Robotically Assisted Cochlear Imaging

Xingchi He, Saumya Gurbani, Alperen Degirmenci

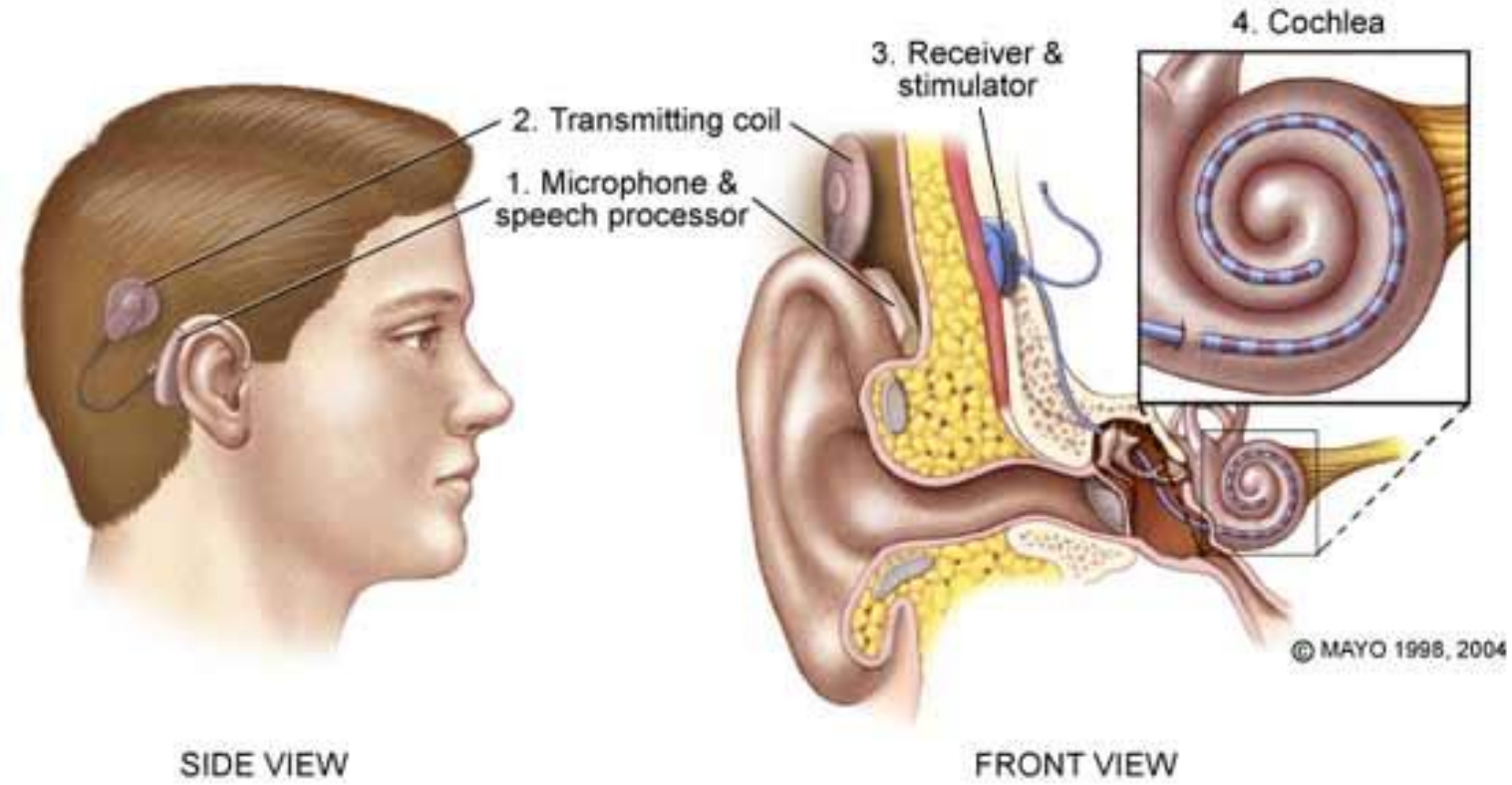
Mentors: Dr. Taylor, Dr. Iordachita
Clinical Advisor: Dr. Chien

JOHNS HOPKINS
UNIVERSITY

Outline

- Background & Motivation
- Project Goal
- Technical Approach
- Deliverables
- Timeline
- Dependencies
- Reserposibilities
- Management Plan
- Reading List

Background & Motivation

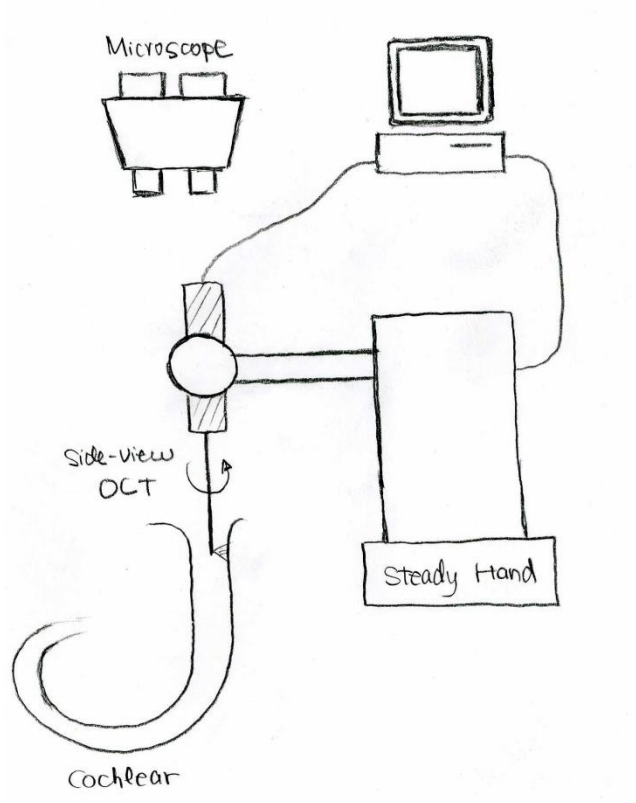


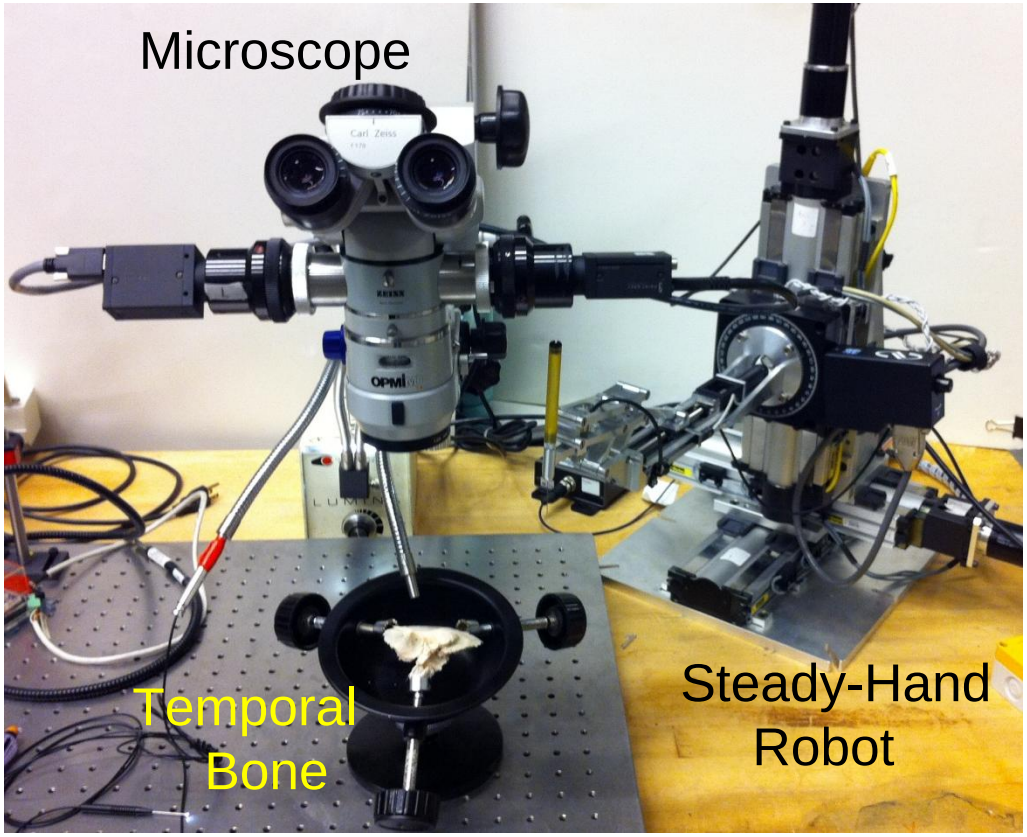
Project Goal

- The goal of this project is to develop a safe procedure to guide the electrode insertion in cochlear implantation by integrating the OCT imaging with the steady-hand robot.

- Components of this project:
  - A hardware adapter which allows an OCT probe (or multiple probes) to attach to the steady-hand robot
  - (A hardware adapter which holds the electrode of the implant for insertion)
  - A software component which will allow the probe to interface with current software.

Technical Approach





Side-view OCT

- Side-view OCT probe

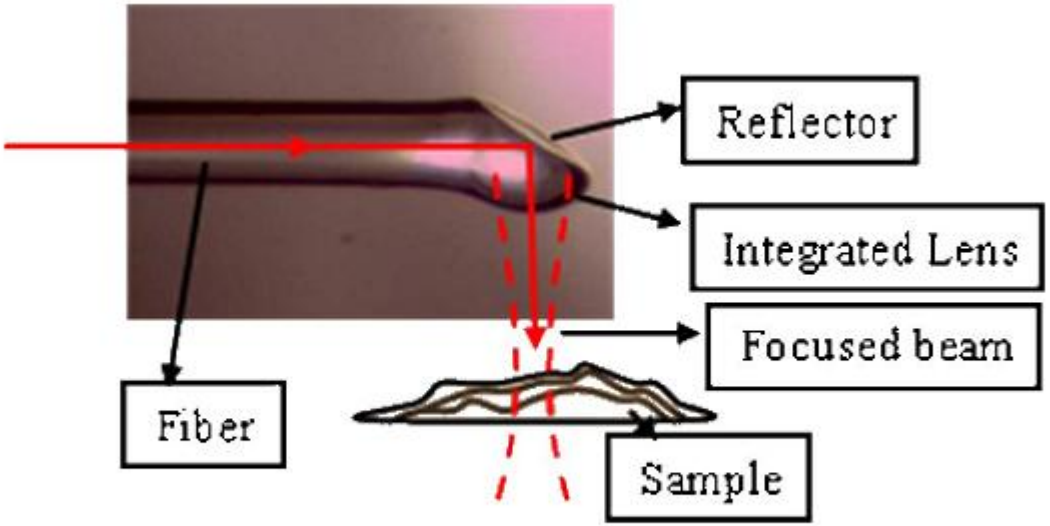
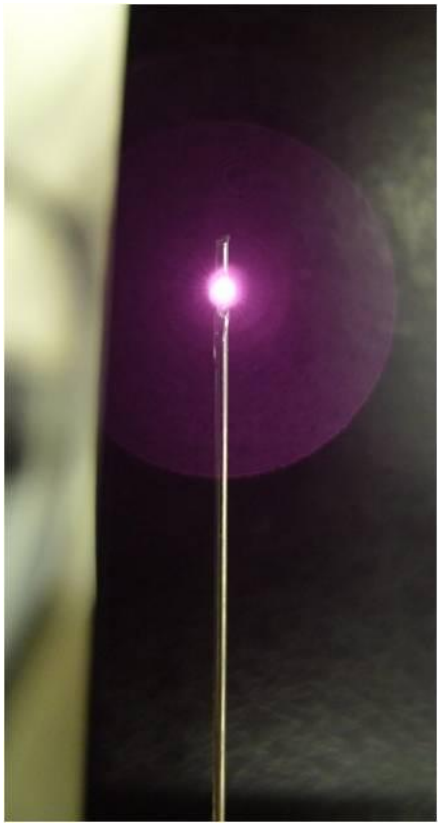


Fig. 5. Photograph of a side viewing fiber probe with integrated lens.

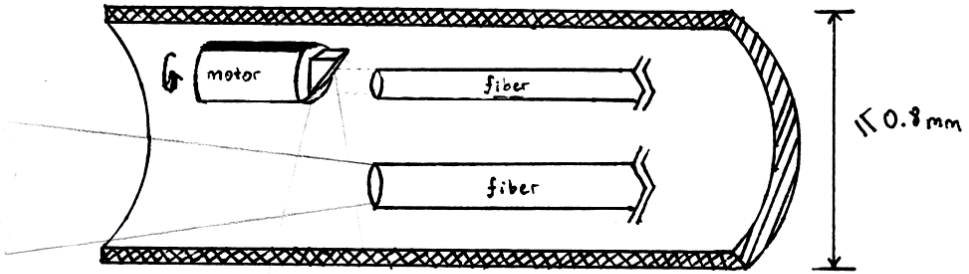
J. Kang



J. Kang

Front View OCT

- One of our goals is to create a front-view OCT probe
- Combined with the side view, this can allow for a complete 3D picture of the cochlea



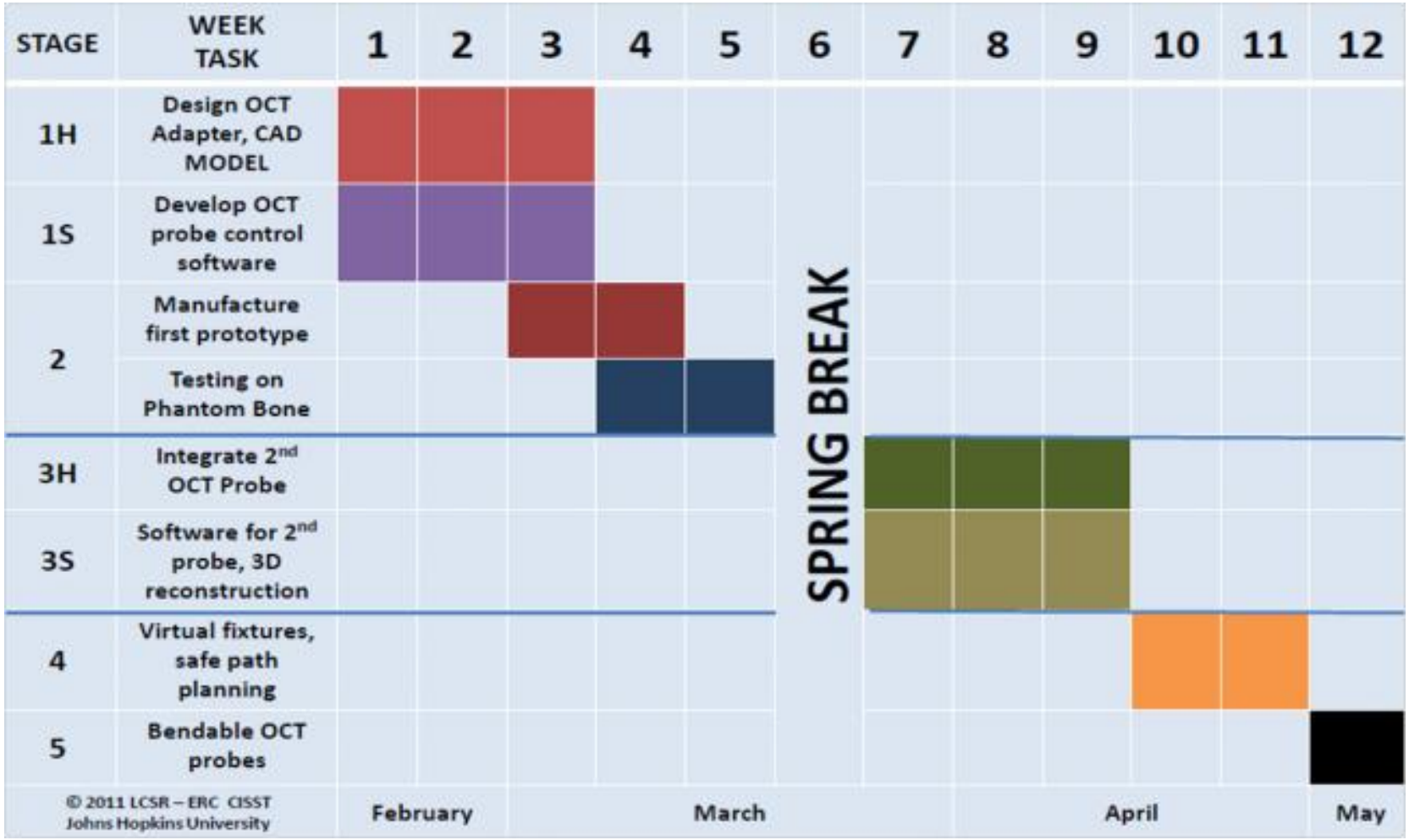
Deliverables 1

- Minimal
  - Develop a (rotationally-free) adaptor for OCT probe to be attached to the steady-hand robot
  - Develop a mechanism for the rotation (+/-180˚) of the OCT probe inside the cochlear canal (if needed)
  - Develop software to control the rotation of OCT probe inside the cochlear canal
- Expected
  - Integrate a second imaging fiber into the OCT probe, directed forward, to increase maneuverability and the field-of-view
  - 3D reconstruction of the cochlear canal using the software available (if needed)

Deliverables 2

- Maximal
  - Develop a hardware adapter which holds the electrode of the implant for insertion
  - Design a bendable OCT probe
  - Generate virtual fixture from the 3D reconstruction of the cochlear canal
  - Suggest safe insertion paths to the surgeon
  - Provide proximity-scaled force-feedback to the surgeon

Timeline


STAGE
WEEK TASK
1
2
3
4
5
6
7
8
9
10
11
12
1H
Design OCT Adapter, CAD MODEL
1S
Develop OCT probe control software
2
Manufacture first prototype
Testing on Phantom Bone
SPRING BREAK
3H
Integrate 2nd OCT Probe
3S
Software for 2nd probe, 3D reconstruction
4
Virtual fixtures, safe path planning
5
Bendable OCT probes
© 2011 LCSR – ERC CISST Johns Hopkins University
February
March
April
May

Dependencies

1. OCT system and software (Dr. Kang)
2. Access to phantom bones and clinical advice (Dr. Chien, clinical advisor)
3. Access to steady-hand robot and the software engineers
4. $2000 budget for manufacturing OCT adapters
5. Access to machine shop for manufacturing prototypes.
6. Access to a motor (Dr. Kang) for testing

Responsibilities

- Xingchi:
  - Design the fixture and rotation mechanism in CAD
  - Generate virtual fixture, safe insertion path planning
  - Integrate front-facing OCT probe with side-view probe
- Saumya:
  - Software to control the OCT probe; interface with steady-hand robot
  - 3D reconstruction of the cochlear canal
  - Generate virtual fixture, safe insertion path planning
- Alperen:
  - Design the fixture and rotation mechanism in CAD
  - Generate virtual fixture, safe insertion path planning
  - Integrate front-facing OCT probe with side-view probe

Management Plan

1. Weekly meeting with Dr. Chien (if he is available)
2. Weekly meetings with each other on Tuesday and Thursday
3. 50 man hrs total per week

Reading List

[1] H.W. Pau, E. Lankenau, T. Just, and G. Hüttmann, “Imaging of Cochlear Structures by Optical Coherence Tomography (OCT). Temporal bone experiments for an OCT-guided cochleostomy technique.,” *Laryngo- rhino- otologie*, vol. 87, Sep. 2008, pp. 641-6.

[2] H.W. Pau, E. Lankenau, T. Just, D. Behrend, and G. Hüttmann, “Optical coherence tomography as an orientation guide in cochlear implant surgery?,” *Acta oto-laryngologica*, vol. 127, Sep. 2007, pp. 907-13.

[3] J.U. Kang and P. Gehlbach, “Endoscopic Functional Fourier Domain Common-Path Optical Coherence Tomography for Microsurgery,” *IEEE Journal of Selected Topics in Quantum Electronics*, vol. 16, Jul. 2010, pp. 781-792.

[4] B.J. Wong, J.F. de Boer, B.H. Park, Z. Chen, and J.S. Nelson, “Optical coherence tomography of the rat cochlea.,” *Journal of biomedical optics*, vol. 5, Oct. 2000, pp. 367-70.

[5] I. Fleming, M. Balicki, J. Koo, I. Iordachita, B. Mitchell, J. Handa, G. Hager, and R. Taylor, “Cooperative robot assistant for retinal microsurgery.,” *Medical image computing and computer-assisted intervention : MICCAI ... International Conference on Medical Image Computing and Computer-Assisted Intervention*, vol. 11, Jan. 2008, pp. 543-50.

[6] Nakabayashi, Koki et. al. “OCT Optical Probe and Optical Tomography Imaging Apparatus”. US Patent Application No. 12/363,021. Filed 30 January 2009.

[7] C.G. Wright, P.S. Roland, and J. Kuzma, “Advanced bionics thin lateral and Helix II electrodes: a temporal bone study.,” *The Laryngoscope*, vol. 115, Nov. 2005, pp. 2041-5.

Temporal Bone

- Temporal Bone