Multi-slice-to-volume registration for reducing targeting error during MRI-guided transrectal prostate biopsy

Andras Lasso[1], Andriy Fedorov[2], Janice Fairhurst[2], Junichi Tokuda[2], Kemal Tuncali[2], Robert Mulkern[2], Nobuhiko Hata[2], Clare M. Tempany[2], and Gabor Fichtinger[1]
[1]Laboratory for Percutaneous Surgery, Queen's University, Kingston, ON, Canada;[2]Surgical Planning Laboratory, Department of Radiology, Brigham and Women's Hospital, Boston, MA, United States

Purpose

MRI has been shown to be a valuable tool for guiding prostate biopsy. Our current MR-guided biopsy workflow utilizes planned biopsy points identified based on multiparametric MRI review that are warped to the intra-procedural configuration of the gland in the beginning of the procedure (Tuncali *et al.* 2011). Intra-procedural motion of the prostate gland may dislocate the target points, leading to targeting errors. Registration of the planning image to intra-procedural scan showing the deformation can be used to reduce errors in needle placement. Herein we evaluate a deformable image registration approach that relies on sparse MR imaging to recover motion and deformation of the prostate during MR-guided biopsy.

Methods

A registration method was developed to align the volumetric image that was used for planning to a set of orthogonal image slices that were acquired during the procedure. The registration method is composed of a sparse volume construction step and two registration stages: a rigid registration to obtain an initial pose of the target planning volume followed by the non-rigid registration to the fixed sparse volume. Mutual information was used as the similarity metric. A grid with 30mm spacing and B-spline interpolation was used to model the deformation. Imaging was done using Siemens Magnetom Verio 3T scanner. Volumetric planning images were acquired using axial T2w TSE sequence (320x320x320 voxels, 0.625x0.625x4.8mm voxel size). Three orthogonal intra-procedural slices were acquired using HASTE protocol (320x244 voxels, 0.94x0.94x3.6mm voxel size, 18 seconds acquisition time) and TrueFISP protocol (320x320 voxels, 1.25x1.25x3.6mm voxel size, 7 seconds acquisition time). The accuracy of the registration was qualitatively assessed by comparing the manually segmented prostate gland contours on the planning and slice images with and without registration. The robustness of the rigid registration step was evaluated by performing repeated registrations with the randomly perturbed initial transformation (±20mm translation and ±10° rotation).

Results

The intra-procedural prostate motion compensation method was tested previously on simulated images. In this paper preliminary results on clinical images of one patient is presented. The distance between the contours without registration was up to 3-4mm. With rigid and additional non-rigid registration the distance was reduced to about 1-2mm and 1mm, respectively. In 95% of the experiments evaluating robustness, the registration result was within 0.4 mm translation and 0.5° rotation difference as compared to the non-perturbed result in case of the HASTE protocol, and within 1.8 mm and 2.5° difference with the TrueFISP. Average computation time of the rigid registration step was 3 seconds. Computation of the non-rigid step took 12 seconds.

Conclusions

The preliminary results on clinical images indicate that the proposed registration technique may be able to estimate the prostate motion and deformation during MRI-guided prostate biopsy procedures by a quick multi-slice acquisition followed by an automatic computation.

References

Tuncali, K., J. Tokuda, I. Iordachita, S S-E. Song, A. Fedorov, S. Oguro, A. Lasso, F. M. Fennessy, Y. Tang, C. M. Tempany, *et al.*, "**3T MRI-guided Transperineal Targeted Prostate Biopsy: Clinical Feasibility, Safety, and Early Results**", *ISMRM 2011*, vol. 19, pp. 53, 2011.