IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol-6, Special Issue-4, May 2018 E-ISSN: 2347-2693

Brain Portion Extraction Scheme Using Chan - Vese and Morphological Operation from MRI of Human Head Scans

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Available online at: www.ijcseonline.org

Abstract— In this research article, a novel segmentation technique to extract the brain portion from Magnetic Resonance Image (MRI) of human head scans based on Chan – Vese and Morphological Operations is proposed. First we extracted the rough brain portion using Chan – Vese method and the applying the morphological Operations to segment the fine brain portion. The initial Contour is drawn at the brain image and then propagated to achieve the boundary of the brain image. Then using morphological operation like Erosion and Dilation, the remaining portions were segmented. Comparison of the numerical results obtained from the extracted images, with the standard manual skull stripping gold images and significant results are presented here. The performance of the method is estimated using the Jaccard and Dice similarity Coefficients. The IBSR datasets of brain images are used to evaluate the efficiency of the proposed method and the results shown that which are better than the existing methods such as Brain Surface Extractor (BSE) and Brain Extraction Tool (BET).

Keywords— *Brain Extraction,Image Segmentation,Magnetic Ressonance Image (MRI),Chan - Vese,Morphological operations.*

I. INTRODUCTION

Segmentation is the process of dividing image into multiple segments. In medical field, a most widely used imaging technique known as Magnetic Resonance Image (MRI), and it gives the details about human brain and its surrounding tissues.

In Neuro image analysis, the Brain Segmentation is one of the vital pre-processing methods. The process of brain segmentation removes every non – brain tissues like skull, sclera, fat, skin, eye balls, neck etc from the MRI human head scan images. The problematic of this evolution is that the ubiquity of various ruin of the image, anatomical variability, variation of contrast properties and poor registration among the brain images.

Brain Extraction Tool (BET) [3] used to fit the brain's surface. The Brain Surface Extraction (BSE) [2] used to separate brain from non-brain tissues. In Image Segmentation field, an Active Contour Models are widely used. The well – known, active contour model known as Chan – Vese method. It is accomplished to encounter both the interior and exterior boundaries of an image. In Chan – Vese method, the iteration requires to extract the brain from MRI head scans. In order to lessen the computational cost and boost the speed of curve propagation, the functional energy is used to emerge the curve to encounter the brain boundary.

II. PROPOSED METHOD

Active contour is a self – regulating dynamic curve. In order to achieve the desired object boundaries, a curve is used to propagate under the consequence of energy functional. The segmentation of brain done by an Active Contour model. An initial closed curve can be shrunk or expanded under the influence of energy functional, which is insistent to generate energy around the boundary of the image.

A) Chan – Vese Active Contour Model

The segmentation technique, Chan – Vese models is established from Mumford – shah model [4]. The two distinct regions for the image are, a_1 (foreground) and b_2 (background), a piecewise constant distinct intensity values. Given an image τ_0 and a closed curve A. For the inner region and outer region, a_1 and a_2 be the average intensity of τ_0. The aim of Chan Vese algorithm is to minimize the energy functional $E\ (a_1, a_2, A)$ and is defined as,

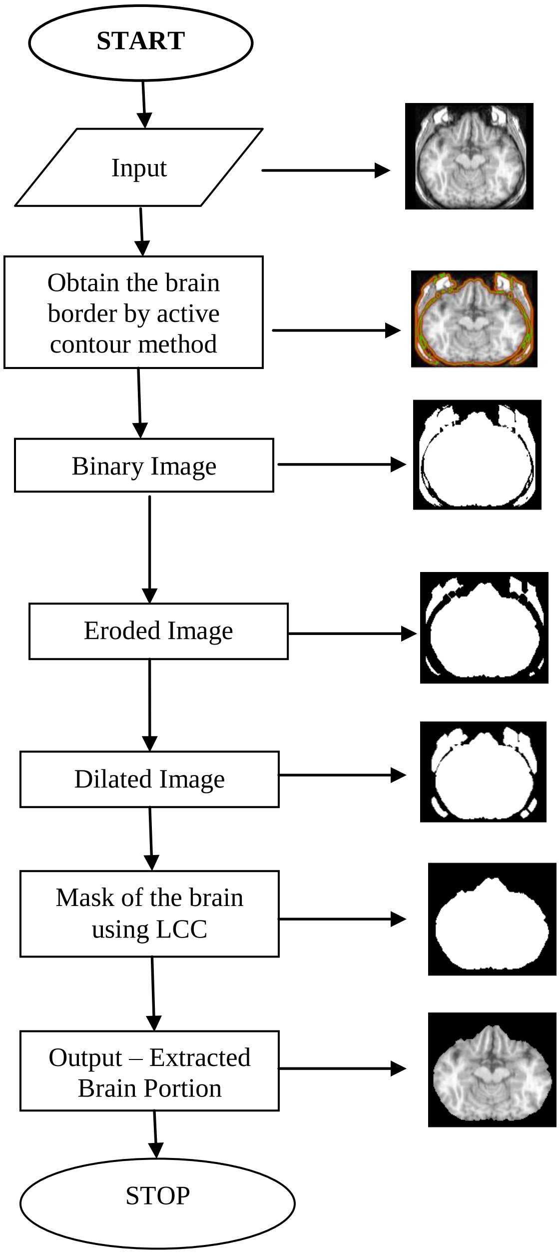
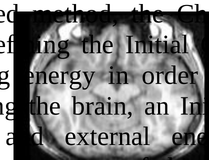


Figure 1: Flowchart of the proposed method

$$E(a, a_2, A) = \tau.Length\,(A) + v.Area\,(inside\,(A)) + \lambda_1 \int_{inside\,(A)} |\mu_0(x,y) - A_1|^2 dxdy + \lambda_2 \int_{outside\,(A)} |\mu_0(x,y) - A_2|^2 dxdy$$

Where, > 0, and $_1$, $_2$ > 0 are fixed parameters. controls the smoothness of zero level set, increases the propagation speed, $_1$ and $_2$ controls the image data driven force inside and outside of the contour respectively. The objective of CV model is to find $a_{1,}$, a_2 and A such that $E(a_{1,}, a_{2,} A)$ is minimized and mathematically expressed as

$$inf\ a_1,$$



In this proposed method, the Chan – Vese model [13] is modified by defining the Initial Contour (IC) to propagate the curve using energy in order to lie outside the region. While extracting the brain, an Initial Contour expanded on both internal and external energy to reach the brain boundary. The advantage of this method is that minimizes the number of iterations and computational cost involved in the curve evolution process that the CV model.

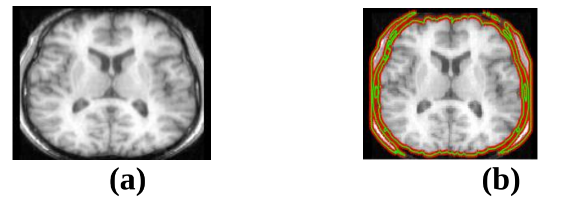


Figure 1: (a) Input Image (b) Initial Contour on rough brain

B) Largest Connected Component

The Largest Component is used to find out the given image out of several regions. The run length identification scheme is used to find the LCC among the regions as

$$R_{LCC} = R\,(\arg\max RA(i))$$

Where, the area $R_A(i)$ is the i^{th} region and $R(i)$ is the total number of pixels in that region.

In this proposed method, we expose the brain portion in the middle slice using the concept of Largest Connected Component (LCC) [15]. In MRI of head scans, when compared to upper slice and a lower slice of the brain, the middle slice is always huge.

C) Erosion Operation

Erosion Operation is used to disconnect weakly connected regions. In order to achieve structuring element SE, Erosion operation is used to removes pixels on the object boundaries. The SE is placed on all pixel positions in the input image X and it is compared with the corresponding neighborhood of pixels and fits the input image. i.e. Y (i, j) – 1 if SE fits X otherwise 0, repeating for all pixel coordinates (i, j). Erosion Operation is denoted by,

$$Y = X \ominus SE$$

D) Dilation Operation

Dilation adds pixels to the object boundaries and it is achieved by using structure element SE. The SE is placed at all pixel positions in the input image X and it is compared with the corresponding neighborhood of pixels. i.e. Y (i,j) – 1 if SE hits X otherwise 0, repeating for all pixel coordinates (i,j). Dilation operation is denoted by

$$Y = X \oplus SE$$

III. BRAIN EXTRACTION USING CHAN – VESE ACTIVE CONTOUR MODEL

The initial contour is drawn on the rough brain area. The Chan – Vese method is used to evolve the Initial Contour (IC) to reach the brain boundary. The Proposed method of CV method [14] can be competent to diagnose the contour that has smooth boundaries or week edges at lesser number of iterations. This method consists of several operations such as brain border can be detected using initial contour, rough brain area can be selected using Chan – Vese method, the mask of the brain can be obtained using Largest Connected Component (LCC), the brain portion can be extracted using erosion and dilation method. The brain segmentation process can be presented in figures.

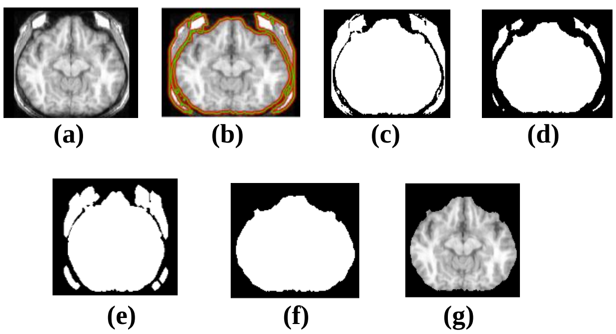


Figure2: (a) Input image (b) Initial Contour (c) Segmented image (d) Eroded image (e) Dilated image (f) Mask of the brain (g) Extracted brain

Algorithm
Input: MRI Head scan volume
Output: Segmented brain value

1. *Input the images.*
2. *Define the initial contour outside the rough brain.*
3. *Find the fine brain border by CV Method.*
4. *Obtain the binary image.*
5. *Select LCC after applying morphological Operations like erosion and dilation.*
6. *Obtain the rough brain mask.*
7. *Output the segmented brain image.*

Performance Evaluation Metrics

The following parameters are used to evaluate the performance of the proposed segmentation methods. Jaccard similarity index (J), Dice Coefficient (D), False Positive Rate (FPR) and False Negative Rate (FPR) are such measurements of asymmetry information on binary regions A and B.

The Jaccard similarity index (J) and the Dice Coefficient (D) are given by:

$$J(a,b) = \frac{|a \cap b|}{|a \cup b|}$$

$$D(a,b) = \frac{2\,|a \cap b|}{|a| + |b|}$$

Where *a* denote the total pixels of the image obtained from the gold standard image and *b* denote the total pixels in the image obtained by the proposed image.

The misclassification of positive and negative have done by the FPR and FNR. FPR is the ratio of the number of pixels incorrectly classified as brain region to number of number of non - brain region and false positive pixels. FNR is the ratio of the number of pixels incorrectly classified as non - brain region to number of number of brain region and false negative pixels.

The FPR and FNR are calculated by

$$\text{FPR} = \frac{|FP|}{|\text{TN}| + |\text{FP}|}$$

$$\text{FNR} = \frac{|FN|}{|\text{TP}| + |\text{FN}|}$$

Where TP and FP are True Positive and False Positive, which are defined as the number of voxels correctly and incorrectly classified as brain tissue by the proposed method. TN and FN are True Negative and False Negative, which are defined as the number of voxels correctly and incorrectly classified as non - brain tissue by the proposed method.

A) Materials

We have used volumes of MRI axial data sets to evaluate the performance of the proposed method. The images are obtained from Internet Brain Segmentation Repository (IBSR). Each image consists with dimensions of 256 × 128 pixels.

TABLE 1: Computed Values for the Parameters Jaccard (J) and Dice (D) for the Images of BET, BSE and Proposed Methods

	Jaccard (J)			Dice (D)		
Image Name	**BET**	**BSE**	**Proposed**	**BET**	**BSE**	**Proposed**
Image1	0.4370	0.0084	**0.9267**	0.6082	0.0167	**0.9620**
Image2	0.8180	0.7224	**0.9033**	0.8999	0.8388	**0.9482**
Image3	0.8426	0.7751	**0.8797**	0.9144	0.8733	**0.9360**
Image4	0.8446	0.7577	**0.9352**	0.9754	0.8621	**0.9665**
Image5	0.8619	0.8635	**0.9694**	0.9259	0.9267	**0.9845**
Image6	0.8572	0.8457	**0.9337**	0.9231	0.9164	**0.9657**
Image7	0.6727	0.3615	**0.8635**	0.8043	0.5308	**0.9257**
Image8	0.4836	0.0017	**0.9503**	0.6519	0.0034	**0.9745**
Image9	0.3001	0.0005	**0.8712**	0.4617	0.0009	**0.9312**
Image10	0.8248	0.8556	**0.9213**	0.9037	0.9222	**0.9590**

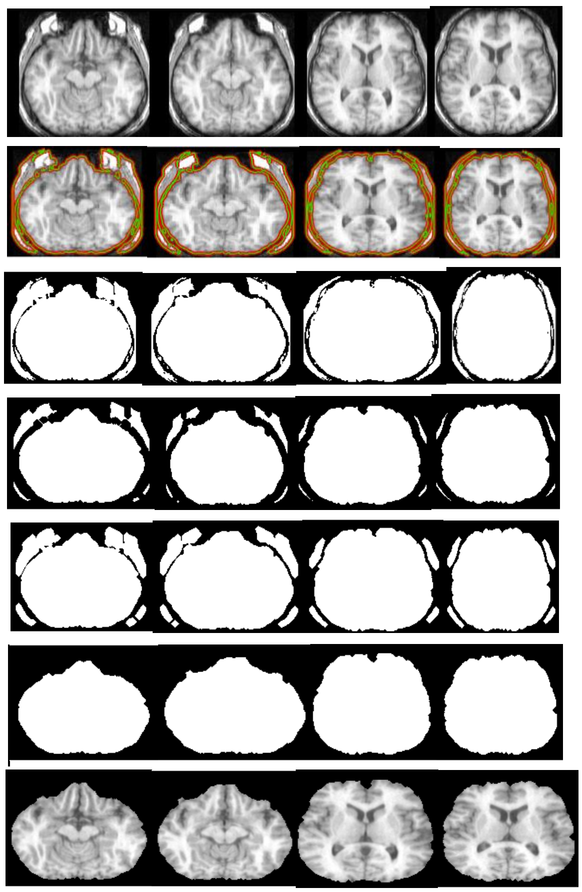
B) Result

The experiments are carried out by applying the proposed method on the selected MRI axial brain images and performed quantitative and qualitative analysis. For quantitative analysis, the Jaccard (J) and Dice (D) were calculated for the sample selected images of IBSR datasets.

The values of J and D computed by using the skull stripping methods BET and BSE for the selected images. The FPR and FNR were also calculated for the images.

TABLE 2: Computed Average Values J, D, S, SP, FPR, and FNR for BET, BSE and the Proposed Methods for the Images

Methods	J	D	S	SP	FPR	FNR
BET	0.69	0.80	0.97	0.94	0.058	**0.003**
BSE	0.52	0.59	0.72	0.96	0.033	0.354
Proposed	**0.92**	**0.96**	**0.98**	**0.99**	**0.003**	0.059



(a) **(b)** **(c)** **(d)** **(e)** **(f)** **(g)**

Figure3: (a) Input image (b) Initial Contour (c) Segmented image (d) Eroded image (e) Dilated image (f) Mask of the brain (g) Extracted brain

IV. CONCLUSION

In this paper, we extract the brain portion using Chan – Vese Contour method. The performance of brain segmentation method was tested on MRI axial brain images and IBSR datasets. The performance of the proposed method is found to be better that of the existing methods BET and BSE.

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