Purpose: For 3D transrectal ultrasound (TRUS) guided prostate biopsy, we evaluate the utility of image-similarity metrics for comparing real-time 2D-TRUS video frames to pre-acquired 3D-TRUS images in order to detect misalignment due to prostate motion and deformation.

Methods: The experiments were conducted on retrospective data of 3D TRUS images from 3 subjects at the start of the biopsy procedure using a mechanically assisted 3D TRUS-guided biopsy system. For each subject, 2D TRUS images were acquired immediately prior to biopsy needle insertion. In this work, simulation and real human studies were performed to explore the utility of two image similarity metrics (normalized cross correlation and mutual information) for the detection of prostate motion during the biopsy procedure. Rigid prostate motion was simulated by translating the 3D volume in the direction orthogonal to the ground truth image, and by rotating the 3D volume around the long axis of the TRUS probe. We calculated similarity metrics for each of these simulated motion images and its corresponding ground truth image. In the human study, we performed preliminary testing of a 2D-to-3D rigid intensity-based registration method and measured its error by calculating its target registration error (TRE), based on identified anatomically homologous intrinsic fiducial pairs.

Results: The registration gave an overall TRE of 2.1 mm, and both the mutual information and normalized cross correlation metrics have a convex shape near the optimal plane.

Conclusions: The convex metric profiles encourage the use of intensity-based registration to compensate for motion and deformation of the prostate during TRUS-guided biopsy. The gradient of the mutual information curves are generally higher, making this metric more sensitive to the detection of small misalignments. The normalized cross correlation has a higher capture range, making it more suitable to be used in an image registration where the initialization may be less than ideal.