Constrained Control for Surgical Assistant Robots

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Presentation Outline

- Summary
  - Project Overview
  - Paper Selection
- Problem
- Experimental Methods
- Results
- Analysis & Conclusions
Overview

• Cochlear Implant: medical device used to restore hearing
  • External: Microphone, Speech Processor, Transmitter
  • Internal: Receiver/stimulator, Electrode Array

• Problem
  • Difficulty of inserting electrode array manually

• Project goals
  • Image the cochlea using 2 different types of OCT Imaging
    • Bulk Scan
    • Side-view Probe
  • Create Models from OCT images
  • Create Virtual Fixtures for use in inserting electrode array
Paper Selection

- Virtual Fixtures
  - Increase safety and precision of procedure
  - Filter out hand tremor
  - Keep surgical instruments in pre-defined safe zones

- Creating VFs for cochlear implant insertion is a main goal of our project
Goals of Paper

• Task Primitives
  • Stay on a point
  • Maintain a direction
  • Move along a line
  • Rotate around a line
  • Stay above a plane

• Hard and Soft Constraints
  • Preferred regions
  • Safety regions
  • Forbidden regions

Image credit: Kapoor et al.
Problem

• Virtual Fixtures are useless without algorithms to implement them

• Paper provides customizable implementation algorithm
Experimental Methods

- JHU Steady-Hand Robot
- Prescribed Motion: Sinusoidal Curve

Image credit: Kapoor et al.
Results

- Algorithm models VFIs using least squares problem
- Solving least squares problems with linear constraints more efficient than solving nonlinearly constrained problems
- Higher accuracy with nonlinear constraints

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Image credit: Kapoor et al.
Results

• “Soft” Virtual Fixtures
  • Provide resistance, do not halt movement
  • Useful in Safety Regions

• “Hard” Virtual Fixtures
  • Completely stop movement
  • Useful in Forbidden Regions
Results

Soft Constraint

Hard Constraint

(a)  

(b)

Image credit: Kapoor et al.
Analysis & Conclusion

• Relevance
  • Framework for creating complex virtual fixtures
    • Broken in to Task Primitives
    • Can be used for inserting cochlear implant along cochlear axis
  • Uses of Soft and Hard Constraints
    • Preferred region: axis of cochlea
    • Safety region: close to edges of cochlea
    • Forbidden region: touching or nearly touching edges of cochlea

• Future Work
  • Experiment on other robots
  • Form changing tools
Questions?