ESTRO

Abstract

Title

Synthetic CT from MRI with deep learning: Assessing the clinical impact of generated errors

Authors

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Purpose or Objective

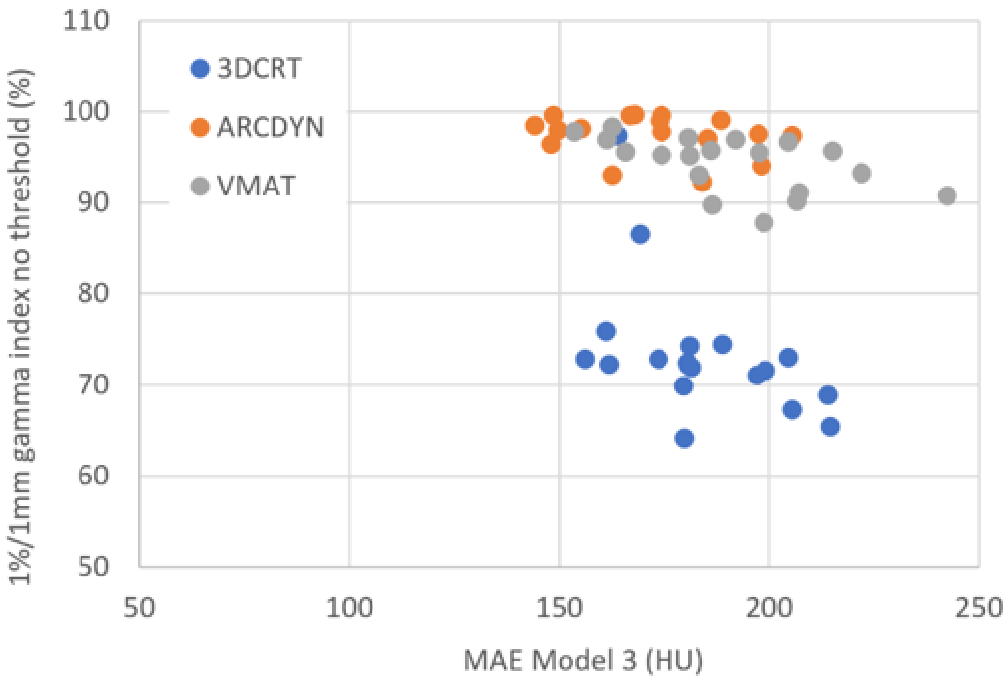
The pseudo Computed Tomography (pCT) generation from Magnetic Resonance Imaging (MRI) using deep learning is a promising method toward improving Radiotherapy (RT). Most studies evaluate the pCT quality using the Mean Absolute Error (MAE). Yet, it is unclear how MAE relates to the dose calculation error. This study aim was to quantify the impact of extreme MAE cases on photon-based RT treatments.

Materials and Methods

The database was composed of 379 patients, split into 190 couples of CT/T1 weighted MRI and 189 CT/contrast enhanced T1 weighted MRI. 242 and 81 patients were respectively used to train and validate the 3D HighResNet (Li et al., Alvarez Andres et al.). The testing cohort was composed of cerebellum brain irradiation location, whole brain, frontal, occipital, parietal, temporal containing respectively 3, 11, 14, 6, 11 and 11 patients. The training was stopped at three convergence steps, i.e. epochs 3, 14 and 48. These epochs were chosen to represent extreme errors scenarios. MAE and Mean Error (ME) within head contours were computed to evaluate the pCT. Lastly, a dosimetry analysis was performed transferring the CT plan to the pCT. In total, 17, 20 and 19 patients received respectively Dynamic Arc (DYNARC-iPlan RT 4.5 Dose, Monte Carlo dose engine), Volumetric Modulated Arc Therapy (VMAT-Raystation 8-B, Collapsed-Cone dose engine) and 3D Conformal RT (3DCRT-Raystation 8-B, Collapsed-Cone dose engine) treatments. 3D global gamma indexes of 1%/1mm, 2%/2mm, 3%/3mm with no dose threshold were computed.

Results

Figure 1 presents the 1%/1mm gamma pass rates as a function of the MAE values for models 3 and 48 by treatment modality.



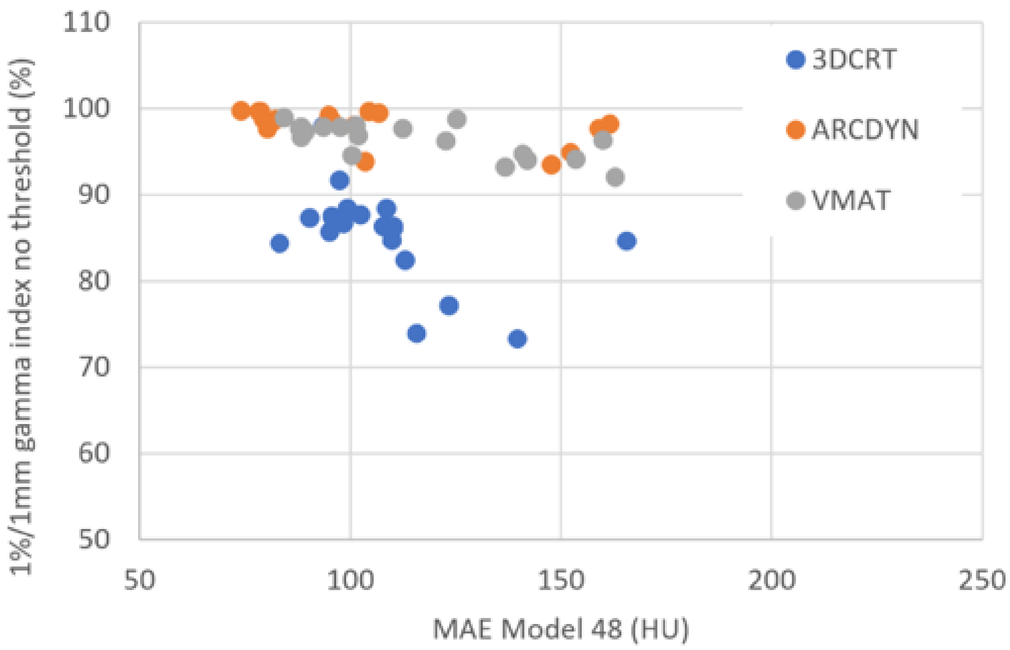


Fig. 1: 1%/1mm gamma pass rates as a function of the MAE values for models 3 and 48 by treatment modality.

Table 1 summarizes the MAE, ME, and gamma indexes achieved for models 3, 14, and 48. MAE of 183.3±21.4 Hounsfield Units (HU) and 109.3±25.3 HU were obtained for models 3 and 48. 1%/1mm pass rates equal to 73.4+/-7.4%, 97.4+/-2.3% and 94.3+/-3.0% were achieved for model 3 for 3DCRT, DYNARC and VMAT treatments respectively. The respective values were equal to 85.3+/-5.7%, 98.0+/-2.0% and 96.4+/-2.0% for model 48. No correlation between tumor location and gamma pass rates was observed.

Table 1: MAE, ME, and gamma indexes for models 3, 14, and 48.

	MAE	ME	1%/1mm	2%/2mm	3%/3mm
Model 3	183.3HU +/- 21.4HU	-44.1HU +/- 29.7HU	88.16% +/- 11.66%	94.52% +/- 6.15%	98.16% +/- 2.27%
Model 14	151.9HU +/- 21.8HU	-18.7HU +/- 24.8HU	90.24% +/- 9.63%	95.90% +/- 4.47%	98.72% +/- 1.46%
Model 48	109.3HU +/- 25.3HU	15.4HU +/- 19.3HU	93.12% +/- 6.70%	97.07% +/- 3.08%	99.11% +/- 1.01%
WE	249.6HU +/- 28.0HU	-134.1HU +/- 32.5HU	77.75% +/- 19.05%	91.82% +/- 8.88%	96.92% +/- 3.85%

Conclusion

Lower MAE pCT were linked to higher pass rates and reduced standard deviations. Extreme pCT generation errors were considered here and proved moderate generation errors had relatively small impact on dosimetry quality for photon-based rotational treatments in our cohort. 3D treatments are much impacted by such deviations. Further analysis of the correlation between MAE, tumor volume and dosimetric results is in progress.