

AbstractID: 4449 Title: 4D Scanning

The purpose of CT simulation in radiotherapy is to acquire patient geometrical information and to build a patient geometrical model for treatment planning. Errors in patient model caused by motion artifacts will influence all treatment fractions and therefore should be handled carefully. Due to the tumor respiratory motion, the captured tumor position and shape can be heavily distorted. The distortions along the axis of motion could result in either a lengthening or shortening of the target. The center of the imaged target can be displaced by as much as the amplitude of the motion.

A newly developed technique that can reduce motion artifacts and provide patient geometry throughout the whole breathing cycle is called respiration-correlated or 4D CT scan. The basic idea for 4D CT scan is that, at every position of interest along patient's long axis, images are over-sampled and each image is tagged with breathing phase information. After the scan is done, images are sorted based on the corresponding breathing phase signals. Thus, many 3D CT sets are obtained, each corresponding to a particular breathing phase, and together constitutes a 4D CT set that covers that the whole breathing cycle. 4D CT scan has been developed at various institutions with slightly different flavors. In this lecture, we will provide an overview of various implementations of 4D CT scan.

4D CT scan can be used to account for respiratory motion to generate images with less distortion than 3D CT scan. 4D images also contain respiratory motion information of tumor and organs that is not available in a 3D CT image. This technology can be used for respiratory-gated treatment to identify the patient-specific phase of minimum tumor motion, determine residual tumor motion within the gate interval, and compare treatment plans at different phases. It can also be used for non-gated treatment planning to define ITV by combining gross tumor volume at all breathing phases or using a method called maximum intensity projection. Of course 4D CT will also play a vital role in the futuristic 4D radiotherapy where the tumor is tracked dynamically during the treatment using multi-leaf collimator.

Existing problems for 4D CT scan include the increased imaging dose, CT tube heating, and data management. More importantly, one has to keep in mind that 4D CT scan is not really 4D. Temporal information is mapped into one breathing cycle. Irregular respiration will cause artifacts in 4D CT images. Patient coaching can improve the regularity of breathing pattern and thus reduce the residual artifacts. However this issue still deserves further studies.

Educational Objectives:

1. Understand the origin and magnitude of motion artifacts in free breathing helical CT scan
2. Understand how 4D CT scan works
3. Understand how 4D CT can be used in radiotherapy
4. Understand the remaining artifacts in 4D CT scan and possible future improvements