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Semi-automatic analysis of tumor changes in response to therapy

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1. Purpose

Cancer disease is one of the leading causes of death in humans. Non-invasive monitoring and assessment of cancer treatment is an important area for MRI. In monitoring the treatment of cancer disease, quantification of the tumor response is an important factor for assessment of the therapy and clinical prognosis by the physician. However, currently intelligent tools to measure tumor response to therapy are mainly non-existent. In the current clinical workflow, tumor response from MRI is assessed visually or manually, therefore semi-automatic quantification would provide additional prognostic information to MRI and help monitor cancer treatment process in the clinical setting. The aim of this study is to develop a semi-automatic segmentation method with minimum user interaction, which is applied to the clinical monitoring of tumor treatment.

2. Material and Methods

8 patients in the age ranges of 9-69 years (5 M, 3 F) with primary and secondary brain tumors are included in the study. All subjects are examined by 1.5T MR imager (Anadolu Medical Center) using post gadolinium, high resolution (~0.5x0.5x1.0mm) 3D T1 weighted gradient echo sequence. For each subject, who is undergoing therapy (such as Cyber-knife, conventional radiotherapy, chemotherapy, or combined therapies), base-line scan and follow-up scans are obtained. Tumors are segmented in each volume by using the semi-automatic system developed. The user is asked to draw a line through the tumor to specify a volume of interest and a combined 3D segmentation algorithm, which uses cellular automata[1] to determine labels for tumor and brain tissue then refines the result using level set method[2,3], is used to estimate the volume of the tumor. (Figure 1)

figure1.gif

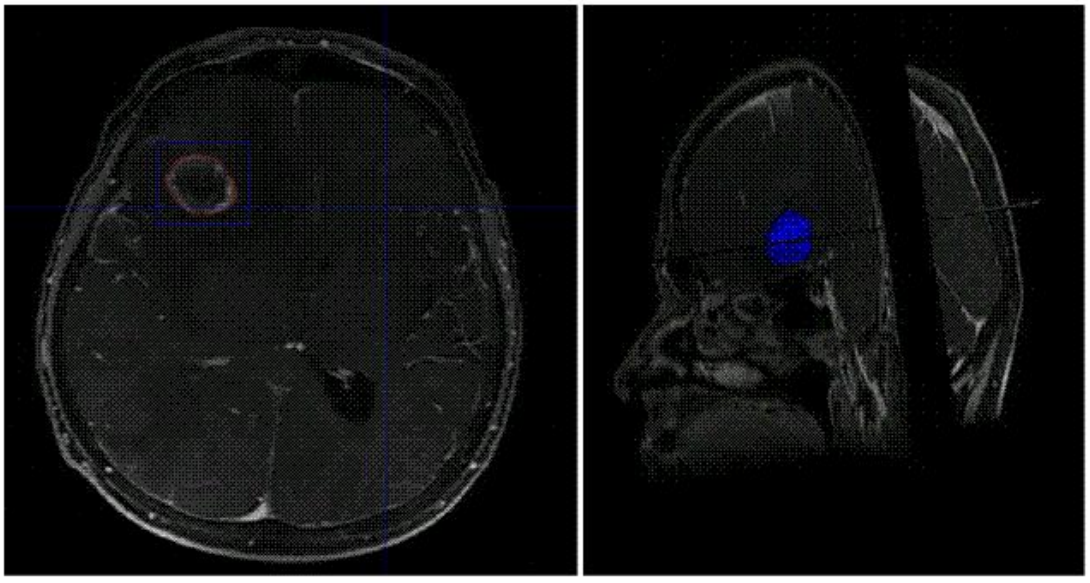

Figure 1. VOI specified by user (blue) and estimated tumor border (red) (left). Tumor volume rendered on 3D MR volume. (right)

3. Results

Tumor volumes of 8 patients with single or multiple (patient 2 and 7) brain tumors, calculated using the developed segmentation algorithm, are given in table 1. Significant volume changes are determined by using t-test with $p < 0.01$ and comparison with radiologist's assessment is given in table 2.

table1.gif

1 (49 M)		09/11/2005 4631±94 mm^3	17/01/2006 5142±154 mm^3	04/05/2006 4413±96 mm^3	09/12/2006 2253±58 mm^3	06/02/2008 1236±41 mm^3
2 (68 M)		10/08/2007	07/12/2007	28/01/2008	06/03/2008	05/05/2008
	a	9529±1901 mm^3	6293±509 mm^3	5501±355 mm^3	5120±958 mm^3	4841±406 mm^3
	b	484±22 mm^3	2489±205 mm^3	3352±55 mm^3	3322±117 mm^3	2699±171 mm^3
3 (69 M)		26/10/2007 7527±137 mm^3	25/01/2008 7851±283 mm^3	15/04/2008 10628±633 mm^3		
4 (63 M)		27/10/2008 2695±139 mm^3	19/01/2009 605±10 mm^3	08/04/2009 303±11 mm^3		
5 (9 F)		18/12/2008 22019±1697 mm^3	27/02/2009 33031±3083 mm^3	02/04/2009 38908±8703 mm^3		
6 (54 F)		31/03/2008 3232±11 mm^3	16/09/2008 2994±22 mm^3	08/04/2009 2708±40 mm^3		
7 (49 F)		24/04/2007	08/04/2008	05/03/2009		
	a	2566±27 mm^3	2644±19 mm^3	2702±33 mm^3		
	b	21654±326 mm^3	22593±1241 mm^3	22040±2078 mm^3		
8 (43 M)		13/10/2008 9105±135 mm^3	16/02/2009 8405±792 mm^3			

Table 1. Tumor volumes calculated using the developed semi-automatic segmentation algorithm.

table2.gif

	1st Follow-up	2nd Follow-up	3rd Follow-up	4th Follow-up
	Method / Radiologist	Method / Radiologist	Method / Radiologist	Method / Radiologist
1	***+ / NC***	***- / NC***	- / -	- / -
2a	- / -	***NC / +***	NC / NC	***NC / -***
2b	+ / NA	+ / +	NC / NC	- / -
3	***NC / -***	+ / +		
4	- / -	- / -		
5	+ / +	***NC / -***		
6	***- / NC***	***- / NC***		
7a	***+ / NC***	NC / NC		
7b	NC / NC	NC /NC		
8	NC / NC			

"NC" : No significant change, "+" : Increase, "–" : Decrease, "NA" : Data not available

Table 2. Comparison of the results with the radiologist's assessment.

4. Conclusion

The results are consistent, compared with radiologist's visual inspection. Volume of "Tumor A" of 2nd patient could not be determined precisely on 06/03/2009, because of low contrast enhancement and smooth borders. The 5 th patient has a tumor at brain stem, which is not enhanced with gadolinium contrast. For the 1 st, 6 th and 7 th patients, our method reported a slight volume decrease, which was visually not significant. Preliminary studies revealed that the proposed method is promising in aiding clinical assessment of tumor change in response to cyber knife therapy. Further measurements such as the largest tumor diameter will be provided to compare the developed algorithm with that of the radiologists' assessment of the tumor response.

5. References

[1] Vezhnevets et.al. "GrowCut - Interactive Multi-Label N-D Image Segmentation By Cellular Automata", Graphicon (2005)

[2] Chan et.al. "An active contour model without edges", Int. Conf. Scale-Space Theories in Computer Vision, 141-151(1999)

[3] Yezzi et.al. "A statistical approach to snakes for bimodal and trimodal imagery", Proc. Int. Conf. on Computer Vision, 898-903(1999)

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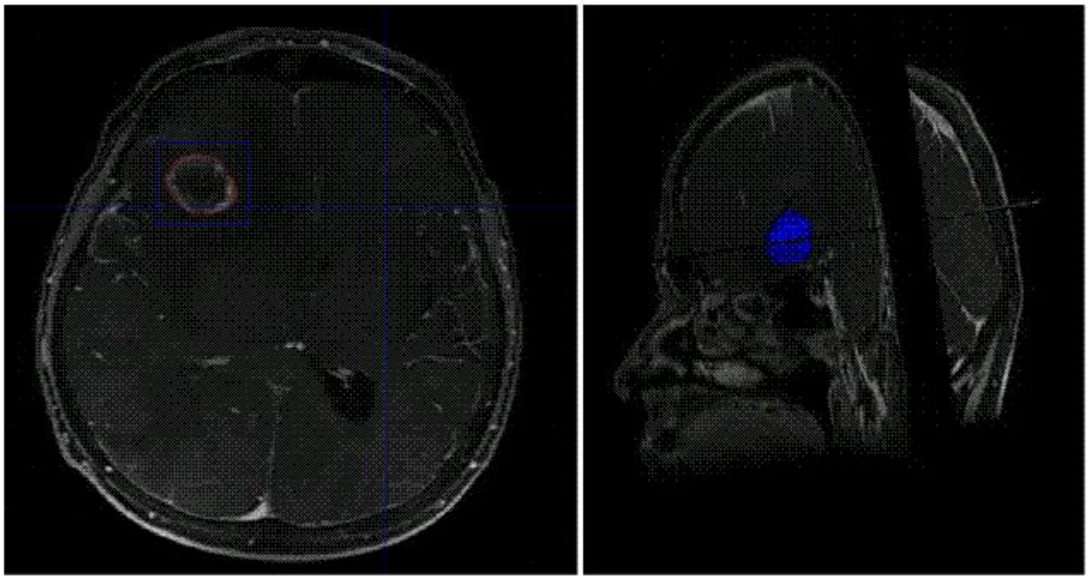
6. Mediafiles

figure1.gif



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2b	+ / NA	+ / +	NC / NC	- / -
3	***NC / -***	+ / +		
4	- / -	- / -		
5	+ / +	***NC / -***		
6	***- / NC***	***- / NC***		
7a	***+ / NC***	NC / NC		
7b	NC / NC	NC /NC		
8	NC / NC			

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