# Analysis of dose volume histogram deviations using different voxelization parameters

Kyle Sunderland, Csaba Pinter, Andras Lasso, Gabor Fichtinger
Laboratory for Percutaneous Surgery, School of Computing, Queen's University, Kingston, Canada

Consortium: Ontario Consortium for Adaptive Interventions in Radiation Oncology (OCAIRO)

**Introduction.** In radiotherapy treatment planning systems, structures of interest such as targets and organs at risk are stored as 2D contours on evenly spaced planes. In order to be used in various different algorithms, the contours must first be converted into binary "labelmap" volumes through voxelization. The process of voxelization results in a loss of information, which has a small effect on the volume of structures which are large relative to voxel size, but can have a significant impact on small structures, which may only contain a few voxels. The accuracy of these segmented structures can affect metrics such as dose volume histograms (DVH), which are used for treatment planning. Our goal is to evaluate the effect that varying voxel size has on the accuracy of DVH for each structure.

**Methods.** We implemented tools for analysis as modules in the SlicerRT toolkit [1] based on the 3D Slicer platform [2]. Within the modules, a series of implicit functions are created that represent simulated physiological structures (Fig. 1.). These structures are then sampled at varying resolutions, and are compared to a labelmap with a high sub-millimeter resolution, in order to calculate Hausdorff distance and Dice similarity coefficient between the labelmaps. Both labelmaps and dose volumes are used to generate DVH, and evaluate voxelization error for the same structures at different resolutions by calculating the agreement acceptance percentage between the DVH.

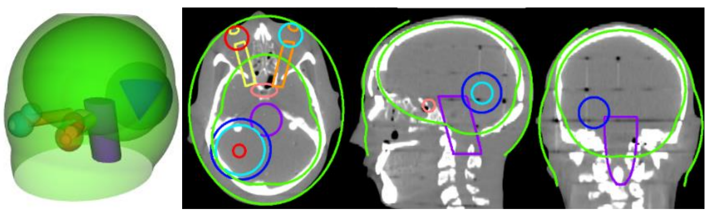

**Fig. 1.** Models representing the implicit functions that are used as the ground truth structures for the head and neck phantom in our experiments, and CT images showing the phantom that is being approximated.

**Results.** We found that while there were small differences in the DVH for large structures, a much larger difference was found for smaller structures such as optic lenses and nerves. The DVH differences were also amplified if the structure was located in a high dose gradient region. This caused several types of artifacts to appear in the DVH for small structures, such as a staircase-like effect, as well as consistent differences between the low resolution and high resolution DVH (Fig. 2).

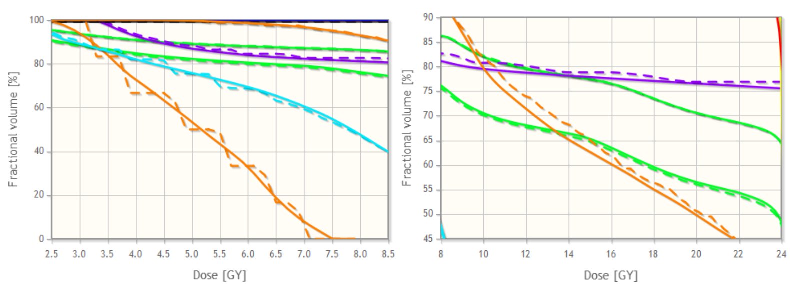


**Fig. 2:** DVH the high resolution (solid) and low resolution (dashed) labelmaps showing the staircase effect of voxelization (left) and consistent differences between DVH (right).

**Conclusion.** Labelmap and dose volume voxel size was found to be an important factor in DVH accuracy, especially for plans which include small structures or in regions with a high dose gradient. It is possible that these effects can potentially cause high errors in the DVH V and D metrics, which are calculated from the dose and volume levels, and are used in treatment planning to assess the quality of a plan. If these errors were large enough, they could potentially cause a suboptimal plan to be accepted. This problem might not be noticed by the physician since the DVH values would support the results, however the problem could be caused by errors in the DVH itself.

[1] Pinter, C., et al., "SlicerRT: radiation therapy research toolkit for 3D Slicer," Med. Phys. 39(10), 6332-6337 (2012).
[2] Fedorov, Andriy, et al. "3D Slicer as an image computing platform for the Quantitative Imaging Network." Magnetic resonance imaging 30(9), 1323-1341 (2012).