AbstractID: 3782 Title: Automated beam direction selection for IMRT based on geometrical concepts of viewability and orthogonality

Purpose: To develop a fast and reliable algorithm to automatically select beam angles for intensity-modulated radiation therapy (IMRT) treatment planning. We hypothesized that such an algorithm could be developed based on purely geometrical concepts as a pre-planning step.

Method and Materials:
We define any point in the target as *viewable* by a given beam if a ray from that beam, which passes through the point, does not intersect any critical structures (i.e., the point can be 'viewed' by that beam). The beam angle selection problem can then be generalized to the multi-set cover problem, a difficult (NP-hard) computer science problem. We also consider *orthogonality*, which captures beam non-overlap outside the target. We hypothesize that increasing 3-viewability (fraction of points viewable by at least 3 beams) and increasing orthogonality typically results in higher quality IMRT dose distributions. This was tested by comparing, for 30 random sets of 5 beam angles, the objective function based on 3-viewability and orthogonality vs. the final objective function value output of a weighted quadratic IMRT optimization. Our beam angle selection algorithm extends a greedy set cover algorithm and aims to find a set of coplanar angles that will make a maximum fraction of target points at least *k*-viewable while also maximizing orthogonality.

Results:
For an IMRT case where beam angle selection impacted IMRT objective function values, there was a strong correlation between the viewability-orthogonality objective function value and the final objective function value of a weighted quadratic IMRT optimization (Spearman correlation coefficient 0.63 ($p<0.0004$)). Our proposed algorithm determines beam angles for a typical plan in 2-4 minutes on a 2 GHz PC.

Conclusion:
We conclude that the purely geometrical concepts of viewability and orthogonality can be used as a basis for automatically and efficiently selecting IMRT beam angles using the class of algorithms proposed.