AbstractID: 12017 Title: 4D treatment planning: rationale, methods and significance

The breathing-induced motion adversely affects the radiotherapy process for pulmonary tumors at all stages. During the conventional 3D imaging, motion causes artifacts that lead to erroneous anatomical information that propagates as a systematic error during planning and delivery. For planning, the standard approach to insure tumor coverage in the presence of geometrical uncertainties is to surround the target with a safety region. The pitfall of the margin expansion approach is that additional high doses are delivered to the normal tissue adjacent to the target, thus increasing the chances of radiation-induced disease, while also limiting tumor dose escalation and, subsequently, the potential for better tumor control. The advent of 4D computed tomography (4D CT) represented a significant step forward toward improved imaging accuracy for regions affected by the respiratory motion due to the ability of reconstructing multiple image sets corresponding to various points during the breathing cycle. The information from the 4D CT is first used to better identify the target region at various stages over the breathing cycle and the extent of motion. Next, the more complete imaging data has to be factored into the planning process. To this end, depending on the treatment delivery strategy, one or more treatment plans are designed for each breathing instance for which data is available. Dose computations are performed on multiple datasets (usually termed as 4D dose calculations), and the cumulative dose is then used to assess the plan quality similar to the conventional 3D planning. The accumulation of doses on a reference image dataset is accomplished by using deformable image registration, which maps corresponding image voxels from one dataset to the reference dataset. To date, several approaches have been developed to fulfill this task. The amount of data available from 4D scans increases significantly the amount of time and effort needed for treatment planning. However, studies have suggested that the dose accumulation process could be reduced to planning on certain datasets only, while preserving at an acceptable level the accuracy that would otherwise be achieved through a full 4D dose computation. Multiple centers have employed the 4D planning approach to study the changes in doses as a result of 4D treatment planning and addressed the clinical significance of the changes observed.
In this presentation, we will discuss the rationale for 4D treatment planning, review the methods available for cumulative dose computation, identify potential sources of error specific to the 4D planning approach, and discuss the clinical importance of the dosimetric changes resulting from 4D-based treatment planning.

Educational Objectives:

1. Understand the rationale for accounting for respiratory motion during treatment planning.
2. Understand the principles of cumulative dose computation.
3. Learn about the clinical importance of the changes induced by the respiratory motion.