AbstractID: 8742 Title: A generalized method for achieving realistic deformable image registration (DIR) using the inverse consistency constraint

Purpose: To present a novel methodology for improving the performance of existing deformable image registration (DIR) algorithms by imposing an inverse consistency constraint (ICC), and achieving physiologically more realistic and robust DIR.

Method and Materials: The proposed approach combines forward and reverse mappings of a registration algorithm by an inverse consistency constraint based on fixed point theory. Unlikely most ICC-DIR algorithms, our method does not require explicitly computing inverse transformations, thus reducing both potential numerical errors and required computations. Here we applied the methodology to the Demons algorithm: inverse consistency Demons (iDemons). However the method is generalized to be applied to many current algorithms, such as accelerated demons and energy minimization methods. The validation and comparison of the iDemons and Demons was carried out on 4DCT clinical lung imaging based on: 1) cross-correlation; 2) inverse consistency errors (ICE); 3) visual verification; 4) robustness.

Results: The registration performance of iDemons was superior to Demons. While both methods achieved similar level of correlation coefficient after 200 iterations, 0.9908 for iDemons and 0.9891 for Demons, the average ICE is reduced by 91%: 0.17mm (iDemons) vs. 1.86mm (Demons), resulting in up to 3mm difference in corresponding contours. Since ICE mostly occurred around organ boundaries, minimizing ICE would improve clinical efficacy of DIR based auto-contouring. Moreover, the iDemons algorithm was shown to be more robustness and less sensitive to parameter selection, which is significant if DIR is to be utilized clinically on routine basis by non-specialists.

Conclusion: The proposed methodology achieves physiologically more realistic DIR. iDemons achieved significant reduction of ICE compared to Demons, which was significant for organ boundaries. Registration results for iDemons were less sensitive to parameter selection, an important consideration for clinical implementation. This novel inverse consistency constraint represents a generalized formalism, which can be applied to other registration algorithms.