Embedded Strain Gage Force Sensor
For Robotic Surgery

Christopher R. Wagner  Robert D. Howe
Harvard University, Cambridge, MA, USA
E-mail: cwagner@fas.harvard.edu

Sensor Characterization:

- Force feedback can decrease applied force magnitudes and errors in robotic surgery [1]
- Commercial robotic surgical systems lack force feedback
  - Masters have actuators
  - Instrument tip force sensing is missing [2]
- Force sensor must accurately sense grip and interaction forces between instrument and tissue

Where can we put the force sensor on a surgical robot?

- Port forces don’t interfere
- Transmission forces don’t interfere
- Can sense interaction forces as well as grasp forces
- Must fit through port

Sensor Design and Construction:

- Use six silicon strain gages for high force resolution and sensitivity in 3 axes
- Embed strain gages in a pourable epoxy (Resin 105 Fast Cure, West System) to avoid complicated bonding procedure
- Single pour construction process easily adapted for mass production – Disposable force sensors
- Benefits of design
  - All wires exit at same spot with intrinsic strain relief
  - Two sensors can fit through 12 mm port

Sensor Characterization:

- Calibration result for X axis force
- Calibration result for Z axis force
- Noise magnitude over 2 seconds, with sensor in an enclosed chamber, RMS noise less than A/D resolution

Future Work:

- Reduce temperature effects
- Analyze effects of moments
- Embed metal grasping surface (for needle gripping)
- Reduce sensor size for 10 mm port

References: