The impact of DICOM import/export on radiotherapy structures in commercial software

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Résumé

Impact de l'import/export DICOM sur les structures en radiothérapie dans les logiciels commerciaux

Introduction: Automatic contouring is now routinely used in radiotherapy, and contour similarity measures (CSMs) are central to validating algorithms, comparing commercial solutions, and monitoring clinical editing. It may be assumed that loading and re-exporting DICOM RT Structure Sets (RTSS) should preserve structure geometry. This study assesses whether commercial contouring systems alter contour boundaries even when no editing is performed and evaluates the resulting impact on CSMs.

Materials and Methods: Two publicly available datasets were used (1,3). The first was the Vitruvian Man dataset, comprising six analytically defined synthetic shapes with variable sampling point density and known ground-truth geometry for validation purposes (2). The second was a case from the AAPM-2017 Thoracic Auto-segmentation Challenge (4), containing expert manual contours and automatically generated contours. Both datasets include paired reference and test RTSS files.

Twelve commercial contouring systems were used. Each test RTSS was imported and a minimal non-editing action -such as applying a paint stroke- was executed solely to force conversion into the software's internal representation after which the unmodified structures were re-exported. Distances between original polygon vertices and the closest point on

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re-exported contours were computed directly in RTSS space. Vertex counts were recorded to identify resampling. CSMs against the original reference RTSS were calculated twice for all structures: once using the original test contours and once using the re-exported contours. RTSS-based CSMs included volumetric Dice (vDSC), 2D mean surface distance (2DMSD), 2D Hausdorff distances (at 50% and 95%), and normalized Added Path Length (nAPL), using the analytically validated implementation (2). Surface-based sDSC and 3DMSD were computed by converting each RTSS to an implicit voxelized representation at original CT resolution, followed by sub-voxel-accurate Marching Cubes meshing.

Results: Several systems preserved polygon positions with negligible deviation, whereas most introduced sub-voxel shifts, with mean differences up to 0.23 mm for thoracic data and 0.61 mm for synthetic shapes. Maximum deviations reached 37.7 mm, caused by topology-altering removal of small, disconnected components. Vertex sampling differed markedly between vendors, ranging from dense resampling to substantial sub-sampling. Resulting CSM variations depended strongly on the measure: vDSC differed by up to 2.6%, 2DMSD by up to 29%, 3DMSD by up to 35%, and Hausdorff distance by up to 21%. nAPL and sDSC were highly sensitive to small boundary changes, showing deviations up to 96–97% at low tolerances.

Conclusions: Importing and exporting RTSS in commercial systems can alter contour geometry and thereby influence CSMs, even without user editing. These effects may bias multi-centre studies or cross-platform comparisons. For clinical monitoring of auto-contouring, contour differences smaller than one quarter of an in-plane pixel size should not be classified as genuine edits. Particular caution is warranted when interpreting tolerance-dependent CSMs such as nAPL and sDSC.

References:

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Mots-Clés: Contrôle Qualité, contourage, mesures de similarités, DICOM RTSS