Atlas based auto-segmentation of head and neck cancer: Performance evaluation of MIM Maestro® software

John Holik[1], Daniel Truant[2], Jonathan Sykes[1,2]
1. School of Physics, The University of Sydney, Camperdown Campus, Sydney, Australia
2. Department of Medical Physics, Blacktown Cancer and Haematology Centre, Blacktown, Sydney, Australia

Contact
Dr Jonathan Sykes
Email: jonathan.skyes@health.nsw.gov.au

Introduction

Atlas Based Segmentation (ABS) using the MIM Maestro® software provides an efficient and consistent method to automatically generate Organ at Risk (OAR) structures [1]. From September 2017 to February 2019, ABS was performed on 82 patients in the Sydney West Radiation Oncology Network undergoing head and neck radiotherapy, using the Multiple Atlas System (MAS) workflow in MIM (see Figure 1). These structures were assessed by a Radiation Oncologist (RO), and edited if necessary before clinical approval and planning use. A comparison between the ABS and clinically approved OAR structures is essential to understand the utility and clinical effectiveness of the ABS workflow [2,3].

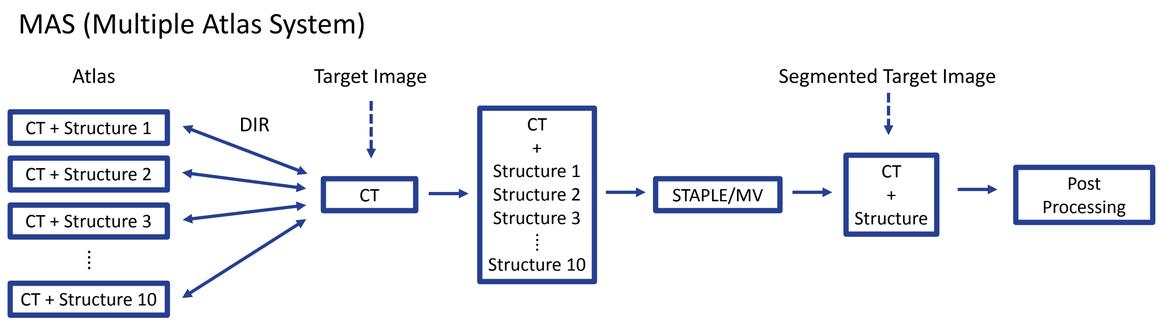

Figure 1: The ABS system used to automatically generate Organ at Risk Structures

Methods

The clinically approved RT structure sets of 34 head and neck patients were exported from the OIS (Varian Aria®) to MIM, and were compared to their initial ABS contours. The following MIM calculated metrics were used for the assessment: Dice Similarity Coefficient (DSC), Volumetric Similarity (VS), Mean Distance to Agreement (MDA), Hausdorff Distance (HD) (See Table 1). Additionally, from DVH data, the prescribed OAR dose constraints were compared between the clinically approved and ABS OARs.

Table 1: The metrics used to compare the ABS contours (A) and the clinically used contours (C). V(A) is the volume of the contour A, a is an element of A and d is Euclidean distance between two elements

ABS comparison metrics	
$DSC = \frac{2\,\lvert A \cap C \rvert}{\lvert A \rvert + \lvert C \rvert}$	$VS = 1 + \frac{\lvert \lvert V(A) \rvert - \lvert V(C) \rvert \rvert}{\lvert V(A) \rvert + \lvert V(C) \rvert}$
$MDA = \frac{1}{\lvert A \rvert \lvert C \rvert} \sum_{a \in A} \sum_{c \in C} d(a,b)$	$HD(AC) = \max\big(h(A,C), h(C,A)\big)$ $h(A,C) = max_A\big(min_C(d(a,c))\big)$

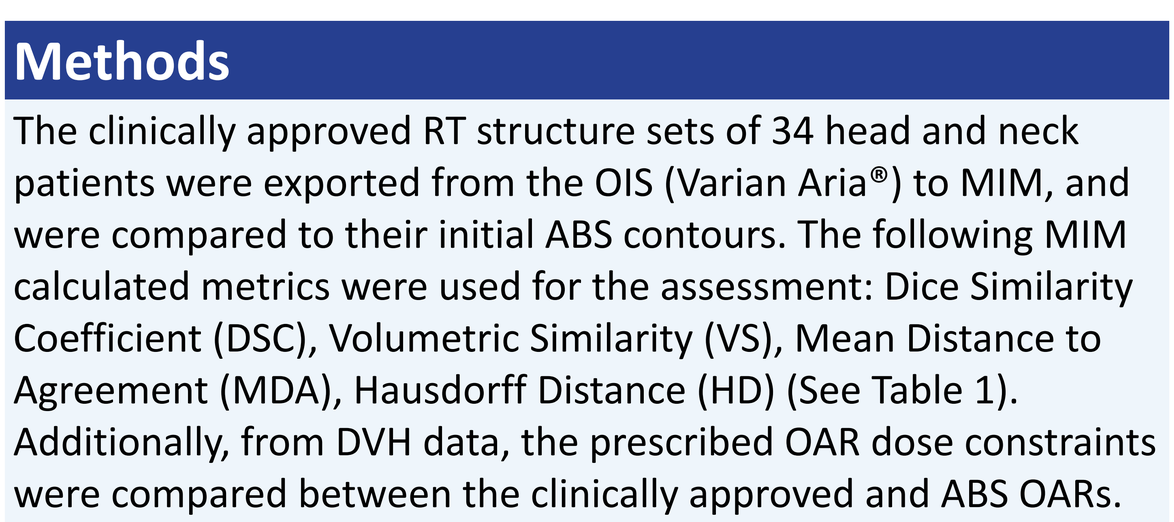

Figure 2: DSC box plot comparison between ABS and clinical OARs for 34 patients

Results

- It was found there were small inherent structure variations (HD < 0.7mm) on transfer between the OIS and MIM.
- Bone defined ABS OARs in general required less editing than soft tissue defined or smaller OARs (see Figure 2, lower DSC indicates more editing performed).
- Good correlation was seen between the DCE/MDA and HD/MDA metrics for most structures.
- Different H&N sub-sites indicated varying levels of editing for the same OAR, e.g. optic OARs had higher DSC values for neck primary sites than nasopharynx primary sites.
- Editing varied based on the RO performing the contouring assessment (see Figure 3), showing inter-observer variation in the perceived ABS accuracy (as well as input atlas structures).
- While there were significant differences in OAR DVHs between clinical and ABS structures, in general, these were not sufficient to exceed the clinical dose constraints.
- For each patient the ABS workflow selects the 4 closest atlas datasets (of the 20 in the MAS). It was found some atlases were used significantly more than others (see Figure 4).

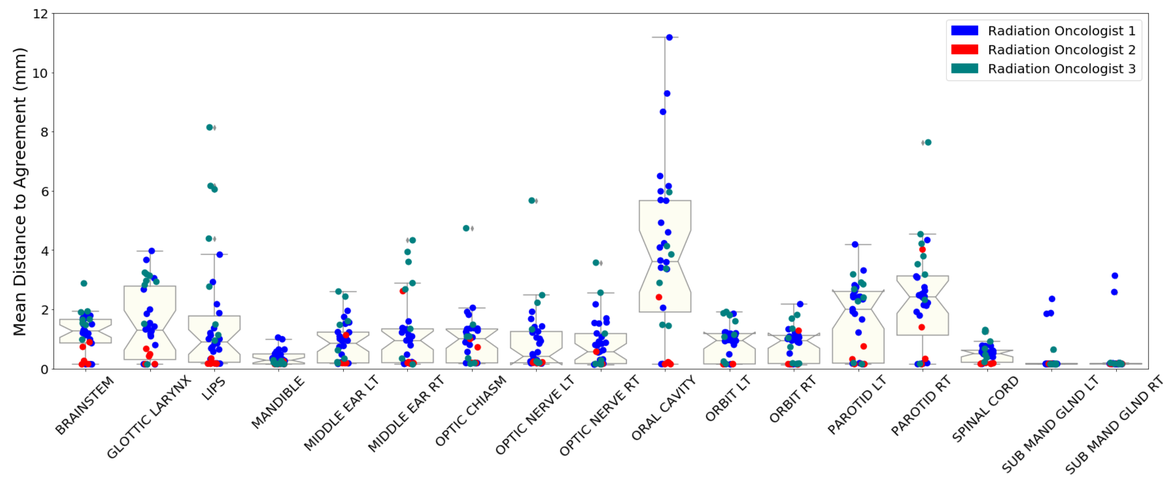

Figure 3: Variation in MDA values for OARs edited by different ROs

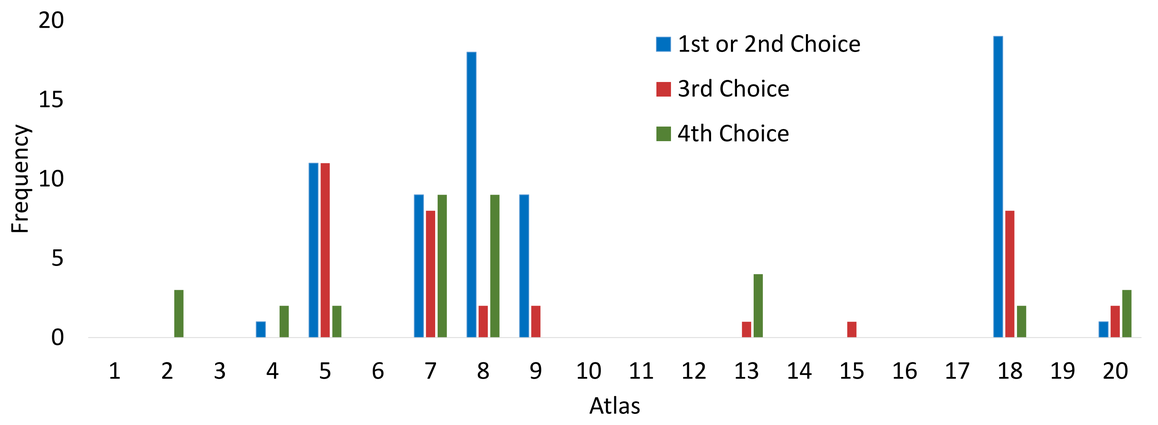

Figure 4: ABS atlas choice frequency for 34 patients

Conclusion

ABS provides an efficient method to generate OARs, but their current clinical utility can be understood by retrospectively assessing the atlas limitations and inaccuracies. This analysis provides avenues to update and improve the atlas for a more efficient future clinical workflow.

References

[1] J Iglesias and M Sabuncu. Medical Image Analysis, 24 (1): 205 – 219, 2015
[2] M La Macchia et al. Radiation Oncology, 7 (1): 160, 2012.
[3] A Hoang Duc et al. Medical Physics, 42 (9): 5027 – 5034, 2016.