AbstractID: 6994 Title: Application of Robust Optimization in Prostate Cancer

The knowledge about patient geometry at the exact time of radiation delivery is rarely complete. The result of radiotherapy should not depend sensitively on inevitable uncertainties. This quality of robustness of a treatment can be enforced during dose optimization by a variety of means, which can be classified by the frequency with which patient information is acquired, the timespan between acquisition and delivery, and the nature of the image information. For prostate radiotherapy, random target and normal tissue motion poses the greatest challenge as it requires high-quality volume imaging and the information content may decay quickly.

Even with today's on-board imaging systems, a fair amount of uncertainty about the patient geometry remains, which is best described by probability distributions (PD) of pointwise displacements. Here, various off-line and quasi on-line image-guided protocols differ mostly in how these PDs are constructed and how frequently it is updated. The PDs can be used to compute the expected values of dose or dose effect at each point of the patient model. This model may either be defined in the treatment room (and dose) coordinate system (TCS) or may be associated with the patient reference geometry and deform along with the anatomy. While the former is the traditional model for dose planning, the latter shifts the focus to the accumulation of dose in the tissue, hence the term tissue-eye-view (TEV).

The most basic probabilistic patient model in TCS is the coverage probability model, where each volume element in a rigid reference patient geometry is weighted with the cumulative probability that some volume of interest can be found there. This information quantifies the relevance of a point in the CTV-to-PTV margin. Despite its apparent simplicity, it is possible to alleviate the common PTV-overlaps-organ paradox to an extent that allows iso-toxic dose escalation by about 10 per cent. Moving to a probabilistic patient model in TEV abandons the PTV concept altogether, at the price of more image information and the need for deformable registration. The potential for iso-toxic dose escalation lies at more than 20 per cent.

Both optimization concepts rely on an a-priori estimate of the pointwise displacement probabilities. A bias or time trend in these PDs would be potentially fatal. Hence, it is essential to update the PD during the course of treatment to minimize the ''uncertainty in the estimates of uncertainties''. In consequence, robust off-line adaptive protocols require some extent of monitoring while on-line protocols require basically off-line probabilistic models predicated (in a Bayesian sense) on the geometry of the day. Apart from the insufficiency in the input image data, another risk arises from the high specificity with which individual source of error influence the optimized dose distribution: a large margin could compensate for many uncertainties, while margin-less optimization schemes need to quantify all of them. This limits the theoretical benefit of the most sophisticated models (daily on-line imaging Bayesian TEV) significantly.
The specific cost-benefit ratio of various protocols remains to be evaluated in practice, in larger populations of patients.