Comparison of Two Atlas-Based Segmentation Methods for Head and Neck Cancer Including RTOG-Defined Lymph Node Levels

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Purpose

Manual contouring of head and neck cancer cases is a time consuming task. Automatic contouring methods for head and neck cancer have been developed including atlas-based segmentation. In a previous work we demonstrated time savings in contouring of 68-87% using atlas generated contours as a starting point (1). Additionally we demonstrated that using multiple atlas matches can improve results compared to using a single best matched subject (2). Our goal in this work is to compare two methods of atlas-based segmentation using a head and neck cancer atlas with RTOG-defined lymph node levels.

Methods

Twenty subjects with CT scans and brachial plexus, brain, brainstem, constrictors, larynx, RTOG-defined lymph node levels, mandible, orbits, parotids, spinal cavity, and spinal cord contours were used to create an atlas database. Two atlas-based segmentation methods were tested: Method 1 used a free-form intensity-based deformable registration while Method 2 used an additional automatic registration approximation method to influence the intensity-based deformation. Atlas segmentation was performed using a leave-one-out analysis (subject being tested was excluded from the atlas). The 5 best matched atlas subjects were automatically chosen and deformed to the test subject (Multi-5). Contours were combined using Majority Vote or where 3 of 5 contours overlapped. Auto contours were compared to the manually defined using the Dice Similarity Index for both methods.

Results

The table shows the results for Method 1 compared to Method 2 where each structure had a higher dice score for Method 2 and were statistically significant ($p < 0.05$) for all structures except for the larynx which trended towards significance ($p = 0.069$).

Table 1
Average Dice Similarity Coefficient

Structure	Method 1	Method 2	P-Value	% Imprv.
Brachial Plexus	0.32 ± 0.13	0.42 ± 0.091	<0.0001	14.4
Brain	0.97 ± 0.02	0.98 ± 0.002	0.017	32.5
Brainstem	0.78 ± 0.10	0.85 ± 0.029	0.0068	32.1
Constrictors	0.49 ± 0.09	0.55 ± 0.067	0.0024	11.4
Larynx	0.75 ± 0.16	0.80 ± 0.075	0.069	21.8
LN Levels	0.66 ± 0.06	0.70 ± 0.049	0.0011	11.7
Mandible	0.82 ± 0.10	0.88 ± 0.03	0.012	31.8
Orbit	0.72 ± 0.17	0.83 ± 0.058	0.0084	38.1
Parotid	0.71 ± 0.09	0.74 ± 0.07	0.0019	9.9
Spinal Cavity	0.76 ± 0.17	0.81 ± 0.16	0.00016	21.6
Spinal Cord	0.71 ± 0.16	0.73 ± 0.15	0.029	8.2

Average Dice Similarity Coefficient across twenty subjects for Method 1 and Method 2.

Figure 1
Atlas-Based Segmentation Workflow

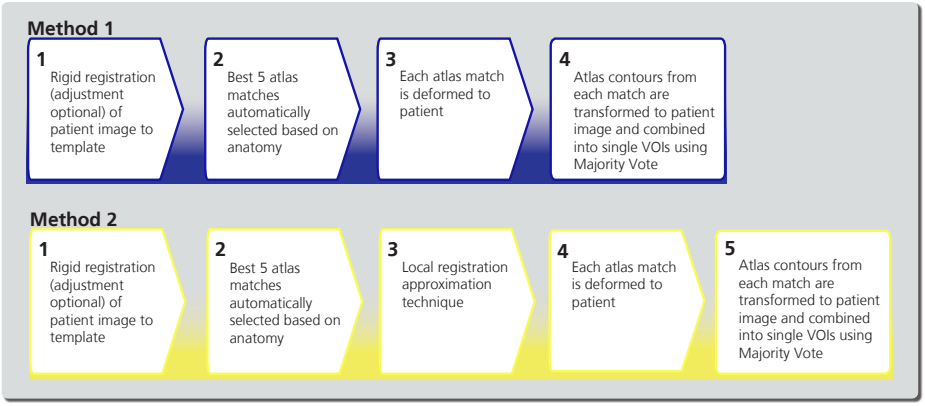
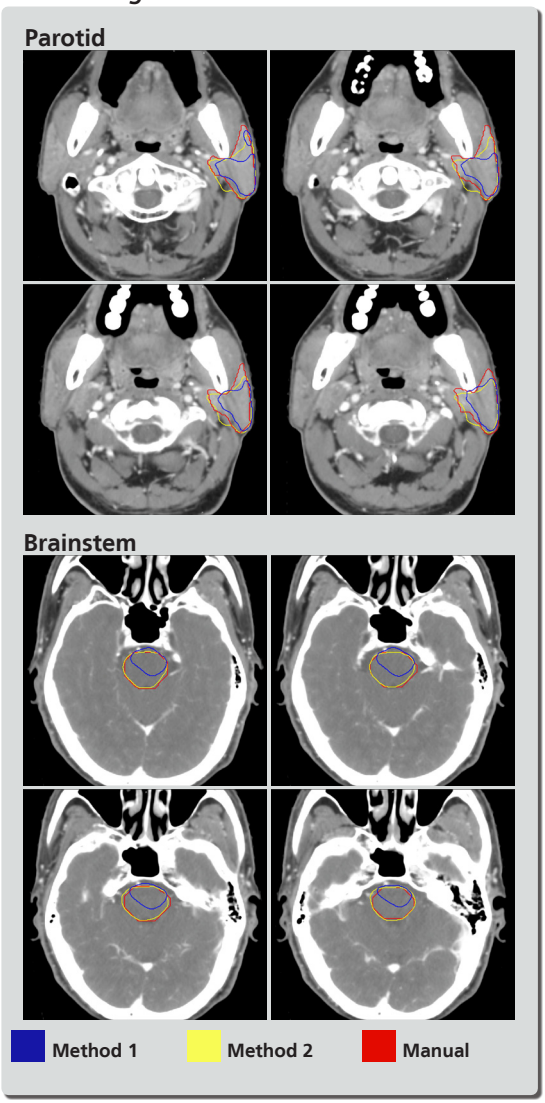


Figure 2
Patient Image



Comparison of segmentation results for the left parotid and brainstem to manual contours using Method 1 and Method 2. Note the improved accuracy using Method 2.

Conclusion

A new method of atlas-based segmentation which uses an automatic registration approximation technique to influence the intensity-based deformation was found to be more accurate than an intensity-based deformation method alone.

References

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2. Pirozzi SD, Nelson AS, Piper JW. Atlas-based Segmentation: Comparison of Multiple Segmentation Approaches for Lymph Level Targets and Normal Structures in Head and Neck Cancer. International Journal of Radiation Oncology * Biology * Physics 1 October 2011 (Vol.81, Issue 2, Supplement, Page S828).