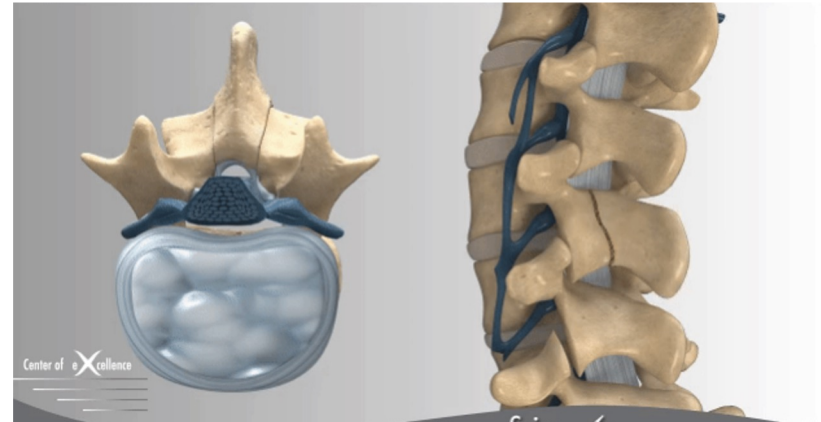
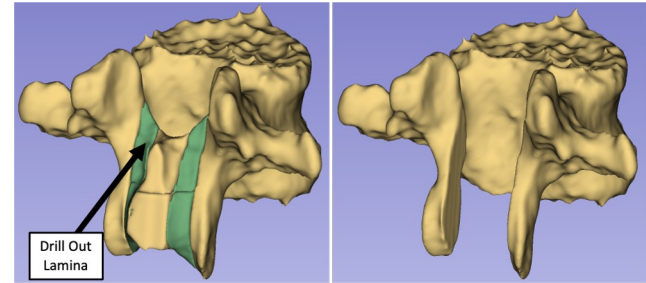


Evaluating Colored VR Navigation for Laminectomy and Mastoidectomy

Team 19: Jonathan Wang, Kesavan Venkatesh, Yi Wang
Mentors: David Usevitch, Hisashi Ishida, Adnan Munawar

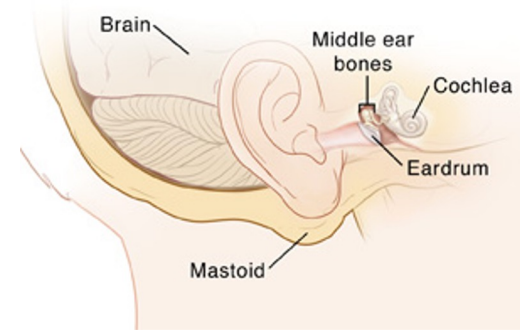
Recap: Laminectomy

- Procedure that **removes portions of the lamina**, a vertebral bone that forms the posterior of the spinal canal covering the spinal cord
- Treat spinal stenosis
- 500,000 cases annually, **11%** result in incidental durotomy [1]



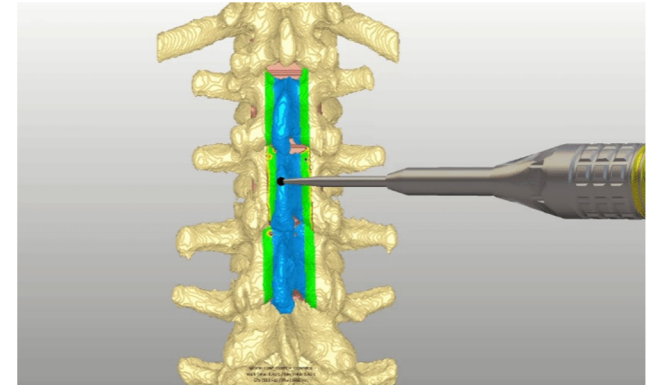
Recap: Mastoidectomy

- Procedure drills into parts of the **temporal bone** to reach the internal auditory canal
- Vital structures are exposed
- 60,000 cases annually, **cognitive load** for surgeons can peak at around 10% [2]



Recap: Project Goals

- **Colored VR navigation** using signed-distance functions (SDF)
- Execute **user-study** on laminectomy
- Execute **feasibility-study** on mastoidectomy

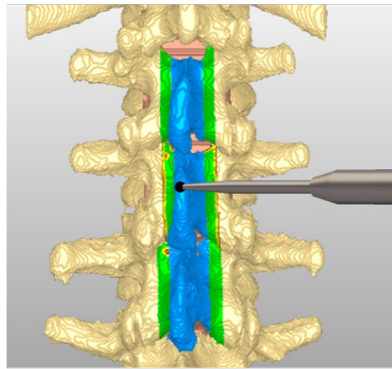


Deliverables: Minimum

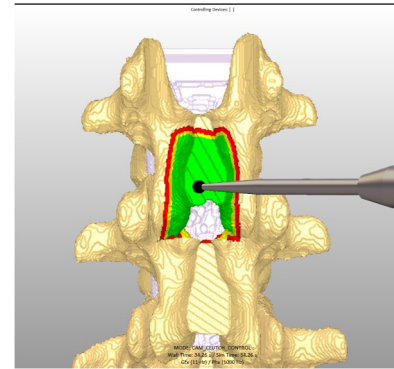
Activities	Results	Status
Familiarize segmenting a lumbar spine CT scan with 3D Slicer	A reproducible protocol for segmenting lumbar spine CTs using 3D Slicer software	COMPLETED
Segmenting lumbar spine CTs following protocol	15 locally-saved segmentation files of lumbar spines	COMPLETED
Build VR simulator and upload 15 lumbar spine segmentations to GUI	Ready-to-use laptop with VR GUI for laminectomy user study	COMPLETED

Built VR Simulator

- Resegmented 15 spines for laminectomy study
- Validated with Dr. Jain



OLD



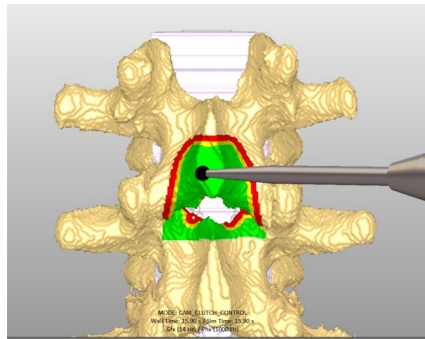
NEW

Deliverables: Expected

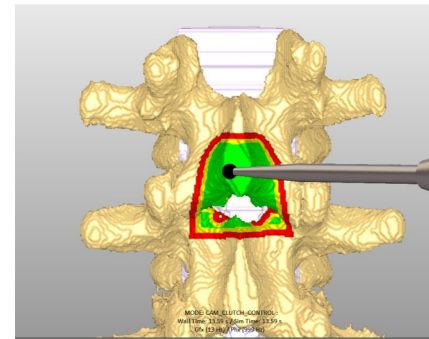
Activities	Results	Status
Conduct laminectomy user sessions at JHH	Collect user VR session data	ONGOING
Performing data analysis	Written results section for <i>IEEE</i> manuscript	NOT STARTED
Determine relevant anatomy to segment for mastoidectomy navigation	A reproducible protocol for segmenting inner ear CTs using 3D Slicer software	ONGOING
Segmenting inner ear CTs following protocol	Collect user VR session data	ONGOING
Upload inner ear segmentations to GUI	Ready-to-use laptop with VR GUI for mastoidectomy user study	NOT STARTED

Delays in User Study

- Communication was **not up-to-date**
- **Access to PC** took longer than expected
- **Debugging necessary** for color-guidance



BUGGY



FIXED

Pivot: Technical Development

- 1) **Playback video** to display data recorded from user-study
 - a) Visualize removed voxels over time
 - b) Trend in applied-force

- 1) C++ plugin for **synchronized data-extraction**
 - a) Improvement from multi-threading

- 1) Redesign GUI for **mastoidectomy** feasibility-studies



User Study: Next Steps

- Transport system to Johns Hopkins Hospital Outpatient Center
- User studies set for **3/30** and **4/06**
- Start **external recruitment**



Adjusted Deliverables: Expected

Activities	Results	Expected By
Conduct 8 laminectomy sessions at JHH Orthopedic Surgery education meetings	Collect user VR session data for 8 subjects	4/6
Recruit and conduct 8 more laminectomy sessions at JHH	Collect user VR session data for 8 subjects	4/21
Performing data analysis	Figures for manuscript comparing user performance	4/24
Drafting results section for manuscript	Written results section for <i>IEEE</i> manuscript	4/28
Point cloud visualization to “replay” user drilling	Video recap of all performed user-studies	4/24

Adjusted Deliverables: Maximum

Activities	Results
Implement a C++ plugin for synchronized data extraction	Unit-tested and documented program for data extraction added into VR simulator
Determine relevant anatomy to segment for mastoidectomy navigation	A reproducible protocol for segmenting inner ear CTs using 3D Slicer software
Redesign GUI for mastoidectomy	GUI with uploaded segmented mastoids
Conduct mastoidectomy user sessions at JHH	Collect user VR session data
Performing data analysis	Written results section for <i>Otology and Neurotology</i> manuscript
Literature review and discussions with mentors and ENT surgeons	First-authored manuscript for <i>Otology and Neurotology</i>

Milestones: Laminectomy Study

Milestones	Exit Criteria	Status
Spine CT segmentation	Five lumbar spines saved as 15 segmentation files of CT scans of L1-L3	COMPLETED
VR platform setup	VR platform with GUI containing spine cases	COMPLETED
Finalize user study protocol for laminectomy user studies	Written and mentor-approved protocol outlining data collection and analysis	COMPLETED
Schedule laminectomy user studies	Confirmed sessions with up to 10 subjects and planned monitoring assignments for team members	ONGOING
Collect surgeon data and perform data analysis	Written results section for <i>IEEE</i> manuscript	NOT STARTED

Milestones: Mastoidectomy Study

Milestones	Exit Criteria	Status
Inner ear CT segmentation	Five inner ears saved as 15 segmentation files of CT scans of L1-L3	ONGOING
Incorporate new features into VR platform	VR GUI with depth perception interface	ABANDONED
Schedule mastoidectomy feasibility studies	Confirmed sessions with up to 5 subjects and planned monitoring assignments for team members	NOT STARTED
Collect surgeon data and perform data analysis	Written results section for <i>Otology and Neurotology</i> manuscript	NOT STARTED

Milestones: VR GUI Development

Milestones	Exit Criteria	Status
Depth perception interface	Functional, unit-tested, and documented Python script that builds a workspace model, captures the current phantom pose as input, and marks the relative position	ABANDONED
Synchronized C++ data extraction	A C++ plugin that captures user pose and drilling progress from ROS and outputs extracted data metrics	NOT STARTED
NEW Point cloud visualization to “replay” user drilling	Video recap of all performed user-studies with voxels removed and force-exerted	ONGOING

Adjusted Timeline

Phase	Task	March	April			May	
Laminectomy User Study	Spine CT segmentation [DONE]						
	Colored virtual-reality platform setup	■					
	Finalize clinical study protocol [DONE]						
	Schedule user studies						
	Collect surgeon data and perform data analysis	■	■	■	■		
	Write draft of results for laminectomy user study				■		
Mastoidectomy Feasibility Study	Inner-ear CT Segmentation	■	■				
	Colored virtual-reality platform setup		■				
	Finalize clinical study protocol		■	■			
	Schedule user studies			■	■	■	■
	Collect surgeon data and perform data analysis			■	■	■	■
	Write draft of mastoidectomy feasibility study					■	■
Virtual-reality GUI Development	Point cloud visualization + documentation	■	■				
	Data extraction plugin + documentation		■	■	■		
Final Presentation & Report					■	■	■

Dependencies

Dependency	Need	Status	Contingency	Planned	Resolved
Study participants	Participate in clinical study	Ongoing	N/A	3/5	Not yet
Github access	Locally build VR system	Completed	N/A	2/20	2/20
CT scans & prior segmentations for laminectomy	Segment anatomy according to ENT surgeon recommendations	Completed	N/A	2/20	2/20
Full IRB approval for user study at JHH	Organize and execute user study	Completed	N/A	3/6	3/17
Linux machine and VR glass	Locally running VR simulator for user studies	Completed	Use lab's equipment	3/6	3/13
Swipe access to LCSR PhD Office	Access to VR glasses	Completed	Have Yi enter the LCSR PhD Office	2/25	3/10
Access to drafted manuscript and IRB documents for laminectomy study	Review prior user study protocols	Completed	N/A	2/20	2/20

Adjusted Team Structure

- **Kesavan Venkatesh**
 - Organize and oversee user study sessions
 - Synchronized data extraction
- **Jonathan Wang**
 - Organize and oversee user study sessions
 - Laminectomy data analysis
 - Point cloud visualization
 - Synchronized data extraction
- **Yi Wang**
 - Laminectomy data analysis
 - Point cloud visualization

References

1. K. Phan, R. J. Mobbs, Minimally Invasive Versus Open Laminectomy for Lumbar Stenosis: A Systematic Review and Meta-Analysis, *Spine* 41 (2) (2016) E91–E100. doi:10.1097/BRS.0000000000001161
2. S. A. W. Andersen, P. T. Mikkelsen, L. Konge, P. Cayé-Thomasen, M. S. Sørensen, Cognitive load in distributed and massed practice in virtual reality mastoidectomy simulation, *The Laryngoscope* 126 (2) (2016) E74–79. doi:10.1002/lary.25449
3. A. Munawar, Z. Li, P. Kunjam, N. Nagururu, A. S. Ding, P. Kazanzides, T. Looi, F. X. Creighton, R. H. Taylor, M. Unberath, Virtual Reality for Synergistic Surgical Training and Data Generation, *Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization* 10 (4) (2022) 366–374, arXiv:2111.08097 [cs]. doi:10.1080/21681163.2021.1999331.