Force Sensing Forceps

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Abstract

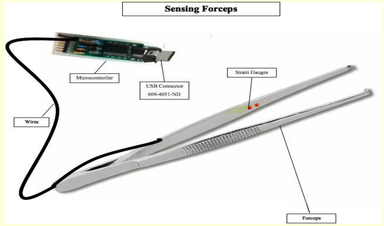
Body tissues have different thresholds of force that may be applied before damage begins to occur. In order to discover what these threshold values are, a specialized forceps needs to measure applied force and give real-time feedback to the user. We will continue development of such a specialized forceps and the associated monitoring system. The data (generated by attached strain gauges) received from the forceps will be brought into a computer program (which we will develop) via a microcontroller and will be processed into useable data. The data will then be output to a display. Our final design combined components of three alternative designs including a color based visual indicator, an auditory alert system and a real time numerical display. All these components are presented on a computer monitor. These three components maximize the feedback to the user without encumbering them.

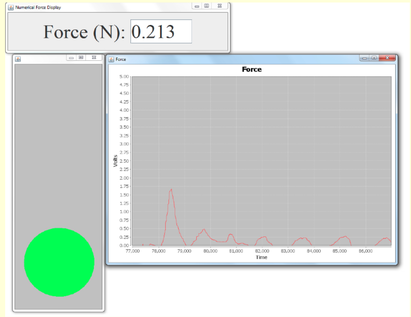
Motivation

- Develop “force sensing forceps”
- Nothing quantitatively known about forces applied to tissues
- Able to determine threshold values of force on certain tissues
- Used as a training tool

Final Design

- Strain Gages
  - Give voltage output
  - Full-bridge circuit configuration
  - EA-06-125PC-350
  - $55 a piece
- Signal sent to a computer
  - USB bridge amplifier
  - Formatted for bridge sensor readout
  - 5V supply
- Java programming converts voltage signal to force (N)
  - Force = 1.0248 Voltage output
  - Corrects for +3.5 V offset
  - Can sense a range of 0 –4N
  - Variable threshold values by user input
- Real time display
  - Continuous feedback via line graph
  - Instantaneous force value displayed
  - Threshold values conveyed via stop light interface
  - Auditory alert system for breached thresholds





Design Criteria

Problem Statement

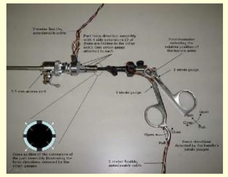
- Training and research device
- Interface with standard surgical forceps
- Measure forces
- Provide quantitative output
- Allow normal use of forceps

Design Criteria

- Maximum cost of $500
- Allow for normal use of surgical forceps holding technique
- Maximum weight of 500 g
- Functional with standard size forceps
- Able to be sanitized
- Provide quantitative and continuous force measurement
- Real time display and feedback
- Display must be easily viewable but not obstructive

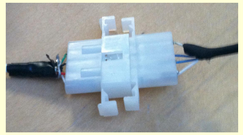
Current Technology

- Force sensing surgical instrument
- Focused on degradation of medical alloys
- Piezomaterials
- Not specific to forceps
- Specific to laparoscopy
- Different type of forceps



Parts List

- Standard forceps
- Wheatstone bridge strain gage set-up
- USB amplifying microcontroller
- Computer with Java interface
- 4-pin wire connectors

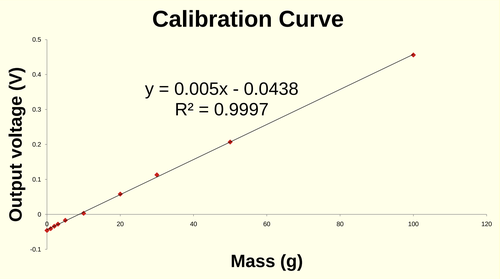


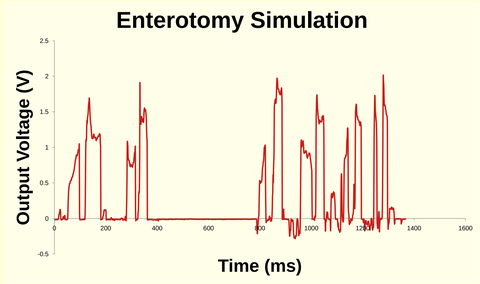
Budget

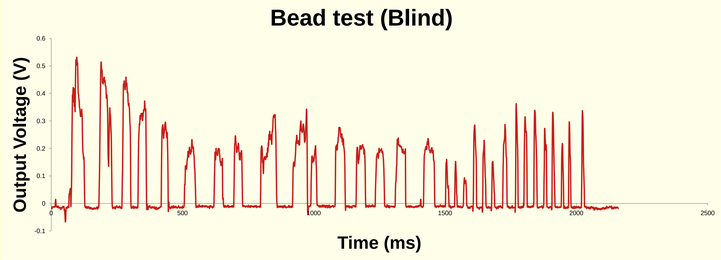
• Strain Gauge Attachment	$163.00
•4-pin connector	$ 7.56
•USB Microcontroller	$300.00
•Microcontroller Case	$ 3.00
•Total	**$473.56**

Testing

- Calibration
  - attached various weights to forceps
  - Found 1 Volt = 1.995 Newtons
  - Showed that the conversion factor is linear
- Constant Force
  - Had subject perform two tests--One with feedback and one without feedback
  - Discovered no significant improvement with feedback
- Pseudo-Surgery (Enterotomy)
  - Surgeons performed artificial colon procedure with and without feedback
  - Excessive force applied when no feedback was given
  - Shows possibility for surgeon improvement
- Bead Test
  - Surgeons moved and placed small cylindrical beads onto a pegged-board
  - Excessive force applied when no feedback was given
  - Shows possibility for surgeon improvement

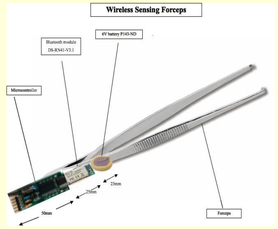






Future Work

- Aesthetically pleasing
  - Current design looks “rough”
- Wireless
  - Avoid hindering surgeon’s movements
  - Allow for greater range of movement
- Axial and torsional measurements
- Autoclave capable
- Freedom to calibrate for different types of forceps
- Include mechanism which prevents excessive force
- Digital display without requirement to have computer nearby



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