AbstractID: 14551 Title: Real-Time-Image Guidance in Radiation Therapy: Is There a Role for Ultrasound Imaging?

The curative potential of External Beam Radiation Therapy (EBRT) is critically dependent on having the ability to accurately aim radiation beams at intended targets while avoiding surrounding healthy tissues. Cone-beam computed tomography, planar x-ray imaging, radiographic or electromagnetic tracking of implanted fiducials, as well as operator-performed ultrasound are currently used for EBRT image guidance. However, these technologies are incapable of addressing the challenge of real-time volumetric (4D) visualization, localization, and tracking of soft-tissue motion and deformation concurrent with treatment beam delivery. Thus a significant opportunity exists for improving the therapeutic ratio and the safety of EBRT. We will present and discuss two solutions that can realize this opportunity through the integration of spatially localized, remotely controlled operator-free ultrasound imaging with radiation delivery systems.

The first approach relies on a custom designed compact ultrasound probe based on two-dimensional matrix array of capacitive micro-machined ultrasonic transducers integrated with radiofrequency electronics. For operator-free imaging, the probe is to be fixed to a subject by a belt with appropriate acoustical coupling. Dedicated beam forming methodology and image reconstruction is necessary to enable large volume data collection at a volume rate of 3 Hz or higher.

The second approach employs a novel, minimally interfering, tele-robotic ultrasound imaging based on commercial transducers. It uses a customized human-safe robotic manipulator to control the pressure and pitch of an abdominal probe while avoiding gantry collisions. A haptic device is integrated to remotely control the robotic manipulator motion and image acquisition outside the therapy room.

Learning objectives:

1. Understand basic relationships between ultrasound imaging system design and performance parameters such as spatial resolution, frame rate, and field of view. Recognize the dependencies between these parameters.
2. Identify limitations of current EBRT ultrasound guidance systems and identify physics, design and workflow causes behind them.
3. Understand how remote-operator free imaging and appropriately designed workflow can enable real-time soft-tissue image guidance concurrent with radiation delivery and reduce ultrasound localization uncertainties.
4. Recognize potential interferences between the radiation delivery system and the operator-free imaging system and appreciate their magnitude and mutual impact.