AbstractID: 2205 Title: A "Candide" Look at Optimization Terminology in Radiotherapy- Taming the Tower of Babel

The practitioner of radiation oncology is confronted with a range of claims regarding the quality and utility of available techniques for solving IMRT planning problems. Automation may still mean work, with a long process of manual interventions and trial and error selections of weighting factors or other reparameterization steps until a suitable solution emerges. Optimization can still mean worry, giving results that may have fallen short of satisfying clinical constraints or improving a clinical goal because of an inadequate plan search. The planning community should be apprised how to judge claims made for the optimization processes, and learn how to better manipulate the existing planning frameworks to generate a preferred solution.

Automated and user-dependent processes for solving planning problems should be distinguished. These approaches have advantages and disadvantages for planning in the face of recognized geometric uncertainties, the desire to explore the effect of shifting constraint bounds within their ranges of uncertainty, and the need to accommodate incompleteness in problem specifications. Finding the weighting factors that will maximize a plan score when a clinical objective reaches its maximum value under a set of constraints is itself an optimization problem. It can be shown that for a particular score function formed from linear combinations of the dose deviations, choosing the weighting factors so the score will be maximized when the optimum dose distribution is produced, and producing the optimum dose distribution itself are dual problems. Solving one problem is equivalent to solving the other.

It may not be possible to simultaneously satisfy all constraints in a problem. The task of determining whether satisfaction is possible or whether the constraints are mutually incompatible is a feasibility problem. Feasibility can be easily checked, but the infeasibility of a problem is much harder to ascertain. One should check whether a solution method tests for feasibility. One avenue of research aims to produce the smallest shift in the constraints that will satisfy an initially infeasible problem. Tradeoffs among the objective and constraints should be demonstrated by frontier or sensitivity analyses.

Even if the constraints are satisfied, the solution may not be optimal. An optimal solution will maximize an objective under the constraints, but suboptimal solutions that meet the constraints can be hard to detect. Solutions might exist that could raise the tumor dose or lower the dose delivered to some sensitive structure without violating the constraints. Convergence of an algorithm is a sign of stability, but not necessarily optimality. Given a solution that meets the constraints, it may be possible to determine how far the objective lies from its highest possible value. This distance, or optimization gap, forms a type of error bound on the produced solution, but can be hard to generate. Stochastic methods allow statistical sampling of the solution space, but how near a given solution lies to the most extreme point in the solution space may remain unknown.

Learning objectives:
1. Understand the vocabulary of optimization.
2. Translate radiation planning concepts into optimization terms.

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3. Become familiar with tests of optimization quality.