ADAPTIVE MANAGEMENT OF PATIENT MOTION IN RADIOTHERAPY

Patient-specific target margin and 4D inverse planning are two typical methods to include treatment relevant patient motion in the treatment planning. Internal target volume (ITV) is probably the earliest technique in constructing patient-specific target volume to compensate for target motion. However, this method only considers motion geometric information in the construction without utilizing inter-patient heterogeneity of dose distribution, therefore the target margin has not been minimized. In contrast, a recent development in patient-specific target margin construction includes motion probability density function (pdf) directly in the 4D dose evaluation; therefore individual dose distribution is included in the target margin design. Utilizing 4D dose calculation, treatment plan can also be optimized by modulating beam intensity with respect to a pre-measured patient motion pdf. Concept of utilizing non-uniform beam intensity to compensate for temporal displacements of target position has been pointed out long time ago, however it has not been implemented until recent years. Process of designing beam intensity by including patient geometric variation or motion pdf in the dose calculation and inverse planning has been called 4D inverse planning. Since this planning process is based on organ displacement information in a frequency domain, instead of the spatial domain used in the gating and tracking techniques, it is insensitive to the uncertainties in the motion phase. However, uncertainties in pdf characteristics could significantly detriment the treatment qualities.

The most significant variation in motion pattern is the target position baseline variation. Study has shown that inter-treatment target baseline variation can be minimized efficiently using daily free breathing cone beam CT imaging location and patient repositioning. However, the relative position variation between target and normal organs, the dose response related organ volume variation, as well as intra-treatment motion pattern variation cannot be easily corrected by repositioning the patient. Therefore, treatment feedback and adaptive planning modification become necessary. In principle, 4D inverse planning is a central part of adaptive planning modification, however to fully accomplish an adaptive planning, the dose distribution in organs of interest which has been delivered previously and may be delivered in future is also important factor and needs to be included in the objective evaluation for 4D planning optimization.

Educational Objectives:

1. Understand the options of 4D planning
2. Understand the sensitivity of 4D planning to the motion uncertainties
3. Understand the key components of adaptive treatment process and their functions

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