A patch-based pseudo-CT approach for MRI-only radiotherapy in the pelvis - DTU Orbit (09/11/2017)

A patch-based pseudo-CT approach for MRI-only radiotherapy in the pelvis

In radiotherapy based only on magnetic resonance imaging (MRI), knowledge about tissue electron densities must be derived from the MRI. This can be achieved by converting the MRI scan to the so-called pseudo-computed tomography (pCT). An obstacle is that the voxel intensities in conventional MRI scans are not uniquely related to electron density. The authors previously demonstrated that a patch-based method could produce accurate pCTs of the brain using conventional T_1-weighted MRI scans. The method was driven mainly by local patch similarities and relied on simple affine registrations between an atlas database of the co-registered MRI/CT scan pairs and the MRI scan to be converted. In this study, the authors investigate the applicability of the patch-based approach in the pelvis. This region is challenging for a method based on local similarities due to the greater inter-patient variation. The authors benchmark the method against a baseline pCT strategy where all voxels inside the body contour are assigned a water-equivalent bulk density. Furthermore, the authors implement a parallelized approximate patch search strategy to speed up the pCT generation time to a more clinically relevant level. The data consisted of CT and T_1-weighted MRI scans of 10 prostate patients. pCTs were generated using an approximate patch search algorithm in a leave-one-out fashion and compared with the CT using frequently described metrics such as the voxel-wise mean absolute error (MAE_{vox}) and the deviation in water-equivalent path lengths. Furthermore, the dosimetric accuracy was tested for a volumetric modulated arc therapy plan using dose–volume histogram (DVH) point deviations and γ-index analysis. The patch-based approach had an average MAE_{vox} of 54 HU; median deviations of less than 0.4% in relevant DVH points and a γ-index pass rate of 0.97 using a 1%/1 mm criterion. The patch-based approach showed a significantly better performance than the baseline water pCT in almost all metrics. The approximate patch search strategy was 70x faster than a brute-force search, with an average prediction time of 20.8 min. The authors showed that a patch-based method based on affine registrations and T_1-weighted MRI could generate accurate pCTs of the pelvis. The main source of differences between pCT and CT was positional changes of air pockets and body outline.

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