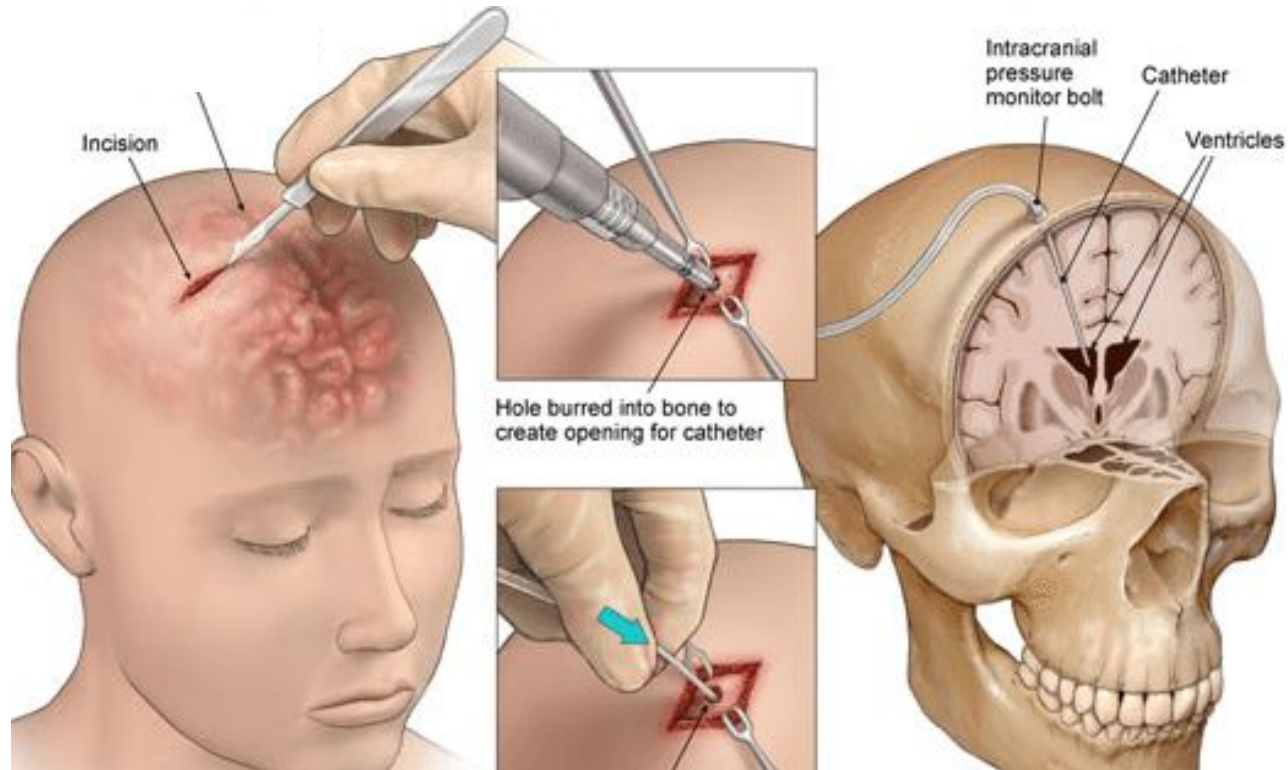


HMD-Based Navigation for Ventriculostomy

Maia Stiber

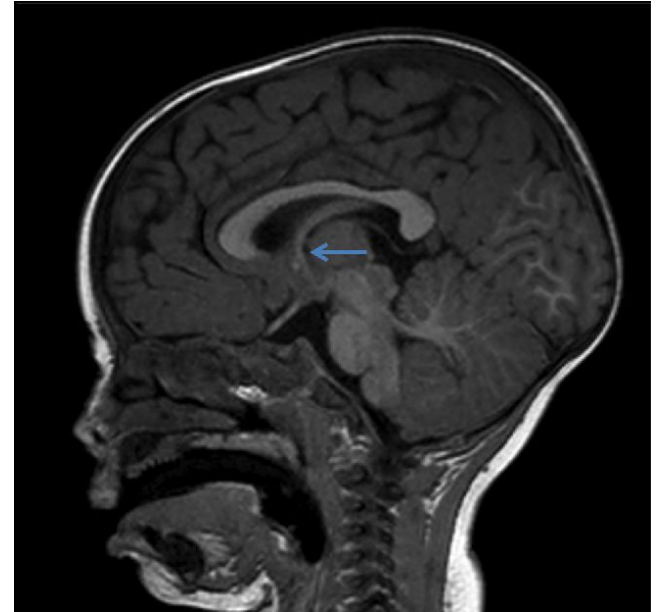
Background: Ventriculostomy



Ghandorh, Hamza & Mackenzie, Justin & De Ribaupierre, Sandrine & Eagleson, Roy. (2017). Development of Augmented Reality Training Simulator Systems for Neurosurgery Using Model-Driven Software Engineering. 10.1109/CCECE.2017.7946843.

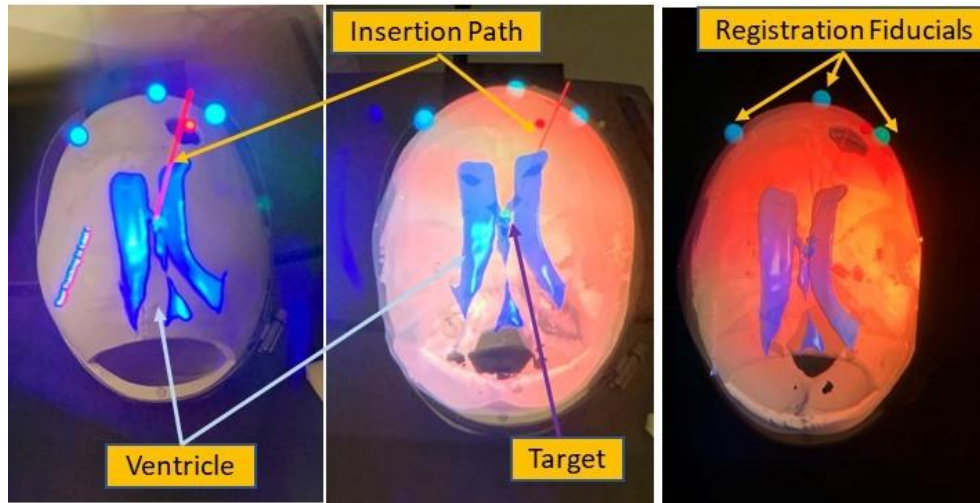
Motivation

- Target: Foramen of Monro
- Surgeons rely on spatial temporal reasoning and experience
- About 33% of insertion attempts are misses
- Time sensitive procedure

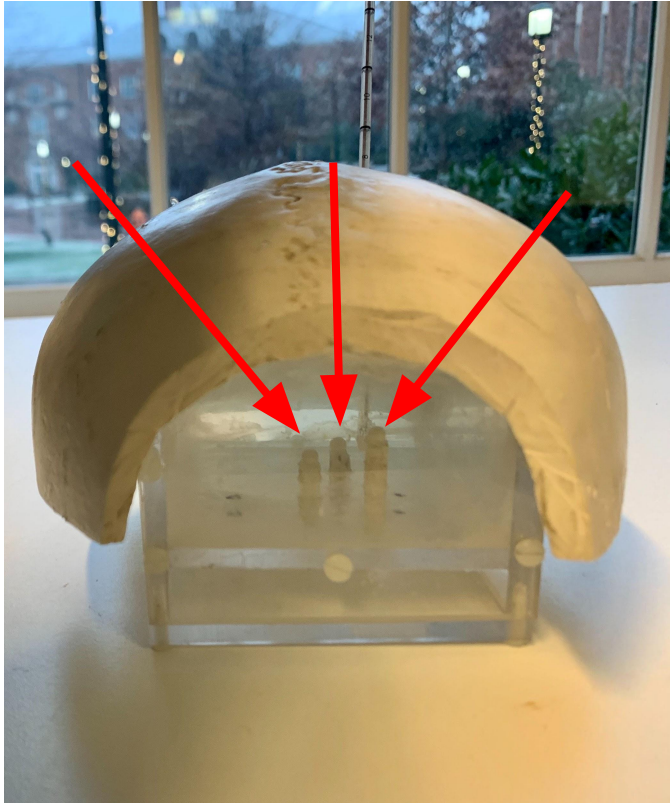


R. Shane Tubbs, Peter Oakes, Ilavarasy Maran, Christian Salib and Marios Loukas. "The foramen of Monro: a review of its anatomy, history, pathology, and surgery." *Child's Nervous System* 30 (2014): 1645-1649.

Background: Current HMD System Approach

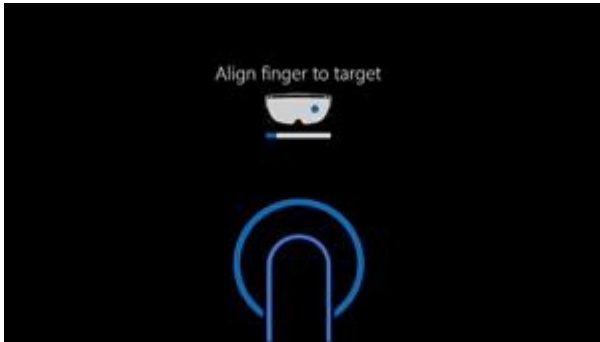


Background: Phantom

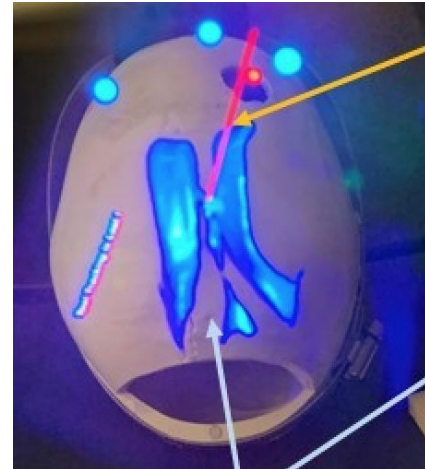


Background: Current Workflow

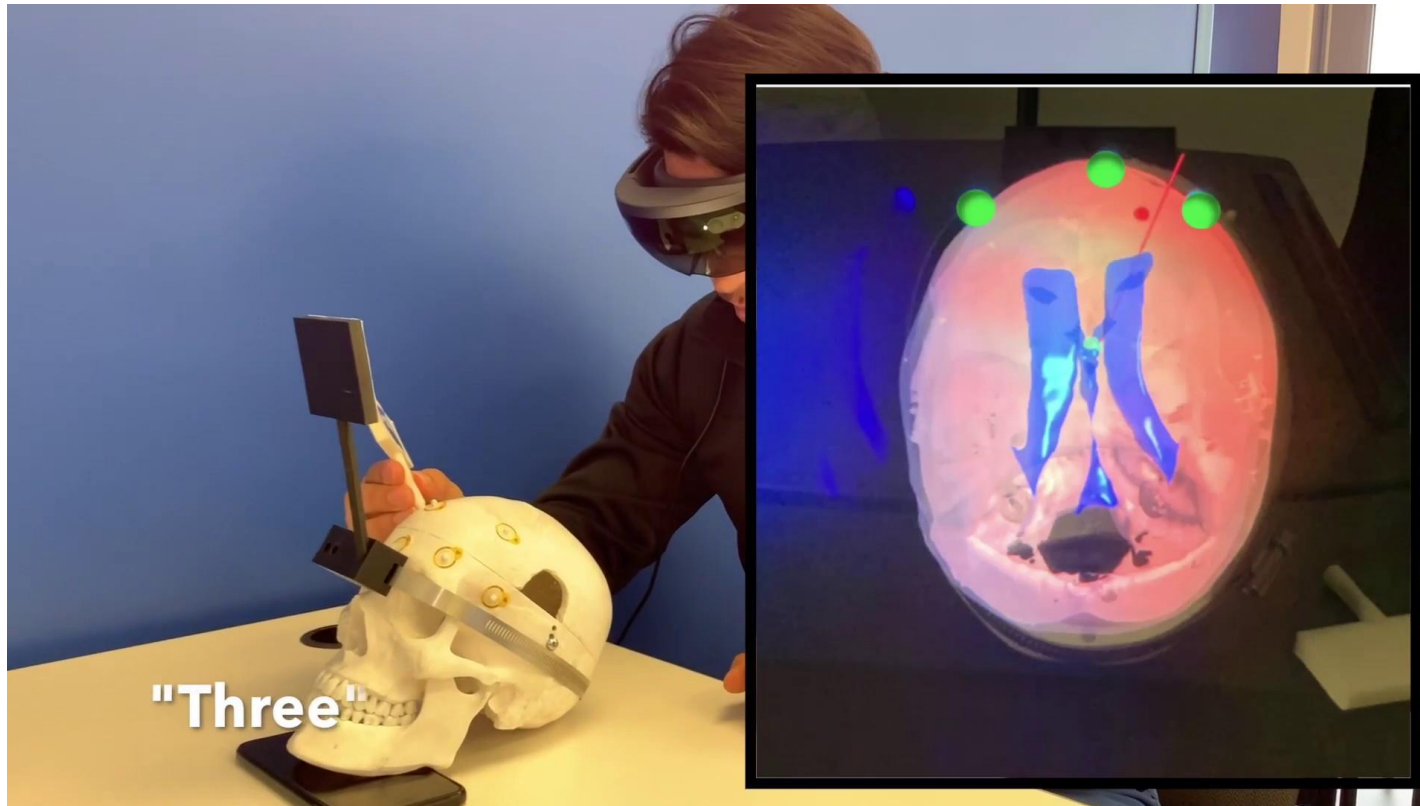
- Calculate Surgeon's InterPupillary Distance (IPD)
- Register CT scan with the phantom/head
- Plan Path



<https://docs.microsoft.com/en-us/hololens/hololens-calibration>



Background: Registration

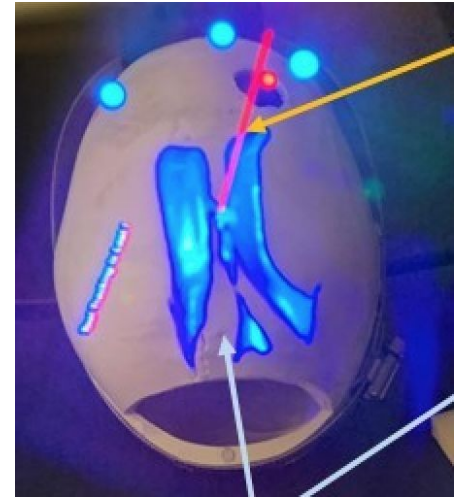


Background: Path Planning and Insertion



Aims

- Prove/See if AR-guided ventriculostomy is preferred by neurosurgeons
- Improve representation of guide line by finding alternatives route to represent depth
- Aid in training of resident surgeons by providing adaptive feedback



Technological Approach: User Study

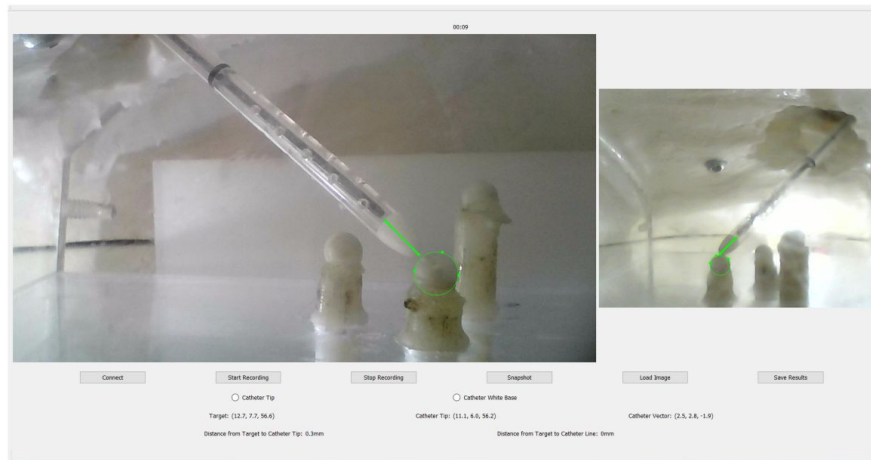
- Hypothesis: AR-Guided ventriculostomy increases accuracy, efficiency, and decreases mental task load.
- Neurosurgery resident will perform catheter insertions
- Within-Subject study

Technological Approach: Data Analysis

- System Usability Scale (SUS)
- Demographics
- NASA Task Load Index (TLX)
- Accuracy of insertion
 - Using borescope cameras
- Video Coding
 - Task time
 - Additional comments said by user during task

Technological Approach: Catheter Alignment Training

- Current accuracy of borescope cameras $\sim 0.3\text{mm}$
 - Not real-time tracking
- Training Module
 - Real-Time Tracking of Catheter
 - Add visualization of catheter in UI
 - Add other feedback such as sound



Deliverables

Minimum:	<ul style="list-style-type: none">● User Study Results and Analysis of Data● Edited UI that has improved visual perception of line
Expected:	<ul style="list-style-type: none">● User Study Results and Analysis of Data● Script that provides feedback to surgeons on how well aligned and how close catheter is to the target in training
Maximum	<ul style="list-style-type: none">● User Study Results and Analysis of Data● Script that provides feedback to surgeons on how well aligned and how close catheter is to the target during actual procedure

Milestones

Milestone	Expected Date Done By	Status
User Study Conducted	3/13/20	In Progress
• Questionnaire Created	2/21/20	Completed
• Video Tutorial Created	2/19/20	Completed
• IRB Approval	2/17/20	Completed
• Neurosurgeon Approval of User Study Questionnaire and Tutorial	2/24/20	Completed
• Pilot Study Conducted	2/29/20	In Progress
• Actual User Study Conducted	3/13/20	Not Started
Data Analysis of the User Study	3/20/20	Not Started
• Video Coding Conducted	3/20/20	Not Started
• SUS/NASA TLX scales analyzed	3/20/20	Not Started
Reading Preliminary Papers	3/17/20	In Progress
Editing AR UI	3/20/20	In Progress
• Learn Unity	3/4/20	In Progress
• Improved visualization of the guide line	3/20/20	Not Started
Training Script for AR-Guided Ventriculostomy	3/31/20	Not Started
• Real-time measurements of catheter distance from target	3/20/20	Not Started
• Add 3D line to represent catheter in UI with real-time orientation	3/30/20	Not Started
• Add multi-modal feedback for catheter alignment and target distance	3/31/20	Not Started
Tracking Catheter Script during Procedure	4/30/20	Not Started
• Prototype various Catheter Tracking Systems	4/15/20	Not Started
• Pick one and implement that system	4/25/20	Not Started
• Edit UI to provide feedback to the surgeons using the catheter tracking	4/30/20	Not Started
Poster Presentation/Report	5/5/20	Not Started

Dependencies (Part 1)

Dependency	Contact	Solution	Alternative Plan	Completed?
Hololens	Peter Kazanzides	Lab has one	Ask another lab for one	✓
Computer	N/A	Lab Computer	My laptop	✓
Catheter	Ehsan A	Get one from Ehsan	Buy a catheter	✓
Cameras	N/A	Camcorder from Lab	Iphone camera	✓
Skull Phantom	Ehsan A	Get the one built in lab	N/A	✓
Neurosurgeon Availability	Dr. Judy Huang	Contact Dr. Judy Huang. She will do scheduling	Use people from the local community	
Data/Code Backup		Github	External HD	✓

Dependencies (Part 2)

Dependency	Contact	Solution	Backup	Completed?
SD Card Reader	N/A	My laptop's SD card reader	USB SD card reader	✓
IRB	PI: Peter Kazanzides	Get added to the IRB	N/A	✓
Doctored CT Images	Ruby Liu	CT scan of skull, doctored so that the balls in phantom are vesicle.	N/A	✓

Management

- Mentors: Ehsan Azimi, Peter Kazanzides, Chien-Ming Huang, Dr. Judy Huang, and Dr. Camilo Molina
- Meet with Chien-Ming Huang Monday 2-2:30
- Meet with all of my mentors biweekly Wednesday 4-5
- Otherwise, contact using Slack/Email

Reading List

- Yudkowsky, Rachel, et al. "Practice on an Augmented Reality/Haptic Simulator and Library of Virtual Brains Improves Residents' Ability to Perform a Ventriculostomy." *Simulation in Healthcare: The Journal of the Society for Simulation in Healthcare*, vol. 8, no. 1, 2013, pp. 25–31.
- Ghandorh, Hamza & Mackenzie, Justin & De Ribaupierre, Sandrine & Eagleson, Roy. (2017). Development of Augmented Reality Training Simulator Systems for Neurosurgery Using Model-Driven Software Engineering.
- Raabe, Clemens & Fichtner, Jens & Beck, Juergen & Gralla, Jan & Raabe, Andreas. (2017). Revisiting the rules for freehand ventriculostomy: A virtual reality analysis. *Journal of neurosurgery*. 128. 1-8.
- Azimi, E., Molina, C., Chang, A., Huang, J., Huang, C. M., & Kazanzides, P. (2018). Interactive training and operation ecosystem for surgical tasks in mixed reality. *OR 2.0 Context-Aware Operating Theaters, Computer Assisted Robotic Endoscopy, Clinical Image-Based Procedures, and Skin Image Analysis - 1st International Workshop, OR 2.0 2018 5th International Workshop, CARE 2018, 7th International Workshop, CLIP 2018, 3rd International Workshop, ISIC 2018 Held in Conjunction with MICCAI 2018* (pp. 20-29). (Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics); Vol. 11041 LNCS). Springer Verlag.
- Amitabh Varshney, Xueting Sun, Sarah Murthi, and Gary Schwartzbauer. "Augmented reality catheter tracking and visualization methods and systems." U.S. Patent Application 16/418,531, filed November 21, 2019.