AbstractID: 14369 Title: Dose calculation and optimization algorithms: a clinical perspective

Commercial clinical treatment planning systems (TPS) employ various algorithms for calculating dose distributions and determining optimal beam fluences and apertures. We present a review of commonly-used computational techniques, as well as considerations relevant to clinical physicists. These include TPS commissioning, verification, heterogeneity corrections, small-field accuracy, and QA. In addition, we discuss newer methods which are becoming more widely adopted such as Monte Carlo dose algorithms and multicore/distributed computational techniques.

Radiotherapy dose calculation algorithms are now almost exclusively model-based instead of correction-based. Model-based algorithms construct from first principles the dose in the patient using models of radiation interaction with matter. The most commonly used model-based algorithm is the convolution/superposition approach but Monte Carlo algorithms are now more generally available in commercial planning systems. The accuracy of the predicted dose distributions is only as good as the performance of the algorithm and the fidelity of the input data. Using data measured using a water phantom, the energy spectrum can be determined from measured depth-dose data while the fluence profile can be determined from profile data. With some IMRT or stereotactic systems not using field flattening systems, the intensity profile can be quite non-uniform. The effect of leaves, collimators and accessories are taken into account with special measurements that depend on the delivery system. New methods of obtaining the necessary data are being established that promise more convenience and accuracy.

Dose calculation algorithms are also being used for other purposes. Independent dose calculations are being used as secondary checks to verify the results of treatment planning systems so that patient-specific measurements may not need to be performed. Dose reconstruction can be used to determine the dose actually received by the patient so that the effect of changes in anatomy or machine output can ascertained. The ICRU will be soon releasing new guidelines for quality assurance of dose calculation systems including specifications for accuracy.

In order to take full advantage of the capabilities of commercial inverse planning solutions, it is critical to have an understanding of the underlying optimization algorithms and optimization tools. The first step in the inverse planning process is to define your treatment goals. The objectives and constraints commonly used in commercial planning systems will be discussed along with the advantages and pitfalls of using biology-based functions such as equivalent uniform dose. After treatment goals have been defined, the treatment plan optimization is then performed. Comparisons will be provided of the key optimization algorithms in routine clinical use along with techniques for improving delivery efficiency such as direct aperture optimization. The final portion of the talk will explore future developments in IMRT planning. For example, we will discuss multicriteria optimization (MCO), and how this enhanced planning capability holds the promise of dramatically reducing treatment planning times by allowing users to rapidly explore tradeoffs in target dose coverage and critical structure sparing.

Learning Objectives:

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1. To understand the physics of model-based dose calculations including commissioning, verification, heterogeneity corrections, small-field accuracy, and QA.
2. To understand the use of dose calculation algorithms in patient QA such as secondary monitor checks and dose reconstruction.
3. To understand the differences between commercial inverse planning solutions and how to best utilize the algorithms to maximize IMRT plan quality.