

Robotically Assisted Cochlear Imaging and Access



Computer Integrated Surgery II

Spring, 2012

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Introduction

Cochlear implant surgery can be an immense auditory, linguistic and developmental benefit to patients with severe hearing deficiencies due to the loss of hair cell transduction within the cochlea. The surgical procedure is potentially complicated by difficulties with implanting electrode array insertion, and serious complications may occur. In this study a new approach is developed that incorporates the cooperative control of a steady hand robot along with the intraoperative OCT imaging to generate virtual fixtures that enable the surgeon to insert the implant precisely inside the patient's cochlea without causing trauma.

Problem

Lack of precise motion and limited visual feedback during cochlear implant insertion

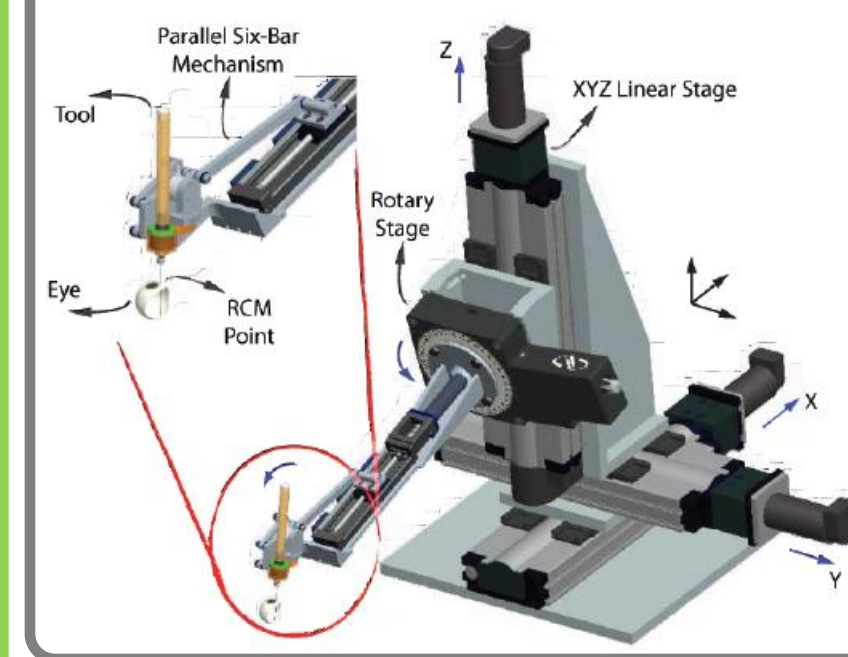
High dependency on the surgeon's skills and experience

Trauma on critical tissues during implant surgery

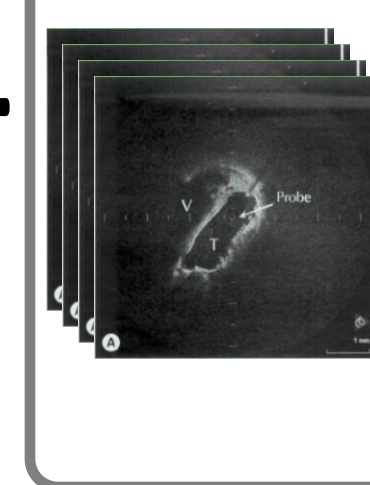
Clinical need for visualization and precise implant insertion

Solution

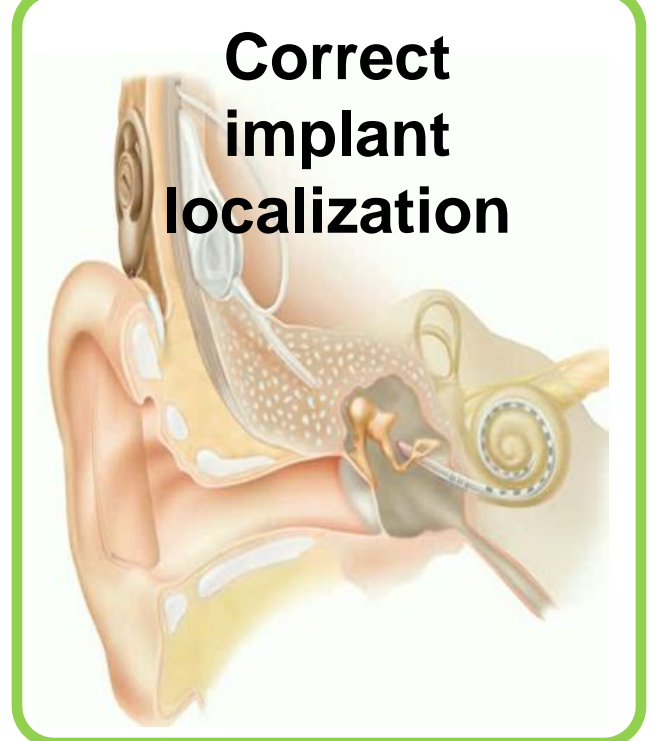
Steady-Hand Robot



OCT Imaging

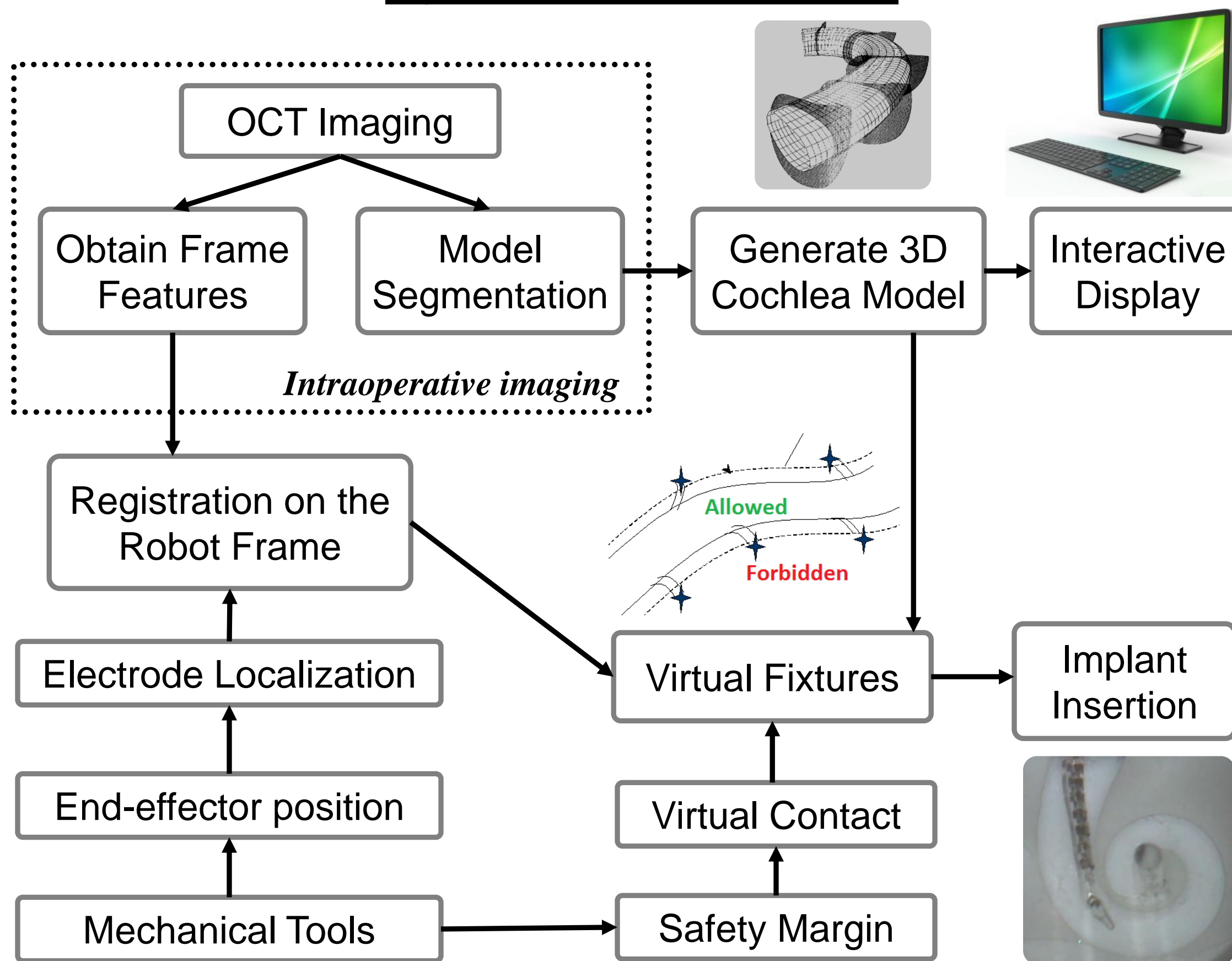


Correct implant localization

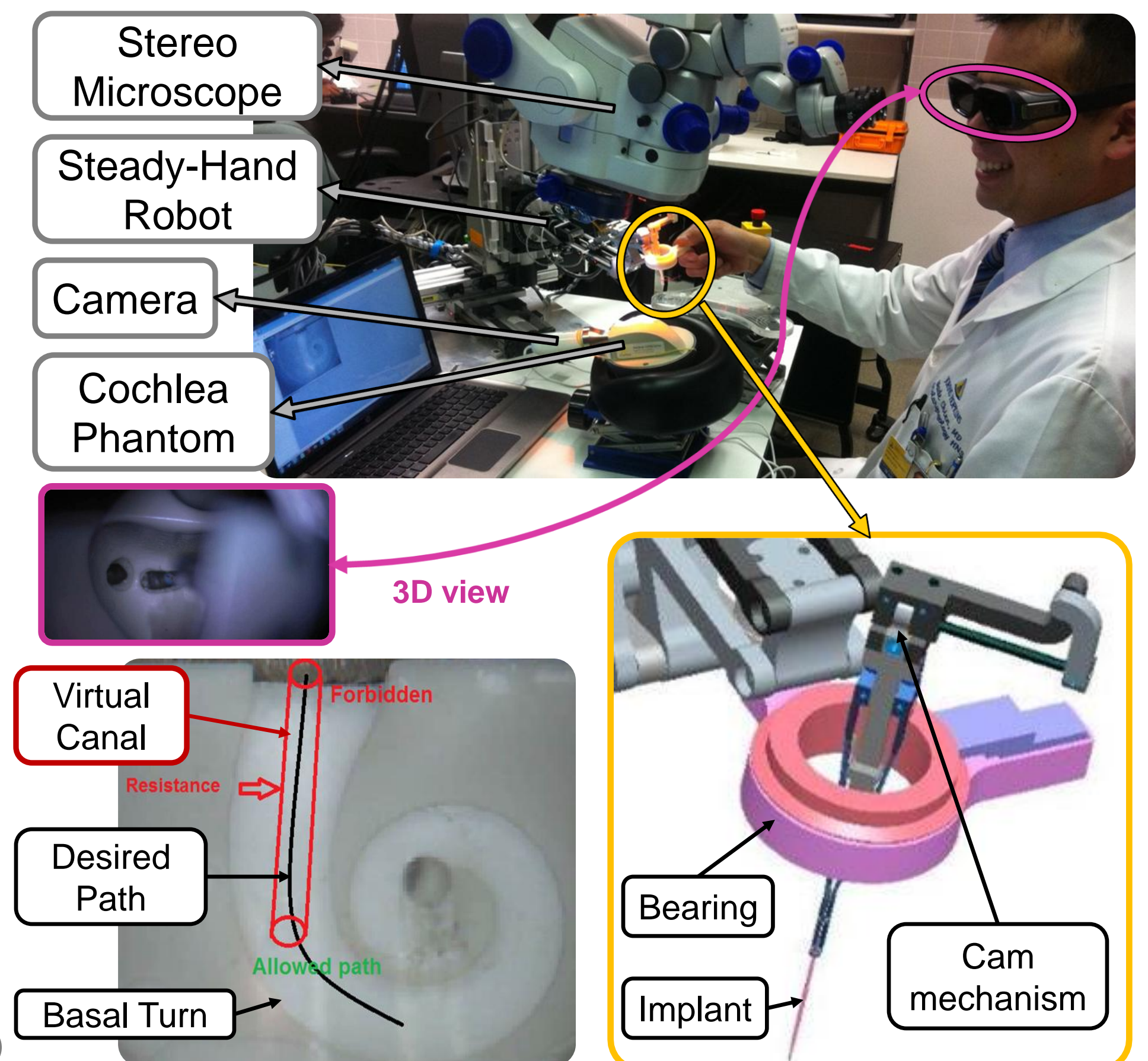


Hypothesis: Using robotic system and intra-operative imaging feedback can enhance the outcome of the procedure.

System Architecture



Prototype Setup



Conclusion

In this study, a steady-hand system for cochlear implant insertion was introduced. The designed end-effector has enhanced the functionality of existing manual tool maneuvers. The preliminary trials have indicated that the implemented virtual fixtures is successful in avoiding collisions with the cochlea walls as well as reducing surgeon's inherent hand tremor.

Lessons Learned

- Microscope field of view and tool compactness is a trade-off, which requires design optimization.
- It is important to allocate enough time and get surgeon's feedback during this period.

Credits

Ehsan Azimi – Software development, virtual fixture implementation.
Berk Gonenc – Mechanical tool design and fabrication.

Future Work

- Improvements on the tooling design for better ergonomics and microscope field of view.
- Fabrication of the robot adapter for the OCT probe.
- Integration of the robotic system with OCT imaging.
- Testing and validation of the overall system on artificial cochlear phantom.
- Experiments on dry temporal bones.
- Experiments on cadaveric bones.