

This is an overview of your abstract number E38-1376:

Session
title

Track **Abstract submission: Physics**

Topic **Physics track: Adaptive radiotherapy and inter-fraction motion management**

Presentation
preference **Oral presentation**

Abstract title **Deep learning improves robustness of contour propagation for online adaptive IMPT of prostate cancer**

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Purpose or Objective

Online-adaptive radiotherapy holds the promise to mitigate daily anatomical uncertainties thereby increasing treatment precision. One of the major challenges here is the development and validation of sufficiently fast, accurate, and robust segmentation algorithms for target volumes and organs at risk. The purpose of this study is to improve contour propagation in the pelvic region by combining deep-learning based auto-segmentation with image registration and to validate it geometrically and dosimetrically for online-adaptive Proton Therapy (PT) for prostate cancer.

Material and Methods

The proposed registration pipeline registers the daily CT scan to the planning, based on a combination of image intensities and, moreover, by an automatic segmentation of the bladder from the daily CT scan using a novel 3D convolutional neural network. The bladder was chosen for its influence on prostate motion. Registration performance is further enhanced by a digital inpainting of gas pockets with realistic bowel content, using a state-of-the-art generative adversarial network. We further perform data normalization and in relevant cases digitally remove contrast agent from the bladder.

Evaluation was performed on CT data from 18 prostate cancer patients, each with 7 to 10 repeat CT scans. Manual delineations of the prostate, lymph nodes, seminal vesicles, bladder and rectum were available for evaluation. Geometric performance was quantified using the Mean Surface Distance (MSD). The pipeline was validated dosimetrically on 11 out of 18 patients by simulating an online-adaptive PT workflow based on the propagated contours. To this end, for each repeat CT, a treatment plan was generated based on the propagated contours and the plan was evaluated using the manual delineations. A dose of 74 Gy was assigned to the high-dose PTV (prostate) and 55 Gy to the low-dose PTV (lymph nodes and seminal vesicles). The generated treatment plans were considered clinically acceptable if dosimetric coverage constraints derived from the manual contours were met (PTV $V_{95\%} \geq 98\%$ and $V_{107\%} \leq 2\%$).

Results

The proposed pipeline achieved a MSD of 1.29 ± 0.33 , 1.44 ± 0.68 , and 1.52 ± 0.45 mm for the prostate, seminal vesicles, and lymph nodes, respectively (Fig. 1). The propagated contours met the dose coverage constraints in 85%, 91%, and 99% of the cases for the prostate, seminal vesicles, and lymph nodes, respectively (Fig. 2). 78% of the cases met all constraints at the same time, compared to 65% when using a standard registration approach. The average runtime for the proposed pipeline is 98 seconds per registration.

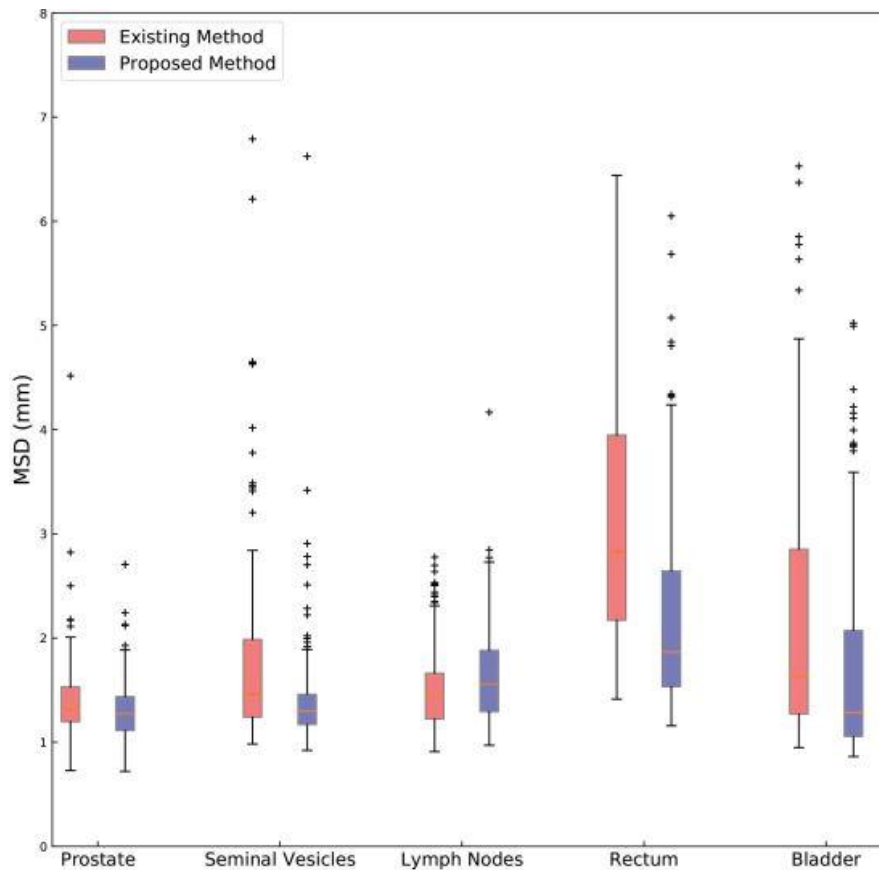


Figure1. Boxplot comparison between an existing method and the proposed method for image registration in terms of MSD for 161 registrations. Values closer to zero are better

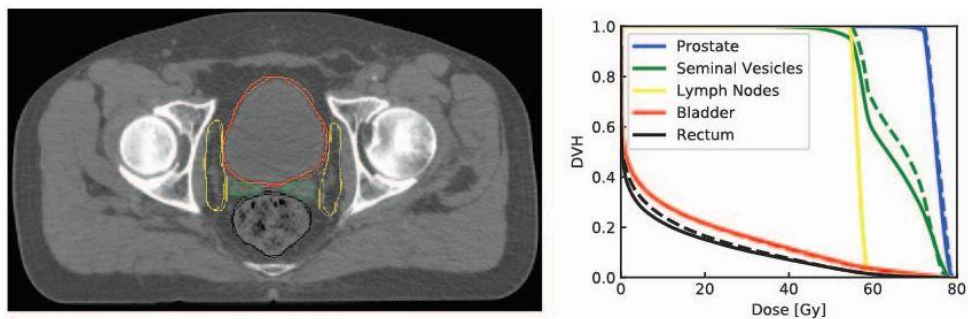


Figure 2. Example for the automatic contours propagation and the corresponding dose volume histograms. The solid line represents the manual contouring results while the dotted line is the automatically propagated one.

Conclusion

The proposed registration pipeline obtained highly promising results for generating treatment plans adapted to the daily anatomy. With 78% of the automatically generated treatment plans directly usable without manual correction, a substantial improvement in system robustness was reached compared to an existing approach. The proposed method therefore facilitates more precise PT of prostate cancer.

I have no potential conflict of interest to disclose

Keyword Artificial Intelligence and Automation