AbstractID: 11682 Title: A method to estimate 4DCT deformable registration errors via Principal Components Analysis

Purpose: To extract continuous deformable image registration error maps from 4DCTs using a small set of ground truth landmarks.

Method and Materials: Assuming that we have a set of displacement vector fields (DVFs) calculated via deformable registration from 4DCT breathing phases, and a small set of validation landmarks, we use principal components analysis (PCA) to separate the eigenmodes of breathing from the error eigenmodes. We then reconstruct the DVF error maps from their principal components. To test this method we made a 2D model of breathing motion in the thorax with a 16x16 pixel DVF to which we added simulated errors. We selected 20 pixels as ground truth landmarks and applied our PCA method to the simulated data to estimate the error maps. We applied the same algorithm to the Point-validated Pixel-base (POPI) 4DCT data set, which consists of a 4D CT in which clinicians have located 41 point landmarks in 10 reconstructed CT breathing phases.

Results: In the numerical simulations our method successfully recovered the artificial DVF error map although the error amplitudes were underestimated by 10-30%. The 4DCT analysis showed PCA eigenvalue spectra that are consistent with the assumptions of our error estimation method and also indicated that the landmarks provided by POPI model are sufficiently representative to be used as ground truth for our analysis.

Conclusion: Point-by-point landmark validation of deformable image registration results can give highly selective results that do not realistically reflect the true spatial distribution of registration errors. Our PCA based method allows a more realistic picture of image registration and 4DCT motion mapping errors.

This research was supported in part by NIH grant P01CA116602