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Cutting planes and relaxations for radiation oncology optimization under dose-volume constraints

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Abstract

Radiation therapy planning for cancer can be understood as an optimization over external beam angles, beam aperture shapes, and intensities of beams to maximize the dose to a target tumor while limiting dose (and thus damage) to surrounding healthy tissues. Especially with the advent of newer Intensity Modulated Radiation Therapy (IMRT) techniques, the number of delivery choices far exceeds the capability of a human planner alone, and formal optimization techniques are required. Fortunately, many features of these problems can be taken as linear in the decision variables, greatly facilitating the planning optimization task. Dose-volume constraints, which are quite common in radiation oncology protocols, constitute a major exception. They set an upper limit on dose at every point in a given healthy tissue, and a lower upper bound required for a specified fraction of the tissue volume so that the tissue will be able to continue function. When tissues are modeled as finite collections of points at which dose is assessed, the effect is to add a multiple-choice combinatorial element to the optimization, leading to an MILP model.

This talk will report results on cutting planes to strengthen the linear programming relaxations of such MILP models of IMRT radiation therapy optimization. The cuts are derived primarily from specializations of the classic disjunctive programming construction. We also consider novel combinations of LP-relaxation and enumeration that yield strong bounds for the models considered.

Join work with Ali Tuncel (School of Industrial Engineering, Purdue University), Mark Langer, M.D. (Indiana University School of Medicine) and Jean-Philippe Richard (School of Industrial Engineering, Purdue University).