Purpose: To create a deformable organ variation probability density function (PDF) estimator for the purpose of treatment dose estimation and adaptive inverse planning optimization in the clinical applications of adaptive radiotherapy.

Methods: Principle Component Analysis (PCA) was applied to variations of organs of interest manifested on multiple treatment CBCT images. Utilizing the PCA model for deformable organ PDF estimation includes the determination of the eigenvectors and the corresponding coefficients. The coefficients can be either random variables or random functions of treatment time depending on the characteristics of organ deformation as stationary or non-stationary random process. The least square regression method with time-varying weighting parameters was applied on the pre-collected patient images to determine the function form of the coefficients. Seven h&n cancer patients, 31 images per patient, were included in the construction of the estimator and the optimization of the corresponding weighting factor in the estimator. The estimator was evaluated using total 19 organs of interest of another eight patients.

Results: The deformable variation of organ can be accurately represented by 3 to 4 eigenvectors. These vectors change and need to be updated with the new image observations during the treatment course. The estimation error in the mean of the organ PDF is less than 3 mm for cord and CTV for elective nodes, and less than 2 mm for the other organs of interest. The estimation error in the standard deviation of the organ PDF is less than 1 mm for all organs of interest.

Conclusions: Deformable organ variation estimator is feasible to perform acceptable estimation for deformable organ PDF during the h&n cancer radiation treatment. This estimator will provide an important role in the treatment course of adaptive radiotherapy.

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