AbstractID: 8785 Title: A theoretical model for respiratory motion artifacts in free breathing CT scans

Purpose: To present a theoretical model that explains the source of motion artifacts in CT scans of tumors undergoing respiratory motion, and the relationship between motion artifacts and the motion parameters of the scanner and tumor.

Method and Materials: A one-dimensional model aligned along the craniocaudal axis in the couch coordinate system is used. The tumor is modeled as an oscillating line segment, while the scanner moves with constant velocity. Equations of motion are formulated for the tumor and scanner, and a geometric method is used to solve for the time intervals at which the scanner will capture the tumor. These time intervals are translated into position intervals, corresponding to the positions at which the tumor would appear in a CT scan.

Results: The model explains the sources of length distortions, tumor splitting, and mean position displacement in CT scans of tumors undergoing respiratory motion. It is shown that splitting artifacts can be eliminated if the scanner speed is above the tumor's maximum speed. It is also shown why slow scanner speeds are useful for obtaining accurate internal target volumes (ITVs), and fast scanning speeds are useful for obtaining accurate tumor lengths. In both cases the maximum possible error is calculated as a function of the scanning speed. A special set of scanning speeds which result in an accurate representation of tumor length are found, and a relationship between the maximum displacement of a tumor image's mean position and the magnitude of its length distortion is derived.

Conclusion: This work shows how knowledge of scanner and tumor motion parameters could be used to produce more accurate representations of a tumor's size and position in free breathing CT scans. In particular, manipulation of scanner velocities can be used to obtain more accurate measurements of a tumor's length, mean position, and ITV.