

PhD Thesis title: 'New concepts for beam angle selection in IMRT treatment planning: From heuristics to combinatorial optimization'

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ABSTRACT: This thesis investigates beam ensemble selection strategies in intensity-modulated radiation therapy treatment planning. Beam ensemble selection strategies are applied to find the very beam ensembles that meet the treatments' objectives at the best possible rate.

(1) A formal description of the beam ensemble selection problem is presented and the characteristics of the search space are discussed with a focus on its non-convexity and exponential complexity. (2) We review existing approaches to beam ensemble selection and provide a comprehensive overview of the field. (3) Conceptual advancements of beam ensemble selection strategies relying on score functions and geometric considerations are introduced. For photons, we demonstrate a clear benefit regarding organ at risk sparing for asymmetric patient geometries as regularly observed within the abdomen or skull. For protons, phantom studies yield plausible beam configurations. The measures taken to guarantee robustness regarding potential uncertainties are promising but require refinements. (4) The simultaneous optimization of beamlet weights and beam orientations is investigated at a very high precision. We apply different metaheuristics for the combinatorial optimization of beam ensembles and confirm the beneficial performance of genetic algorithms in this context.

Both heuristic selection and combinatorial optimization of beam ensembles may yield extensive benefits for complicated planning cases. In the future it will be critical to transfer automated beam ensemble selection to the clinic for the benefit of the patient.

References to author publications that relate specifically to the dissertation:

Mark Bangert and Uwe Oelfke: *Spherical cluster analysis for beam angle optimization in intensity-modulated radiation therapy treatment planning*, 2010 Physics in Medicine and Biology 55 <http://iopscience.iop.org/0031-9155/55/19/025>