatore, 2014, pp. 7-11

[8] Dr. S. Vijayarani, Mrs. M. Vinupriya, "Performance Analysis of Canny and Sobel Edge Detection Algorithms in Image Mining", International Journal of Innovative Research in Computer and Communication Engineering

[9] Kirti, Abhishek Bhatnagar, "Image Segmentation Using Canny Edge Detection Technique", International Journal of Techno-Management Research, Vol. 04, Issue 04, March 2017 ISSN: 2321-3744

[10] Dr. R. Manicka Chezian, D. Poobathy, "Edge Detection Operators: Peak Signal to Noise Ration Based Comparison", I.J. Image, Graphics and Signal Processing, 2014, 10, 55-61