AbstractID: 6729 Title: Detecting Dose Reconstruction Errors

Purpose In radiation therapy, delivered doses can be accumulated over fractions for adaptive treatment planning. However, the dose reconstruction fidelity can be compromised by image registration errors. The resultant dose discrepancy is hard to measure. This paper proposes a new method to assess the difference between the delivered dose and the warped dose.

Method and Materials

The dose warping discrepancy is dominated by deformable image registration errors and source-dose distributions. Registration errors can be specified within a finite element framework as an unbalanced energy δ_R , which is defined at element j by

$$\delta_R(j) = \sum_{i=1,\dots,4} \left| d_i^{(j)} \tilde{F}_i \right|, \qquad \tilde{F}_i = E_0 \sum_j \Phi_j(d_{i_1}^{(j)}, d_{i_2}^{(j)}, \dots, d_{i_4}^{(j)})$$

where E_0 and d_i are Young's modulus and the displacement vector fields of the registration R . $E_0\Phi_j$ is an assembly of all the element forces relating to the node i . Consequently the dose warping discrepancy at voxel k can be defined as the convolution of the dose divergence $Div(D)$ and δ_R :

$$\varepsilon_{D,R}(k) = \int Div(D(k)) * \delta_R(k-\tau)d\tau.$$

The effectiveness of the dose-discrepancy-convolution (DDC) defined above is demonstrated through applying it to dose computed on ten prostate-CT images. An IMRT treatment plan is developed on the planning image. In nine subsequent treatments, images are acquired to calculate the corresponding delivered doses. Their mean and standard-deviation in C^i , a target contour automatically expanded from prostate delineated on the time-of-treatment image i , are compared with those of their warped doses measured on the planning target volume. The differences in their means and standard-deviations are denoted by E_ε and E_σ , respectively.

Results δ_R , $\varepsilon_{D,R}$, E_ε and E_σ are computed for the nine treatment fractions. Fraction one and eight have the largest warping discrepancies identified in all the four evaluation criterions.

Conclusion Defined in terms of the deformable registration error, the voxel-based DDC can be employed for the automatic evaluation of dose reconstruction in the whole dosing domain. Its measurement is consistent to the contour-based dose warping evaluation performed in the planning target volume.

Conflict of Interest: No.