PO-1658 Inverse Consistency Error for quantifying uncertainty in DIR: validation on three different sites

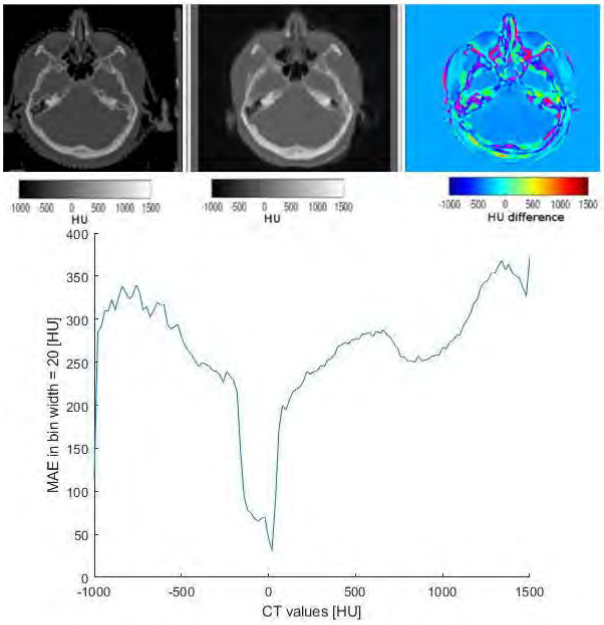

Figure 1. Top from left to right: transverse slices for CT, synthetic CT and difference map. Bottom: average mean absolute error in bins of 20 HU

Table1. The segmentation indices for classified bones, airways, and soft tissues on sCT compared to CT are given for MDPBM and CNN. The segmentation indices included DIce (DI), SEnsitivity (SE) and SPecificity (SP) for each structure type.

Type of sCT	Structures	DI	SE	SP
MDPBM	BONE	0.83 ± 0.03	0.83 ± 0.03	0.96 ± 0.0
	AIR	0.74± 0.04	0.75± 0.08	0.99 ± 0.0
	SOFT	0.95 ± 0.0	0.95 ± 0.0	0.96± 0.0
CNN	BONE	0.84 ± 0.04	0.82 ± 0.04	0.98 ± 0.0
	AIR	0.63 ± 0.04	0.66 ± 0.05	0.99 ± 0.0
	SOFT	0.94 ± 0.01	0.95 ± 0.01	0.96± 0.0

Conclusion

A promising study on the generation and validation of CT-substitute from standard clinical T2 MRI is presented. The algorithm is based on convolutional neural networks. A dosimetric evaluation of the sCT for radiotherapy treatment planning is to be done. Also, further work will be done to assess and improve the method on more patients and different clinical sites.

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M. Fusella[1], C. Fiandra[2], M. Vagni[3], N. Michielli[3], A. Scaggion[4], C. Vecchi[5], S. Zara[5], F. Molinari[3], G. Loi[6]

[1]Veneto Institute of Oncology - IOV IRCCS, Medical Physics, Padova, Italy; [2]University of Turin, Department of Oncology, Radiation Oncology, Turin, Italy; [3]Politecnico di Torino, PoliToBIOMed Lab, Biolab, Department of Electronics and Telecommunications, Turin, Italy; [4]Veneto Institute of Oncology IOV-IRCCS, Medical Physics Department, Padua, Italy; [5]Tecnologie Avanzate T.A. Srl, R&D, Turin, Italy; [6]University Hospital Maggiore della Carità, Department of Medical Physics, Novara, Italy

Purpose or Objective

To assess the performances of a novel automatic approach based on a voxel-based measure, the Inverse Consistency Error (ICE), to evaluate the accuracy of the Deformable Image Registration (DIR) in clinical practice.

Materials and Methods

The ICE was computed directly from the deformation vector field (DVF) provided by the Treatment Planning System (TPS). In order to verify the results obtained from the ICE analysis, the ground truth was generated through three digital phantoms based on real Head-Neck, lung and pelvis patient datasets; DVFs were produced by ImSimQA mimicking clinical observed anatomical changes during treatment. For each site, from the original datasets, two different DVFs were generated, simulating different level of organs changes and motion [1]. All Regions of Interest (ROIs) contoured by Medical Doctors (MDs) in the reference datasets were generated using the same DVFs as reference; they were then imported and registered in RayStation TPS. All

generated DVFs were exported making them comparable by rescaling the deformation grids and the intensity values. The ICE, Mean Distance to Conformity (MDC) and Conformity Index (CI) were computed for each mapped ROI. From ICE distribution were extracted mean, max, median and the four percentiles. Then CI and MDC standard metrics (described and analyzed in previous studies [1,2]) were correlated with the ICE parameters.

[1] https://doi.org/10.1002/mp.12737
[2] https://doi.org/10.1016/j.prro.2019.11.011

Results

Analyzing the data obtained from a total of 68 ROI, any statistically significant difference was found in terms of applied DVF for all metrics. Significant differences ($p<0.05$) were found between sites (lung differs from the others) for all analyzed metrics. Carrying out a multilinear regression between MDC, IC and ICE parameters the mean value of ICE (ICE_mean) resulted a significant predictor of MDC ($p=0.0121$). Figure 1 represents the correlation between ICE_mean and MDC. As shown by the Bland-Altman plot in Figure 2 ICE-mean predicted MDC with a precision inferior to the voxel size (3 mm). Even if a bias of 1.27 mm was found between the metrics setting a threshold of 3 mm (sub-voxel accuracy) the True Positive Ratio resulted 0.97.

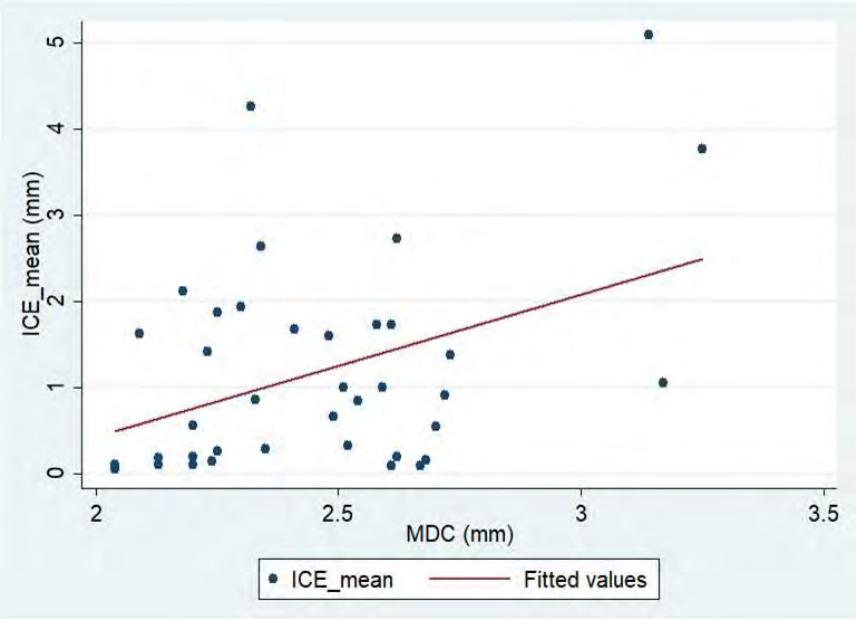

Figure 1. Correlation between ICE_mean and MDC.

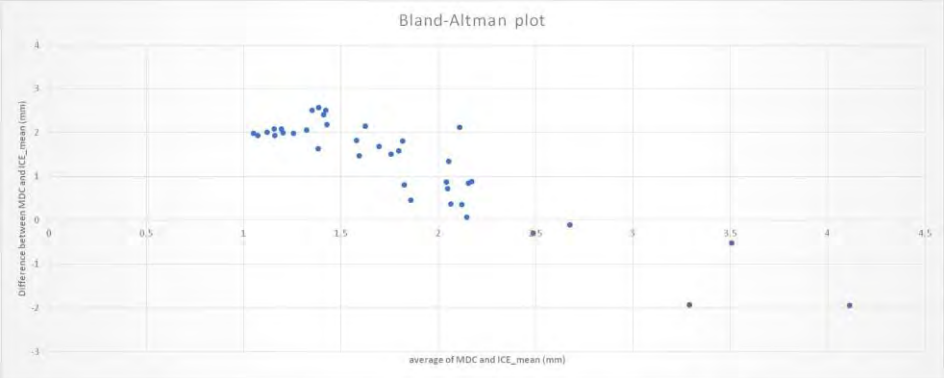

Fig.2 Bland-Altman plot showing the limits of agreements (LOA) between ICE_mean and MDC. The LOA were inferior than 2.2 mm (ICE-mean predicts MDC with sub-voxel precision).

Conclusion

This study represents the first comparison between contour based and volumetric metrics for DIR validation. The results indicate that in the presence of clinically consistent deformation, ICE is a valuable indicator for patient-specific DIR verification. Associated with known and used metrics (such as MDC) at sub-voxel accuracy, ICE adds a volumetric information that generally lacks in previous studies representing a promising tool for quantifying uncertainty in the DIR process. Further developments will focus on validating these findings in a multicenter scenario.

PO-1659 Clinical validation of an automatic atlas-based segmentation tool for male pelvis CT images

M. Casati[1], S. Piffer[2], S. Calusi[2], L. Marrazzo[1], G. Simontacchi[3], V. Di Cataldo[4], D. Greto[3], I. Desideri[2], M. Vernaleone[3], G. Francolini[3], L. Livi[5], S. Pallotta[6]

[1]AOU Careggi, Medical Physics Unit, Florence, Italy; [2]University of Florence, Department of Experimental and Clinical Biomedical Sciences " Mario Serio", Florence, Italy; [3]AOU Careggi, Radiation Oncology Unit, Florence,