AbstractID: 7522 Title: A Closed-Loop Control Framework for Adaptive Radiation Therapy (ART)

Purpose: While ART has been studied for years, the specific quantitative implementation details have not. In order for this new scheme of radiation therapy to reach its potential, an effective ART planning strategy capable of taking into account the dose delivery history and patient's on-treatment geometric model must be in place. This work performs a study of dynamic closed-loop control algorithms for ART and demonstrates their utilities with data from phantom and clinical cases with on-treatment cone-beam CT images.

Method: In closed-loop control, the controller is not run just once but repeatedly, each time receiving the current state of the system as its input. To meet the requirements of different clinical applications, two classes of algorithms are developed: those *Adapting to Changing Geometry* (ACG) and those *Adapting to Geometry and Delivered Dose (AGDD)*. The former takes into account organ deformations found just before treatment. The latter optimizes the dose distribution accumulated over the entire course of treatment by adapting at each fraction not only to the anatomic information just before treatment but also to the dose delivery history. The closed-loop algorithms are showcased by phantom and clinical cases.

Results: A comparison of the approaches with conventional open-loop IMRT without adaptively incorporating feedback information indicates that closed-loop ART may significantly improve the current practice. In both phantom and clinical studies, AGDD outperforms ACG algorithms in three aspects: target dose coverage, sensitive-structure sparing, and steeper gradients around the tumor. Within the AGDD formalism, it is beneficial not to correct all the previous dosimetric errors at once right after the information is available but over a number of fractions until next set of feedback data is available.

Conclusion: ART with closed-loop dynamic algorithms substantially improve the dose distribution. In addition, the differing performance of the specific implementations shows that the algorithmic details matter.