AbstractID: 13876 Title: NURBS-based deformable image registration

Purpose: The current trend of incorporating multi-modality and multi-instance imaging in treatment planning for external beam radiotherapy has highlighted the need for fast and accurate deformable image registration techniques. One current implementation of non-rigid registration uses uniform B-Splines to parametrically represent the displacement vector field (DVF). The piecewise B-spline segments are joined at "knots" that define the local region of support and influence for each segment. This approach has limited flexibility and can require a fairly large number of control points to describe local complexity in the DVF. The authors present the implementation of a more general functional representation of B-Splines, Non-Uniform Rational B-Splines (NURBS) as an alternative DVF model.

Method and Materials: To demonstrate the improved accuracy that NURBS can provide, we have made numerical fits to a one-dimensional scalar DVF in the shape of a Gaussian. We first fit the DVF with a uniform B-Spline to establish baseline accuracy. We then fit the Gaussian with a 1D NURBS model with the same number of control points but now with non-uniform knots and weighted control points. The metric of comparison of the two fitting routines is the sum of the squared differences between the curve fit and the target Gaussian.

Results: For the same number of control points, the NURBS fit produced a sum of squared differences of .0019 compared to 1.625 for the uniform B-Spline fit.

Conclusion: NURBS offer an attractive alternative to uniform B-Splines in modeling the DVF. They carry forward the mathematical compactness of B-Splines while simultaneously introducing new degrees of freedom. The additional free parameters gained from the generalization to NURBS curves offers increased local control as well as the ability to explicitly represent topological discontinuities.