Automatic identification of landmarks for lung CT registration

Diploma Thesis
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Abstract

Radiotherapy is an integral technique in tumor treatment. One important aspect of radiotherapy planning is the determination of the target volume and risk organs. Especially in radiotherapy planning of lung cancer breathing motion can lead to problems with target volume determination. In order to account for organ motion, information about breathing motion and the tumor movement in the respiratory cycle is needed. Image registration is essential to learn about the deformation of the lung and the tumor movement.

In order to get breathing motion information, a landmark-based registration technique with automatically extracted landmarks is needed, because manual selection of landmarks is time-consuming and often inaccurate. We use pronounced vessel bifurcations as landmarks because these form a unique feature with good localization. These landmarks are extracted from automatically extracted vessel trees in the maximum inhale and the maximum exhale CT thorax data sets.

The output of the vessel tree extraction is a centerline representation consisting of the centerline points of each segment and the radius of the vessel at that particular position. Pronounced bifurcations are extracted from that centerline representation as landmark candidates. Correspondences between the bifurcations in both data sets are determined by comparing the shape context of Belongie *et al.* of each bifurcation. The shape context of

a bifurcation represents the *shape distribution* of the vessel centerline relative to the bifurcation. After correspondences are determined we apply a MAD-based outlier rejection method to define the landmark candidate set that is used in the transformation estimation. A vector field is estimated using interpolation methods with radial basis functions, elastic body splines or an affine transformation. Best results are achieved with thin-plate spline interpolation.

The alignment accuracy is determined from locations of *ground truth* points that were manually selected by an experienced physician. The resulting average landmark discrepancy in IS-direction lies within the slice thickness of the CT data sets (2.5 mm). However, these results are dependent on the *ground truth* uncertainty. In order to incorporate a second method that does not depend on manually selected *ground truth* points we also apply visual inspection by analyzing the difference images before and after registration. Thereby we learn that the registration method shows promise near vessels and the tumor but fails at the lung surface, what is evident as we do not have any landmark point on the lung surface.

Applying a thin-plate spline interpolation in the alignment step can improve the average landmark discrepancy after registration compared to an affine registration. However, in some data sets the improvement is small so that the clinical significance of the improvement by thin-plate spline interpolation has to be investigated taking into account the increased computing time needed for elastic registration.