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Evaluation of Two Different Systems for the Deformable Segmentation of a Lung Tumor in the Treatment of NSCLC using SBRT

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INTRODUCTION

- Respiratory motion can cause motion artifacts and may significantly influence the accuracy and reproducibility for radiation treatment planning and delivery during Stereotactic Body Radiation Therapy (SBRT).
- 4DCT is one of the common methods to evaluate the tumor motion and allows for accurate delineation of tumor and critical structures.
- Delineating the Gross Tumor Volume (GTV) on all phases of respiratory cycle is the most straightforward way to delineate the Internal Target Volume (ITV) from the 4DCT dataset.
- Manual delineating the GTVs in all 10 phases is tedious and time consuming.
- Automatic contour propagation tools can significantly decrease the ITV delineation time by automatically propagating a manually delineated GTV from one phase to all other phases.
- There is also substantial inter and intra physician variation in tumor segmentation[11].
- Algorithm based tumor segmentation involving non-rigid deformation may provide a consistent method of tumor delineation and may yield better results.

AIM

To evaluate MIM and Eclipse system for the 4DCT automatic propagating contour of lung tumors in the Treatment of non-small cell lung cancer (NSCLC) using SBRT and compare the result with physician's segmented tumors.

METHOD

- 24 patients of NSCLC with various lobe location were tested.
- Two methods: brute deformation and sequential deformation were used to generate the internal target volume (ITV) by propagating the manual contouring of Gross Tumor Volume of 50% phase (GTV50), i.e. end exhalation to other phases.
- Brute: GTV50 was directly propagated to phase of 0, 10, 20, 30...90.
- Sequential: the contour was sequentially deformed and propagated to adjacent phases with each subsequent phase then becoming the primary phase for deformation.
- ITV were defined by combining the GTV on all 10 phases of the respiratory cycle
- 4 datasets is compared against physician's drawn ITV by using Dice similarity coefficient (DSC)
- DSC represent the the size of overlap of two segmentations divided by the total size of both objects. Mathematically, $DSC = \frac{2(V_{auto} \cap V_{ref})}{V_{auto} + V_{ref}}$
  where V_{ref} is the gold standard 10 phase PTV, and V_{auto} is the compared ITV.
- A DSC score of 1.0: two volumes are identical, whereas 0.0: no physical overlap.
- A dependent-samples t-test was conducted to test the hypothesis that the two method and two system were associated with statistically different DSC

RESULTS

- Table.1 & Table 2 show the average and standard deviation of manual and the algorithm based delineated mean volume and DSC of the ITV by the two methods for MIM & Eclipse, respectively.
- In the cohort of patients studied, MIM underestimated the ITVs while Eclipse overestimated the same.
- The brute method and sequential method using MIM has a DSC = 0.89 ± 0.03 and 0.89±0.04, respectively.
- The brute method and sequential method using Eclipse has a DSC = 0.82 ± 0.04 and 0.76±0.07, respectively.
- The DSC in all the systems were higher than 0.70 and hence could be classified as a good match between them.
- Fig. 1 and Fig. 2 show brute method yielded better DSC than sequential method in the two systems
- Fig.3 and Fig. 4 show the MIM are slightly better in automatic contouring propagation of ITV than Eclipse as indicated by higher average DSC and smaller standard deviations for our set of data at the maximum.
- A dependent-samples t-test showed that difference between volumes and DSC of both the systems was statistically significant.

CONCLUSIONS

- This study found brute deformation method can create a slightly better ITV than sequential deformation method in cohort of studied patients
- The MIM software performed slightly better in automatic contouring propagation of ITV than Eclipse.
- Incidentally, the brute method is also most work flow efficient.
- Even though ITV generated using all the 10 phases of a 4DCT dataset remains the gold standard for planning of NSCLC tumors using SBRT, our results of using deformable segmentation with a DSC of almost 0.9 using commercial systems are very encouraging.
- Automated 4DCT contour propagation tools offer a useful tool in a busy clinic so long as the resultant volumes are vetted by the physician.

CONTACT INFORMATION

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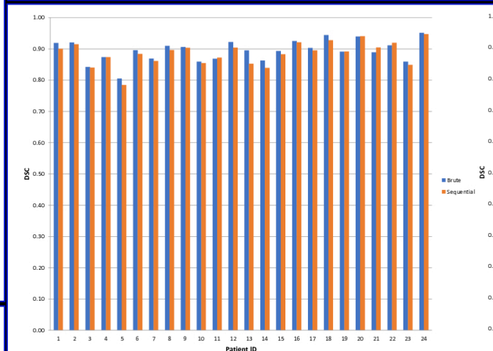

Fig. 1 The DSC for brute deformation method and sequential deformation method using MIM

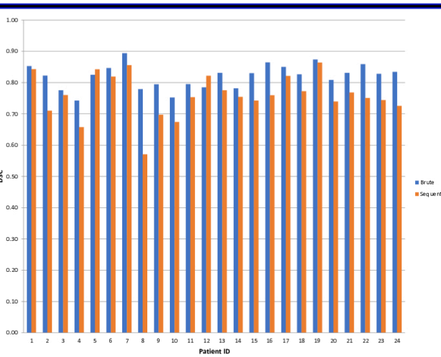

Fig. 2 The DSC for brute deformation method and sequential deformation method using Eclipse

MIM	Location	V_{bru} (cm^3)	V_{seq} (cm^3)	V_{god} (cm^3)	DSC_bru	DSC_seq
AVERAGE	LLL	25.68	24.62	26.52	0.90	0.90
	LUL	17.07	16.96	19.54	0.92	0.92
	RLL	20.41	19.67	20.89	0.88	0.86
	RML	12.30	11.99	15.51	0.88	0.87
	RUL	17.74	17.13	20.83	0.89	0.88
	ALL Patient	17.44	16.95	19.74	0.89	0.89
STDEV	LLL	18.74	16.97	15.39	0.04	0.04
	LUL	3.26	3.11	3.88	0.02	0.02
	RLL	9.02	8.75	9.04	0.02	0.02
	RML	11.73	11.37	16.75	0.04	0.04
	RUL	10.17	9.58	11.32	0.04	0.03
	ALL Patient	11.50	10.82	12.54	0.03	0.04

Table.1 The average and standard deviation of manual and the algorithm based delineated mean volume and DSC of the ITV by the two methods for MIM.

Eclipse	Location	V_{bru} (cm^3)	V_{seq} (cm^3)	V_{god} (cm^3)	DSC_bru	DSC_seq
AVERAGE	LLL	28.83	33.95	26.33	0.84	0.75
	LUL	19.72	22.88	19.28	0.84	0.79
	RLL	23.53	21.53	16.65	0.71	0.63
	RML	13.90	27.16	23.81	0.72	0.63
	RUL	19.78	22.65	20.63	0.80	0.74
	ALL Patient	19.78	22.57	19.51	0.82	0.76
STDEV	LLL	20.02	23.30	15.28	0.01	0.02
	LUL	4.17	7.97	4.11	0.03	0.05
	RLL	8.98	8.06	9.11	0.03	0.02
	RML	12.35	13.11	16.63	0.04	0.10
	RUL	9.64	10.19	11.33	0.05	0.08
	ALL Patient	12.21	14.01	12.50	0.04	0.07

Table.2 The average and standard deviation of manual and the algorithm based delineated mean volume and DSC of the ITV by the two methods for Eclipse.

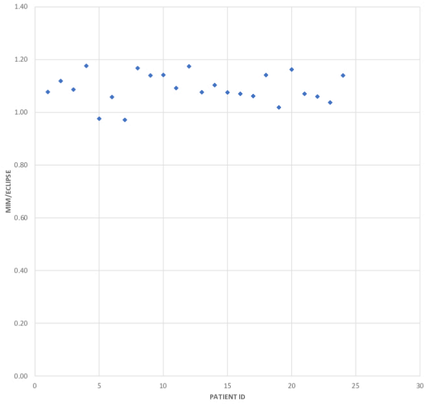

Fig. 3 The ratio of DSC of MIM over Eclipse for brute deformation method

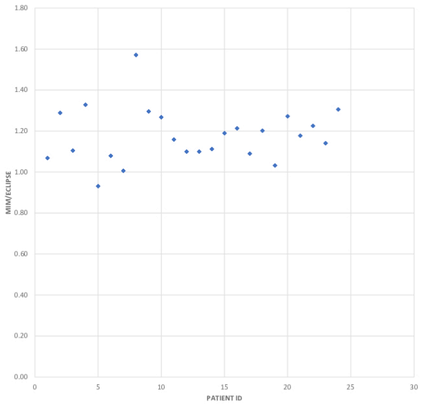

Fig. 4 The ratio of DSC of MIM over Eclipse for sequential deformation method