# HMD-Based Navigation for Ventriculostomy


*Computer Integrated Surgery II*

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*Mingyi Zheng and Yiwei Jiang, under the auspices of Professor Peter Kazanzides and Dr. Ehsan Azimi*


## Introduction

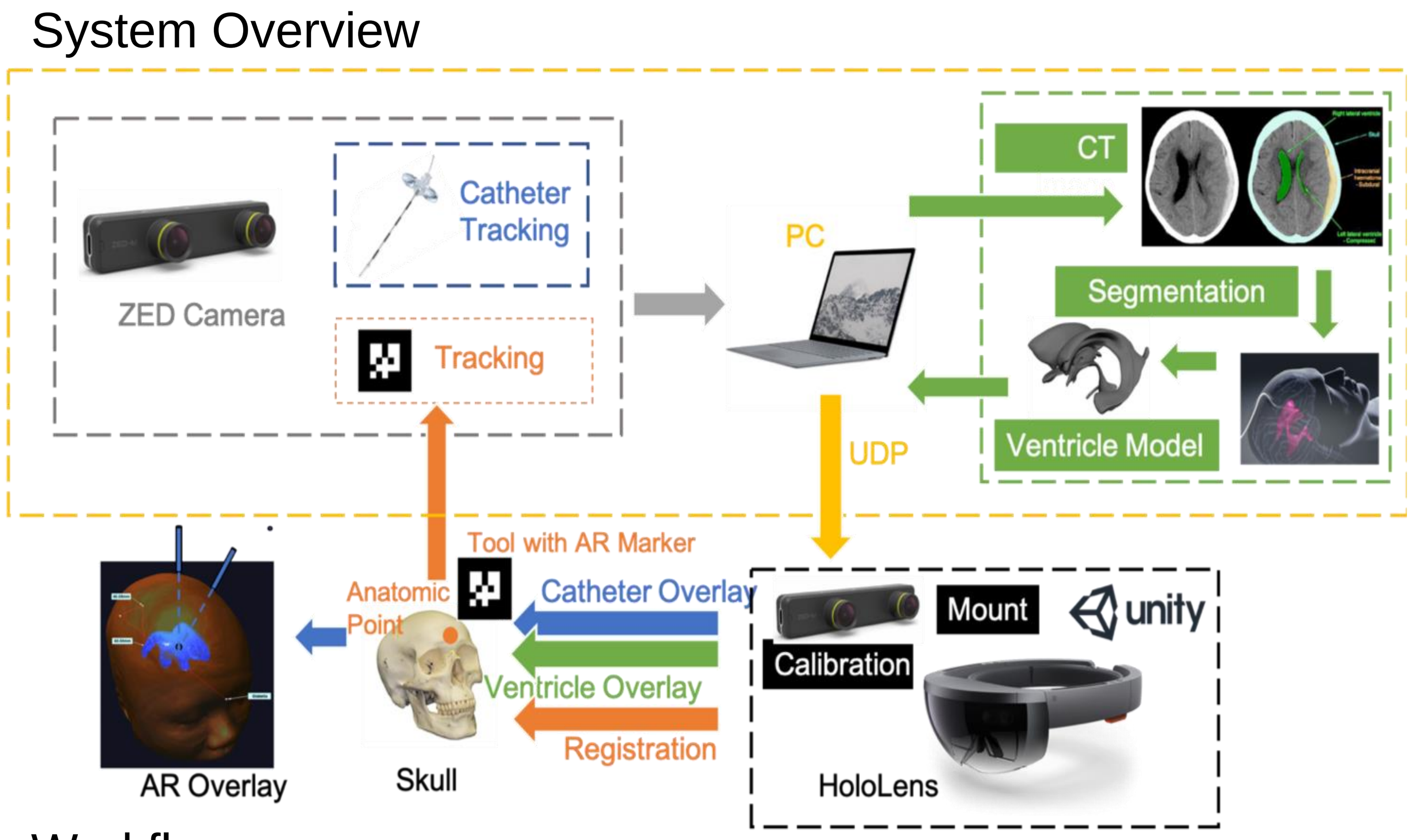
- The goal is to introduce image guidance via augmented reality on HoloLens to improve success rate of catheter placement in ventriculostomy
- The image guidance will include the AR overlay of
  1. Ventricle model from CT image
  2. Catheter guide overlay

## The Problem

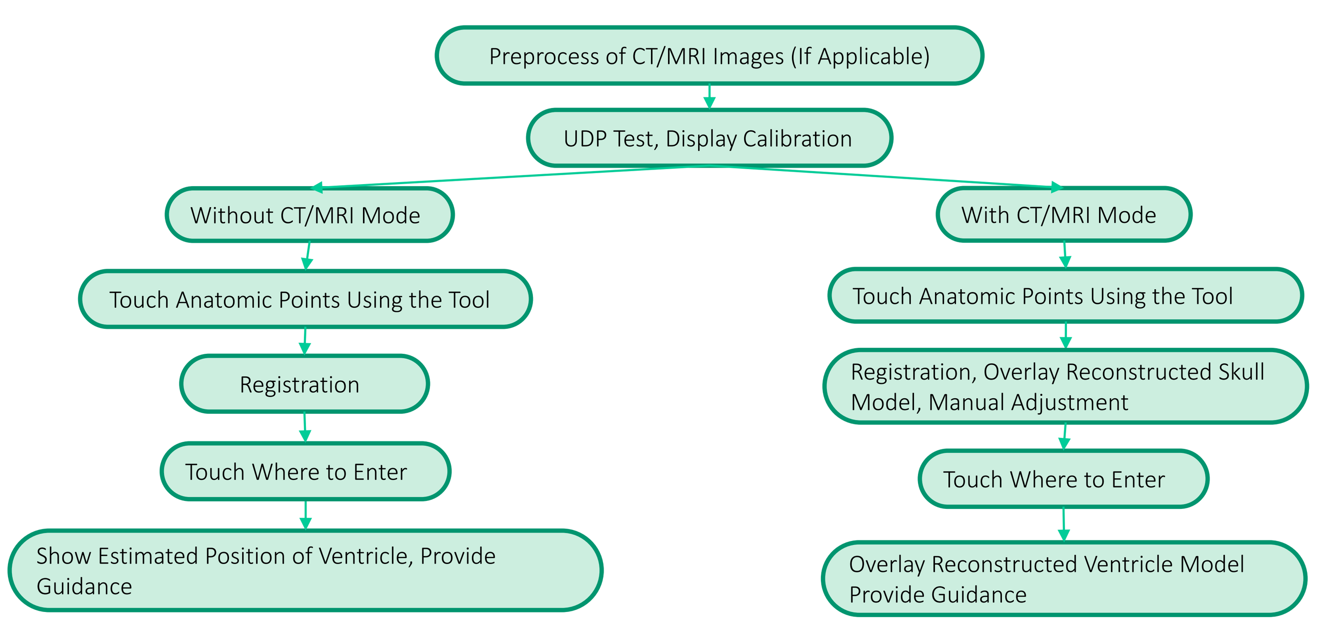
- Ventriculostomy is a neurosurgical procedure that involves creating a hole within a cerebral ventricle for drainage.
- Current procedure relies on surgeons to guess the location of ventricle from CT image and anatomic points, which leads to 30% catheter misplacement.

## The Solution

- System Overview




- Workflow




- Hardware
  Zed Mini for catheter tracking and AR tracking while providing larger field of view, the angle of view is also changeable.

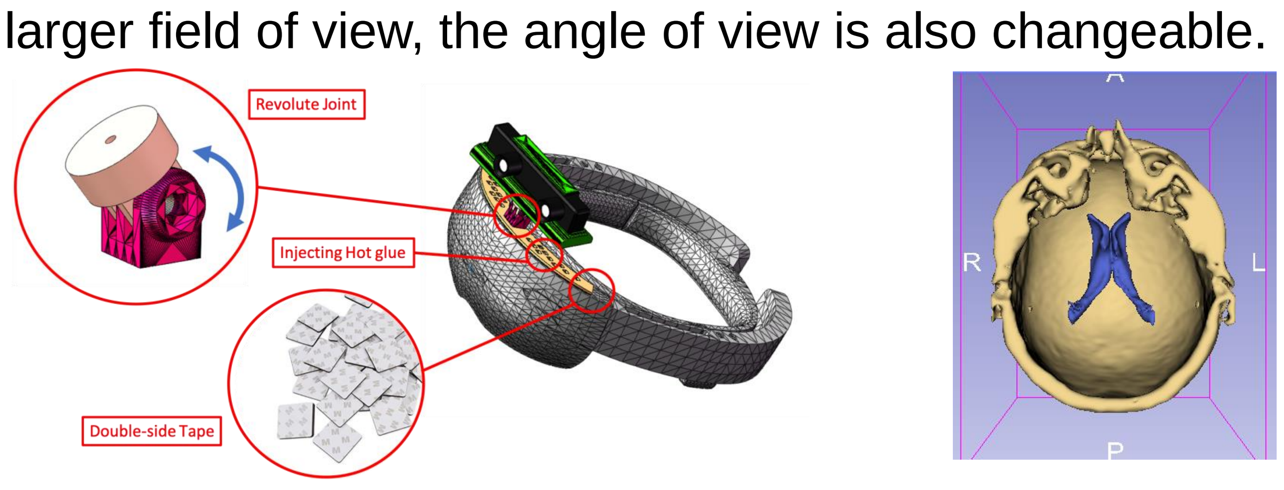



**Fig.1 (a) CAD Design (b) Reconstructed Model**

- Software Architecture
  The software of our system mainly consists of two parts, one is on PC, for AR markers tracking and depth sensing, another is running on HoloLens, for registration, AR overlay and UI.
- Calibration
  Pivot Calibration [1] for the pointer tip and Display Calibration [2] for OST-HMD overlay.

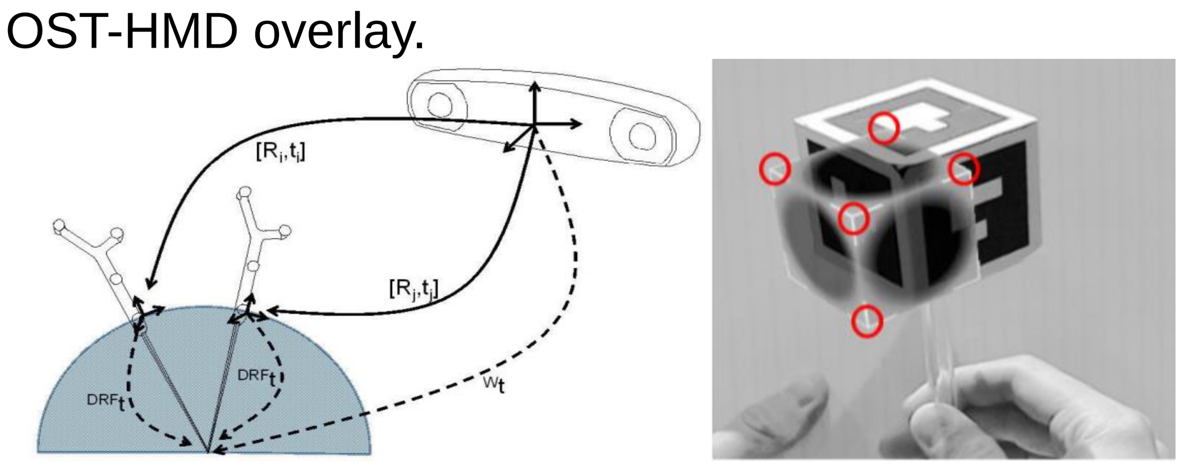


**Fig.2 Schematic (a) Pivot Calibration (b) Display Calibration**

- Registration
  Based on existing clinical workflow, we designed this Three-Point Registration process to register virtual skull models to its real counterpart. We added another Manual Registration process for better alignment.

- Catheter Tracking
  1. Generate mask Hand color tracking and depth info
  2. Probabilistic Hough transformation to find catheter endpoint
  3. Thresholding based on geometric constraint
  4. Calculate endpoint position and angle of catheter

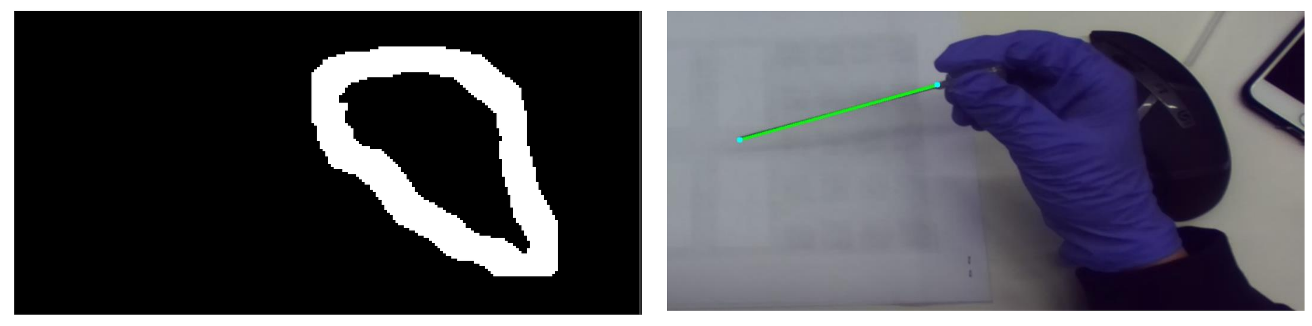


**Fig.3 (a) Hand Mask (b) Tracking Result**

## Outcomes and Results

User wear HoloLens to perform catheter insertion on skull phantom 5 times, record the number of time that hit ventricle to evaluate success rate. The score is compute by the following criteria:

- Center: 20
- Other region: 10
- Miss: 0

| **Without** HMD-based Navigation System | | | | | | Evaluation |
|---|---|---|---|---|---|---|
| Trial # | 1 | 2 | 3 | 4 | 5 | Total Score (100) |
| User 1 | 0 | 20 | 10 | 0 | 10 | 40 |
| User 2 | 0 | 0 | 10 | 10 | 10 | 30 |
| **With** HMD-based Navigation System | | | | | | Evaluation |
| Trial # | 1 | 2 | 3 | 4 | 5 | Total Score (100) |
| User 1 | 0 | 20 | 20 | 20 | 20 | 80 |
| User 2 | 20 | 20 | 20 | 20 | 20 | 100 |

**Table. 1 Pilot Tests Results**

**Fig.4 (a) Pilot Test (b) Overlay of Results**

We can obviously see that users perform better with the help of our navigation system.

## Future Work

- Yiwei will continue working on this project this summer.
- Machine Learning methods will be utilized for segmentation of skull and ventricle. Depth information probably will be taken advantage for registration based on ICP.
- Catheter tracking algorithm needs to be tested and integrated.
- Formal User Study and evaluation

## Lessons Learned

- AR overlay drift and latency due to HoloLens SLAM inaccuracy and processing performance
- Depth information from Zed Mini is inaccurate for reflective material of catheter coating.
- AR marker tracking is influenced by lighting and background

## Credits

- Yiwei is responsible for software design, AR marker tracking, registration, calibration, communication, Unity UI, tracking accuracy tests and evaluation, as well as user study evaluation.
- Mingyi is responsible for hardware design, ventricle and skull segmentation, catheter tracking algorithm design, skull phantom test design and user study evaluation.

## Publications


[1] Yaniv, Ziv. "Which pivot calibration?" Medical Imaging 2015: Image-Guided Procedures, Robotic Interventions, and Modeling. Vol. 9415. International Society for Optics and Photonics, 2015.

[2] 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)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