Force Sensing Forceps

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Overview

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- Problem Statement
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- Design Option 3 – Strain Gages
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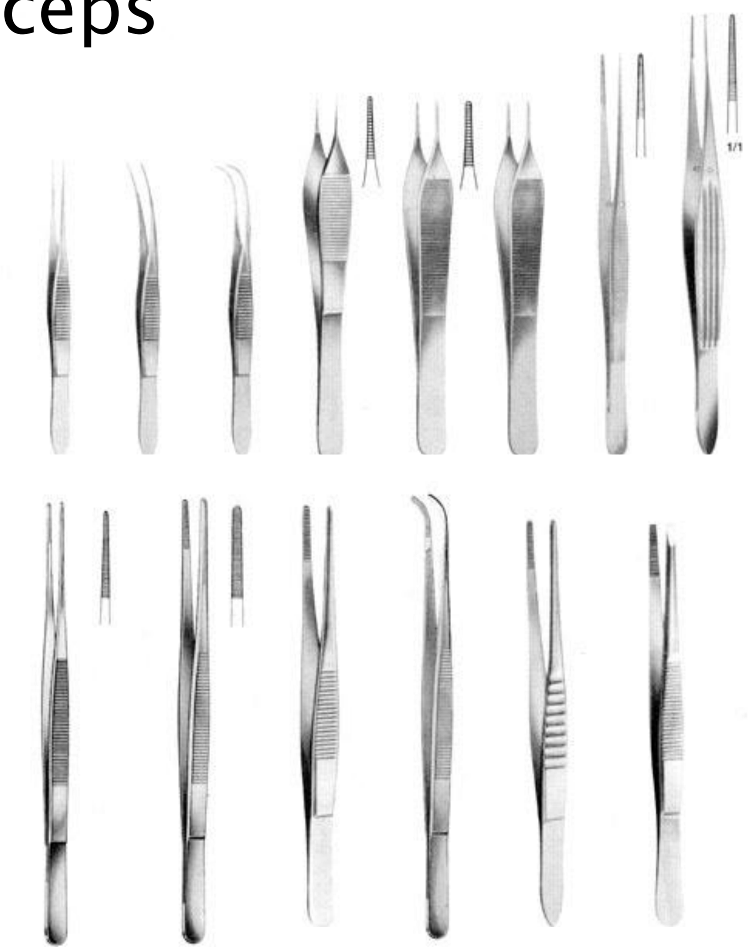
Background/Motivation

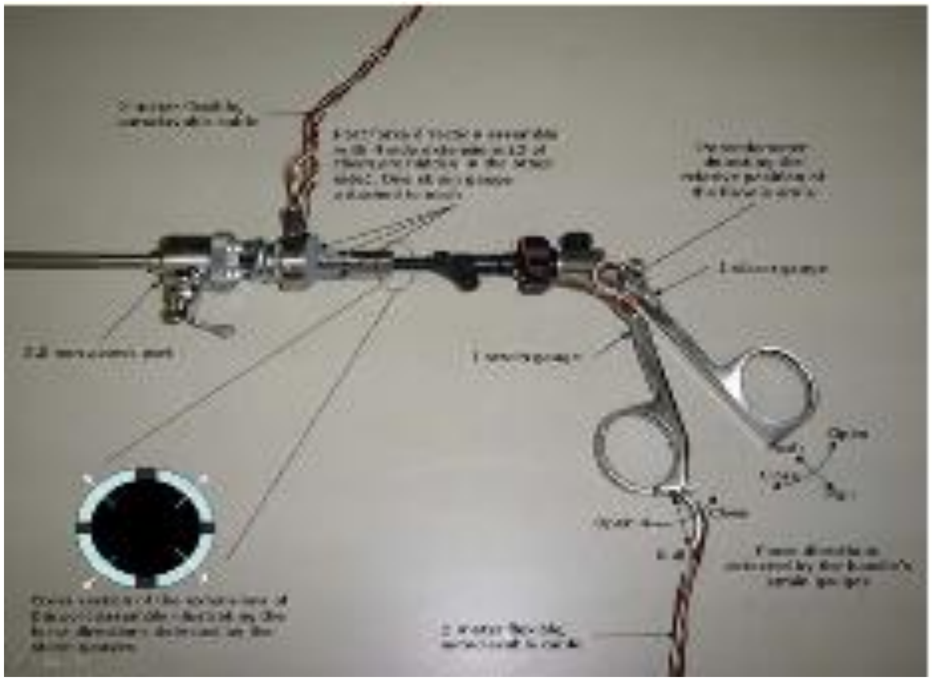
- Develop ‘force sensing forceps’
- *Nothing*, quantitatively, known about forces applied to tissues
- Currently based on “trial and error”
- Used as a training tool
- Visual or auditory cue



Current Devices

- Similarities
  - Developed force sensing surgical instrument
  - Used piezo materials
- Differences
  - Not specific to forceps
  - Focused on degradation of medical alloys

Current Devices Continued



Similarities

- Developed force sensing surgical instrument
- Used strain gages
- Design considerations

- Differences
  - Specific to laparoscopy
  - Different type of forceps

Problem Statement

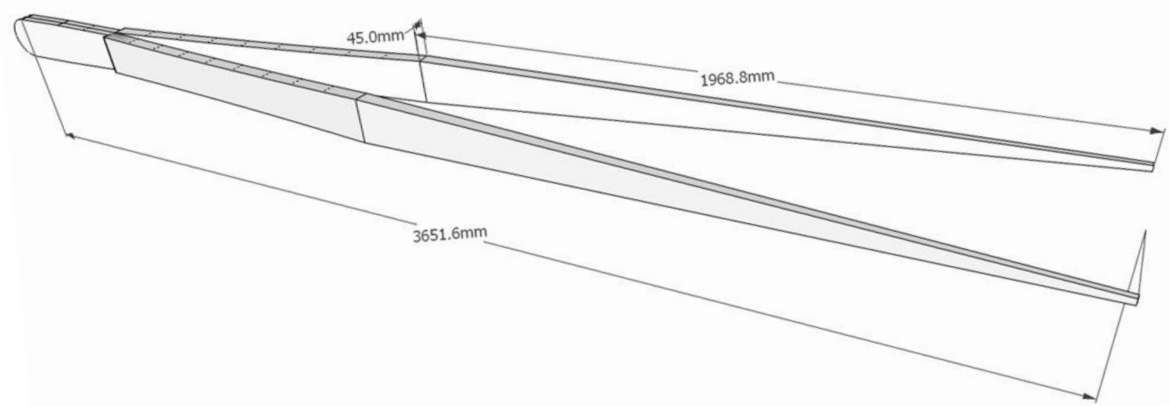
- Training and research device
- Interface with standard surgical forceps
- Measure forces
- Provide quantitative output
- Avoid hindrance to normal use of forceps

Client Specifications

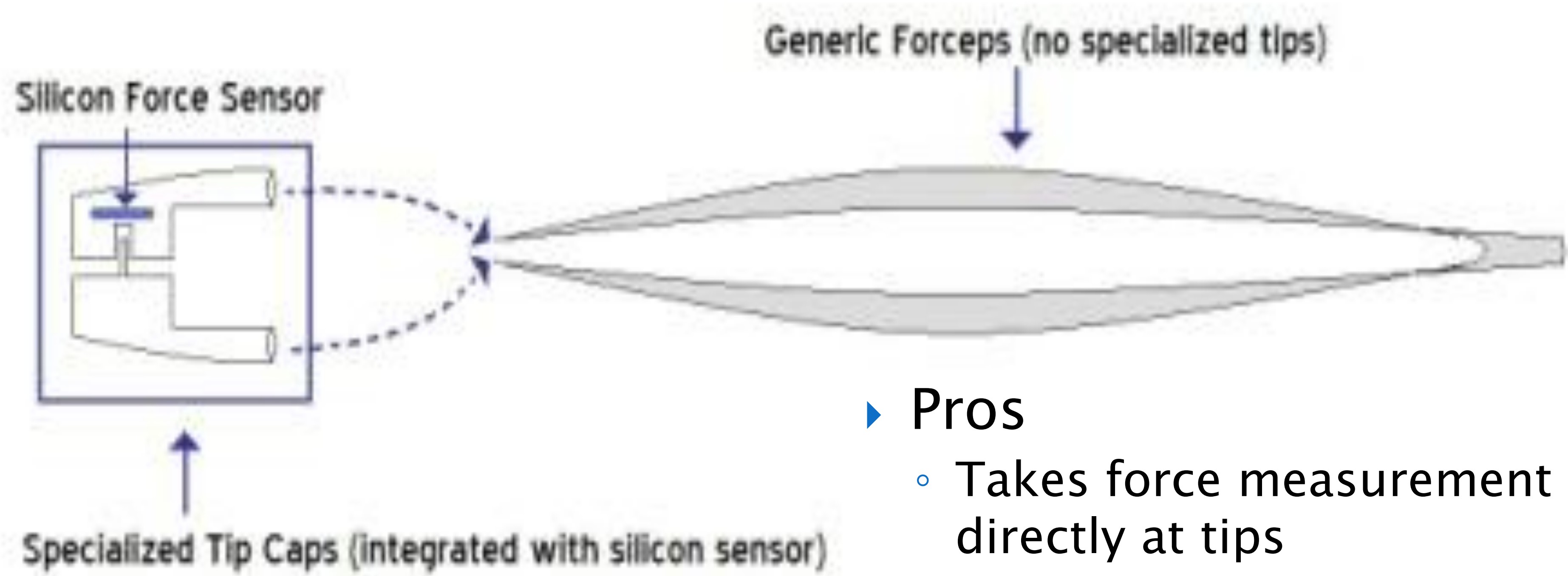
- Requirements:
  - Production of 1 initial working prototype
  - Allow for normal use of surgical forceps
    - Holding technique
    - Lightweight
    - Standard size forceps
  - Sanitation
  - Quantitative forces measurement
    - Convenient output
    - Calibration
  - Bio Safe

Client Specifications Cont.

- Preferences
  - Prevention of excessive force
  - Aesthetically pleasing
  - Wireless
  - Digital display
  - Axial and torsional measurements



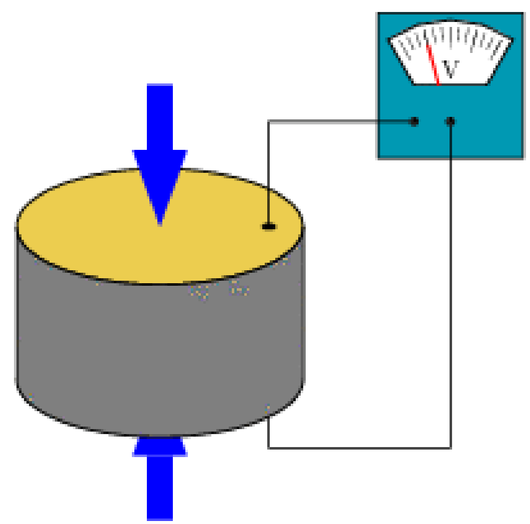
Design Option1 – Silicon Macro Force Sensor Caps



- Pros
  - Takes force measurement directly at tips
- Cons
  - Difficult to manufacture
  - Requires many cap types
  - Temperature sensitive

Design Option 2– Piezoelectric Sensors

• Uses the charge retaining properties in certain solid materials
• Measurable *piezoelectricity* is released upon deformation



Design Option 2, cont.

Pros

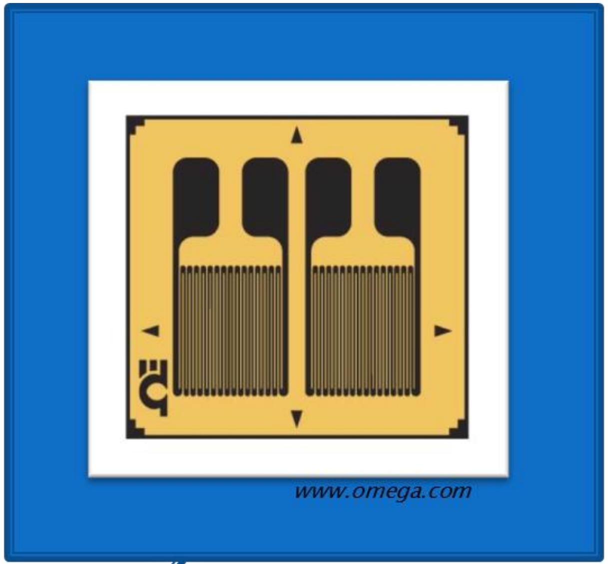
- Can be effective when space is limited; strain gage transducer can be up to 30 times larger
- Two wires connecting sensor

Cons

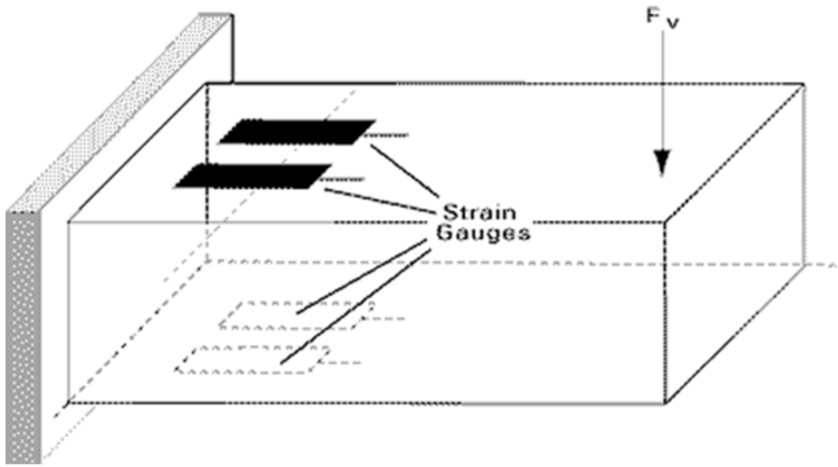
- Considerable drift is present, making them more short-term
- Doesn’t compensate for temperature effectively

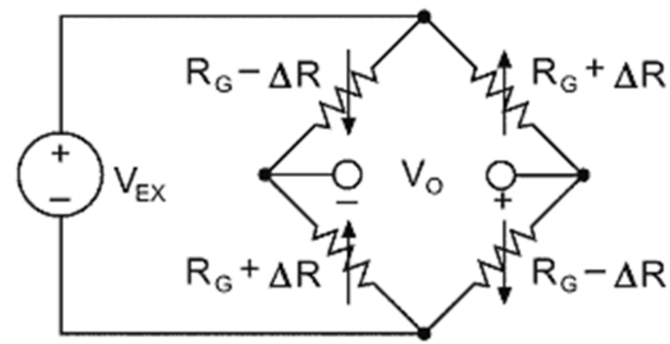
Design Option 3 – Strain Gages

- Converts mechanical motion into electronic signal
- Uses metallic foil organized into grid like pattern
- Depends on proportional variance of electrical resistance to strain
- Full bridge configuration – uses a total of 4 strain gages



Design Option 3 Continued





Omega.com

- Pros:
  - Using 4 strain gages helps eliminate temperature effects
  - Choose range/accuracy easily
  - Easy to manufacture/low cost (5 strain gage dual grids for 49$)
  - Light-weight
- Cons:
  - 4 wires running down side of forceps
  - Need of calibration – dependent on the stability of the stainless steel
  - Will need assistance to mount strain gages onto forceps

Design Decision Matrix

	Weighting	Design Capped Ends silicon macro force sensor	Strain Gages	Piezo electric
Does not detract from function of standard surgical forceps	25	22	23	24
Range of force measuring capability	20	15	19	19
Does not obstruct proper forceps holding technique	10	10	10	10
Precision of measuring capability	20	15	18	16
Ease of manufacture	5	1	3	4
Measurement consistency with varying conditions	20	15	19	12
Total	100	78	92	84

Future Work

- Consult surgeons on typically applied loads
- Signal conditioning
- Build rough version of the forceps
- Test measurement accuracy under various conditions
  - Experiment with sensor location
- Develop calibration technique

Future Work

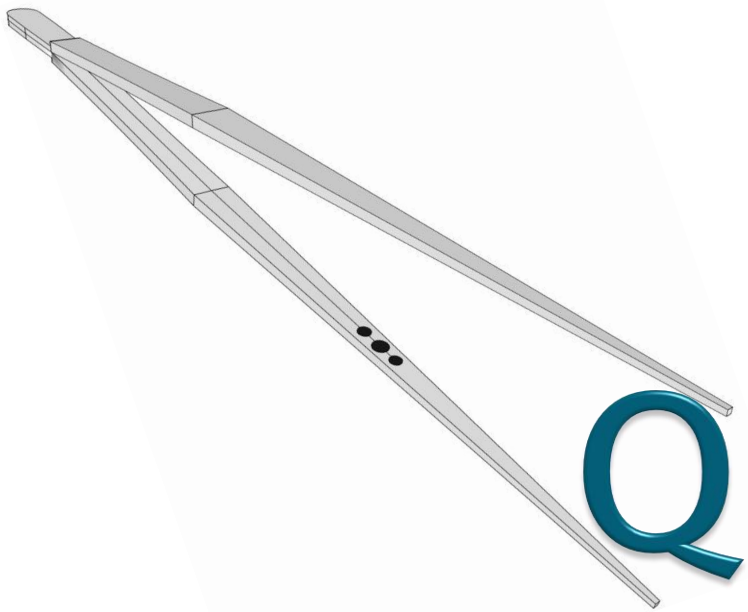
- Make forceps wireless
- Audio/visual feedback for surgeon
- Measurement of force in multiple dimensions
  - Requires more complicated sensor setup
  - Measure push/pulling force
  - Measure twisting force
- Compatibility with cauterization technique

Acknowledgements

- Dr. Michael Zinn
- Carter Smith
- Professor Webster
- John Dreger

References

- “Load Sensing Surgical Instruments”, Jacq, Maeder, Ryser”
- “Development of Force Measurement System for Clinical Use in Minimal Access Surgery,” Hanna, Drew, Arnold, Fakhm, Cuschieri”



Questions?