AbstractID: 3489 Title: A method for modeling individual patient geometric variation: Implementation and Evaluation

Purpose:
We present and evaluate the method of *Principal Component Analysis* for modeling individual organ motion/deformation. This method provides the most important factors to characterize deformable organ motion, therefore assists adaptive radiotherapy planning.

Method and Materials:
Input are N organ shape samples, described by the positions of a set of corresponding surface points. The covariance matrix of displacement vectors is determined and diagonalized.
Each eigenvector defines a 3D-vectorfield of correlated displacements for the surface points, a so-called *eigenmode of deformation*. Each eigenvalue gives the variance of the shape samples in direction of the corresponding eigenmode, thereby providing an importance ranking for the eigenmodes with respect to the displacement direction and magnitude.
Weighted sums of eigenmodes can be used to represent organ displacements/deformations. We evaluated the ability of eigenmodes to represent the measured samples by calculating the residual errors for the organ surface points, using a varying number of eigenmodes. The method was applied to four datasets of prostate/bladder/rectum with N=15-18 CTs to assess interfractional geometric variation. Typically a few thousand surface points were used in the analysis.

Results:
The spectrum of eigenvalues is clearly dominated by only few values. This indicates that the geometric variability of the input samples of prostate/bladder/rectum shapes is governed by only a few patient specific 'deformation modes', quantitatively given by the corresponding eigenvectors.
The distribution of residual errors shows convergence with the number of eigenmodes used to represent the organ shapes. Using 4 dominating modes, the range of average residual errors is 1.3-2.0mm (prostate), 1.4-1.9mm (rectum) and 1.5-1.9mm (bladder) for the four patients.

Conclusion:
Individual geometric variation information taken from multiple imaging data can be described accuratuly by few dominating eigenmodes. This approach provides an efficient statistical model to characterize individual organ deformation, which quantitatively takes into account correlated motion of adjacent organ structures.