AbstractID: 2506 Title: Dynamic Intraoperative Prostate Brachytherapy Using 3D TRUS Guidance with Robotic Assistance

Purpose: Develop a dynamic intraoperative prostate brachytherapy system, in which all phases of the procedure are performed in one session, including planning, monitoring of prostate changes, dynamic re-planning, optimal needle insertion including oblique trajectories and automatic seed localization in US images, to deal with variabilities in the current procedure.

Method: The system consists of 3D TRUS imaging, a robot and software tools for prostate segmentation, intraoperative planning, oblique needle segmentation and tracking, seed segmentation, and 3D dose planning. The robot and 3D TRUS coordinate systems are unified with robot and image calibrations. In 3D TRUS images, the prostate is segmented using discrete dynamic contour method, and optimal implantation plan is performed by applying geometric optimization followed by simulated annealing. The robot can be controlled to guide the needle to target points in 3D TRUS images along oblique trajectories accurately and consistently. The inserted needles are segmented and tracked using grey-level change, and seed segmentation is performed using 3D line segment patterns.

Results: Needle placement accuracy of the robot at “patient” skin was 0.15mm±0.06mm, and needle angulation error was 0.07°. Needle targeting accuracy was 0.79mm±0.32mm. The average difference between manual and the prostate segmentation algorithm of prostate boundaries was -0.20±0.28mm. In our needle tracking tests, errors in determining needle orientation were less than 2° in robot *yaw* and 0.7° in robot *pitch* orientations, for up to 20° needle insertion angles when the needle insertion distance was greater than 15mm. The true-positive rates for the seed segmentation algorithm in 3D TRUS images were 100% for agar and 93% for chicken phantoms. With optimal planning tools provided, 98% of prostate volume receives 80% of dose coverage.

Conclusions: The result of this work provides a tool to achieve dynamic intraoperative prostate brachytherapy using 3D TRUS imaging and robotic assistance together with efficient segmentation software.