## AbstractID: 12727 Title: Real-Time Soft-Tissue Imaging Concurrent with External Beam Radiation Therapy Delivery

Purpose: The challenge of real-time visualization, localization, and tracking of organ motion and deformation concurrently with external beam radiation therapy (EBRT) delivery remains unmet and unattainable by existing image guidance technologies. We propose to address this challenge in the development of a novel, minimally interfering, robotic ultrasound image guidance system that can be integrated with existing medical linear accelerators. Method and Materials: The span of ultrasound transducer motion required for trans-abdominal prostate imaging was quantified via optical tracking of a probe during free-hand acquisitions. This information was incorporated into the design of a customized human-safe robotic manipulator to remotely control the transducer position and pressure while avoiding LINAC gantry collisions. The effect of accelerator-induced electromagnetic interference on the robot was investigated. In addition, a treatment plan with beam directions restricted to sectors that do not interfere with the ultrasound transducer was evaluated. Results: Prostate image integrity was sensitive to probe pitch, thus the manipulator was designed to actively control abdominal pressure (0-10N) and transducer pitch (-40°-90°). Probe placement in other directions remains adjustable to accommodate anatomy variations. Human-safety requirements translated into the design via a torque limiting friction clutch, lightweight backdriveable links, and remote center of motion pitch mechanism. Collision avoidance was confirmed by rotating the gantry 360° around the robot mounted on the LINAC couch in a typical treatment setup. The control system of the robot behaved similarly with the LINAC beam off and on, with mean servo cycle intervals of 1000.03µs and 1000.06µs, respectively. For a representative prostate setup, remotely-controlled robotic ultrasound image acquisition was successfully demonstrated on a volunteer. Dose volume histogram (DVH) for an IMRT plan with restricted sectors remained virtually identical to a clinically employed DVH. Conclusion: Remotely-controlled robotic ultrasound imaging is feasible and may offer real-time intra-fractional soft-tissue guidance concurrent with EBRT delivery.