PATIENT MOTION MODELING & TREATMENT ADAPTATION

Patient anatomical variation during the radiotherapy course can be described using a stochastic process. In this process, spatial position of each subvolume in patient organs of interest during the treatment course is represented using a random vector with an intrinsic probability distribution function (pdf). Two main parameters, the mean and the standard deviation, of the pdf have been historically used to characterize patient anatomical variation, the systematic and random variations, during the radiation treatment. It has been demonstrated that treatment dose distribution in an organ of interest can be evaluated using these two parameters alone, without the full knowledge of organ motion distribution. The approximation is, however, dependent on the size of the motion as well as the number of treatment fractions. It is straightforward to estimate these two parameters if patient anatomical variation process is stationary. In this case, the two parameters are constants or time-invariance during the treatment course. However, the estimation will be relatively difficult if patient anatomical variation process is non-stationary.

Patient anatomical variation in radiotherapy can be managed using multiple or 4D image guided or feedback treatment techniques. Among them, adaptive approach is the most effective methodology in utilizing the 4D feedback information. Image guided adaptive radiation therapy is a closed loop treatment process which is designed to include the individual treatment information, such as organ dose that has been delivered and/or could be delivered in future, in the treatment evaluation and planning optimization. To include delivered organ dose in the planning optimization, deformable image registration is necessary. On the other hand, the measured organ variations are used to estimate what may happen in the future treatment. The patient specific information is, then, included in 4D adaptive planning modification or optimization. Based on a pre-determined control strategy, adaptive planning modification can be performed either offline with signal or multiple modifications, or online. However, selection of control strategy is quite complicated not only depending up on the nature of patient variation process, imaging sampling and estimation methodology, but also the clinical load and practical issues.

The lecture will provide an overview of the model and description of patient anatomical variation process during the radiotherapy. In addition, effect of the variation on treatment dose, and options of control strategy will be discussed.

Educational Objectives:

1. Understand the characteristics and dynamic model for patient anatomical variation during the course of radiotherapy
2. Understand the effects of patient anatomical variation on treatment dose
3. Understand the options and potentials of control strategy for image guided adaptive radiotherapy