AUTOMATIC SEGMENTATION OF MRI BRAIN USING MORPHOLOGICAL OPERATORS

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Abstract— **The paper presents an automatic method for segmenting T1-weighted brain MRI using morphological operators. The MRI brain image contains skull and noisy background. The latter have to be removed for further analysis. Elimination of any obstacles and noise from the image is the primary function of the morphological operators. We use simple morphological operators like dilation, erosion, opening and closing to the binarized MRI brain image. The results of segmenting the skull from MR image with the use of disk shaped structuring elements are presented in the paper. The proposed method has been applied to a large number of MR images showing promising results for various image qualities, encouraging for future.**

Keywords— **Image segmentation, skull stripping, Morphological operator, brain segmentation**

I. INTRODUCTION

Magnetic resonance imaging (MRI) is a popular means for non-invasive imaging of the human body. MRI provides images with the exceptional contrast between various organs and tumours that is essential for medical diagnosis and therapy. MRI is an advanced medical image technique providing rich information about the anatomy of human soft tissue [5].

Brain is one of the most complex organs of a human body so it is a vexing problem to discriminate its various components and analyse its constituents. Common image processing and analysis technique provide ineffective and futile outcomes. Magnetic resonance images are very common for brain image analysis. Magnetic resonance images (MRI) of the brain are invaluable tools to help physicians diagnose and treat various brain diseases including stroke, cancer and epilepsy. The MRI of the normal brain can be divided in to 3 regions other than the background, white matter (WM), Grey matter (GM) and Cerebrospinal fluid (CSF) or vasculature.

The major problems that affect the quality of MRI segmentation are noise, inhomogeneous pixel intensity distribution and blunt boundaries in the medical MR images caused by MR data acquisition process [2, 3, 4]. These problems do make manual quantitative analysis of brain imaging data a tedious and time consuming procedure, prone to observer variability [2]. Due to the characteristics of brain MRI, development of automated segmentation algorithms require preprocessing which includes denoising, stripping of skull.

This paper presents a method for denoising and skull segmentation using a sequence of mathematical morphological operations: erosion and dilation, and their compositions i.e., opening and closing. The operators of morphological processing are particularly useful for the analysis of binary images so that MRI images need to be previously binarized.

The next section presents some basics on morphological operations. Section 3 describes our methodology. Finally we show some results in section 4 and draw some conclusions and future work perspectives in section 5.

II. MATHEMATICAL MORPHOLOGY CONCEPTS

Mathematical morphology is a non-linear image analysis technique that extracts image objects information by describing its geometrical structure in a formal way [7]. Mathematical morphology has been largely used in several practical image processing and analysis problems. Here we briefly review some mathematical morphology operators and the corresponding operations used in this work.

Mathematical operators take two data as an input: an image to be processed and a structuring element, which is a matrix used for defining a neighbourhood shape and size [1]. By choosing the shape and size of the element, we can influence the morphological operations sensitivity to specific shapes appearing in the processed image. The elementary shapes of symmetrical structuring elements used in the following processing are shown in Fig. 1.

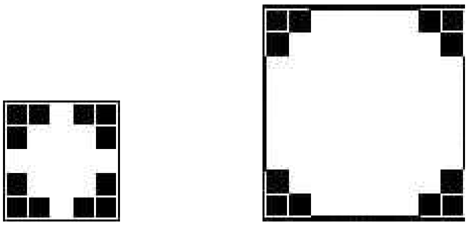
The erosion of binary image I by structuring element S is defined by the formula [1]:

$$I \otimes S = \{x,y : S_{xy} \subseteq I\} \quad (1)$$

The dilation of binary image I by structuring element S is defined by the formula [1]:

$$I \oplus S = \{x,y : S_{xy} \cap I \neq \varnothing\} \quad (2)$$

The operations of closing and opening are the combinations of erosion and dilation, both using the same structuring element. Morphological opening is erosion followed by dilation and morphological closing is dilation followed by erosion. The Fig.3 shows that in a binarized image there are some remaining pixels that represent the noise. To remove the left-over pixels the opening operation was used.



(a) (b)

Fig. 1. Disk shape structuring elements: (a) 2-pixel radius, (b) 5-pixel radius

III. PROPOSED METHODOLOGY FOR STRIPPING SKULL TO SEGMENT BRAIN

This section presents the proposed methodology for segmenting brain MRI images. The fundamental task in brain MRI segmentation is the classification of volumetric data into grey matter, white matter and cerebrospinal fluid but it is not easy as there are some inherent difficulties associated with image segmentation; among them are RF coil in homogeneity, brain tissue susceptibility and other systematic artifacts. Various preprocessing steps have been proposed to deal with some or all of these difficulties. Skull stripping is the first processing step in the segmentation of brain tissue.

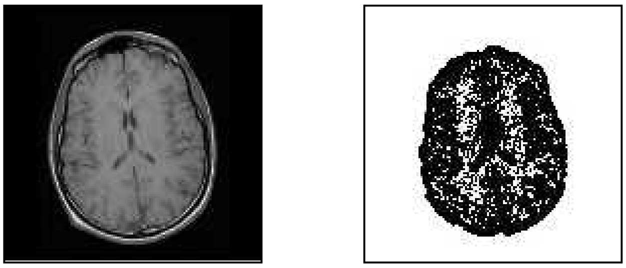
In the proposed method for skull stripping, we see the brain surface as a smooth manifold with relatively low curvature that separates brain from non-brain regions. Also, the brain cortex can be visualized as a distinct dark ring surrounding the brain tissues in the T1-weighted axial MR images.

The steps involved in the proposed methodology for skull stripping and brain extraction consists of three steps.

1. Binarization of every image.
2. Opening operation and closing operation on every image in the sequence using the structuring element.
3. Applying the binary mask to the received MRI input image.

A. *Binarization*

Binarization is the process that converts a grey level image into a binary image. The binarization process involves examining the grey-level value of each pixel in the enhanced image, and if the value is greater than the global threshold, then the pixel value is set to a binary value one; otherwise it is set to zero.



(a) (b)

Fig. 2. (a) Input Image, (b) Binarized Image

B. *Morphological Operation*

The binary morphological operators are then applied on the binarized image. Elimination of any obstacles and noise from the image is the primary function of the morphological operators. The morphological operators namely, opening and closing are being employed in the proposed method.

1) Opening: An opening operation consists of erosion followed by dilation with the same structuring element. The Fig. 3 shows the image after applying the opening operator.

Fig. 3 Binarized image after applying opening operator

2) Closing: A closing operation consists of a dilation followed by an erosion with the same structuring element. The Fig. 4 shows the image after applying the closing operator.

3) Erosion: Erosion operation on an image I containing labels 0 and 1, with a structuring element S, changes the value of pixel i in I from 1 to 0, if the result of convolving S with I, centered at i, is less than some predetermined value. We have set this value to be the area of S, which is basically the number of pixels that are 1 in the structuring element itself. The structuring element (also known as the erosion kernel) determines the details of how particular erosion thins boundaries.

4) Dilation: Dual to erosion, a dilation operation on an image I containing labels 0 and 1, with a structuring element S, changes the value of pixel i in I from 0 to 1, if the result of convolving S with I , centered at i , is more than some predetermined value. We have set this value to be zero. The structuring element (also known as the dilation kernel) determines the details of how a particular dilation grows boundaries in an image

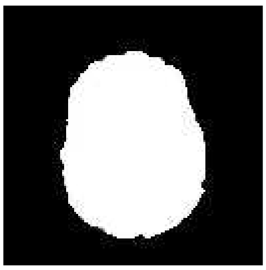


Fig. 4. Brain Mask

C. Region-based binary mask extraction

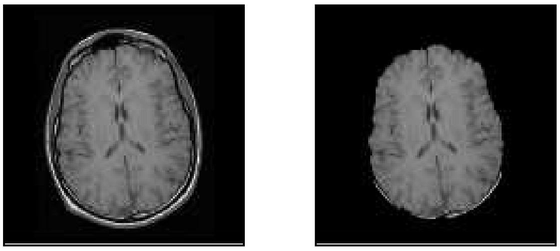
Region-based extraction is done by examining the properties of each block that satisfy some criteria. We have used one of two criteria. One criterion is to look at the max-min difference and the other is to determine the mean values of the blocks. The process results with a brain mask that is then applied to the original MRI data. Consequently, we attain a brain MRI image with its brain cortex stripped as shown in Fig. 5.

Fig. 5 Skull Stripped Brain Image

IV. EXPERIMENTAL RESULTS

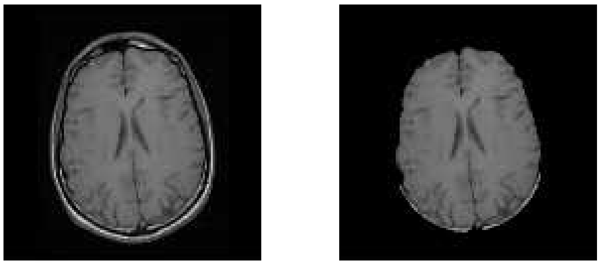
The experimental results of the proposed methodology for segmenting brain MRI images are presented in this section. The proposed methodology is implemented in Matlab (7.4). The input to the proposed methodology is T1-weighted brain MRI images collected from publicly available databases. Regarding T1-weighting, every tissue in the human body has its own T1 and T2 value. This term is used to indicate an image where most of the contrast between tissues is due to differences in the T1 value. The proposed methodology is based on Intensity Thresholding (IT), which is the easiest and fastest segmentation method, often adopted for preprocessing of medical images and preregistration problems.

The sample results of brain MRI segmentation obtained using the proposed methodology is shown in the following Fig.6 to Fig. 10.



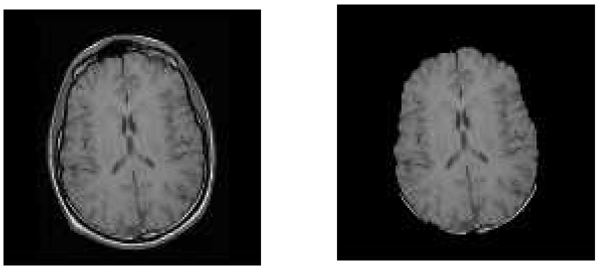
(a) (b)

Fig. 6 (a) Input Image, (b) Segmented Brain Image



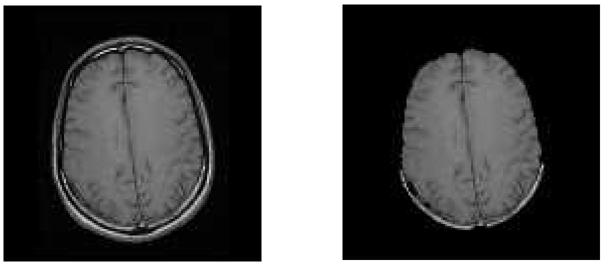
(a) (b)

Fig. 7 (a) Input Image, (b) Segmented Brain Image



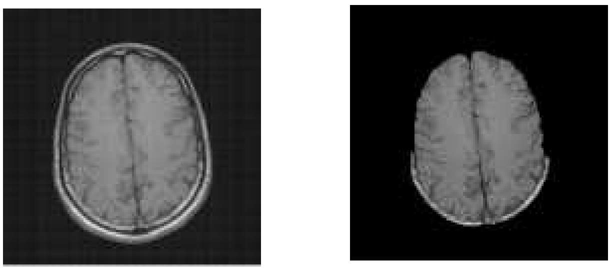
(a) (b)

Fig. 8 (a) Input Image, (b) Segmented Brain Image



(a) (b)

Fig. 9 (a) Input Image, (b) Segmented Brain Image



(a) (b)

Fig. 10 (a) Input Image, (b) Segmented Brain Image

V. CONCLUSION

In this paper, an automated, simple and efficient brain MRI segmentation method for classifying brain tissues has been presented. Initially, the cortex present in the brain MRI images is extracted by combining preprocessing techniques and incorporating mathematical morphology. Experimental results have showed that the proposed method does a reasonably good job in terms of segmentation. In future from this segmented brain image we can segment grey matter, White matter and cerebrospinal fluid.

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