AbstractID: 11359 Title: Efficient 4D treatment planning using CT datasets synthesized via deformable image registration

Purpose: 4D treatment planning is often a time-intensive process, requiring a series of procedures on multiple (up to 10) CT-datasets. We hypothesize that more efficient strategies exist for lung cancer, 4D planning, and that dosimetrically, these methods are equivalent to plans based on the typical 4D process.

Method and Materials: Three strategies were tested: (a) Exhale and Inhale CT-datasets were registered using deformable image registration (ITK "demons") and the resulting displacement vector field (DVF) was used to "synthesize" 8 additional CT datasets, at equally spaced phases between inhale and exhale. A single dataset, based on average CT-number of the 10 datasets was then generated for planning purposes, CT_{AVE_SYN}. (b) Ten CT-datasets were retrospectively reconstructed during a patient 4D scan, and an average dataset was generated for planning purposes, CT_{AVE_4D}. (c) Dose is computed on each of the ten datasets independently, dose accumulation is performed (trilinear interpolation), to yield a "warped" 4D, benchmark dataset, CT_{WARPED_4D}. A step-and-shoot IMRT plan was developed and applied to the CT_{AVE_SYN}, CT_{AVE_4D}, and CT_{WARPED_4D} datasets. Dose calculations were performed using Monte Carlo (BEAMnrc/DOSXYZnrc) integrated with Pinnacle. Doses were mapped to the reference image dataset (end-exhale) for dosimetric comparison.

Results: PTV and ITV mean doses generated using the CT_{AVE_SYN} and CT_{AVE_4D} datasets agreed within 0.5% of each other. Mean doses generated using CT_{WARPED_4D} agreed with the CT_{AVE_SYN} and CT_{AVE_4D} datasets within 1% and 1.5% for the ITV and PTV, respectively. Biological dose indices, including EUD (ITV and PTV), and NTCP and mean lung dose (normal lung tissue) were within 1% agreement for treatment plans using all 3 datasets.

Conclusion: Results are suggestive that 2 CT-datasets used to synthesize an average 4D dataset (via a DVF and CT-number averaging) may be a feasible approach, offering the potential for improved efficiency in the lung cancer 4D planning process.

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