Robotically Assisted Cochlear Imaging

Computer Integrated Surgery II
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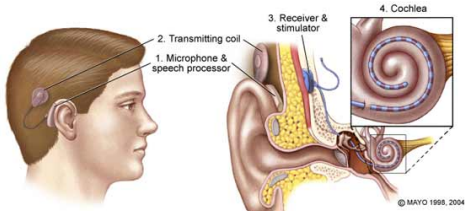
Xingchi He, Saumya Gurbani, Alperen Degirmenci
Mentors: Dr. Iulian Iordachita, Dr. Russell Taylor

Introduction

- Cochlear implant is surgery is a very delicate operation, and has the risk of damage to sensitive tissue if the electrode is not properly inserted.
- Goal is to develop a safe path for electrode insertion using micro borescope and steady hand robot.



The Problem

- In the current practice of cochlear implant surgery, the insertion of the electrode into the cochlear is typically performed manually without intraoperative imaging.
- Manual insertion of electrode can generates forces that are large enough to damage the sensitive tissue of the cochlea. This damage can further reduce the residual hearing of the patient.
- It is difficult to properly register pre-operative imaging data with a tool while it is inside the cochlea.

The Solution

- Micro borescope (0.5mm diameter) enables intraoperative imaging within the 1mm diameter cochlear canal.
- Steady hand robot provides positioning precision of 1μm.
- Steady-hand robot adapter mount which allows for easy switching between imaging and implant tools makes registration simpler and more accurate.
- Safe insertion path can be generated by analyzing image data from borescope.

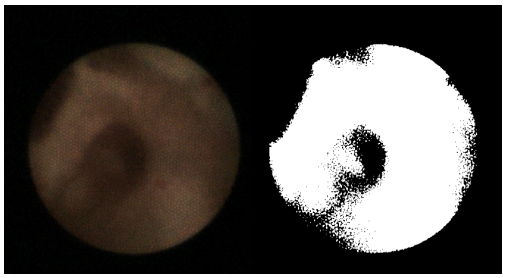
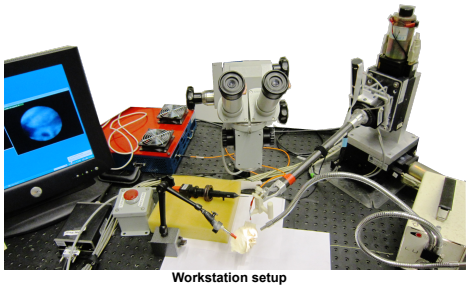


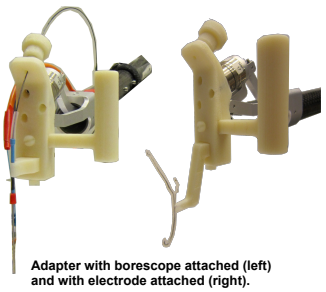
Image of cochlear round window taken by borescope (left), and segmented image (right). Both can be processed in real time.



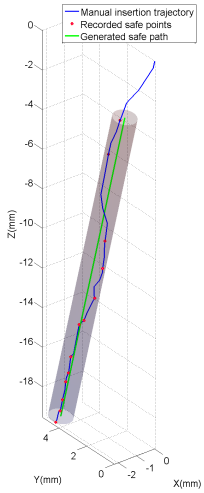
Workstation setup

Outcomes and Results

- Adapter with interchangeable tips for imaging probe and electrode
- Manual safe path finding
- Robot position recording
- Safe path generation
- Real-time segmentaion
- Borescope calibration



Adapter with borescope attached (left) and with electrode attached (right).



Safe path generation output. Maximum trajectory error is 0.57mm

Future Work

- 3D reconstruction of cochlear canal
- Automatic safe path and virtual fixture generation
- Precise robot movement through inverse kinematics

Lessons Learned

- Always have a backup logistics plan
- Cross platform coding requires lots of troubleshooting

Credits

- Alperen Degirmenci: adapter design and prototyping, optical flow, borescope calibration
- Saumya Gurbani: segmentation, safe path GUI, EyeRobot interfacing, safe path recording
- Xingchi He: adapter design and prototyping, safe path generation, borescope calibration

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