AbstractID: 5005 Title: 4D-Image-Guided Treatment Planning Optimization for Management of Organ Motion in Radiotherapy Planning

The management of breathing-registered IMRT treatment planning is explored by direct incorporation of 4D images within the planning process. The movement of the voxels from one CT timeframe to another is ``tracked'' and modeled. A timestamp for each voxel is used to specify its position throughout the breathing cycle. A single treatment model incorporates planning constraints throughout multiple time periods. Robustness of the algorithm, plan quality, and potential clinical significance are evaluated.

4D-CT scans of lung/liver cancer patients were acquired with different breathing phases(phases 0-9, 0:full-inhale, 5:full-exhale), Three treatment planning strategies are performed and compared. 1)Standard planning with a static PTV based on a single selected phase (control). 2)The Internal Target Volume (ITV) approach, where ITV is defined as the union of CTVs in all breathing phases. 3)Single-stage-4D-image-guided planning, where within a single treatment optimization model, planning constraints are incorporated on each voxel for each phase throughout the multiple-phase period. Sophisticated computational optimization techniques are used to solve these models.

For both lung/liver cases, the static-PTV-plan results in unacceptable PTV-underdose. Compared to ITV-pamns, 4D-image-guided-plans offer good coverage and comparable min-PTV-dose; while in lung, it reduces normal-lung-mean-dose by 20%, heart-mean-dose by 20%, and esophagus-max-dose by 15%; and in liver, it reduces normal-liver mean-dose by 15% and other normal-tissue mean-dose by 20%, with improved PTV-conformity of 10%.

4D-Image-Guided treatment planning optimization can provide good PTV-coverage plans, improve PTV-underdose, and significantly reduce dose to organs-at-risk, especially those organs in the proximity of the tumor. Evidence of morbidity reduction to organs-at-risk is observed. The challenge involves the ability to solve a large-scale treatment planning problem. With sophisticated mathematical optimization modeling and computational strategies, such planning is possible and can be made available for clinical use. Clinical studies are needed to validate the importance of our approach to treatment outcome.