JOHNS HOPKINS UNIVERSITY

HMD-Based Navigation for Ventriculostomy
- Checkpoint -

Group 15:

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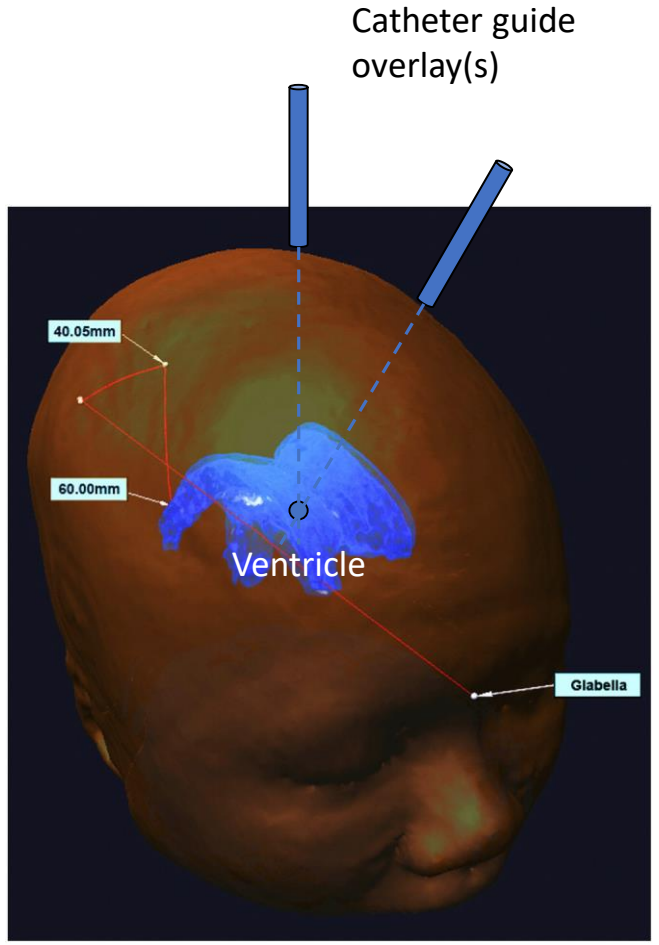
Prof. Peter Kazanzides

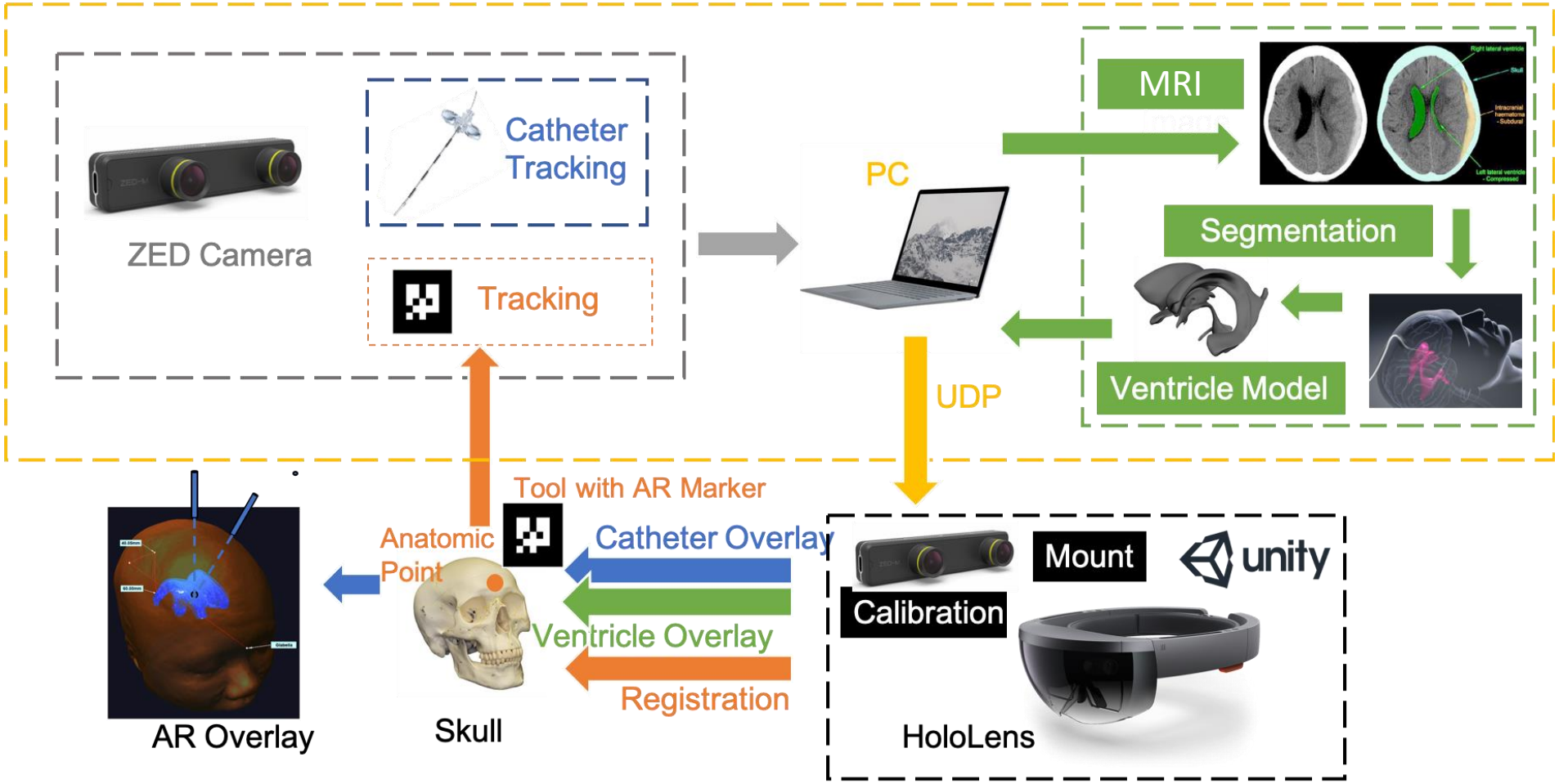
Project Goal

- The goal is to introduce image guidance via augmented reality on HoloLens
- The image guidance is AR overlay of ventricle model from MRI image and catheter guide overlay.

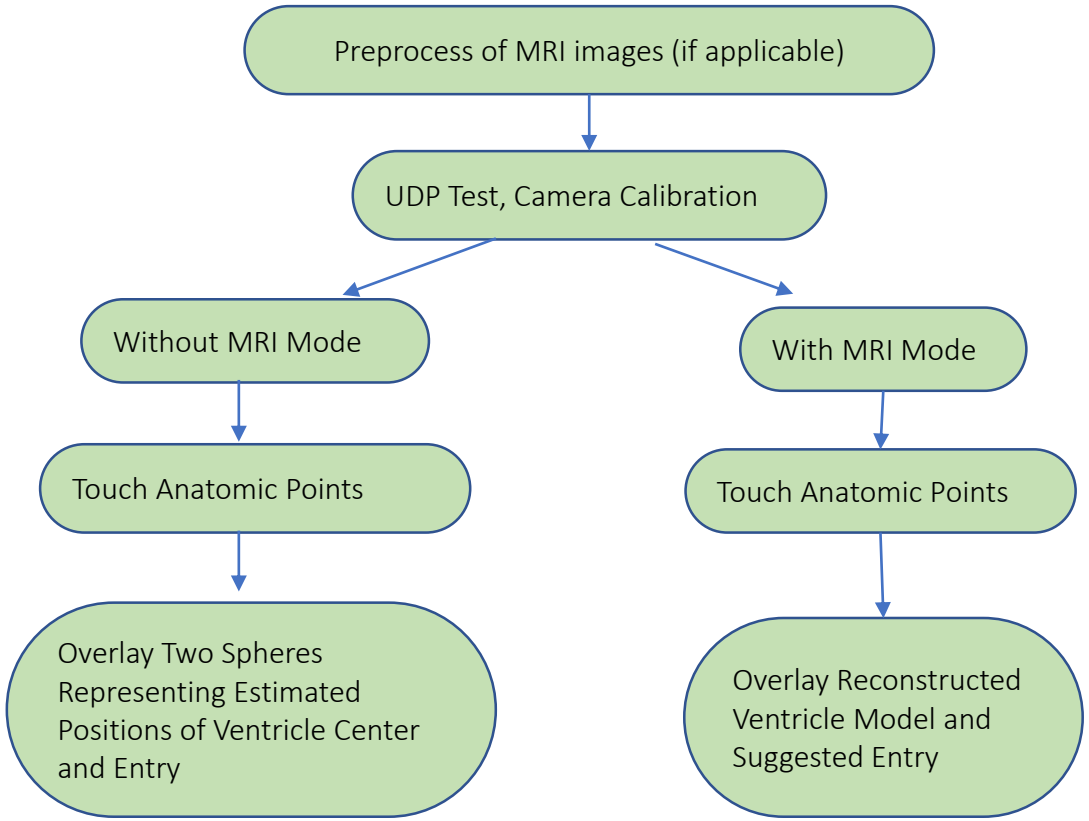


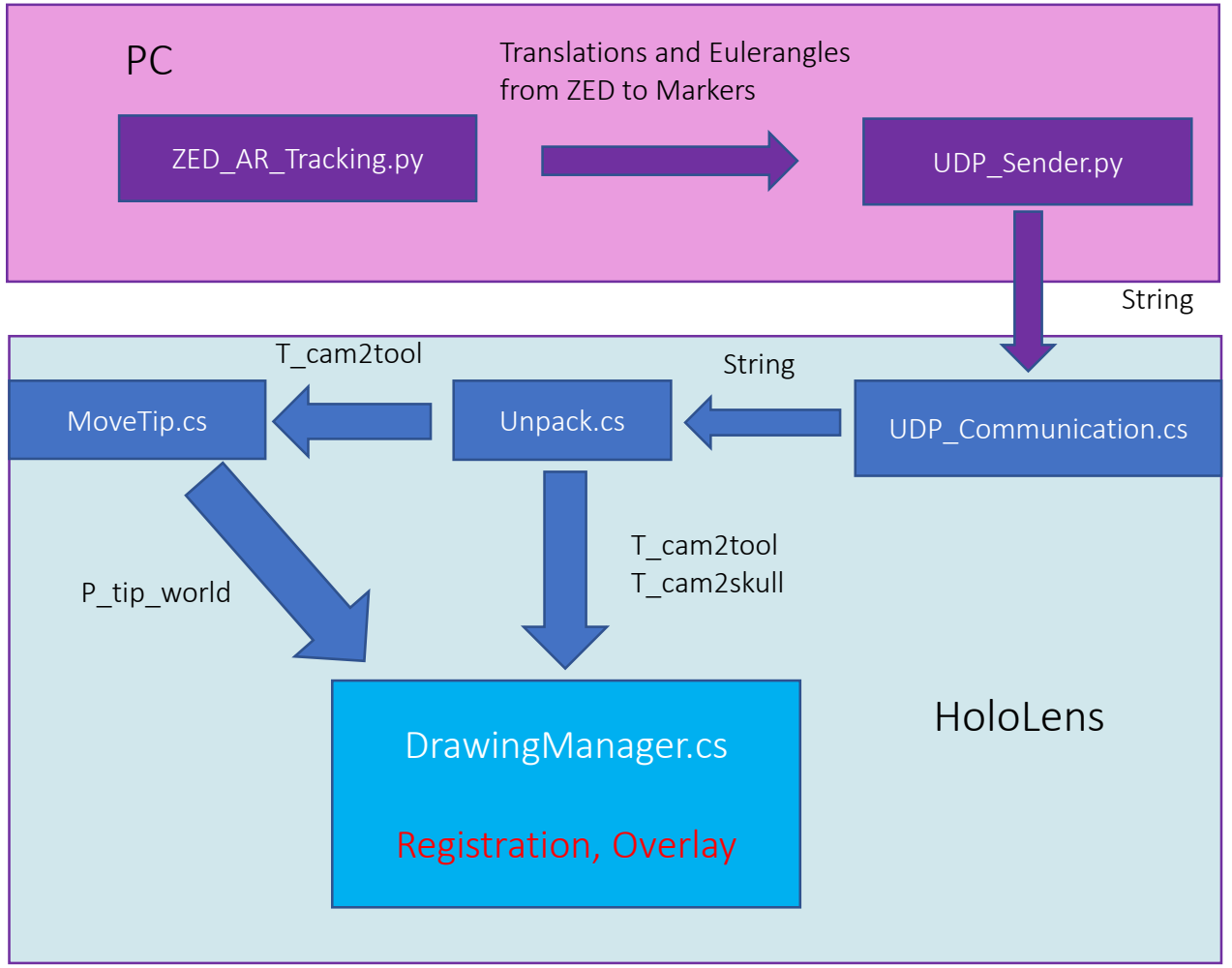
Azimi, E., et al.: Can mixed-reality improve the training of medical procedures? In: IEEE Engineering in Medicine and Biology Conference (EMBC), pp. 112–116, July 2018

Technical Approach - Overview



Workflow and Software Design





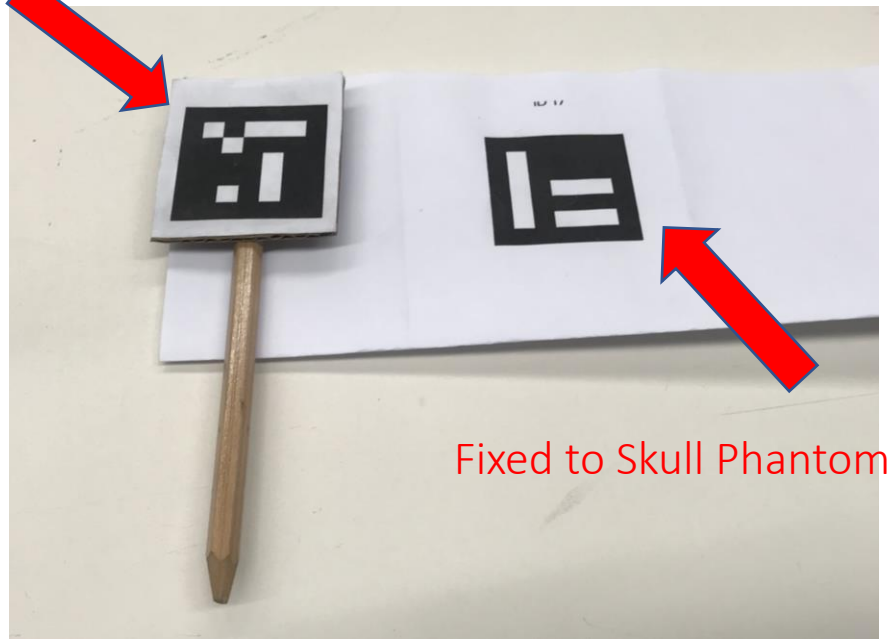
Technical Approach - Setup

ZED Mini

Pointing Tool

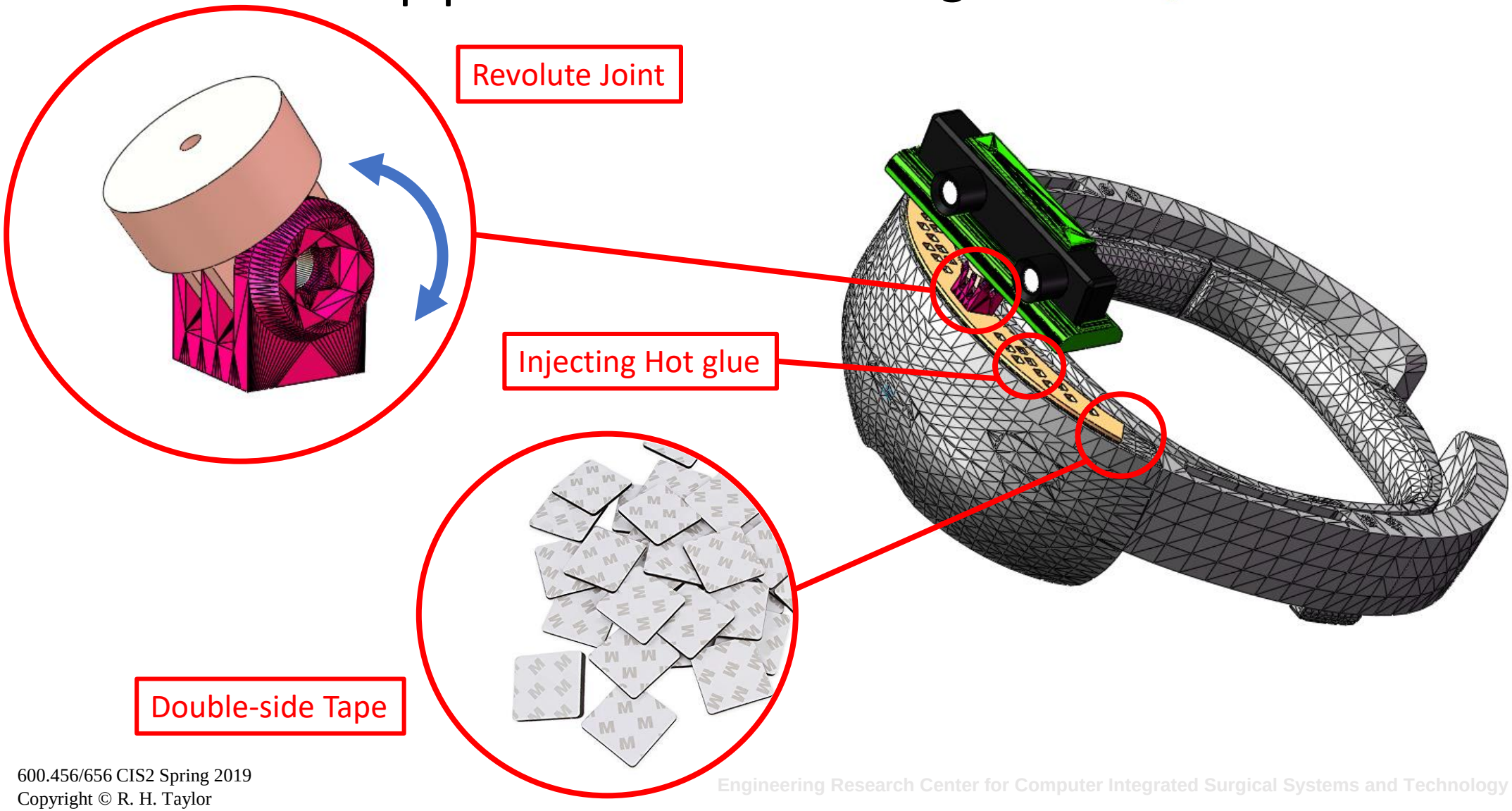
Connected to PC

HoloLens



Fixed to Skull Phantom

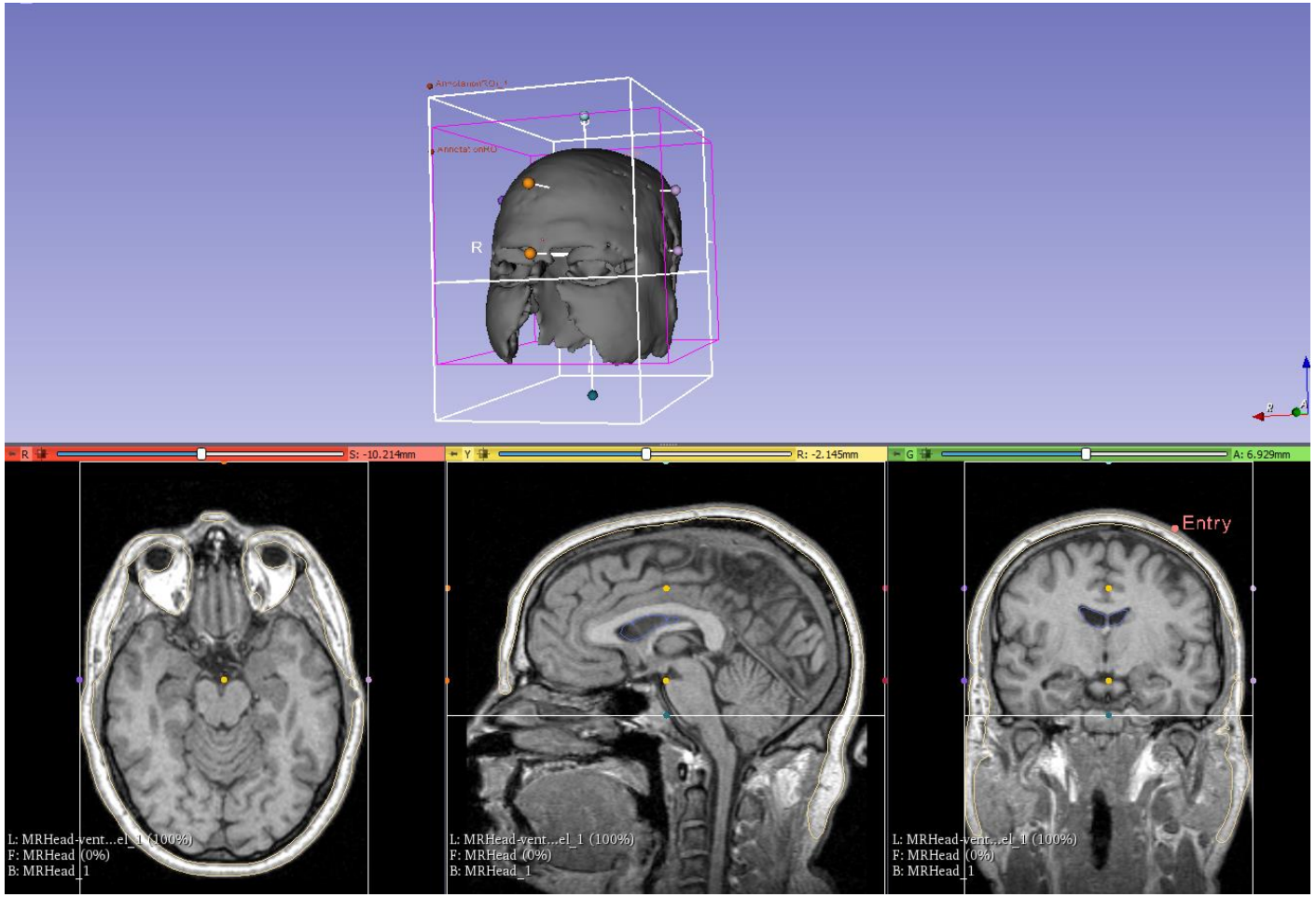
Technical Approach - CAD Design



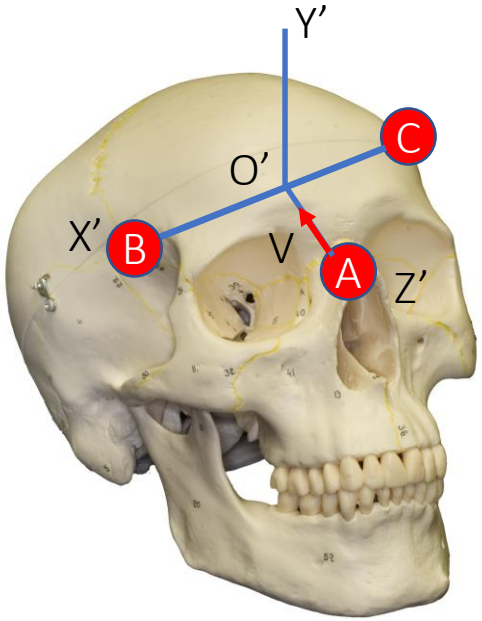
Technical Approach -Segmentation

- Ventricle and Skull segmentation in 3D slicer
  - Thresholding
  - Select target object
  - Close holes
  - Smooth and mesh

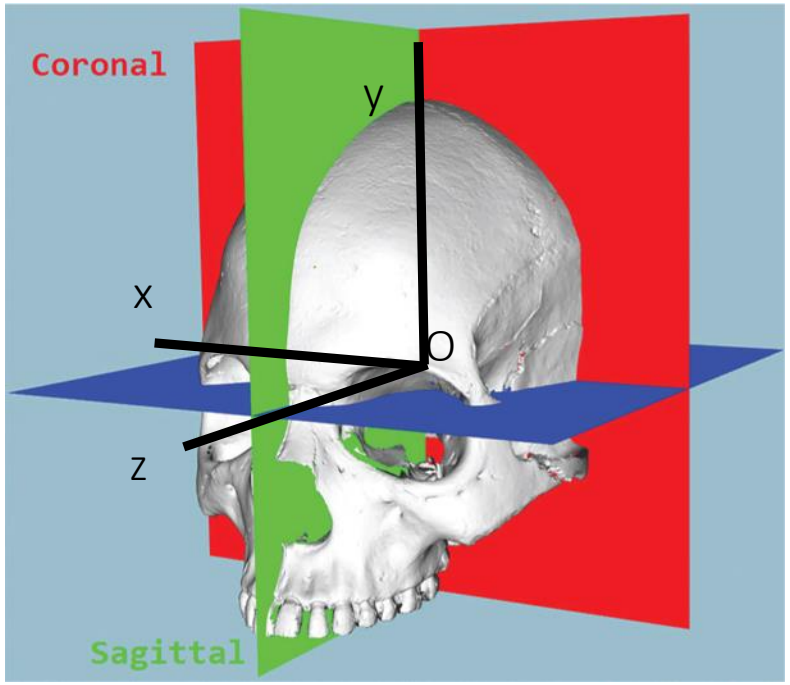
- Manually select anatomic point and entry point to get relative position



Technical Approach - Registration

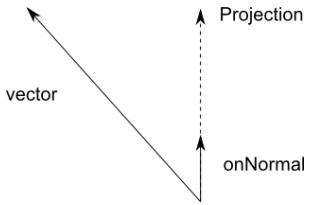



```
Vector3 V = B + Vector3.Project(A - B, C - B) - A;
Vector3 H = Vector3.Project(B - A, V);
Vector3 O = A + H;
Vector3 x0 = Vector3.Normalize(A - O);
Vector3 y0 = Vector3.Cross(C - O, A - O).normalized;
Vector3 z0 = Vector3.Normalize(C - O);
```



CraMs: Craniometric Analysis Application Using 3D Skull Models

Vector3 Project(Vector3 vector, Vector3 onNormal);



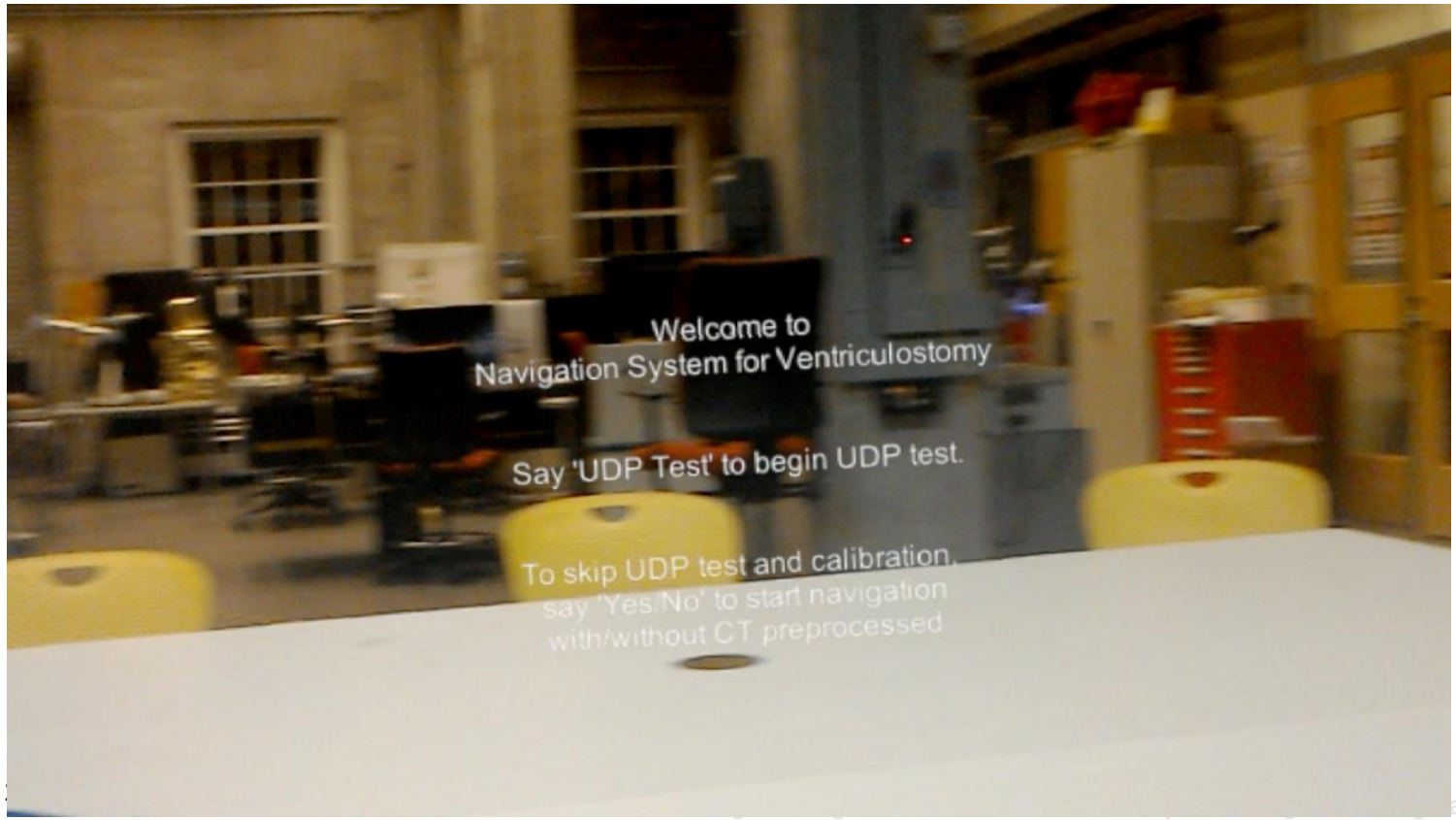
Technical Approach - Overlay

Without MRI Mode

- Overlay a 5cm sphere on the origin of the constructed frame;
- Cast a ray from the origin, At a 45 degree angle to the x'o'y' plane.

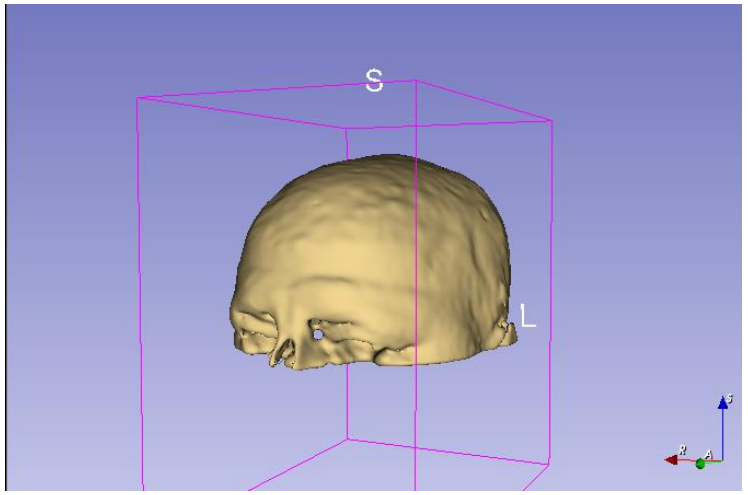
With MRI Mode

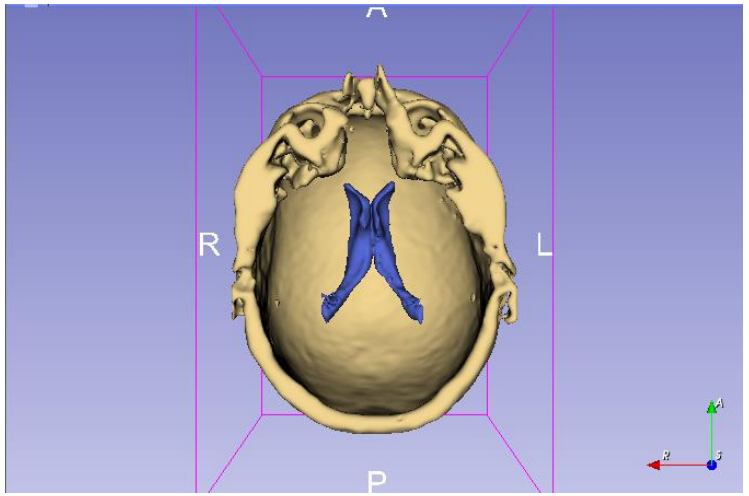
- Overlay a 3D ventricle model on T_ventricleCenter_anatomical(x,y,z,R,P,Y) obtained from MRI;
- Also overlay a 3cm sphere on P_entry_anatomical(x,y,z);
- Cast a line from the center of ventricle to entry.



Technical Approach - Test

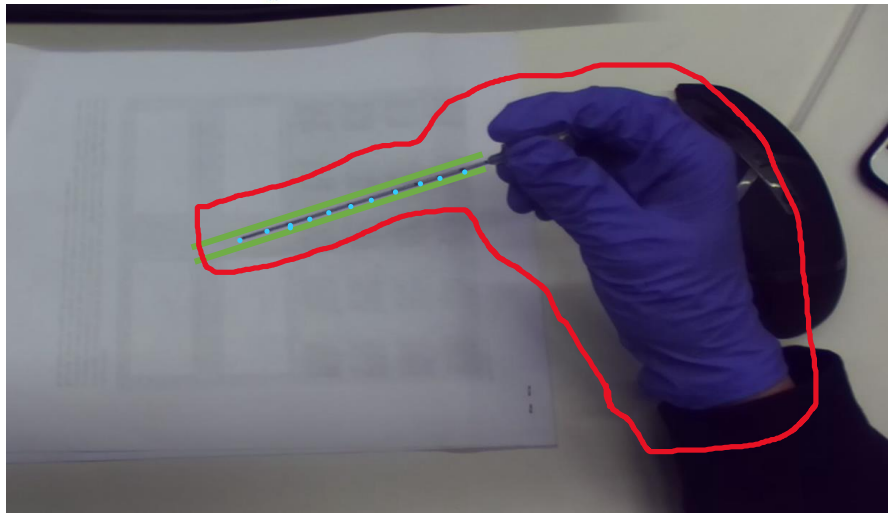
- 3D print top half part of segmented head
- Print 2 parts, skull and ventricle
- Skull
  - A hole for entry point for catheter insertion
- Ventricle
  - A base with a post to connect ventricle
- Test
  - User wear HoloLens to perform catheter insertion on the 3D-printed model 10 times, record the number of time that hit ventricle to evaluate success rate

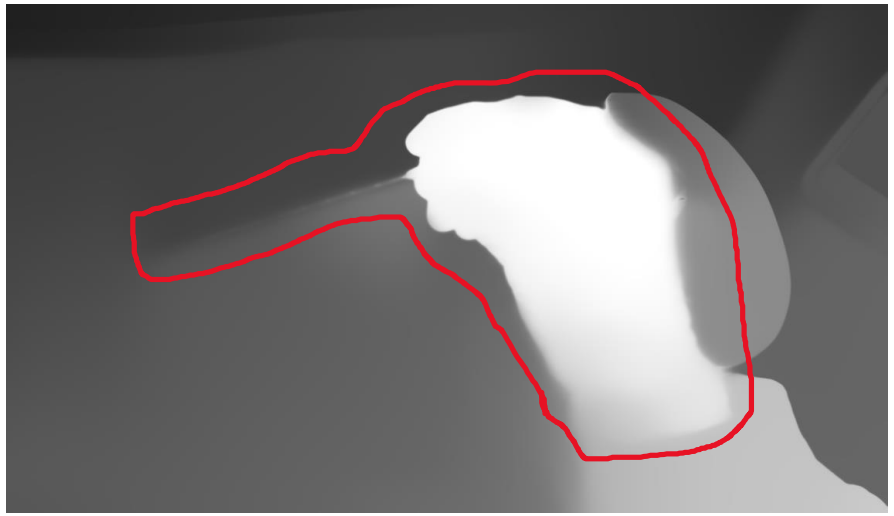




Technical Approach -Catheter

1. RGB image to locate hand position as seed points with purple gloves
2. Mask the region around seed point with similar depth
3. Hough Transformation to find the catheter
4. Thresholding to get tip and scale lines
5. Calculate tip position and angle of catheter





Deliverables

Minimum

- Documentation and Code for Navigation System 1.0 includes:
  - ~~Anatomic points registration by AR Marker~~ Anatomic points registration by tool with AR Marker in Zed mini camera
  - AR overlay system indicating ventricle centroid and catheter guidance based on anatomic points
  - ~~Report of accuracy test Video to demonstrate~~
- Video demo for the workflow with Navigation System 1.0

Expected

- Documentation and code for Navigation System 2.0 includes:
  - User interface with workflow instruction and voice command
  - Camera system integrated to HoloLens
  - ~~Semi-automatic~~ Ventricle segmentation program on 3D slicer
  - ~~Report of accuracy test~~ Camera mount design
- Video demo for the workflow with Navigation System 2.0

Maximum

- Documentation and Code for Navigation System 3.0 includes:
  - ~~fully-automatic ventricle segmentation program~~
  - Catheter tracking system with guidance of insertion error and insertion depth
- 3D-printed skull with ventricle for performance test
- Report of performance test
- Video demo for the workflow with Navigation System 3.0

Dependencies

Dependency	Solution	Status
Access to SMARTS Lab	Need Prof. Kazanzides sign the form	Resolved
Software: Unity, ZED SDK, 3D Slicer, SOLIDWORKS, OpenCV	Download from official websites	Resolved
Microsoft HoloLens	Ehsan will share his HoloLens with us	Resolved
ZED Camera	Order from Internet	Resolved
ArUco Markers	Generate online and Print	Resolved
MRI Images	Get from Internet	Resolved
Prior Work Code	Get from Ehsan and Long	Resolved
3D Printer	Contact Long, use LCSR 3D Printer	Resolved
~~Skull Model~~	~~Get from SMARTS Lab~~	~~Due Mar. 12~~
Catheter	Use one in SMARTS Lab	Resolved

Schedule

	Feb.19	Feb.26	Mar.5	Mar.12	Mar.19	Mar.26	Apr. 2	Apr. 9	Apr.16	Apr.23	Apr.30	May.7
Get familiar with Unity, ARToolKit												
~~finger Tracking~~ ZED AR Tracking												
Depoly Application to HoloLens												
Navigation system 1.0 without MRI												
~~Global camera setup~~ Zed mini Camera Mount Design												
~~Evaluate Accuracy~~ Zed mini Camera Calibration												
Skull and Ventricle segmentation with anatomic points												
Navigation system 2.0 without MRI												
Navigation system 3.0 with Catheter Tracking												
Documentation												
Evaluation of performance with skull phantom												
Final Presentation and Report												

Setbacks and Difficulties Solutions

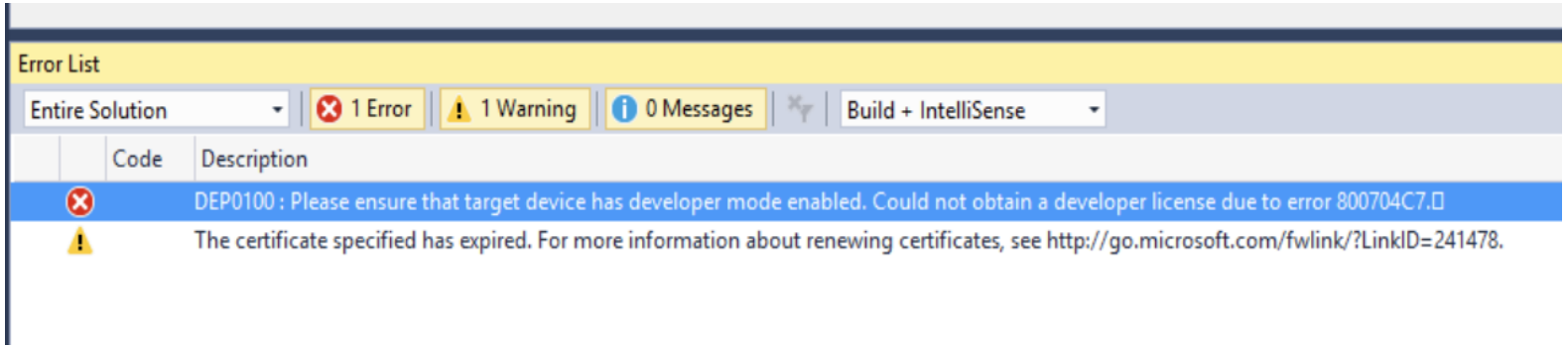
1. Problem with deployment
2. ZED SDK, CUDA installation
3. Unity Version
4. Hardware
5. Accuracy
6. Latency

CUDA 10.0 installation kills Windows 10

sergei.inyushkin

I am trying to install CUDA 10.0 on a fresh HP Omen lapto
but once I reboot it would never load Windows, goes to rec
and restoring OEM setup. Repeated second time, same re
Please advice. Thank you.

Posted 01/01/2019 06:05 PM



Milestones

Milestones	Date
Segmentation and 3D reconstruction of Skull and Ventricle	3/5 ✔
Deploy Application to HoloLens	3/23 ✔
Navigation System Without-MRI Mode	4/5 ✔ **Implemented, but**
Navigation System With-MRI Mode	4/10 ✔ **needed to be optimized**
ZED Camera Calibration	4/13 ✔ **Need Tuning**
Catheter Tracking	5/3
Evaluation of Performance with Skull Phantom	5/6
Final Report and Poster	5/9

Management Plan

	Member Responsibility
Mingyi	1. Segmentation and Reconstruction 2. Camera Mount Design， Skull Phantom Design 3. Catheter Tracking 4. Accuracy Evaluation
Yiwei	1. AR Tracking 2. Unity Implementation, AR Overlay 3. Registration 4. Camera Setup, Communication, Calibration 5. Accuracy Evaluation

- Weekly Meetings with mentors
  - Wednesdays 3 pm
- Team Meeting
  - Twice a week (Monday and Friday)
- Code
  - GitHub repository
- Documentation, Data and Reports
  - JH Box
  - Course Wiki page

Reading List

1. Azimi, E., Doswell, J., Kazanzides, P.: Augmented reality goggles with an inte- grated tracking system for navigation in neurosurgery. In: Virtual Reality Short Papers and Posters (VRW), pp. 123–124. IEEE (2012)
2. Azimi, E., et al.: Can mixed-reality improve the training of medical procedures? In: IEEE Engineering in Medicine and Biology Conference (EMBC), pp. 112–116, July 2018
3. Sadda, P., Azimi, E., Jallo, G., Doswell, J., Kazanzides, P.: Surgical navigation with a head-mounted tracking system and display. Stud. Health Technol. Inform. 184, 363–369 (2012)
4. Chen, L., Day, T., Tang, W., John, N.W.: Recent developments and future chal- lenges in medical mixed reality. In: IEEE International Symposium on Mixed and Augmented Reality (ISMAR), pp. 123–135 (2017)
5. Qian, L., Azimi, E., Kazanzides, P., Navab, N.: Comprehensive tracker based dis- play calibration for holographic optical see-through head-mounted display. arXiv preprint arXiv:1703.05834 (2017)
6. Saucer, F., Khamene, A., Bascle, B., Rubino, G.J.: A head-mounted display system for augmented reality image guidance: towards clinical evaluation for imri-guided nuerosurgery. In: Niessen, W.J., Viergever, M.A. (eds.) MICCAI 2001. LNCS, vol. 2208, pp. 707–716. Springer, Heidelberg (2001).
7. Azimi, Ehsan, et al.: 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*. Springer, Cham, 20-29.(2018).

Thank You!

Any Questions?