

Development of Auto-Contouring Tools for Pediatric Organ Segmentation for Computed Tomography Images used in Radiotherapy Treatment Planning - Results from the Childhood Cancer Survivor Study Expansion Pilot Study

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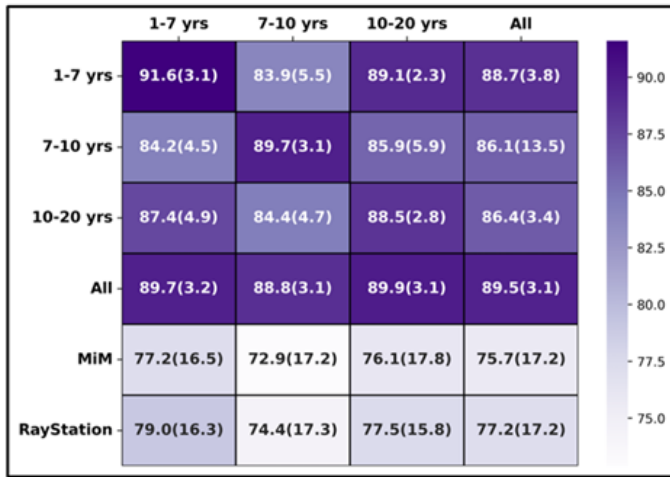
Background/Purpose: A future expansion of the Childhood Cancer Survivor Study to include survivors treated with contemporary radiation therapy (RT) would require collection of CT-based treatment planning records as DICOM files rather than paper records. Once collected, dose-volume histograms will need to be generated for all organs within the computed tomography (CT) images that were not segmented. Auto-segmentation could overcome the time and resource limitations of manual segmentation at the time of treatment planning. However, existing commercial auto-segmentation solutions are trained on adult populations, potentially leading to suboptimal performance for pediatric patients. This study investigates whether pediatric age-specific models (for ages 1–7, 7–10, 10–20 years) and a combined model (1–20 years) can outperform adult-trained platforms (MiM, RayStation) for auto-segmentation in pediatric CT scans.

Methods: A total of 276 non-contrast pediatric CT scans (ages 1–20, 151 male, 125 female) treated with RT 2000-2022 were collected from four institutions for an ongoing CCSS pilot study assessing cohort expansion feasibility. Three age-specific cohorts (1–7, 7–10, 10–20) and one combined cohort (1–20) were defined for model development. Each dataset was used to train an nnUNet model using 5-fold cross-validation to report average performance. Metrics included Dice similarity coefficient (DSC) and dose-volume differences (Dmax, V5). Models were tested on their respective and other age groups for generalizability. Adult-trained models served as baselines.

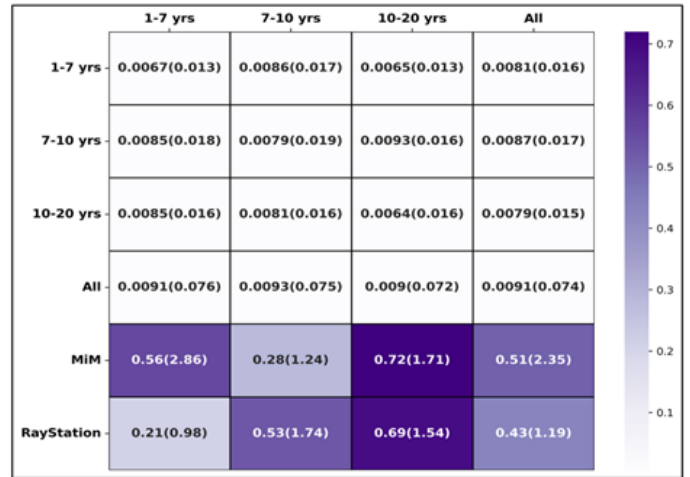
Results: All pediatric models demonstrated high DSC values within their respective age groups (1-7 yrs DSC: 91.6±3.1; 7-10 yrs DSC: 89.7±3.1; 10-20 yrs DSC: 88.5±2.8). Notably, the 1–7 and 10–20 models performed consistently across each other's age groups (1-7 yrs DSC: 89.1±2.3 [10-20 yrs cohort]; 10-20 yrs DSC: 87.4±4.9 [1-7 yrs cohort]), suggesting anatomical similarities that support a unified model approach. In contrast, the 7–10 yrs model, yielded lower performance for the other two cohort (1-7 yrs DSC: 84.2±4.5; 10-20 yrs DSC: 85.9±5.9) indicating that a dedicated, age-specific model may be warranted for the 7–10 years group to ensure optimal segmentation accuracy. The combined (1–20) model achieved consistently DSC (≥88.8%) across all age subsets. In contrast, adult-trained platforms showed lower DSC (as low as 72.9%) and larger deviations in Dmax (up to 0.72 cGy) and V5 (up to 38.69 cc). Pediatric-trained models exhibited minimal differences in dose-volume metrics (Dmax <0.01cGy, V5 ~7–8 cc) across the 1–20 years age cohort.

Conclusion: Pediatric-trained models, both age-specific and combined, significantly outperformed adult-trained commercial platforms across the 1–20 age range. A single combined model offers robust performance comparable to age-specific models, suggesting that routine pediatric radiotherapy workflows, including a future CCSS expansion cohort, can benefit from a unified pediatric-trained approach without compromising accuracy.

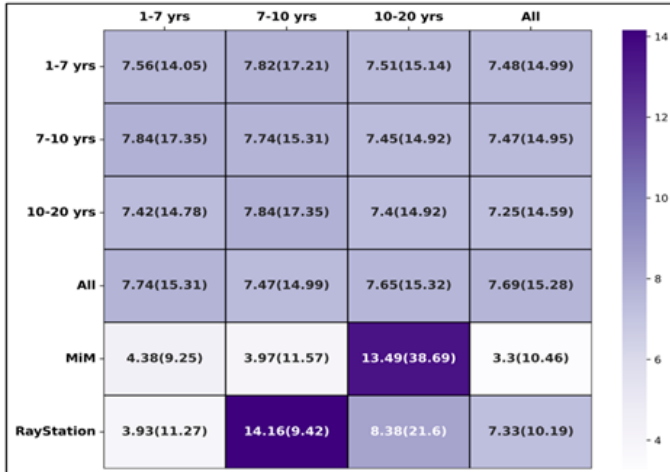
a) DSC(STD)[%]



b) ΔD_{max} (STD)[cGy]



c) ΔV_5 (STD)[cc]



d) ΔD_{mean} (STD)[cGy]

