Haptics in Robotic Assisted Surgery

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BME 473 Course Project Presentation
Outline

- Need for minimally invasive surgeries
- Overview of robotic-assisted surgery
- Haptics
- Sensors
- Proposed project
Why Should You Care?

• Robotic Assisted Surgery can provide many benefits
  • Teleoperated
  • Corrections for Human Error
  • Smaller Incisions
  • This all leads to shorter hospital stays
What is Laparoscopic Surgery

• Named after the Laparoscope

• Also known as Minimally Invasive Surgery (MIS)

• First performed in 1987: cholecystectomy

• Performed through small incisions

• Abdomen inflated with CO2

• Trocars inserted to create portals for instruments

• Fulcrum Effect
Laparoscopy vs Open Surgery

**Laparoscopic**
- 3-5 half inch incisions
- less pain, less scarring
- faster discharge time
- reduced risk of infections
- fairly new

**Open**
- incisions 6-12 inches
- considerably longer hospital stay and larger degree of pain
- are considered the standard
History of Robotic Surgery

- The PUMA 560
  - 1st Robot used in surgery
- ROBODOC
  - 1st FDA approved robot
- Computer Motion Develops AESOP and ZEUS
  - Bought out by Intuitive Surgical
- Intuitive creates da Vinci, ZEUS off market
da Vinci Surgical System

- Approved by FDA in 2000
- 3 Main Components
  - Surgeon’s Console
  - Patient Cart
  - Vision System
- 200,000 surgeries performed in 2012
Benefits of Robot Assisted Surgery

• Vision (vs Laparoscopic)
• Dexterity
• Tremor Reduction
• Movement Scaling
• Fatigue Reduction
Main Issues with Robotic Surgery

• Palpation
  • Surface Characteristics
  • Pulse Readings
• Knot Tying
Background on Haptics

- “sensing by touch”
- CHARM Lab: Dr. Allison Okamura
  - Teleoperations
  - Surgery and Training
Previous Research in Haptics

• Methods for haptic feedback in teleoperated robot-assisted surgery
  • Dr. Okamura
  • Strain Gauges
  • Kinematics
  • Visuals

• Haptic Feedback in Robot-Assisted Minimally Invasive Surgery
  • Dr. Okamura
  • Mostly Force Feedback
  • Mahvash et al. Palpation
  • Reiley et al. Knot Tying
Previous Methods Cont.

- Palpation Probe
- SynTouch Biotac
Sensors

**Tactile Sensors**
- Respond to contact forces
- Localized Interaction
- Array of touch sensors
- Slip sensing - relative movement
- Higher hardware demand

**Force/Torque Sensors**
- Measure total forces
- Force feedback to hand
- Integration in dextrous instruments
- Not all DOF accounted for
- Delays and feedback
Goals in Haptics

- Imitate the human tactile response
- Real-time feedback to surgeon
- Surface and pulse detection
- Varied responses
- Frequency responses
A Novel Probe

- Piezoelectric effect
  - Quartz or transition metal ceramics
- Soft sensor probe
- Vulcanized silicone rubber “skin”
- Dilatant fluid
  - Silicon suspended in PEG
- Multiple piezoelectric pressure transducers
Why and How it Helps

- Piezoelectrics are small
- Self-exciting sensor
- Chemically inert and flexible
- Extremely high accuracy
- Low hysteresis
- High repeatability
- Give feedback to operator
Benefits/Projected Outcome

- Real time fast response
- Sensitivity
- Wide dynamic signal range
- Allow Surgeon to Palpate the tissue through the Robot
  - Geometry
  - Pulse
  - Surface (rough, smooth, etc.)
- Knot Tying
  - Feel tightening of knot and feel if the tissue is being deformed
Wrapping it up..

• What is RAS and why should we care?
• How does RAS improve Laparoscopic procedures?
• What is the field of haptics?
• Previous Research in haptics
• Our proposed idea to integrate haptics into RAS
References

- http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2701448/
- http://X2bQ18x2ZEFt41AUAshm1aQAAa7p/Ka1nt5t4XK//1x00/human-hand-cyber-hand.jpg
- http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1317565/
- http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2701448/