

T2-weighted MR image registration of rectal tumors and mesorectum during radiotherapy

Ahmed Bani Yassien¹, Ghazaleh Ghobadi², Marius Staring³, Baukelien van Triest¹, Doenja Lambregts⁴, Anja Betgen¹, Corrie A.M. Marijnen², Uulke A. van der Heide¹

¹Department of Radiation Oncology, The Netherlands Cancer Institute, Amsterdam, The Netherlands.

²Department of Radiotherapy, Leiden University Medical Center, Leiden, The Netherlands.

³Division of Image Processing, Department of Radiology, Leiden University Medical Center, Leiden, The Netherlands.

⁴Department of Radiology, The Netherlands Cancer Institute, Amsterdam, The Netherlands.

Abstract

Purpose: To monitor tumor changes in rectal cancer patients undergoing sequential MRI during radiotherapy, deformable image registration (DIR) is required. However, applying DIR may result in unrealistic tissues expansion or folding, particularly in the case of tumor shrinkage. We developed and evaluated two registration approaches of T2-weighted (T2W) MRI for spatial mapping of tumor and mesorectum.

Methods and Materials: Thirteen patients received weekly repeated T2W-MRI (3T) for five weeks (n=62 scans). Both approaches were implemented in Elastix, using a B-splines transformation and mutual information as a similarity metric. For registration of non-tumor structures in the mesorectum manually selected landmarks and/or rectum contours were utilized to refine the registration when needed. For tumor mapping, the transit point from tumor to normal rectum wall was used for tumor alignment assuming tumor volume preservation.

Results: Registration of non-tumor structures resulted in average dice similarity coefficient (DSC) of $90\pm 6\%$ and mean surface distance (MSD) of $1.53\pm 0.48\text{mm}$ between mesorectum segmentations. Refinement using landmarks was required for one patient improving MSD and DSC, from 18.0 to 1.27 mm and 62% to 96% respectively. Refinement using rectum contours was required for another patient improving MSD from 3.0 to 2.7 mm. Tumor mapping resulted in satisfactory alignment when evaluated visually. For an average-sized tumor ($\sim 30\text{cc}$) with 44% volume shrinkage MSD was 1.5 mm between rectum delineations.

Conclusion: We obtained accurate registrations between T2W-MRIs over time within the mesorectum. This can be used for monitoring tumor response and toxicity of normal tissue in radiotherapy of rectal tumors.