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A FAST DEFORMABLE REGION MODEL FOR BRAIN TUMOR BOUNDARY EXTRACTION

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Abstract – **We present a modified deformable region model for the extraction of brain tumor boundary in the 2D MR images. Deformable region model tolerates a rough initial plan when compared with the active contour model. However, it is time consuming for computing and comparing the gray level distribution of the object and its every boundary points. Using a point sampling technique, the number of boundary point processed is greatly reduced. Performance of our modified deformable region model is evaluated on MR image. The modified model is fast while similar results are obtained.**
Keywords – **deformable model, tumor boundary, MR image**

I. Introduction

Managing non-surgical therapy of brain tumor involves periodic monitoring of tumor development in terms of area, volume, shape, etc. Although radiologists can manually trace the tumor boundary in the 2D MR images, it is really a tedious and time-consuming process. Moreover, the results may not be consistent and repeatable owing to substantial intra-observer and inter-observer variability.

Active contour model [1] can be used to extract the boundary of brain tumor from an initial plan. Based on this model, other contour models [2], [3], have been proposed with various energy functions and optimizing methods. All these models require the initial plan to be close to the actual boundary. Moreover, they have difficulties progressing into boundary concavities. To overcome these, Xu and Prince [4] proposed an external force, gradient vector flow (GVF), for the active contour model. It is computed as a diffusion of the gradient vectors of a gray level or binary edge map derived from the image. Lie and Chuang [5] developed a no-search movement scheme for the active contour model with gradient vector flow as the external force. However, other objects and noise can also give high gray level gradients in the image. The optimization functions may have many local optima. The extracted boundary will be greatly dependent on the location of initial plan. Therefore, such models still require the initial plan to be close enough to the object. To deal with this problem, region information [6] of the image can be used for the model.

In this paper, we present a modified deformable region model for the extraction of brain tumor boundary in the 2D MR images. Deformable region model [6] tolerates a rough initial plan when compared with the active contour model. However, it is time consuming for computing and comparing the gray level distribution of the object and its every boundary points. Using a point sampling technique in the modified model, the number of boundary point processed is greatly reduced.

II. Methodology

Deformable region model [6] is to find a maximum area region with the same gray level distribution using a shrinking-growing method. The Kolmogorov-Smirnov (KS) test method is used to test whether the boundary pixel set and the object pixel set have the same gray level distribution. The Kolmogorov-Smirnov distance D is defined as

$$D = \max_{0 \le g_s \le 255} | F_B(g_s) - F_O(g_s) | \qquad (1)$$

where F_o and F_B are the gray level cumulative frequency distribution of object and boundary respectively. The hypothesis $F_o = F_B$ is accepted when $D < d$, and d is defined as

$$d = \frac{c}{\sqrt{\frac{A \cdot L}{(A+L)}}} \qquad (2)$$

where c is the significance level of the test, A is the area of object, and L is the length of boundary.

When $D > d$, the region plan covers a region different from the tumor. Shrinking is performed to deform the region to meet $D < d$. Hence, the homogeneity of the region can be guaranteed. The shrinking algorithm is the erosion operation. It only deletes the region boundary elements, which has a different gray level distribution. In the modified model, the boundary points are sampled with intervals of k pixels. Instead of processing all boundary points of the object, one of every k boundary points will be computed. When $D < d$, the region plan covers a region inside the tumor. The region, however, may not cover the whole tumor. To obtain the maximum area, growing is performed until $D > d$. The growing algorithm is the dilation operation of the whole object. In the modified model, the growing algorithm remains unchanged. After each shrinking and growing, the new region area is compared with the previous one. If the region area does not change, the process stops; otherwise, the iteration of shrinking and growing continues.

III. Results and Discussion

Deformable region model and the modified deformable region model were implemented using MATLAB code. In the experiments, the significance level of the test c was fixed at 3. In the modified model, the boundary points were sampled with intervals of 5 pixels. Performance of both models was tested using Pentium III PC computer.

A MR image (8-bit grayscale, 256 x 256 pixels) with a brain tumor was used. The pixel size is 0.898mm x 0.898mm. In Fig. 1, an initial plan outside the brain tumor was set manually. The boundary of brain tumor was located using deformable region model and the modified deformable region model. Both models gave similar boundary results. The time required by deformable region model and the modified deformable region model were 102s and 28s respectively. In Fig. 2, an initial plan inside the brain tumor was set manually. Again, similar boundary results were obtained by both models. The time required by deformable region model and the modified deformable region model were 22s and 12s respectively. The results show that the time required for processing is reduced by the modified model. The difference in time required will be greater if the initial plan is set outside the tumor. It is because the modified model differs in that the point sampling technique was used only in the shrinking part of the model. In the first case, shrinking was mostly used for an initial plan outside the tumor. In the second case, growing was mostly used for an initial plan inside the tumor.

IV. Conclusions

In our modified model, it can tolerate a rough initial plan. The time required for the extraction of brain tumor boundary in MR image is greatly reduced.

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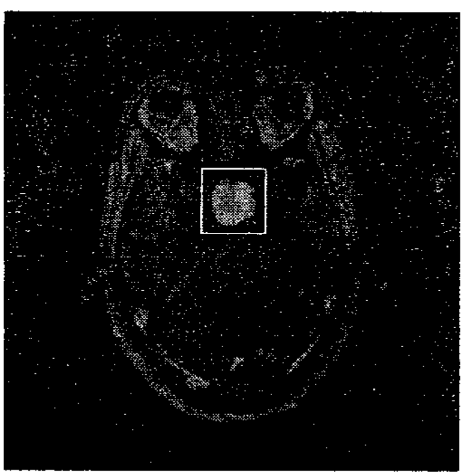

Fig. 1. An initial plan outside the brain tumor

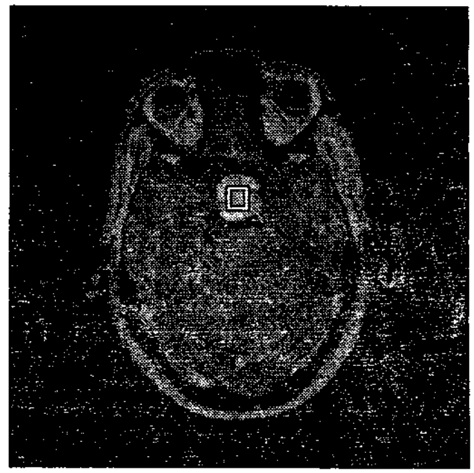

Fig. 2. An initial plan inside the brain tumor

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