AbstractID: 2215 Title: Inclusion of organ motion and deformation in dose calculations

Deformable registration and patient modeling combined with advancing technology of daily soft tissue imaging using cone-beam CT or tomotherapy has facilitated the ability to perform more accurate dose calculations by taking into account patient variations at the time of, and during, radiation treatment. The importance of including these variations into the dose calculation process may become more significant with increasing use of IMRT, dose escalation, and hypofractionated treatment. 4D dose calculation methods can be divided into two main categories: predictive and direct. Predictive methods use a limited sampling of the patient and prior patient population data to develop a probability-based dose accumulation. Direct methods perform daily imaging to determine the exact position of the patient at the time of treatment, and therefore, the actual dose received by the patient.

Predictive models have been described using pre-treatment scans at physiological normal extrema of motion (i.e., normal inhale and exhale or full and empty bladder or rectum) or at multiple instances of motion using 4D tomographic data. In predictive models, probability functions describe the likelihood that the patient will be at each position during the treatment procedure and the amount of time that the position will be maintained. Dose calculations can then be performed on the images obtained or by interpolating between images to determine intermediate states not directly imaged. Deformable registration is utilized to relate the multiple instances of geometry and the dose distribution corresponding to each. Alternatively, convolution methods can be used to incorporate motion into the dose calculation by convolving the fluence distribution with the probability distribution function describing the motion.

Direct methods, yielding potentially more accurate results, also require more patient intervention. Daily imaging of the patient is performed and registered to the original model of the patient. The dose distribution for that treatment fraction is calculated using the daily image and related to the previous delivered dose through the patient model. This information can then be used to optimize future treatments to obtain the desired cumulative dose distribution.

The combination of predictive and direct methods allows optimum treatment plan development with the possibility of refinement during the radiation treatment course. Daily soft tissue imaging combined with deformable patient models can allow predictive models to be refined by image guidance for both optimum dose delivery and accurate dose calculation. The accuracy of 4D dose accumulation is dependent on accurate deformable registration to relate multiple instances of the patient to one common representation for dose summation. The inclusion of organ motion and deformation in 4D dose calculations has the potential to reduce normal toxicity and improve tumor control through safe dose escalation and margin reduction.

Educational Objectives:
1. Review the different methods of 4D dose calculations.
2. Understand the tradeoffs between using predictive and direct dose accumulation methods.

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3. Discuss current research in the integration of 4D imaging and deformable registration into radiation treatment planning for accurate dose accumulation.