AbstractID: 9420 Title: Design of a next generation treatment planning system that incorporates motion and uncertainty in inverse planning

Purpose: The safety margin approach to handle uncertainty and motion in radiotherapy treatment planning has limitations. For example, in the context of respiratory motion, the safety margin concept is over-conservative and leads to increased doses to lung or liver tissue. Furthermore, in intensity-modulated proton therapy (IMPT), the safety margin approach fails and cannot be applied successfully. Therefore, future treatment planning systems should have the option to directly incorporate uncertainty and organ motion into treatment plan optimization for IMRT and IMPT. We suggest a mathematical basis and practical implementation guidelines for a next generation treatment planning system that can handle various types of uncertainty within a coherent framework.

Methods: Mathematically, our program follows the probabilistic approach: The delivered dose, and hence the objective function, depend on a set of random variables that parameterize the uncertainty. Treatment planning is performed by optimizing the expected value of the objective function. Practically, this approach was implemented in C++ in an object-oriented setting. A key component of the program is an abstract base class called DoseDeliveryModel. A particular type of uncertainty is implemented in a derived class. Aspects that are specific to the type of uncertainty considered can be hidden in derived classes, whereas the remaining program communicates with the DoseDeliveryModel via standardized public member functions.

Results and Conclusion: Different applications have been implemented: Those include setup errors, respiratory motion with variations in the breathing pattern, or range uncertainties in IMPT. As a result, we obtain treatment plans that are qualitatively different from conventional plans. For IMPT we obtain plans that are robust against range and setup errors that simply cannot be obtained by margin approaches. For moving lung tumors a reduction of integral lung dose in the order of 10 - 20% was observed.

Research partially supported by Siemens Medical Solutions.