

A Testbed for Multi-lumen Steerable Needle Experiments

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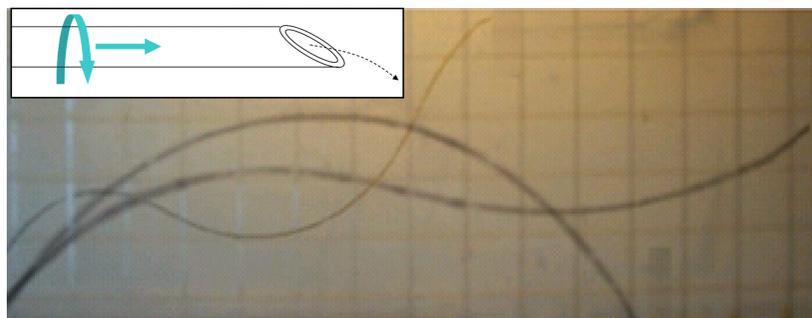
Introduction

- Steerable needles offer the potential to “turn corners” within the body during insertion
- Avoid obstacles, reduce placement error, enable less-invasive access to challenging locations
- We have developed an experimental testbed to for two popular steering mechanisms

Two Steering Modalities

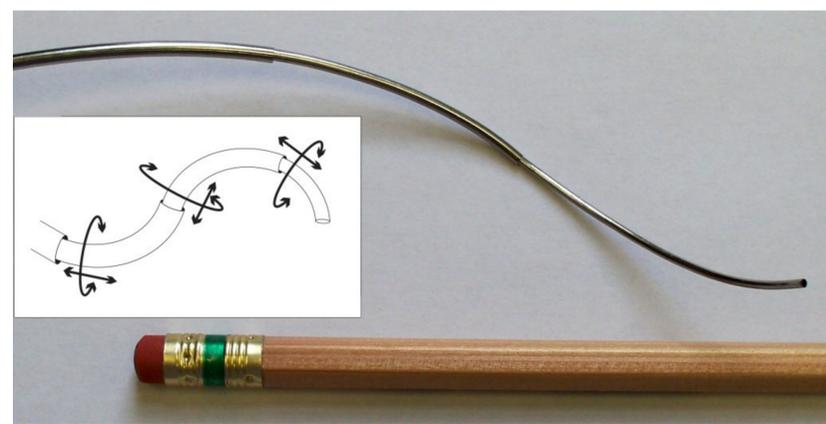
Bevel Steered Needles

- Flexible needle with an asymmetric (bevel) tip
- Tip-tissue interaction forces cause the needle to travel in a curved path through the tissue
- Axial rotation at the needle base changes the plane of the needle curve



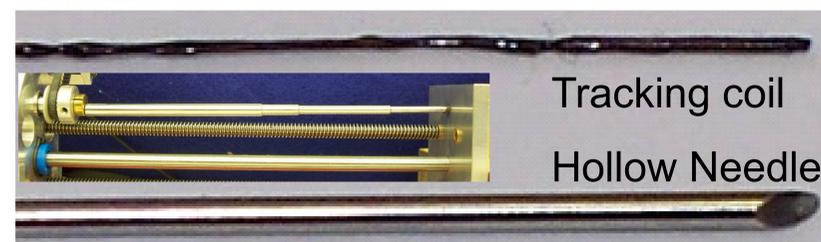
Active Cannula Robots

- Multiple tubes: pre-curved, arranged concentrically
- Actuated by axial translation and rotation of the base of each component tube
- Shape control for in tissue or free space



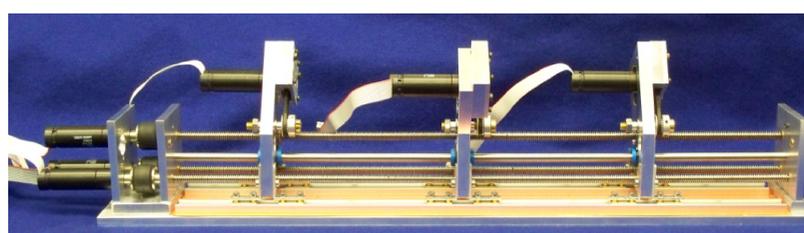
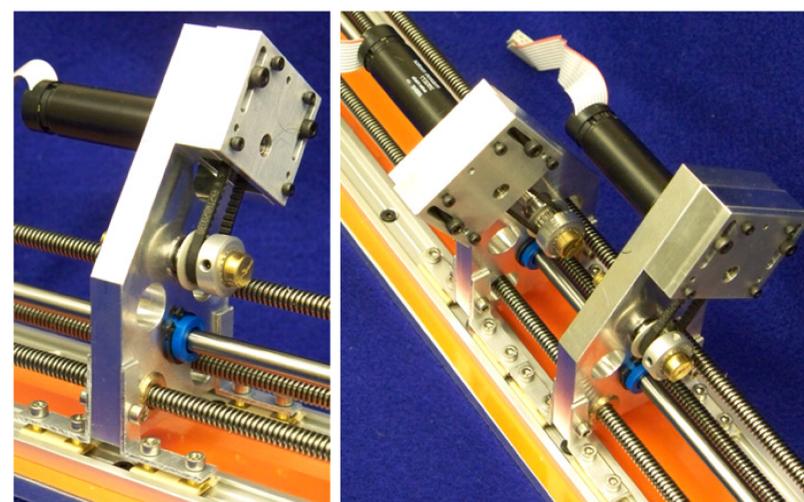
Magnetic Position Tracking

- The needle is a tube of superelastic Nitinol alloy
- A magnetic tracking coil (Aurora 5 DOF sensor, NDI, Canada) is fixed inside the tip of the needle
- For bevel-steering, a bevel is ground at the tip
- Buckling prevented outside tissue by a telescoping sheath



Robotic Actuation Platform

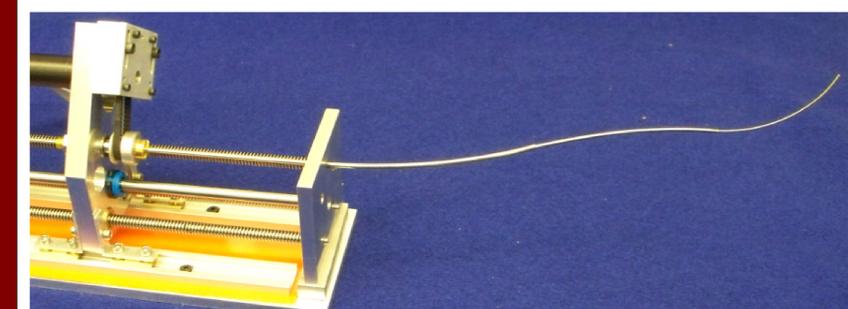
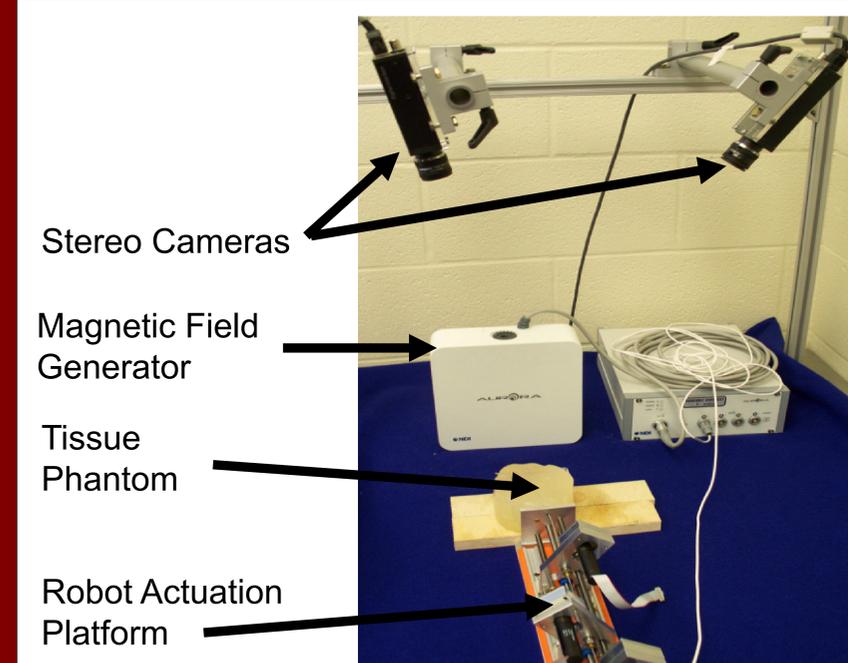
- Useful for Bevel Steering and Active Cannula control
- Modular design: tubes can be added easily
- Each module can rotate and translate the base of one component tube.
- Compact design: The grip points of the tube bases can come close to each other.



Stereo Imaging and Visual Tracking

- Cameras (Sony XCDX710) are mounted on an adjustable frame
- Image processing gives the 3D location of the entire needle or cannula shaft

System Integration



- Tubes extend out of the front plate of the device

Future Work

- Validation of a trajectory following controller for bevel tip needle steering
- Validation of Jacobian-based control in free-space for Active Cannulas
- Combinations of Active Cannula actuation and bevel tip steering