

Purpose:

Complex intensity maps in an IMRT plan may have several undesirable effects: increased leakage and integral dose, higher sensitivity to delivery errors, longer treatment time. On the other hand, the potentially negative impact of a reduction of the complexity on the dose conformality is not a priori clear. We propose to study the interplay between complexity and dose conformality in an interactive multi-objective planning approach.

Method and Materials:

Two surrogate measures of complexity have been studied in previous approaches: The number of multileaf collimator (MLC) segments (in step and shoot IMRT delivery), and the number of monitor units (MUs). The first is difficult to incorporate into optimization strategies because it is an “NP hard” problem and the calculation would be time prohibitive. Fortunately, one MLC vendor has proven that the MLC hardware and control software can be designed such that the pure number of MLC segments is not a limiting factor anymore. We therefore use the number of MUs as the measure of complexity. Mathematically, the number of MUs is given by the sum of positive gradients of the intensity map along the direction of leaf motion. We include the sum of positive gradients as a linear objective function in our plan optimization framework. In our approach we find solutions that are Pareto optimal, i.e., their complexity cannot be further reduced without compromising conformality. The results are incorporated into an interactive plan navigator by means of a “complexity slider”, which allows the user to interactively explore the impact of a change of the plan complexity on the dose distributions.

Results:

Examples of optimized IMRT plans in the head and neck region and in the prostate will be presented. The potential of reducing complexity is case dependent but in comparison with current IMRT planning approaches a substantial reduction of the number of MUs (in the order of 20%) is often achievable without compromising the dose distribution. The complexity slider allows one to explore the whole spectrum of plans including the extrema, i.e. simple but not conformal or highly conformal but complex plans.

Conclusion:

The complexity of an IMRT plan can be limited or reduced with various methods. In general there is a price to be paid for this. Multi-objective optimization can help to find the most suitable tradeoff.

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