AbstractID: 14235 Title: The Role of 4DCT Sorting in Treatment Planning for Image-guided Radiation Therapy

Purpose: Deformable image registration (DIR) is an integral component of adaptive radiotherapy, however reconstruction artifacts induced from improper 4DCT sorting can be detrimental to DIR performance. This study evaluated, both in phantom and patient, the impact of a novel hybrid amplitude-based 4DCT sorting algorithm on DIR quality, and the results were compared with conventional phase-based sorting.

Method and Materials: A series of phantom experiments were performed using a respiratory motion platform programmed with phantom ($(1\text{-}\cos^2)$, 5 second cycle) and patient (abdomen displacement from RPM data) breathing curves with lung-tumor excursion in S-I direction. 4DCT images were acquired, and corresponding datasets were sorted (10 phases) using both phase and hybrid amplitude-based sorting algorithms. DIR was performed between phases using a Diffeomorphic Demon's algorithm and the resultant displacement vector fields (DVFs) were analyzed. The unbalanced energy (UE), a metric proven to detect registration errors, was assessed between sorting techniques, with high UE values indicating regions of non-physical deformation. Our approach was further validated through retrospective evaluation of a lung cancer patient's 4DCT.

Results: A marked improvement in 4DCT sorting with the hybrid amplitude gating approach and the resulting UE was observed for all phantom experiments. An average decrease in UE of 34.0% (range: 19.7 - 43.2%) and 31.5% (range: 25.0 - 42.9%) for the mean and maximum, respectively, were observed. The retrospective patient study revealed significant improvement in DIR performance; the hybrid amplitude approach reduced the average UE magnitude ~30%, particularly near the diaphragm-lung interface.

Conclusion: We have demonstrated the potential improvement in DIR performance offered by hybrid amplitude-based 4DCT sorting. An improvement in DIR quality, both visually and as quantified by UE, was observed for both phantom and patient. By describing the applicability of this technique, improvements in 4D dose calculation may be realized, potentially streamlining adaptive radiotherapy into clinical practice.