MRI-Compatible Pneumatically Actuated Robot:

Challenges:
- Long pneumatic transmission lines up to 10 m are unavoidable because of MRI-compatibility issues of valves, resulting in:
  - Introduction of time delay;
  - Slow pressure dynamics from valve to the cylinder pressure.

Steerable Needles:
- In diagnostic and therapeutic procedures such as biopsy and radiofrequency-ablation, needle bending occurs due to needle and soft-tissue interaction, which can result in errors in targeting and hence lead to sampling errors and poor treatment outcomes.
- SMAs (Shape Memory Alloy) are attractive for applications, where large forces or displacements are required and limited space is available.
- SMA wires are employed to control bending angles to account for bending errors and for steering inside soft-tissue.
- SMA wires are trained to bend upon thermal actuation. SMA wires are heated via resistive (joule) heating.
- PWM controller with stereo image feedback is used for controlling the amount of bending at each joint.

MRI-Compatible Pneumatically Actuated Robot:

Challenges:
- Long pneumatic transmission lines up to 10 m are unavoidable because of MRI-compatibility issues of valves, resulting in:
  - Introduction of time delay;
  - Slow pressure dynamics from valve to the cylinder pressure.
- Friction along the motion range of the device is highly non-uniform.
- Sliding mode control (SMC):
  - Non-uniform friction is treated as uncertainty by sat( )
  - The sliding surface, $s$, determines the performance.
  - Good estimation of maximum friction is needed.
- Force sensor:
  - Optical approach is inherently MRI-compatible as signals are transmitted in the form of light and electrical wires are eliminated.
  - A force will cause a deformation in the elastic frame structure, resulting in a displacement in the reflector.
  - By monitoring the reflected light intensity, the force acting on the loading point can be computed.
  - A topology optimization technique is also used to provide a systematic algorithm aiding engineers in designing the elastic frame structures that are needed.
- Satisfactory performance of the system is obtained.

AFM-Based Breast Tissue Characterization:
- AFM allows quantification of cell and tissue mechanical properties at the micro-scale.
- Epithelial and Stromal sections in cancerous breast tissue histology specimens studied.
- We have observed decrease in stiffness in cancerous specimens compared to normal tissue.
- Automated Image-guided Tissue Characterization:
  - AFM based characterization is slow and low in throughput.
  - AFM tip occludes location of sampling, hence image-guided specimen placement will improve throughput and accuracy of results.

This work was supported in part by NIH grant R01EB008713, NIH grant R01EB006615, NIH grant R21EB008796, NSF grant CCF0704138, NSF grant CMMI0826158, and STMD-Maryland Technology Development Corporation grant 08071517.