

Intrafraction tumor motion management techniques in imaging, treatment planning, and IMRT delivery

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Anatomic motion can affect the radiation treatment of disease sites in the thorax and abdomen. With four dimensional (4D) imaging modalities, respiratory motion can be defined on a patient specific basis. From 4D data sets, radiotherapy techniques can be devised to account for tissue motion. Systematic and random uncertainties must be characterized for each 4D imaging modality utilized. Some modalities, such as 4D-CT, require multiple motion trajectories in order to fully define the uncertainties associated with the imaging system. This is investigated in this work for a clinical 4D-CT scanning protocol and the methods used can be applied to any 4D imaging modality. Once all of the relevant tissues and their associated motion have been defined, with corrections to account for any associated uncertainties in the 4D data sets, treatment plans can be generated. For lung cancer, unique challenges arise when inverse planning is used, typically in the case of IMRT, because density differences between lung tissue and other tissues can result in quite different dose distributions. Because inverse planning is an optimization algorithm, the degree of optimization is dependent on the input parameters. One important input factor is the image set that is used for the dose calculation. For three image sets supplied to a commercial inverse planning algorithm (Average Image and an exhale phase image with motion envelope defined from a maximum intensity projection image, both with and without a density override to the motion envelope), dose calculated on the Average Image was found to be in best agreement with the dose calculated on the 4D-CT. Finally, when IMRT is delivered to mobile tumors, it is possible for the dose to the tumor to vary from treatment to treatment. Therefore, numerous methods have been investigated in order to reduce this variation. A computer simulation algorithm has been developed to predict the variation on a two spatial dimension plane and comparisons are made with measured data in a similar configuration. Variable tumor motion has also been considered in this respect.