Intrafraction prostate motion correction using a non-rectilinear image frame

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Motivation

- Prostate cancer is the most common cancer affecting men.
- External beam radiation therapy is frequently used for treatment.
- Despite careful positioning at the start of treatment, the prostate may move during the dose delivery.
- Thus, there is a need for intrafraction monitoring of prostate position.

Non Rectilinear Frame

Images captured by the mechanical probe fall naturally in a cylindrical coordinate frame.

Probe: Side View Top View Volume: Side View Top View

Conversion from Pixel to World Coordinates

Conversion from World to Pixel Coordinates

Interpolation / Derivatives

Use of this coordinate frame in an intensity based registration framework requires the ability to interpolate image values at non-integer pixel positions, and to compute image derivatives relative to world space.

Interpolation is performed in the image space, which maps to a sector in physical space.

\[
X = \{i,j,k\}: \text{pixel coordinates} \\
X_w: \text{world coordinates} \\
D: \text{matrix of direction cosines}
\]

A typical case. Little movement has occurred at this point.

Here there is a difference between the two results, caused by distortion due to movement during the scan.

Cases/Results:

Case P1S2

A typical case. Little movement has occurred at this point.

Here there is a difference between the two results, caused by distortion due to movement during the scan.

Case P2S2

Relatively large rotation and shift. Rotations are subtle to detect due to roughly spherical shape of prostate.

Evaluation and Discussion

Image sequences were captured from healthy volunteers. The prostate position was tracked using sequential registration. The direct use of a non-rectilinear image was compared to results obtained with a typical reconstruct and register approach.

Case P1S2

115 0.277 0.143 0.237 0.827 0.483 0.560

Mean registration time and positional difference between methods.

These results show that registration using cylindrical coordinates compares favorably with the use of a rectilinear image. While registration with the cylindrical image is slightly slower, there is a considerable overall time saving by avoiding reconstruction.