Development and Implementation of a Knowledge Base for Automated Segment Review

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BACKGROUND

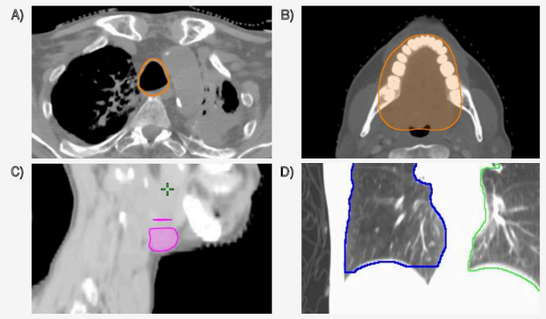
- A knowledge-base of normal tissue structure characteristics was established for use in automated structure evaluation.

		LATERALITY		VOLUME			MEAN AREA		
CONTOUR	MATCH	PLAN	KB	PLAN	KB	Δ	PLAN	KB	Δ
SpinalCord	SpinalCord			26.6	30.0	11%	0.7	1.00	30%
Lung_R	Lung_R	RIGHT	RIGHT	987.3	1343.7	27%	64.1	65.1	2%
Lung_L	Lung_L	LEFT	LEFT	1194.9	1343.7	11%	61.0	65.1	6%
Liver	Liver			1395.0	1441.2	3%	89.0	94.4	6%
Heart	Heart			738.0	704.9	5%	82.6	66.8	24%
Esophagus	Esophagus			70.2	31.3	124%	3.8	1.5	153%
Carina	Carina			6.0	6.3	5%	2.1	2.7	22%
Kidney_L	Kidney_L	LEFT	LEFT	107.1	162.0	34%	12.1	16.2	25%
Kidney_R	Kidney_R	RIGHT	RIGHT	107.8	162.0	33%	14.8	16.2	9%

Sample output of the contour integrity checking tool that implements the normal-tissue structure knowledge base as an automated structure review tool. Values listed in red represent under-contouring or missing slices errors. Those listed in yellow represent over-contouring errors.

MANUAL CONTOUR REVIEW

- Of the 800 manually-reviewed contours, 93 were marked unacceptable (51% under-contoured, 39% over-contoured, 8% incorrect structure, 3% uninterpolated)

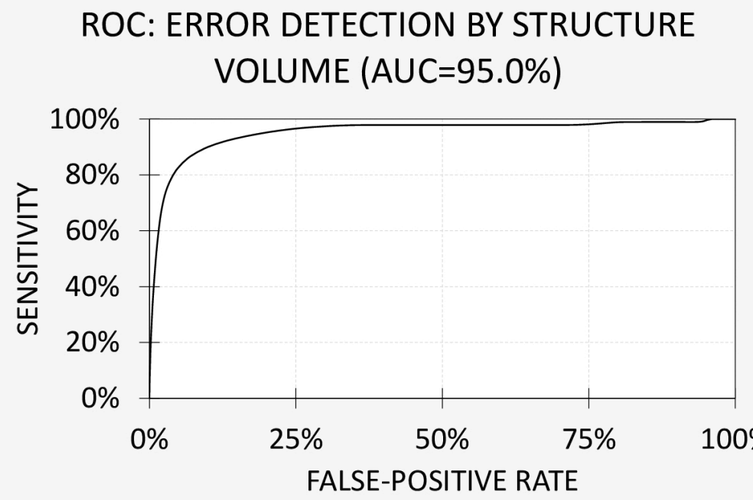


Examples of contouring errors: **A)** incorrect structure (structure labeled as Esophagus) **B)** over-contoured oral cavity, **C)** uninterpolated submandibular gland, and **D)** under-contoured lung.

METHODS

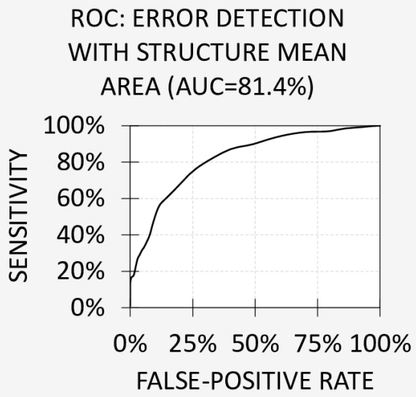
- Geometric characteristics of 4436 normal tissue structures were gathered from patients that were treated clinically with photon IMRT or VMAT plans.
- Gathered metrics include:
  - Structure volume
  - Mean area per contour slice
  - Extent (length) of the structure in the three cardinal directions
  - Patient gender
  - Organ/structure type
  - Geometric center coordinate
  - Maximum dose to the structure from delivered treatment plans
- Characteristics of non-anatomical structures (those used for optimization, avoidance, etc.) were not recorded.
- From the collected data, a structure knowledge-base was created by determining the mean and standard deviation of each geometric characteristic.
- Data were separated by structure type and patient gender.
- An additional 800 contours were manually reviewed by a physicist and categorized as acceptable or unacceptable.
  - For those marked unacceptable, the contouring error category was also recorded:
  - A receiver-operating characteristic (ROC) curve for detecting contouring errors was generated by evaluating the manually-reviewed dataset metric q with the knowledge-base (KB) values using a variable decision threshold m.

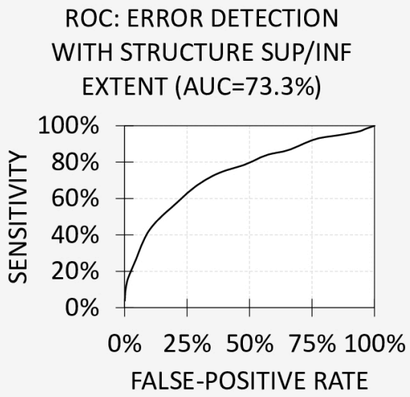
RESULTS



The ROC curve generated by using structure volume to detect contouring errors. For a decision threshold of m=0.8, structure volume was able to detect contouring errors with sensitivity of 87%, specificity of 94%, and accuracy of 93.4%.

- Structure volume outperformed mean area and superior/inferior extent in detecting contouring errors (AUC=95.0%, 81.4%, and 73.3% respectively).





- Using a decision threshold of m=0.8, structure volume was able to detect contouring errors with sensitivity=87%, specificity=94%, and accuracy=93.4%.