AbstractID: 14503 Title: Basic Concepts in Multicriteria Optimization and their Application in Radiation Therapy

The challenge in radiation therapy planning for IMRT (but also for other modalities) is to optimally cover the tumor target volume and to maximally spare the surrounding organs at risk. This is an optimization problem with multiple conflicting objectives. Yet, until recently, all commercial IMRT optimization systems have used a single objective. Multiple objective ("multicriteria") optimization systems have been developed in research environments, but they have only recently found their way into the clinic and into commercial systems.

There are several ways to handle multiple objectives in multicriteria optimization. One of them, prioritized optimization, is to work on the objectives one by one, starting with the most important objective and then working towards the less important ones. Another one, which will be the focus of this presentation, is to calculate a multitude of plans on the "Pareto frontier". A Pareto optimal plan is one in which one cannot improve one objective without making at least one other objective worse. If there are only two objectives, the Pareto frontier is the classical tradeoff curve. When there are more objectives, it is a higher dimensional surface.

We will describe methods to calculate Pareto-optimal plans, and how the Pareto frontier can be sampled with relatively few points (i.e., Pareto optimal plans) using a "sandwiching" technique. Surprisingly, relatively few Pareto plans (20-50) suffice to obtain a good approximation of the Pareto frontier, even in high-dimensional cases with up to 10 objectives (target volume and 9 critical structures). One reason for this is that different objectives are not fully independent.

Finding the most suitable treatment plan for a patient then means to interactively "navigate" on the Pareto frontier. Navigating in an up to 10-dimensional space seems like a daunting task. Yet, in practice it is quite doable, especially with a user-interface that allows to "clamp" objectives, and to exploit correlations between objectives. The Pareto navigation approach can in fact drastically reduce the IMRT planning time, especially for complex cases, and can at the same time yield more suitable treatment plans. Using several examples we will show that Pareto optimality is indeed an important concept for understanding the unavoidable tradeoffs in treatment planning. It is also a requirement for meaningful comparisons between different treatment modalities. Other types of objectives such as plan complexity and delivery time can be incorporated.

Learning Objectives:
1. To be able to define the meaning of Pareto optimal
2. Name the pros and cons of prioritized optimization vs. navigating the Pareto frontier

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