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Evaluation of synthetic CT generation from CBCT using a deep learning model

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INTRODUCTION

Cone-beam computed tomography (CBCT) scans are used in image-guided radiation therapy for patient positioning and treatment adaptation.
Due to lack of CT number accuracy and missing field-of-view (FOV) information, CBCT scans are less accurate for treatment planning purposes.
Advances in deep learning have allowed for CT number recovery from CBCT via synthetic CT (sCT) generation.

AIM

To evaluate the potential of an sCT generation model for the purposes of radiotherapy treatment planning.
To quantitatively compare the CT numbers acquired by CBCT and sCT to those in ground truth TPCT images.

I. METHODS

For a cohort of 20 pelvic radiotherapy patients, sCT images were generated from CBCT scans using a deep learning model that was trained on independent data external to our centre. This model is part of the Elekta Advanced Medical Imaging Registration Engine (ADMIRE) software package, which is currently available only for research purposes.
CBCT and sCT images were normalized and then registered to their respective treatment planning CT (TPCT) images that were used as the reference image.
Three different volumes were considered in our comparison: (1) the CBCT volume within the external body contour for each patient; (2) the manually contoured prostate volume; (3) the manually contoured femur volume.
For each of these volumes, the CT number accuracy was quantified by taking the mean absolute error (MAE) for sCT-TPCT and CBCT-TPCT image pairs. All contoured volumes were done by a radiation oncologist or a radiation therapist. Variations in patient positioning in the TPCT and CBCT were not accounted for.

II. RESULTS

Sample line profiles showing variations between CBCT, sCT, and TPCT are presented in *Figure 1*. Compared to TPCT images, sCT images provide much better agreement, while CBCT images are less accurate in terms of CT number reproduction.

A comparison of MAE for the three contoured areas investigated is presented in *Figure 2*. sCT-TPCT MAE are systematically lower than CBCT-TPCT. MAE is lower for the prostate, an area of almost entirely soft-tissue, but higher for a more bony region such as the femur.

Considering the reduced external CBCT patient volume, contoured prostate, and contoured femur, the MAE for sCT-TPCT are (47.1 ± 9.7) HU, (20.0 ± 11.5) HU, and (136.6 ± 83.1) HU, respectively. For the same volumes, the MAE for CBCT-TPCT are (248.1 ± 19.7) HU, (269.4 ± 10.9) HU, (443.9 ± 78.3) HU, respectively.

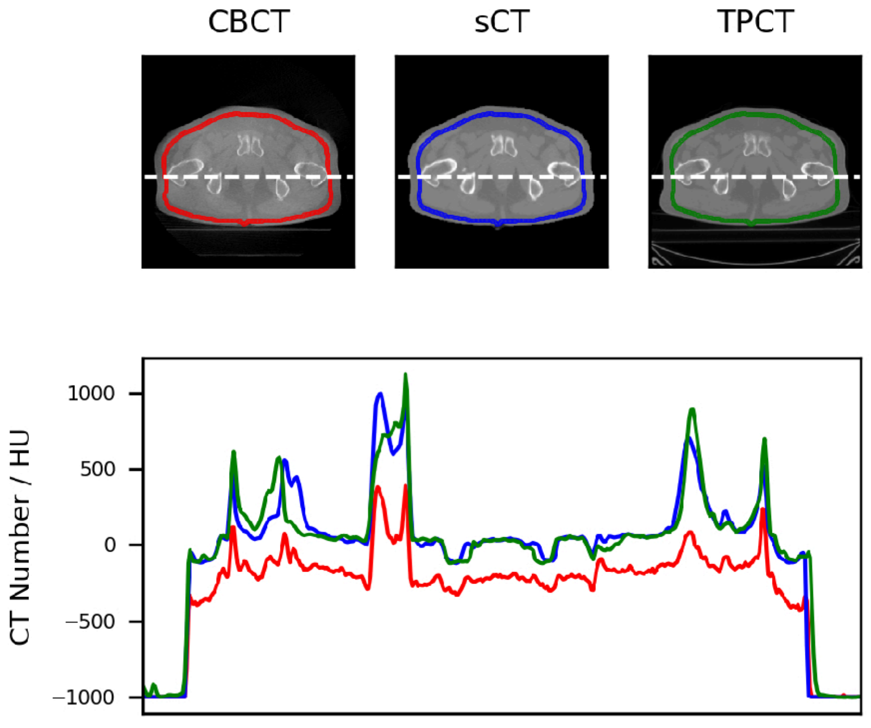

Figure 1: Transverse view of a slice taken with the three modalities, including the contoured region where MAE is calculated shown. CT number line profiles for CBCT (red), sCT (blue), and TPCT (green) plotted for white dashed line.

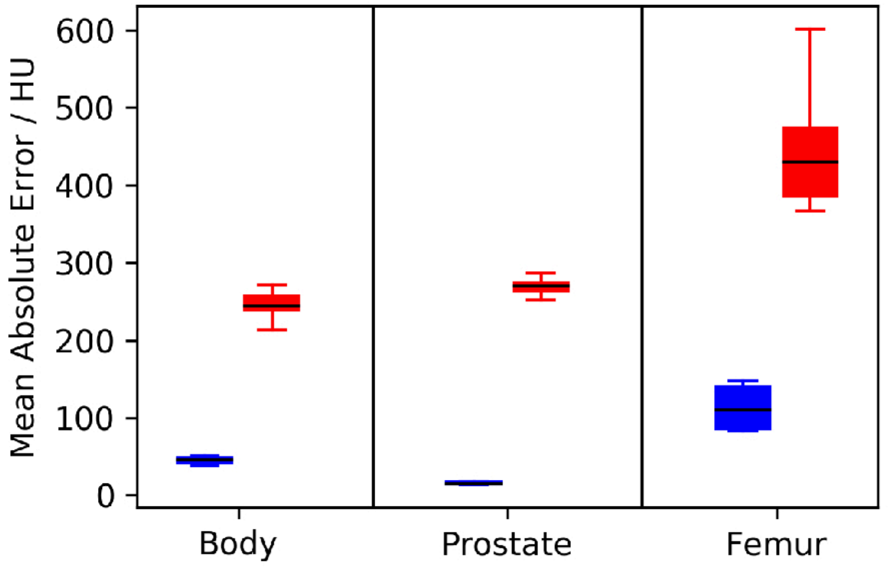

Figure 2: Box plots of the distribution of MAE for the CBCT volume within the external contour (Body, n=20), contoured prostate volume (Prostate, n=8), and contoured femur volume (Femur, n=8). For each volume, sCT-TPCT (blue) and CBCT-TPCT (red) presented. First and third quartiles shown by the box with the thick line (black) representing the median value. Whiskers extend to 1.5 times the interquartile range.

III. DISCUSSION

Current work in the area of synthetic CT generation is centered around MR-based image generation. Studies have compared generated sCT images with fan-beam CT images.
Han investigated this application in 18 brain tumour patients using an open-source deep learning framework and found a MAE of (84.8 ± 17.3) HU.
Maspero et al., used a similar open-source package and applied their model to a cohort of 59 pelvic patients and found a MAE of (61 ± 9) HU.

IV. CONCLUSIONS

The ADMIRE sCT module shows promise for synthesizing TPCT-like quality images with accurate CT number reproduction.
In future work, with a model that is trained on local data, we anticipate improved agreement between sCT and TPCT images.
Work towards a dosimetric evaluation is currently underway, comparing various dose metrics for treatment plans run on sCT, CBCT, and TPCT images.

REFERENCES

[1] **Han X.** MR-based synthetic CT generation using a deep convolutional neural network method. Medical physics. 2017 Apr;44(4):1408-19.

[2] **Maspero M**, Savenije MH, Dinkla AM, Seevinck PR, Intven MP, Jurgenliemk-Schulz IM, Kerkmeijer LG, van den Berg CA. Dose evaluation of fast synthetic-CT generation using a generative adversarial network for general pelvis MR-only radiotherapy. Physics in Medicine & Biology. 2018 Sep 10;63(18):185001.

CONTACT INFORMATION

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