Registration of Supine and Prone CT Colonography Data: Method and Evaluation

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PURPOSE: To develop and experimentally validate a method to anatomically register complementary supine and prone CT colonography (CTC) datasets, using linear stretching/shrinking operations on the central colon path based on the relative path geometries.

METHOD/MATERIALS: Initial data processing involves colon segmentation and automatic determination of a central colonic path extending from the rectum to the cecum, sampled at 1mm intervals. The axial (z) coordinates of path points are interpreted as a function of distance along the path (DOP). The local extrema are computed and clustered for z_{prone} and z_{supine}. The mean of each cluster along the path serves as a landmark corresponding approximately to path inflection points. We first match the starting and end points of the two paths. The two most cephalad landmarks for each path, usually corresponding with colonic flexures, are compared for the path length difference (D) between them. If ($|min(D)|<\delta$) then the supine path is linearly stretched/shrunk such that $min(D)=0$, where δ is set to 100mm as an upper bound to the linear shift. The above processes are repeated recursively (maximum recursion level = 2) to the left and right hand sides of the landmark, keeping the previously shifted landmarks fixed (We have also implemented this to iterate over the coronal (x) and/or sagittal (y) path point coordinates, but observed no improvement in performance for this dataset). To compare improvement in spatial registration of identical anatomy in supine and prone datasets, one radiologist determined 5 unique reference points (RP) in each of 5 patients by viewing supine and prone data simultaneously. Reference points included polyps, diverticulae, unique folds, or the ileocecal valve. For each RP, we computed the difference of DOPs between the RPs in supine and prone data both before and after path registration.

RESULTS: The registration decreased the mean±s.d. DOP between RP pairs on prone and supine paths from 51.0±42.8 mm to 16.2±12.0 mm (-68.3%). The maximum (minimum) DOP between RP pairs was decreased from, 151.0mm (7.0mm) to 22.5mm (0.54mm) after registration. The mean DOP between 4 of 25 RP pairs increased from 14.3±11.9 mm to 26.1±22.6 mm.

CONCLUSIONS: Initial results suggest that our algorithm is capable of registering supine and prone CTC data anatomically within an approximate range of ±16mm, which corresponds to 1% error with respect to the average colon length. This will allow for simultaneous registered viewing by radiologists and the correlation of computer-aided detection results between patient positions.