ABSTRACT

ESTIMATING RIGID BODY REGISTRATION GROUND TRUTH USING COMBINATORIAL RIGID REGISRATION OPTIMIZATION (CORRO)

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Clinical image pairs provide the most realistic test data for image registration evaluation. However, the underlying ground truth is unknown. Using combinatorial rigid registration optimization (CORRO) this dissertation demonstrates a method and statistically characterizes reference data sets for image registration by estimating the ground truth.

Landmark pairs were manually selected for each CT/CBCT image pair for 64 cases. Two of the data were head and neck, two thoracic, and sixty pelvic images. From the landmark pairs selected, combination subsets of a k number of landmark pairs were generated without repeat to form a large set of k-combination (k-set) for k=4,8,12.
A rigid registration between the image pairs was calculated for each k-combination set (2,000-8,000,000). The mean and the standard deviation of the registration were used as the final registration for each image pair. Joint entropy was employed to measure and compare the quality of CORRO to commercially available software.

The number of landmark pairs selected ranged from 91-212 for each CT/CBCT image pair. The joint entropy evaluated for each k-set of each case was smaller than those from three commercially available registration software programs indicating a stronger

correlation between the image pair after CORRO was used. As further proof of the efficacy of CORRO the joint entropy of each member k=4 composed of 30,000 and 170,000 k-combination sets were calculated for one of the thoracic cases. The minimum joint entropy was found to exist at the estimated mean of registration indicating the CORRO approach converges to the optimal rigid-registration results. The minimum joint entropy determined for one case was found to exist at the estimated registration mean in agreement with CORRO approach.

The results demonstrate that CORRO works even in the extreme case of pelvic anatomy where the CBCT suffers from reduced quality due to increased noise levels. The estimated ground truth was found to be lower than results from commercial programs. Additionally, the k-set of 4 resulted in overall best outcomes when compared to k=8 and 12, which is anticipated because k=8 and 12 are more likely to have mismatched points that would affect the accuracy of the registration.