Abstract:

Four-dimensional computed tomography (4DCT) is a technique for acquiring dynamic anatomic information via CT, in which we use periodic motion to replace the time dimension with the phase dimension. Acquisition of anatomic information via 4DCT allows us to personalize the planning of radiation therapy by explicitly accounting for respiratory motion on a patient-specific basis. The two different approaches for the acquisition of 4DCT images are image binning and projection binning. In image binning, the CT scanner is operated in cine mode, multiple images are acquired with the table in a series of adjacent fixed positions, each image is associated with an acquisition time, and images with acquisition times closest to the phase acquisition times are binned. In projection binning, the CT scanner is operated in helical mode at a very low pitch, a large number of projections are acquired, each projection is associated with an acquisition time, projections with acquisition times closest to the phase acquisition times are binned, and binned projections are reconstructed. In both cases, the result is a set of several CT data sets, each data set corresponding to a different phase of the respiratory cycle. In principle we can use the 4DCT data sets to explicitly perform 4D dose calculations, but in practice, we use the 4DCT data to generate a maximum intensity projection (MIP) image to aid in delineating the target volume, and perform dose calculations on an average (AVG) CT data set. Two sources of artifacts in 4DCT image acquisition are inadequate sampling and irregular breathing. Inadequate sampling can be overcome by ensuring appropriately slow table translation to acquire adequate data. Irregular breathing can be mitigated somewhat by patient training prior to scan acquisition or by possible patient coaching using audio or video prompting. Post-scan processing has been shown to be of some, but limited, utility in mitigating effects of irregular breathing. With the introduction of faster gantry motion and larger detectors, it may be possible to acquire a complete set of 4DCT information in a single gantry rotation, at which time, issues of inadequate sampling and irregular breathing may be resolved.

Educational Objectives:

At the conclusion of this presentation, the participant will be able to answer the following questions:

1. What do we mean by 4DCT?
2. Why would we need 4DCT?
3. How do we obtain 4DCT images?
4. How do we use 4DCT images?
5. How can we improve the quality of 4DCT images?

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