Fast Tracking MR only Adaptive Radiotherapy; Automatic Segmentation on Planning, Daily MRI and the synthetic CT

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Purpose/Objective:
CT based deep learning automatic segmentation (DLAS) has proven to improve the time efficacy of clinical workflows. However, very limited work and success is seen for MR based clinical workflows, including MR only adaptive radiotherapy (MROART), where planning and daily images require anatomy (target and organ at risk (OAR)) segmentation, with the aid of synthetic CT (sCT) to retrieve electron densities to calculate dose, contouring of OARs remain a challenge. In this study the feasibility of using a non-sequence specific module to generate sCT from daily or planning MRI and segmentation on these MRI and sCT for on-couch plan adaptation of prostate RT on MR-Linac is discussed.

Material/Methods:
A unique 3-level architecture comprised of recursive, convolutional, and multi-cephalic neural networks was used to train the MR and sCT segmentation models. A cycle generative adversarial network was used to generate sCTs from MRI. For testing a planning T2 3D Space on 3T MR scanner, a daily T2 3D Tra on 1.5T MR-linac and a sCT generated from the daily MRI, were acquired for 2 clinical patients, and 2 male volunteers. The segmentation on MRI and sCT was reviewed on slice-by-slice basis to evaluate clinical accuracy. Additionally dice similarity coefficient (DSC) was calculated to evaluate the 3D accuracy of the MRI segmentation

Results:
Percentage of clinically acceptable segmentation, from slice-based contour analysis, is shown in the table below. Fast segmentation (40 seconds) was successful for the sCT, plan and daily MRIs. DSC calculated was (0.8, 0.8,0.8,0.8,0.8) and (0.98,0.87,0.8,0.5,0.7) for bladder, prostate, rectum, seminal vesicles, and penile bulb for the daily and plan MRI. The following observations were made during evaluations; 1) sCT generation suffers in the presence of edge-of-scan artifacts in MRI, 2) accuracy on MRI is dictated by bladder liquid (in the absence of liquid the tool was unable to segment the bladder), and 3) segmentation was successful in capturing large anatomical changes, such as large air pockets in the rectum.

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	Bladder			Prostate			Rectum			SeminalVes			Penile Bulb		
	Plan	Daily	sCT	Plan	Daily	sCT	Plan	Daily	sCT	Plan	Daily	sCT	Plan	Daily	sCT
1		18%	89%	91%	77%	95%	94%	95%	97%		63%	89%	62%	100%	100%
2	95%	93%%	94%	94%	87%	93%	97%	99%	99%	86%	86%	86%	93%	100%	94%
3	100%	40%	78%	83%	84%	91%	97%	98%	86%	32%	93%	72%	100%	100%	100%
4	72%	0%	55%	84%	69%	93%	96%	73%	89%	86%	94%	80%	88%	100%	100%

Conclusions:

The use of the proposed segmentation module can simplify, automate, and expedite easy plan and re-plan adaptation, especially for pelvic anatomy, where the organ filling changes can severely influence the adaptive radiotherapy workflow and patient on-couch time. We aim to conduct dosimetric evaluations to further investigate the utility of the workflow.