A semi-automatic segmentation of brain tumor using DTI data set

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Introduction

The Visualization of both tract fibers and tumor lesions in 3D is valuable tool for identifying the relative positions of those objects and for surgical planning. Normally, the DTI data set consists of some DW images and T2 images to track nerve fibers correctly. However, these images often have similar contrast in terms of the tumor and other regions, which makes the segmentation of the tumor from the other regions more difficult. The aim of this study was to segment brain tumors using the DTI data set without any additional image data, and to display them in 3D by fusing them with the tract fibers.

Methods

Figure 1 shows block diagram of our segmentation method. Firstly, the images in DTI data set are de-noised by an anisotropic diffusion filter with edge preservation [1]. Secondly, The images in the data set were interpolated for slice direction to approximate an isotropic voxel. And a ROI (Region Of Interest) is set on a tumor in a single slice of the DTI data set to measure the mean (**m**) and the standard deviation (σ) values. Next, the Fast Marching Level Set method [2] is applied by using the following speed function F: $F(x,y) = g(I(x,y))\cdot D(I(x,y))$, where I(x, y) is a pixel intensity on the image, g(I) is an edge function and D(x) is: $(-x + m) / S_u$ (if $S_u \geq x \geq m$), $(x - m) / S_l$ (if $S_l \leq x \leq m$), otherwise 1.0, and where $S_u = m + \alpha_u\cdot\sigma$, $S_l = m - \alpha_l\cdot\sigma$. The segmented region can be adjusted by changing α_u and α_l. Similar pixel contrast values in tumor and the ventricle in either T2 or DW images causes over-segmentation, which means that the segmented tumor will be connected to the ventricle. To separate the tumor from ventricle, Erosion and Dilation are used. However, after such a processing the original topology of the tumor is often lost. Since the segmented ventricle has a relatively large volume, excluding the ventricle from other original regions is possible by setting a threshold level following a subtraction of the image of the first segmentation and the Erosion Dilation result. Adding the original regions other than the ventricle to the Erosion and Dilation result can restore the original tumor shape. Finally, the updated mean and standard deviation values are computed from the newly segmented tumor, and then the Fast Marching method using those new values is applied again with masking the discarded ventricle.

Results

Figure 2 shows the results of the segmentation. In this case, T2 images of 28 slices were interpolated to 70 slices, which were used instead of DW images. Figure 2 (a) shows the segmentation result for Fast Marching 3D. The mean and standard deviation were computed from a single ROI having 720 pixels. Both the tumor and a ventricle were segmented, but the connection between them is still visible. Figure 2 (b) shows the result of selecting a tumor by tracking from the initial ROI after applying Erosion and Dilation processing (26 neighbors $\times$ 2) . The shape of the resulting tumor region seems to be different from the original one. In Figure 2 (c), the tumor shape was successfully acquired by applying restoration and the second Fast Marching processing. The computational time was approximately 12 seconds on a Pentium 4 3GHz machine with 3 Gbytes memory.

Conclusion

Tumor segmentation using only the DTI data set became possible with a practical computational time. The resulting tumor was also successfully fused to the tract fibers for 3D display. In addition, Erosion and Dilation with restoration techniques enabled the prevention of over-segmentation effectively. The usage of two adjustable parameters (α_l, α_u) enabled us to refine the segmentation result.

Reference

1. G. Gerig al., IEEE trans. Med. Imaging, 11(2):221-232 (1992)
2. J. A. Sethian, Level set methods and fast marching methods. Cambridge University Press (1999).

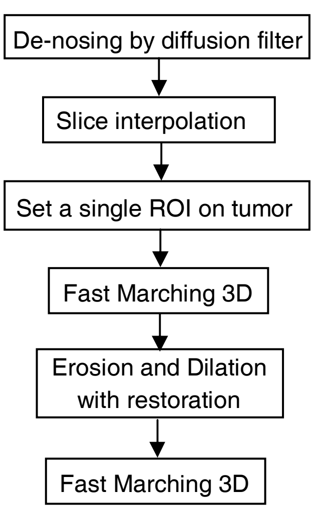

Figure 1: Block diagram

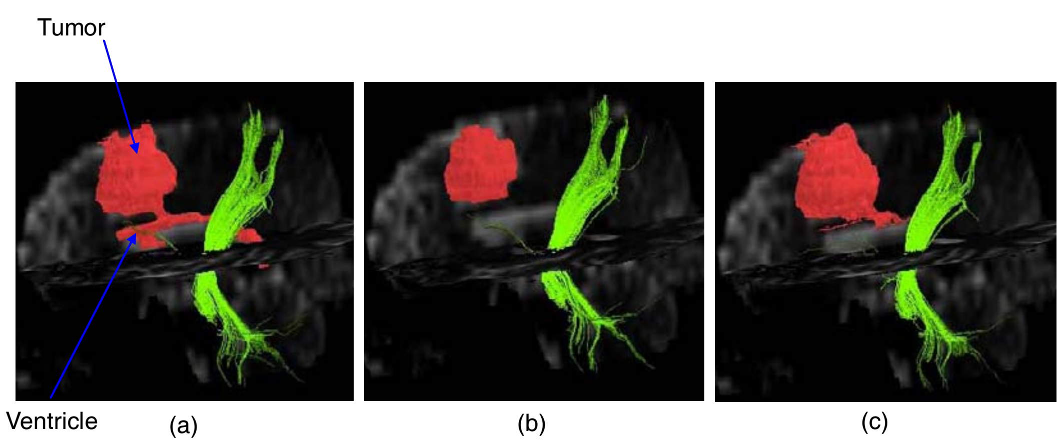

Figure 2: Results of segmentation (a) Only Fast Marching 3D (b) plus Erosion and Dilation (26 neighbors $\times$ 2)(c) Erosion and Dilation with restoration process and then Fast Marching