# MR-CT REGISTRATION IN IMAGE-GUIDED RADIOTHERAPY OF PROSTATE CANCER USING A Ni-Ti PROSTATE STENT

Korsager, A.S.[1*], Carl J.[2], Østergaard L.R.[1]

[1]Department of Health Science and Techology, Aalborg University, Denmark
[2]Aalborg Hospital, Aarhus University Hospital, Aalborg, Denmark
[*]Corresponding author (e-mail: asko@hst.aau.dk)

## 1. INTRODUCTION

Challenges in the MR-CT registration for planning of radiotherapy of prostate cancer relate to the prostate mobility, resulting in different positions and orientations relative to the pelvic bones. Image registration based on anatomical landmarks will therefore introduce a risk for a misalignment of the prostate. [1] A fiducial marker inserted in the prostate can be used to locate the prostate, which enables co-registration of the volume surrounding the prostate. A removable thermo-expandable Ni-Ti prostate stent has been developed at Aalborg Hospital and is now used for localization of the prostate during radiotherapy at the Hospital [2]. The method presented here is automatic based the region containing the Ni-Ti prostate stent.

*Keywords: MR-CT image registration, image-guided radiotherapy, prostate cancer*

## 2. METHODS

The material consists of CT scans (1x1x2.5 $mm^3$) and axial MR scans (0.5469x0.5469x3 $mm^3$) from 10 patients all diagnosed with local or locally advanced prostate cancer and referred to the department of oncology for curative intended radiotherapy.

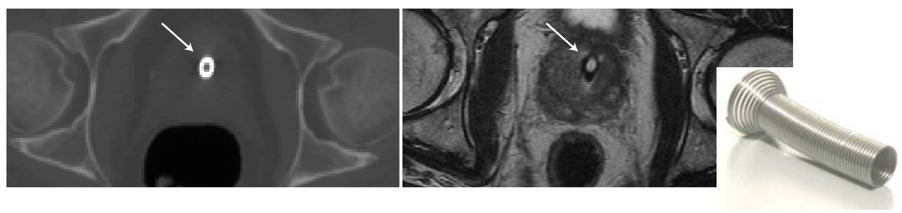

*Fig. 1. The prostate stent in CT and MR marked with white arrows. The prostate stent is shown in the right corner*

The method is an automatic six-parameter rigid registration (3 rotations and 3 translations). The registration is performed using mutual information and the registration tool minc-tracc. [3] The registration is a two-step approach, first an initial registration followed by a local restricted registration of the region of interest, see Fig 2.

### Initial registration

The first step is performed as an automatic registration of the pelvic bones to account for differences in patient setup with an expected misalignment of the prostate stent.

### Local registration

The second step is a MR-CT registration of the prostate stent to avoid any influence of the pelvic bones. A volume tightly surrounding the stent is therefore defined in the MR data set. The registration is performed on gradient images to enhance the stent and rotation constraints are applied where rotations in the axial plane are restricted to avoid unrealistic rotations about the center axis of the stent. Also studies have shown that the prostate movements primary occur in the sagittal and in a smaller extent the coronal image planes.

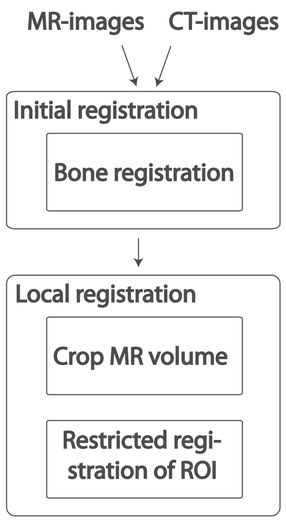


*Fig. 2. Block diagram of the registration approach*

## 3A RESULTS

### Initial registration

The initial registration showed a close alignment of the pelvic bones in MR and CT in all scans. Fig. 3 shows an example of the initial registration. The initial registration showed in some cases a small misalignment of the prostate stent as was expected.

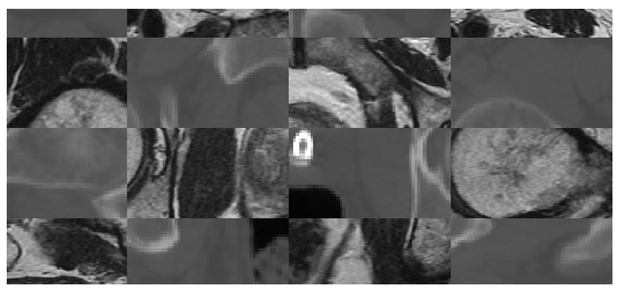

*Fig. 3. A checkerboard illustration of an initial alignment of the pelvic bones in MR and CT.*

## 3B RESULTS

### Local registration

A visual validation of the automatic MR-CT registration was performed to validate the alignment of the stent in MR and CT showing an accurate alignment in all data sets. Fig. 4 shows three examples of the registration solely based on region surrounding the prostate stent.

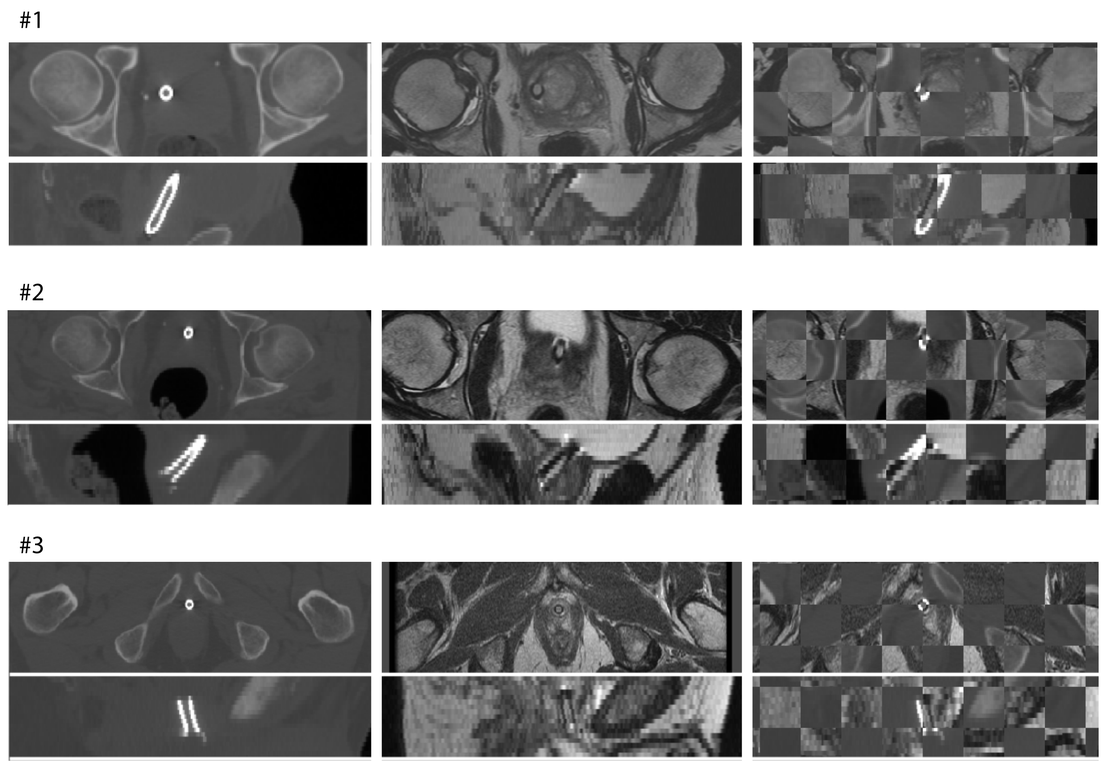


*Fig. 4. Axial (top) sagittal (bottom) view of the prostate. From left: CT, MR, and a checkerboard illustration of the local registration.*

The absolute rotation of the prostate relative to the bones in the sagittal plan was 3.09 deg (0.14-5.73). No rotation in the coronal or axial plane occurred due to the rotation constraints.
The movement of the prostate relative to the bones in the sagittal, coronal, and axial plan was 3.05 mm. (0.09- 8.31 mm), 2.51 mm (0.00-1.00 mm), and 3.20 mm (0.16-6.05 mm).

## 4. CONCLUSION

A two step registration approach was applied for accurate registration of MR and CT images. A bone registration was followed by a local registration solely based on the prostate stent and a tightly surrounding volume. Both steps are fully automatic using mutual information. The advantages of this approach are that the final registration is not influenced by e.g. pelvic bones but solely on the region of interest and the results can easy be replicated.
All data sets showed accurate alignment of the MR and CT scans with minimal misalignments of the surrounding structures.
The results showed that a local registration of the prostate is a crucial step to ensure an accurate registration of the prostate and that a registration solely based on bony landmarks can result in a misalignment of the prostate.

## 5. REFERENCES

[1] Langen, K., Jones, D.: Organ motion and its management. Int J Radiat Oncol Biol Phys 50(1) (2001) 265-278
[2] J. Carl, et al., "A new fiducial marker for image-guided radiotherapy of prostate cancer: clinical experience," Acta Oncologica. 47(7), (2008)1358–1366
[3] D. L. Collins, P. Neelin, T. M. Peters, and A. C. Evans, "Automatic 3d intersubject registration of mr volumetric data in standardized talairach space," Journal of computer assisted tomography, 18(2) (1994)192

## VENUE

ESTRO 31, May 9-13, 2012, Barcelona, Spain