MRI Brain Image Segmentation by Edge Detection and Region Selection

Anagha S.Kulkarni[1], R. S. Kamathe[2]
P.E.S. Modern College of Engineering /E&TC, Pune, India
Email: anaghakulkarni0@gmail.com[1], rupali.kamathe@gmail.com[2]

Abstract **— The boundaries of different tissues in MRI brain images are indistinct and the intensity change is very less. Therefore, accurate segmentation of brain images is very difficult task. To segment MRI brain image, here two methods are applied, Edge detection, Region selection. Method will separate out white matter, gray matter and CSF structure from brain image. The discontinuity present in brain tissues will be segmented by edge detection, special highly sensitive detector (canny detector) will be used to extract gray matter. The connected and homogenous part of brain tissues are segmented by region based segmentation method, such as region growing which will extract white matter as well as CSF matter. These method are widely applicable in medical field which helps in diagnosis of many brain diseases.**

Index Terms **— Image Segmentation, Canny edge detector, Edge detection, Region growing,**

I. Introduction

Brain image segmentation is one of the most important parts of clinical diagnostic tools. Brain images are mostly containing noise in homogeneity therefor accurate segmentation of brain images is very difficult task. Nevertheless, the accurate segmentation of these images is very important and crucial for correct diagnosis by clinical tools.

Many methods have been proposed for MRI brain tissue segmentation. [1] The boundaries of different tissues in MRI brain images are indistinct and the intensities of the white and gray matter are very close. The intensity of the MRI image of human tissue is homogeneous and the structure of each tissue is connected, but it is difficult to separate the adjacent tissues due to the small intensity changes and smoothed boundaries between the tissues.

The edge map derived from the edge detector of different scales represents the edges of different strengths and accuracy. A multi-scale edge detector is used to represent significant edges on the outer There are two main types edge detection: one is the first derivative-based edge detection operator to detect image edges by computing the image gradient values, e.g. Sobel operator, Roberts operator, Prewitt operator; also the other one is the second derivative-based edge detection operator such the second derivative zero-crossing to edge detection, such as LOG operator, Canny operator. [7]

From MRI brain images, the gray level discontinuity is very small between white and gray matter. Therefore, highly sensitive edge detection is required to discriminate between white and gray matter. Here, we use the Canny operator [7] (the first derivative of Gaussian) as our edge detector because of its good localization and high S/N output ratio.

The edge detector of the larger scale detects significant edges, thus suppresses noise, but loses detailed edges and accuracy. On the other hand, when decreasing the threshold during the edge selection, discontinuous and homogeneous regions are separated. The smaller the threshold finer the structure of the homogeneous regions.

Region based methods are based on the principle of homogeneity - pixels with similar properties are clustered together to form a homogenous region. The criteria for homogeneity are most of the time related with gray level of pixels. Region based method segment the tissue connectivity present in interested brain structure. Region growing which is region based segmentation method is used to separate white matter present in homogeneous region.

II. Methodology

Segmentation refers to the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). An objective of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. [6]

There are two types of segmentation:

2.1] Edge based segmentation
2.2] Region based segmentation

2.1) Edge based segmentation

The edge is the basic characteristic of image. Edge is a collection of pixels with its surrounding pixels have a grayscale step-like changes .The edge mostly present between objects and background, objects and primitives. These edges contains rich information, like step property, shape etc., which is helpful to describe the target object. Edge detection are of two types: one is step change edge whose pixels gray scale of two sides has significantly difference; the other one is roof edge that is the turning point from increase to decrease of gray value

Edge is basically the symbol and reflection of discreteness of partial image [10]. It symbolizes the end of one area and the beginning of the other area. The edge detected may become wide or discrete with the existence of noisy and ambiguity. Thus to obtain edge is we need to detect the discreteness of partial image and then eliminate breaking points of edges. Then the complete edge is obtained by these edge pixels.

A] First order derivative method:

First-order based edge detection-the first order derivative at a pixel is used to decide the existence of an edge. Then search the first order derivative for the maximum or the minimum value and the pixel containing this value is considered an edge. [5, 10]
There are two main types [2]: second derivative zero-crossing to edge detection, such as LOG operator, canny operator**.**

Gradient is a measure of the function changes. It also the first order derivative of the image

corresponds to two-dimensional function. The image can be perceived as a continuous derivative of image intensity of sampling points group. Gradient is a type of two-dimensional equivalent of the first derivative. So it can be defined as vector.

$$G(x,y)=\begin{bmatrix} G_x \\ G_y \end{bmatrix}=\begin{bmatrix} \frac{df}{dx} \\ \frac{df}{dy} \end{bmatrix} \quad (1)$$

There are two important properties. First, the vector G (x, y) direction is same as the direction of the maximum rate of change of increasing function f (x, y) (e.g. formula(2)); Second, the gradient amplitude (e.g. formula (3));

$$|G(x,y)| = \sqrt{G_x{}^2 + G_Y{}^2} \quad (2)$$

$$\alpha(x,y) = \arctan\,(G_x/G_y) \quad (3)$$

For partial derivatives of edges almost same as differences. Thus the edge frequently lies on the differential value of the minimum, maximum or zero.

$$G_x = f[x+1,y] - f[x,y]$$
$$G_y = f[x,y+1] - f[x,y] \quad (4)$$

The first order derivative method described above uses a boundary point. In this method may lead to the edge points to detect excessive data storage. Hypothetically more effective way is to determine the point with maximum value in ladder and these points are to be considered as edge point. This method can detect more precise edge. First derivative of the local maximum corresponds to the second derivative zero-crossing point. Hence the more accurate edge points can be found by the determination of the zero crossing point of the second derivative of the image gray.

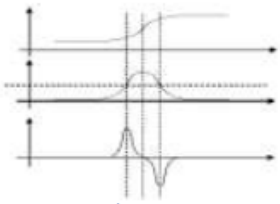


Figure 1. Image second derivatives

Different Edge Operators:

I) Robert Operator:-

Robert operator is a first-order operator, in which a partial differential operator is used to find the edge. It uses the approximation between the two adjacent pixels of the diagonal direction of the gradient amplitude to detect edge. In the field of 2x2 diagonal derivative, respectively the two convolution kernels, are given as;

$$G_x = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$
$$G_y = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} \quad (5)$$

Robert operator is defined as:

Figure 2. Robert operator

Gradient size of Robert operator represents the edge strength of the edge and direction of the gradient and the edge are vertical. An operator edge has higher positioning accuracy, but it is easy to lose a part of the edge. The operator with a steep low-noise image corresponds the best.

II) Sobel operator:-

Sobel operator is in the form of the filtering operator. This operator is also used to extract the edge. In the image each point is the two nuclear convolutions. Of these two one checks maximum response of the vertical edge, and the other one checks maximum response of the horizontal edge. The maximum value of two convolutions will be referred as output value of the changing point.

Sobel operator is comparatively easy to achieve in space, and it has a smoothing effect on the noise, is nearly affected by noise, can provide more accurate edge direction information but it will also detect many false edges with coarse edge width.

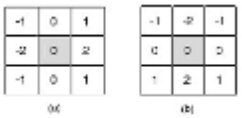


Figure 3. Sobel operator

III) Prewitt operator:-

The Prewitt operator is one type of an edge model operator. Prewitt is a method of edge detection in image processing which calculate the maximum response of a set of convolution kernels to find the local edge orientation for each pixel. Fig. 5 shows that two convolution kernel formed Prewitt operator. The model operator is made from an ideal edge sub-image composition. Detect the image using edge model one by one, and then take the maximum value of the model operator that is most similar to the detected region as the output of the operator. The Prewitt operator and Sobel operator, both uses the same differential and filtering operations, but the only difference is, the template does not use the same image.

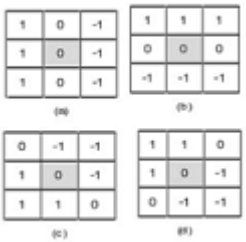


Figure 4. Prewitt Operator

Figure 4(a) shows the template used to detect the vertical edges, termed as Px. Figure4 (b) shows the template used to detect the horizontal edges, termed as Py. Figure 4(a) and (b) can be separated into two one-dimensional components. The component in the direction of the edge work as an averaging filter and

the other component compute the first-order differentiation in the direction of the edge response.

IV) Line Detector:

Line detector is used to detect line from image. Line detection method used to detect line in horizontal direction vertical direction and diagonally Every direction have separate mask shown in figure 5,

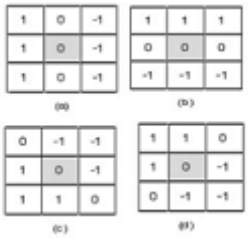


Figure 5. Line detector

a) Horizontal direction mask b) Positive 45° direction mask c) Vertical direction mask d) Negative 45° direction mask

B] Canny edge detector:

The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. John Canny developed it in 1986.[6]

Based on these criteria, the canny edge detector first smooths the image to eliminate and noise. Then It finds the image gradient for highlighting the regions with high spatial derivatives. Then the algorithm tracks these regions and suppresses any pixel that is not at the maximum (Non maximum suppression). Using hysteresis the gradient array is now further reduced. Bascialy the hysteresis is used to track the remaining pixels which have not been suppressed. The hysteresis process uses two thresholds and if the magnitude is below the first threshold, it is set to zero (made a non-edge) or if the magnitude is greater than high threshold, then an edge is present and if the magnitude is between the two thresholds, it is then set to zero unless there is a path from this pixel to a pixel with a gradient above T2.

The algorithm runs in 5 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 large magnitudes.
3. Non-maximum suppression: Only local maxima should be marked as edges.
4. Double thresholding: Potential edges are determined by thresholding.
5. Hysteresis: Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge.

2.2] Region Based Segmentation:-[9]

Region based method is alternate type of Image segmentation method.

Region Growing:

Region based image segmentation is Region Growing. Region growing is depending on similarity criteria. It utilize the concept of size, similarity between a candidate pixel and pixels that grown so far and shape of region being grown A simple approach to image segmentation is to start from some pixels (seeds) representing distinct image regions and to grow them, until it covers the entire image.

A rule is required for region growing, which describes a growth mechanism and a rule checking the homogeneity of the region after each growth step by step Group of pixels or sub regions into larger regions based on predefined criteria (gray tone or texture).

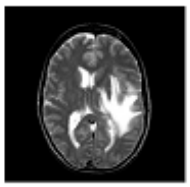
General Algorithm for Region Growing:

1. Assume we find a good threshold, to partition the regions into pure black and white.
2. Use different labels to identify different objects.
3. Use region growing to connect parts that should have belong to the same region. This is called "Connected component analysis"
4. The region with the same label generates one segment.

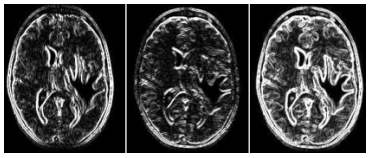
Apply all above basic concept of region growing method is used for separation of homogeneous region MRI brain image

III. Results

.The real data base is used while experimentation. The experimentation was done on MATLAB 11b.

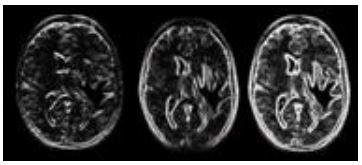


Original Image



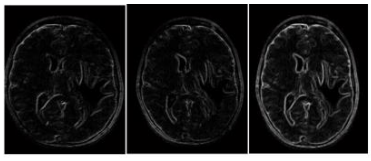
x gradient y gradient final image

Figure 6. Sobel operator



x gradient y gradient final image

Figure 7. Prewitt operator



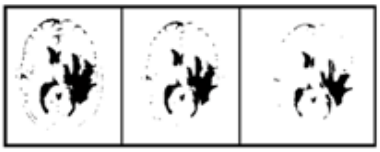
x gradient y gradient final image

Figure 8. Robert operator

$\sigma = 0.5\,1, 1.5$

Figure 9. Canny detector

x gradient y gradient final image
a) S= 5, 10, 20



x gradient y gradient final image
b) S=50, 80,100

Figure 10. Region based Segmentation

Fig.6 shows sobel it includs x and y gradient images with final image. Fig .7 and fig. 8 shows prewitt operator and robert operator with its gradient and final images. Fig 9.shows result of canny operator, with different standard deviation values i.e. with (0.5, 1, and 1.5). Fig.10 represent the region segmentation with variety of value of seed points that is S.

IV. Discussion

In this paper, we present two approaches for MRI brain Image segmentation. The edge based approach and region based approach. The analysis done by different first order operator, such as Roberts, Sobel and Prewitt using which were able to handle MRI images of more gray-scale gradient and noise. Prewitt operator is more sensitive to horizontal and vertical edges than Sobel operator. Canny edge detector gives more accurate image. The resultant images from the canny detector of different scales represent the edges of different strengths and accuracy. The smaller the scale, the finer and more accurate the edges. However, the edge detector of a small scale is also sensitive to noise. The canny operator solves the problem occurs in first order edge detector The Canny operator [6] (the first derivative of Gaussian) give results with good localization and high S/N output properties. Line detection detects the lines to horizontal direction, vertical direction and diagonal directions. The second approach is Region based segmentation which segments the homogeneous region of MRI brain image .The border region of MRI brain image getting from region growing method are perfectly thin and connected.

V. Conclusions & Future Work

This paper presents the MRI brain image segmentation with different methods. It is observe that edge detector detects the edges with noise. The analysis shows that Robert operator gives more accurate edges. Sobel is less sensitive to horizontal and vertical edges. All first order edge detection method finds edges using the approximation to the derivative. Then it returns edges with points where the gradient of the image is maximum. Canny edge detector gives image with low error rate and good localization.

In future, canny edge detector can be compare with the K-means clustering method with divides an image with their similarity criteria. This can be useful to detect the edges more accurately.

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