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Evaluation of an Open Source Registration Package for Automatic Contour Propagation in Online Adaptive Intensity-Modulated Proton Therapy of Prostate Cancer

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Objective: Our goal was to investigate the performance of an open source deformable image registration package, `elastix`, for fast and robust contour propagation in the context of online-adaptive intensity-modulated proton therapy (IMPT) for prostate cancer.

Methods: A planning and 7–10 repeat CT scans were available of 18 prostate cancer patients. Automatic contour propagation of repeat CT scans was performed using `elastix` and compared with manual delineations in terms of geometric accuracy and runtime. Dosimetric accuracy was quantified by generating IMPT plans using the propagated contours expanded with a 2 mm (prostate) and 3.5 mm margin (seminal vesicles and lymph nodes) and calculating dosimetric coverage based on the manual delineation. A coverage of $V_{95\%} \geq 98\%$ (at least 98% of the target volumes receive at least 95% of the prescribed dose) was considered clinically acceptable.

Results: Contour propagation runtime varied between 3 and 30 s for different registration settings. For the fastest setting, 83 in 93 (89.2%), 73 in 93 (78.5%), and 91 in 93 (97.9%) registrations yielded clinically acceptable dosimetric coverage of the prostate, seminal vesicles, and lymph nodes, respectively. For the prostate, seminal vesicles, and lymph nodes the Dice Similarity Coefficient (DSC) was 0.87 ± 0.05, 0.63 ± 0.18, and 0.89 ± 0.03 and the mean surface distance (MSD) was 1.4 ± 0.5 mm, 2.0 ± 1.2 mm, and 1.5 ± 0.4 mm, respectively.

Conclusion: With a dosimetric success rate of 78.5–97.9%, this software may facilitate online adaptive IMPT of prostate cancer using a fast, free and open implementation.

Keywords: intensity modulated proton therapy, image registration, open source software, `elastix`, prostate cancer