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 g rowing 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 i mplementations 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 a pplied for segmentation, for instance interactive threshold ing aided by morphological information [1], region grow ing and region splitting and merging [2], active contours [3], the use of cluster analysis methods[1], watershed tr ansformation [4], or level set. These methods have been proposed and implemented for a challenging task. How ever, 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 s egmentation algorithms are obtained by carefully customi zing combinations of components [5]. The parameters of these components are turned for the characteristics of t he 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-platfo rm system that provides developers with an extensive su ite of software tools for image analysis [6]. ITK provid es 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 segmen tation components which includes several implementation s such as Connected Threshold, Otsu Segmentation, Nei ghborhood Connected, Confidence Connected and Isolate d Connected. Connected Threshold Method (CTM) and Confidence Connected Method (CCM) are the most repr esentative implementations of Region Growing.

In this paper, we use CTM and CCM to extract scalp o f brain. This is the important step before brain segment ation, which can allows us to distinguish clearly the reg ion of background and brain. Since scalp can narrow th e application region of image segmentation.

2. Methods

2.1 Region Growing

Region Growing is one of the simplest region-based ima ge segmentation methods and it can also be classified a s one of the pixel-based image segmentations because it involves the selection of initial seed points [7]. This a pproach 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 fro m 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 y should also be considered part of the object. The basi c algorithm starts with a single pixel and adds new pix els slowly following as:

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

Region Growing algorithms vary depending on the criter ia 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 si mple criterion for including pixels in a growing region. There is a ConnectedThresholdImageFilter in ITK which uses the flood fill iterator. Most of the algorithmic co mplexity of a region growing method comes from visiti ng neighboring pixels [5]. The algorithm is left to estab lish a criterion to decide whether a particular pixel shou ld be included in the current region or not.

First of all, we choose a set of seed points. And the in itial region now is the exact location of these seeds. Th en the regions are grown from these seed points to adja cent points depending on a threshold we make. The thre shold used by the ConnectedThresholdImageFilter is base d on an interval of intensity values provided. Values of lower and upper threshold should be provided. The regi on growing algorithm includes those pixels whose intens ities are inside the interval [5]. The following equation i llustrates the inclusion criterion used by this filter,

$$I(X) \in [\text{lower, upper}] \qquad (1)$$

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 are selected that satisfy the criterion, the algorithm is considered to have finished its first iteration. And 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,

$$I(X) \in [m - f\sigma,\ m + f\sigma] \qquad (2)$$

Where m and σ 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.

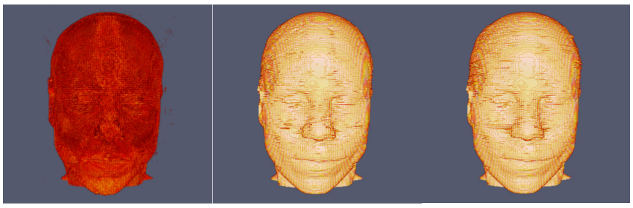
(a) (b)

Fig.1 (a) Original brain MR image. (b) Input brain MR image which takes off the noise. (The 74th slice of brain MR images)

Then we make segmentation of scalp by using CTM and CCM of region growing for each slice of brain MR images, and get two set of 2D scalp images. Base on these 2D images, we build 3D scalp image for each method. These images are shown in Fig.2 and Fig.3.

(a) (b)

Fig.2 The segmentation of scalp in 2D brain MR image. (a) The scalp image of CTM. (b) The scalp image of CCM. (The 74th slice of brain MR images)



(a) (b) (c)

Fig.3 3D original brain image and the segmentation of scalp in 3D brain image. (a) The 3D original brain image in coronal plane. (b) The 3D brain image of CTM in coronal plane. (c) The 3D brain image of CCM in coronal plane.

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.

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