**Ultrasound-Guided Robotic Needle Steering for Percutaneous Interventions in the Liver**

**Room:** Building 320, Room 105 (Main Quad)

**Date:** Tuesday, November 3, 2015

**Time:** 1:00 pm

**Abstract:**

Liver cancer is a significant health concern worldwide. Percutaneous ablation of liver tumors is a common treatment that suffers from significant limitations, primarily the inability to treat larger tumors and tumors in certain regions of the liver. Robotic needle steering is a technique for inserting flexible needles along controlled, curved paths through tissue. Applying robotic needle steering in percutaneous ablation of liver tumors could potentially allow clinicians to correct for errors during insertion, steer around obstacles to previously unreachable targets, and reach multiple targets from a single insertion site. To date, however, robotic needle steering has largely been limited to artificial tissues and tightly controlled bench-top settings.

The goal of this dissertation was to move robotic needle steering closer to the clinical domain, by solving several technical problems specific to percutaneous ablation of liver tumors. Clinical application of robotic needle steering necessitates real-time medical imaging methods, steerable needles that can curve tightly and reach the majority of the liver volume, and a control approach that allows the clinician to define targets and provide feedback using medical imaging. First, a method for automatically segmenting a steerable needle from 3D ultrasound data is proposed, which uses mechanical vibration of the steerable needle to make it visible in power Doppler images. Second, finite-element and experimental studies of steerable needle insertion are described, and demonstrate that average radius of curvature of approximately 50 mm can be achieved in liver tissue through optimization of bent-tip geometry. An articulated-tip design, which uses a miniaturized rotary joint to articulate a distal section is also presented. Third, to allow closed-loop control of a needle steering robot using ultrasound measurements, an estimation scheme based on an unscented Kalman filter is proposed. Finally, a complete pre-clinical system for image-guided needle steering is presented, which combines the described methods for imaging, needle design and control. Validation testing in a porcine cadaver is described, in which simulated targets are introduced into the liver, and the system is used to place the steerable needle tip at the target.