Segmentation of Scalp in Brain MR Images
Based on Region Growing

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Abstract
The aim in this paper is to show how to extract scalp of a series of brain MR images by using region growing segmentation algorithm. Most researches are all forces on the segmentation of skull, gray matter, white matter and CSF. Prior to the segmentation of these inner objects in brain, we segmented the scalp and the brain from the MR images. The scalp mask makes us to quickly exclude background pixels with intensities similar those of the skull, while the brain mask obtained from our brain surface. We make use of connected threshold method (CTM) and confidence connected method (CCM). Both of them are two implementations of region growing in Insight Toolkit (ITK). By using these two methods, the results are displayed contrast in the form of 2D and 3D scalp images.

1. Introduction
For medical MR images, many methods were recently applied for segmentation, for instance interactive thresholding aided by morphological information [1], region growing and region splitting and merging [2], active contours [3], the use of cluster analysis methods [1], watershed transformation [4], or level set. These methods have been proposed and implemented for a challenging task. However, there is no best approach that can generally solve the problem of segmentation alone for the large variety of image modalities existing today. The most effective segmentation algorithms are obtained by carefully customizing combinations of components [5]. The parameters of these components are turned for the characteristics of the image modality used as input and the features of the anatomical structure to be segmented [5].

The Insight Toolkit (ITK) is an open-source, cross-platform system that provides developers with an extensive suite of software tools for image analysis [6]. ITK provides a basic set of algorithms that can be used to develop and customize a full segmentation application. Region Growing is the one of the most commonly used segmentation components which includes several implementations such as Connected Threshold, Otsu Segmentation, Neighborhood Connected, Confidence Connected and Isolated Connected. Connected Threshold Method (CTM) and Confidence Connected Method (CCM) are the most representative implementations of Region Growing.

In this paper, we use CTM and CCM to extract scalp of a brain. This is the important step before brain segmentation, which can allow us to distinguish clearly the region of background and brain. Since scalp can narrow the application region of image segmentation.

2. Methods
2.1 Region Growing
Region Growing is one of the simplest region-based image segmentation methods and it can also be classified as one of the pixel-based image segmentations because it involves the selection of initial seed points [7]. This approach exploits the important fact that pixels which are close together have similar gray values. Also the basic approach of a region growing algorithm is to start from one or more pixel as a seed region. The seed region is considered to be inside the object to be segmented. The neighboring pixels are evaluated to determine if the neighboring region pixels are similar to the seed.

(1) Choose the seed pixel
(2) Check the neighboring pixels and add them to the region if they are similar to the seed
(3) Repeat step 2 for each of the newly added pixels; stop if no more pixels can be added.

Region Growing algorithms vary depending on the criteria used to determine neighbors, and the strategy used to visit neighboring pixels.

2.2 Connected Threshold Method (CTM)
Evaluate intensity value inside a specific interval is a simple criterion for including pixels in a growing region. There is a ConnectedThresholdImageFilter in ITK which uses the flood fill iterator. Most of the algorithmic complexity of a region growing method comes from visiting neighboring pixels [5]. The algorithm is left to establish a criterion to decide whether a particular pixel should be included in the current region or not. First of all, we choose a set of seed points. And the initial region now is the exact location of these seeds. Then the regions are grown from these seed points to adjacent points depending on a threshold we make. The threshold used by the ConnectedThresholdImageFilter is based on an interval of intensity values provided. Values of lower and upper threshold should be provided. The region growing algorithm includes those pixels whose intensities are inside the interval [5]. The following equation illustrates the inclusion criterion used by this filter,
2.3 Confidence Connected Method (CCM)

The criterion used by the ConfidenceConnectedImageFilter is based on simple statistics of the current region. First, the algorithm calculates the mean and standard deviation of intensity values for all the pixels currently included in the region. A factor provided by the user is used to multiply the standard deviation and define a range around the mean. All of the neighbor pixels whose intensity values belong to the range are accepted and included in the region. When there are no more neighbor pixels that satisfy the criterion, the algorithm is considered to have finished its first iteration. Then the mean and standard deviation of the intensity levels are recomputed using all the pixels currently included in the region [5]. This iterative process is repeated until no more pixels are added or the number of iterations is reached at the maximum number. The following equation illustrates the inclusion criterion used by this filter,

\[ I(X) \in [m-f\sigma, m+f\sigma] \]  

(2)

Where \( m \) and \( \sigma \) are the mean and standard deviation of the region intensities, \( f \) is a factor, \( I() \) is the image and \( X \) is the position of the particular neighbor pixel being considered for inclusion in the region [5].

3. Results

There are 160 slices of brain MR images in Sagittal plane. Each slice have a size of 240×256. By programming we change the direction to obtain 256 slices of brain MR images in Horizontal plane, each of which has a size of 240×160. In this paper, 2D image is shown with 74th slice of brain MR images.

Generally if an MR image contains noise, their presence can change the pixel intensities, which will result in an incorrect membership and improper segmentation. In this case, there are a huge number of noises existed in the background. We have to take off these noises before segmentation. So we make values of all the background pixels with zero and get the original image and input image in Fig.1.

4. Conclusion

In this paper, we apply connected threshold method (CTM) and confidence connected method (CCM) of region growing algorithm to make 2D brain MR image segmentation of scalp. The results show that comparing CTM, either 2D or 3D, the effect of CCM is more smoothly. However, there are still some problems that require further investigation. First, we don’t evaluate the segmentation performance quantitatively. Second, we don’t compare with other segmentation algorithm. Consequently, we could not make a comprehensive assessment. It is worthwhile to study in depth.

References