Simulation Assisted Navigation for Skull Base Surgery

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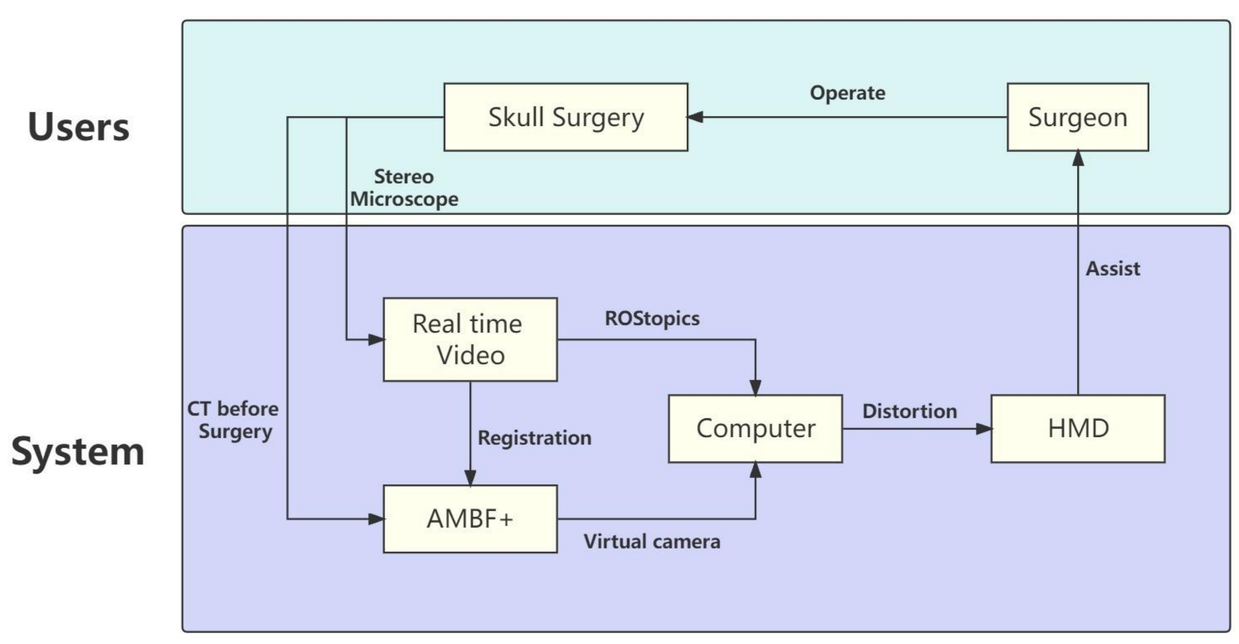
Introduction

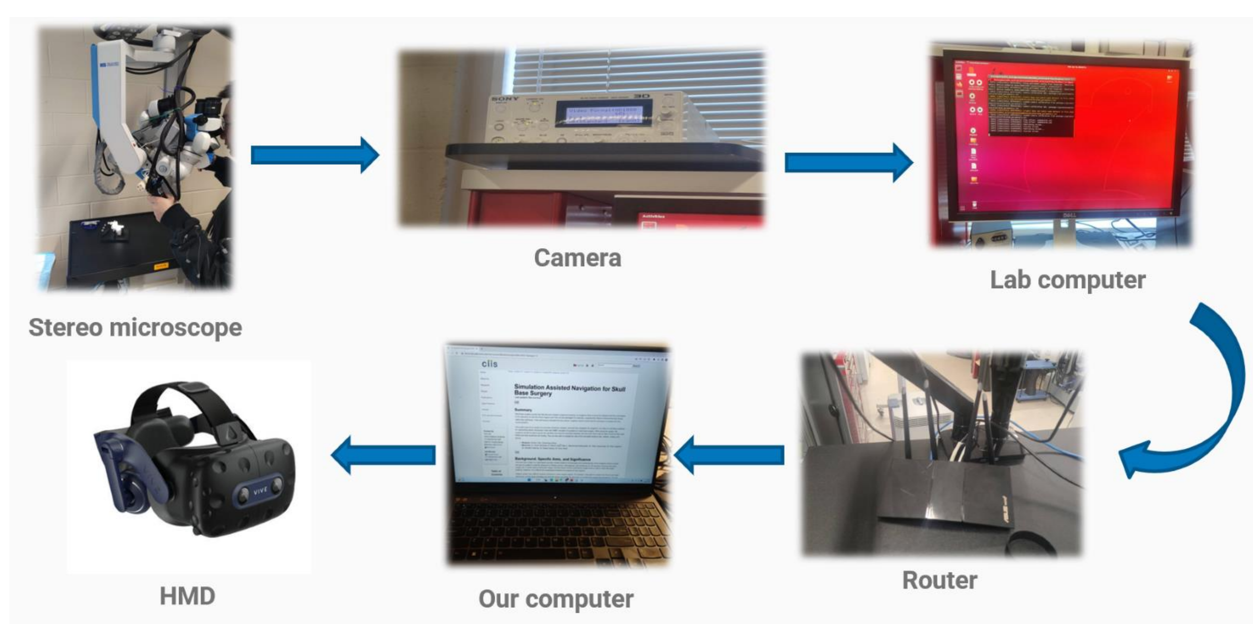
- During the skull base operation, surgeons hope to see both simulation and microscopic views of the anatomy so that the critical regions won't be hurt and damaged [1].
- Our project goal is to provide immersive, detailed, and real-time navigation for surgeons.
- We developed a pipeline for augmenting stereo microscopic video with AMBF simulation for guidance in skull base surgery.
- While performing the surgery, the surgeons can pause the operation and load the both simulation and microscopic view to get idea of how far have they drilled and what anatomies are nearby. (including change the view of simulated anatomy)

The Problem

- Skull base surgery usually has delicate and complex surgical procedures.
- Patients have usually different anatomy structures in some surgical regions [2].
- Surgeons normally rely on their experience with support of microscope to do the operation, which creates high risks of surgery [2].

The Solution

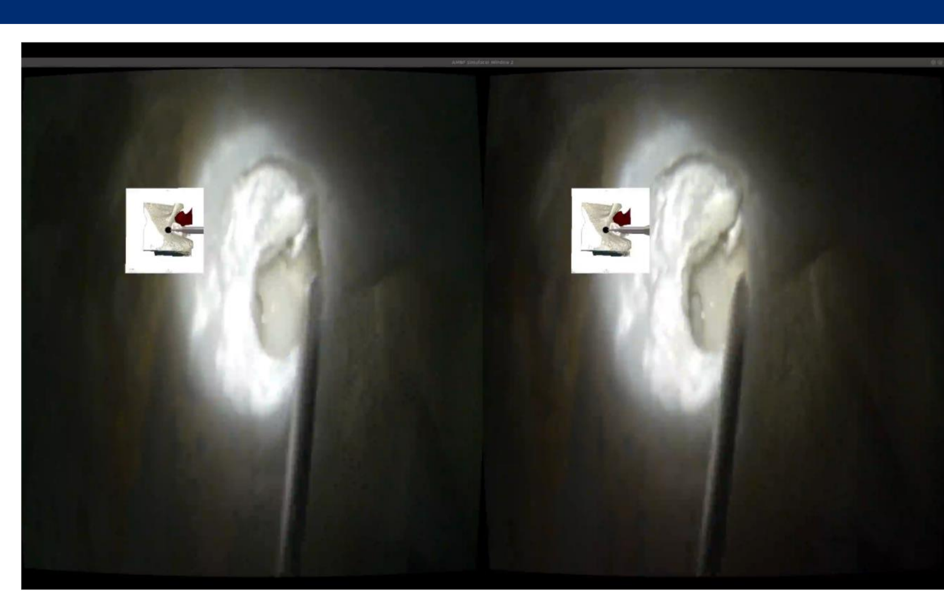


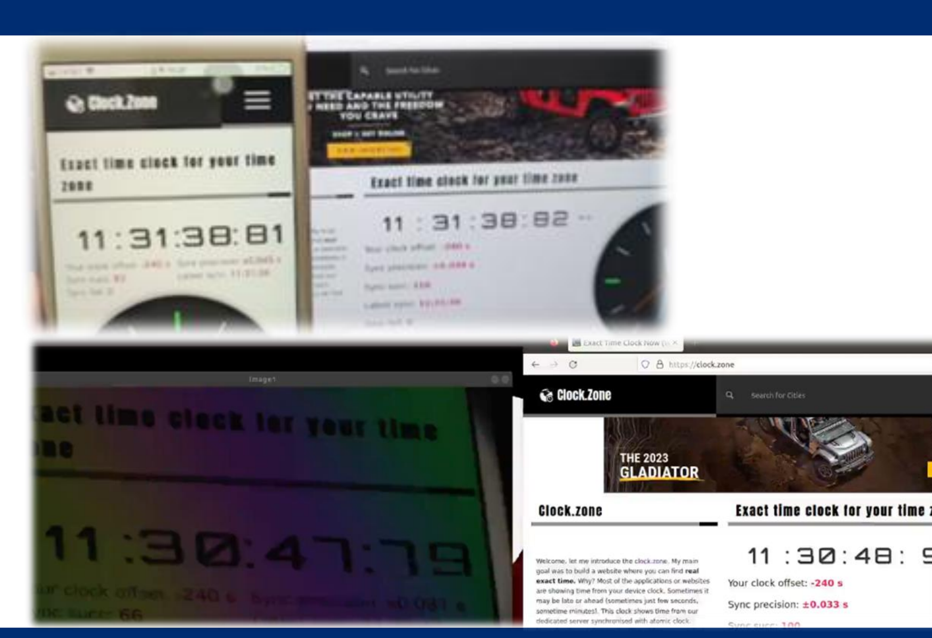


- Workflow: We have a stereo microscope to produce real time video from surgery. We also have CT scan before surgery to construct the model in AMBF. We already have ICP (Iterative Closest Point) registration through optical tracker system between real time video and simulation environments to connect them together [3]. This step enables the drill in AMBF+ to move and cut the same thing as the drill in real surgery. Then, we process both videos and transmit them to HMD. Surgeons can see both real time video and simulation video in HMD. They have four choices to view the videos.
- Read Videos: Both simulation and microscopic videos are published to ROS topics, so we read them using ROS subscribe method.
- Process Video: Distort the video so that it can be displayed on HMD. Followed by a third-degree polynomial describing radial lens distortion. a: Barrel distortion; b: Pincushion distortion; c: Even wavy distortion. $r_{src} = (ar_{dest}^3 + br_{dest}^2 + cr_{dest} + d)r_{dest}$ $\quad d = 1 - a - b - c$
- Display Video: VIVE Pro headset

Outcomes and Results

- Reading videos from stereo microscope
- Processing videos to fit HMD
- Showing two stereo videos together
- Four modes of views on HMD
- 0.3 seconds latency time





Future Work

- Integrate Registration
- Further minimize the latency time of this system
- Realize the user interface
- User study and user report

Lessons Learned

- Learned knowledge about OpenGL and ROS
- Improved C++ programming skill
- Understood the mechanism of VR distortion video
- Improved collaboration and communication skills

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Reference

[1] Munawar, A., Li, Z., Kunjam, P., Nagururu, N., Ding, A. S., Kazanzides, P., ... & Unberath, M. (2022). Virtual reality for synergistic surgical training and data generation. Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization, 10(4), 366-374.

[2] Skull base surgery. Skull Base Surgery | Johns Hopkins Medicine. (2019, November19). Retrieved February 14, 2023, from https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/skull-base-surgery

[3] Shu, H., Liang, R., Li, Z., Goodridge, A., Zhang, X., Ding, H., ... & Unberath, M. (2022). Twin-S: A Digital Twin for Skull-base Surgery. arXiv preprint arXiv:2211.11863.