

# Thresholded and Morphological Operations Based Brain Image Segmentation

S.Naganandhini, P.Shanmugavadivu

**Abstract**—Skull Stripping is an inevitable computer-assisted medical brain image pre-processing mechanism that aims to segregate the non-designated regions, in order to extract the designated brain regions. Those resultant brain region images are further subjected to diagnostic analysis to discover the brain diseases/ disorders. This paper presents an efficient method named, Threshold and Morphological Operations based Segmentation, (TMOS) for skull stripping is, exclusively designed for MRI brain images (Magnetic Resonance Images). It has two phases: the first phase localizes the brain region using Region of Interest (RoI) and in the second phase, morphological operations are applied to precisely extract the brain region by stripping out the skull. The performance of TMOS is validated using Minimal Interval Resonance Image in Alzheimer Disease (MIRIAD) dataset. The accuracy of TMOS is visually confirmed.

**Keywords**—Skull Stripping, T1-Weighted MRI brain images, Otsu's threshold, Region of Interest method, Morphological Operation.

## I. INTRODUCTION

The fully/semi-automated brain image analysis aims to discover brain abnormalities/ disorders and other diagnosis. Skull stripping is an essential step in extracting the brain regions for morphometric studies of Magnetic Resonance Images (MRI). In this article, a new segmentation scheme for MRI termed as, Thresholded and Morphological Operations based Segmentation (TMOS) is proposed. The following sections are organized as: Section II presents the review of a few significant MRI segmentation methods; methodology of TMOS is elucidated in Section III; results of TMOS and the related discussions are given in Section IV and the concluding remarks of this research work are furnished in Section V.

## II. RELATED WORK

Hundreds of MRI brain segmentation techniques are already available in the literature. The common principles and mechanisms designed and developed are reported in [1 - 6]. Shijin kumara *et al.*, [7] described about a skull-stripping technique which is designed based on the principle of connected regions as well as the morphological image operations for MRI images. 2D region growing algorithm by Park *et al.*, [8] automatically selects two exclusive seed pixels for the brain region and its counterpart. This approach is apparently confirmed to effectively segment the images of poor illumination and homogeneities and corrupted images.

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Rosniza *et al.*, [9] presented a technique for MRI brain image for brain segmentation. However, this method fails on the brain images with intensity homogeneity. Even though numerous techniques are reported in the studies of skull stripping, region-growing and mathematical morphology method are widely employed for segmentation.

Sudipta Roy *et al.*, [10] developed an automatic method for Artifacts and skull removal of brain in MRI using computational geometry, wavelet decomposition and thresholding as intermediate steps.

Benson *et al.*, [11] proposed two computationally simple techniques for MRI, based on mathematical morphological operations for two pre-processing operations - brain image enhancement and skull stripping, respectively.

Sajjad Mohsin *et al.*, [12] proposed an improved fully automated skull stripping technique. It assures higher accuracy when compared to its competitive methods.

Shafaf Ibrahim *et al.*, [13] proposed Seed-Based Region Growing (SBRG) technique based on the consensus among the radiologist and radiographers. It is concluded that this skull stripping method is quite efficient.

The proposed TMOS is designed, using Region of Interest (RoI) and morphological operations. The primary objective of TMOS is to accurately segment the brain image, with minimum computational and time complexity. It is important to underline that TMOS is free from under-segmentation as well as over segmentation. Hence, TMOS, is confirmed to be an ideal pre-processing tool in brain image processing and analysis.

## III. THRESHOLDED AND MORPHOLOGICAL OPERATIONS BASED SEGMENTATION (TMOS)

The MRI brain segmentation by TMOS involves RoI and thresholding-based region selection and morphological operations based segmentation.

In TMOS, the input MRI is binarized using Otsu's thresholding wherein the selection of threshold is automatically done using [14-16]. This proven global thresholding method iterates through all the possible threshold values in order to optimally separate the foreground from the background.

The process of brain segmentation is optimized with the automatic/semi-automatic selection of RoI. In TMOS, the RoI is chosen based on the elliptical mask using interactive tool.

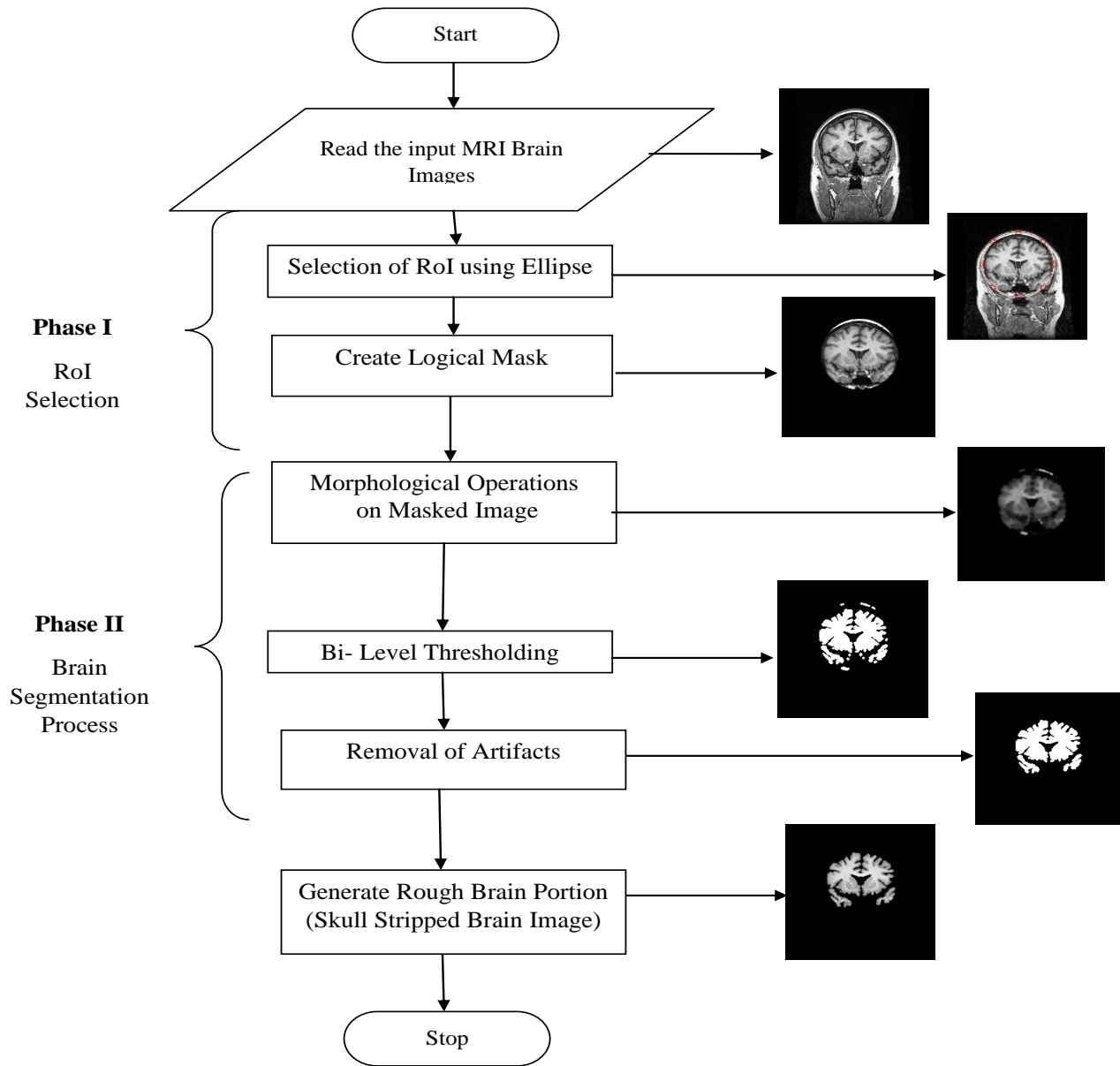


Fig. 1 Flowchart of TMOS

The masking operations with reference to the chosen RoI, facilitates the selection of pixels confined within the boundary of RoI. The pixels bounded by the RoI are preserved while the remaining pixels are discarded using the *ellipseConvolution* filter. This convolution operation enables to separate the RoI from MRI image, leaving out the remaining pixels (i.e) unwanted pixels. In general the morphological image operators viz., *erosion*, *dilation*, *opening* and *closing* are applied on digital images separately or is combination, in order to refine the process of segmentation using structuring element of varying size, as required. The TMOS uses *opening* and *closing* for this purpose of skull stripping on the brain image obtained out of RoI selection. The *opening* of A by B is computed as the *erosion* of A by B, which is succeeded by *dilation*. The *opening* of A by B is:

$$A \circ B = (A \ominus B) \oplus B \quad (1)$$

Morphological *closing* is similar to *dilation* in which the boundaries of foreground regions are based on the given structuring element. The *closing* of A by B is:

$$A \bullet B = (A \oplus B) \ominus B \quad (2)$$

**E. Algorithm of TMOS**

*Input* : Grayscale Image I(Normal/AD)

*Output*: Extracted Brain Portion

- Step 1: Read the input MRI brain images
- Step 2: Select the coordinates for RoI selection with ellipse  
 $e = imellipse(gca[Xlim, Ylim, radius1, radius 2])$
- Step 3: Set color draw RoI boundary  
 $Setcolor(e, 'new\_color');$
- Step 4: Add a new position call back to RoI object  
 $addNewPositionCallback(e, @(p) title(mat2str(p,3)));$

Step 5: Adjust and limit the ellipse boundary using X and Y limit

```
fcn=makeConstrainToRectFcn('iml ellipse', get(gca, 'XLim'), get(gca, 'YLim'))
setPositionConstrainFcn(e, fcn)
```

Step 6: Create Logical mask in the image

```
BW=createMask(e, h_im)
```

Step 7: Define Structuring Element (SE) and apply erosion

```
Se=strel('disk', 2, 0);
XPX=imerode(XPX, se);
```

Step 8: With Structure inf apply Dilation

```
Se1=strel('disk', 2, 0);
```

Step 9: Apply Top-Hat filtering for refinement

```
se3=strel('disk', 30);
ft=imtophat(XPX1, se3);
```

Step 10: Apply morphological operations to separate the brain images using Opening and Closing function

```
se4 = strel('disk', 3);
s = imopen(ft, se);
se = strel('disk', 3);
closeBW = imclose(s, se);
```

Step 11: Segment brain image using Otsu threshold method

```
Thr=graythresh(ft);
```

Step 12: Convert the segmented image into binary image

```
lt=im2bw(ft, Thr);
```

Step 13: Remove artifacts in binary image

```
bw1 = bwareaopen(BW, p, conn);
```

Step 14: Segment the brain image

```
seggray=zeros(256, 256);
```

```
for i=1:256
```

```
for j=1:256
```

```
if bw1(i,j)==1
```

```
seggray(i,j)=img(i,j);
```

```
end
```

```
end
```

```
end
```

```
seggray2=mat2gray(seggray);
```

Step 15: Stop

#### IV. RESULTS AND DISCUSSION

In this study, normal and abnormal images of MIRIAD dataset

(<http://www.ucl.ac.uk/drc/research/methods/miriad-scan-database>) [19] are used to evaluate the performance of TMOS. It was tested on 120 images of MIRIAD. The visual perception of the segmented results validate the effectiveness of TMOS. The indicative results of TMOS for Normal Control and AD affected brain images are given in Fig. 2 & Fig. 3 respectively. The TMOS is implemented using MatlabR2013A.

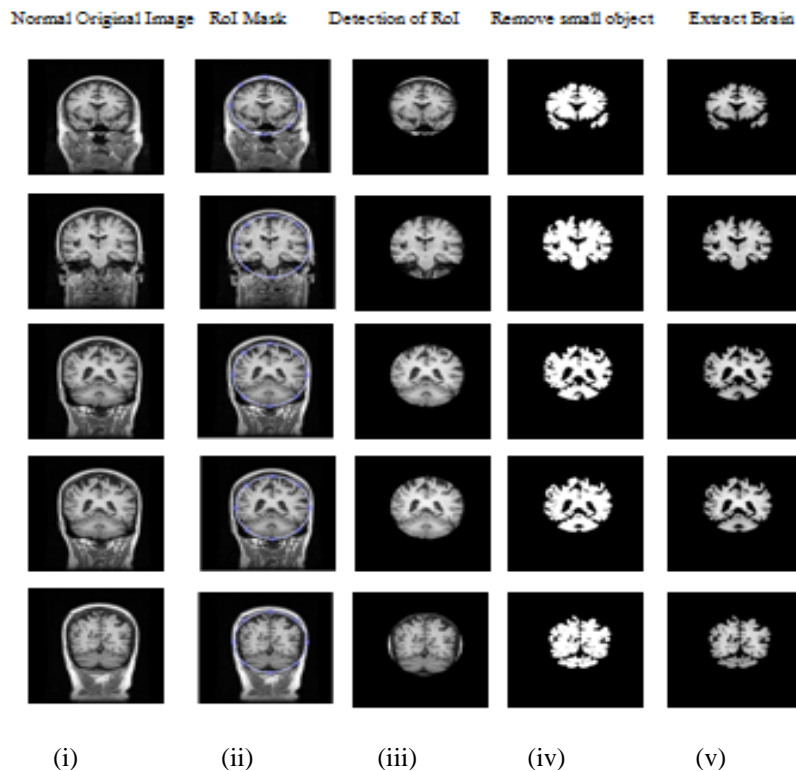
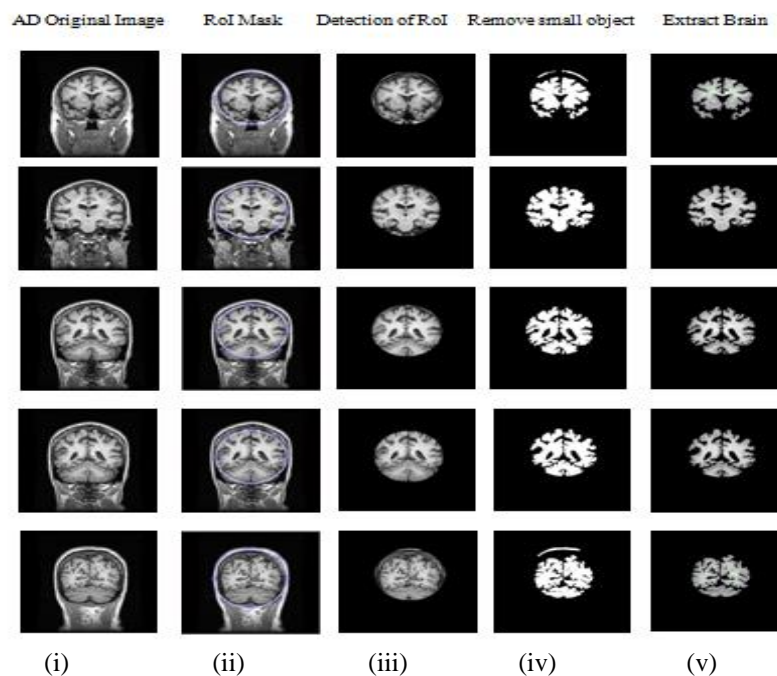


Fig 2: (i) Normal MRI brain images (ii) Selection of RoI Mask (iii) Detection of RoI (iv) Artifacts Removed Brain images (v) Segmented by TMOS



**Fig. 3: (i) AD MRI brain images (ii) Selection of RoI Mask (iii) Detection of RoI (iv) Artifacts Removed Brain images (v) Segmented by TMOS**

The sample images from the dataset and their corresponding segmented images are depicted in Fig. 2 & Fig.3. In Fig. 2, column 1 contains the Normal MRI Brain images, column 2 contains the Selection of RoI Mask, column 3 contains the Detection of RoI, column 4 contains the Artifacts removed brain images, and column 5 contains the segmented brain images by TMOS (Proposed). The respective columns in Fig.3 show the results on AD-affected MRI brain images.

## V. CONCLUSION

A new technique TMOS for brain portion extraction is presented in this paper. It is designed using RoI selection and morphological operations for skull stripping. The developed method was tested on T1-weighted MRI brain images of MIRIAD (Minimal Interval Resonance Imaging in Alzheimer Disease) dataset. The visual perception of the skull stripped brain confirms the efficiency of TMOS. This method due to its accuracy finds application it is apparent that the devised TMOS accurately segments the brain regions from MRI brain images of two different datasets. The results of the TMOS can be directly used for higher degree of image processing

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doi:10.1016/j.neuroimage.2012.12.044. at MIRIAD:  
<http://www.ucl.ac.uk/drc/research/methods/miriad-scan-database>.