AbstractID: 7383 Title: Improved Deformable Image Registration Using Hybrid Models: An Application to Solitary Pulmonary Nodule

Purpose:
To present a fast and robust hybrid deformable image registration algorithm (Juggler) for target motion estimation, automated segmentation and internal target volume (ITV) generation in 4DCT lung imaging.

Method and Materials:
The Juggler algorithm utilizes two alternating separately optimized diffusion models: one for low gradient features (soft tissues), the other for high gradient features (bony anatomy). Clinical lung imaging, acquired from 4DCT, consisted of free breathing CT and 10 phased CT sets. Comparison with three other conventional algorithms (demons, accelerated demons, and free-form deformation method) was carried out using both simulated data and clinical 4DCT. Algorithm validation was carried out using comparison of 1) displacement vectors (for simulated data), 2) correlation coefficient, 3) difference imaging, and 4) vector streamlines. Clinical efficacy of Juggler was evaluated by visual inspection of anatomical structures mapped from the reference onto target imaging using the deformation map. Tumor motion/ deformation was determined using image moments.

Results:
For simulated data, Juggler achieved the highest correlation coefficient and minimum error. Its unique alternating mechanism greatly improved the convergence rate, resulting in at least 40% reduction in iterations. For 256x256x80 imaging, Juggler required <3 min for 50 iterations using Pentium-4 3.2 GHz PC. For clinical 4DCT, Juggler performed best based on correlation coefficient and visual inspection. We used Juggler for generating ITV, and autosegmenting normal structures onto the phased CTs based on the initial segmentation on the reference CT.

Conclusion:
Juggler demonstrated the benefits of utilizing multiple diffusion models into a single unified model. Initial experiments indicated Juggler achieved the fastest rate of convergence per iteration, and overall superior registration based on correlation coefficient, difference imaging and error analysis. Its success in autosegmentation and ITV generation make this highly promising in implementation of adaptive radiation therapy. With new computer hardware, <30sec computation times are expected.