



JOHNS HOPKINS

WHITING SCHOOL
of ENGINEERING

Checkpoint Presentation: Simulation Assisted Navigation for Skull- base Surgery

Group 13: Xinhao Chen, Zhaomeng Zhang

Mentors: Dr. Adnan Munawar, Dr. Manish Sahu, Max Li, Mohammad Salehizadeh, Dr. Peter Kazanzides, Dr. Pete Creighton, Dr. Danielle Trakimas, Dr. Deepa Galaiya, Dr. Russ Taylor

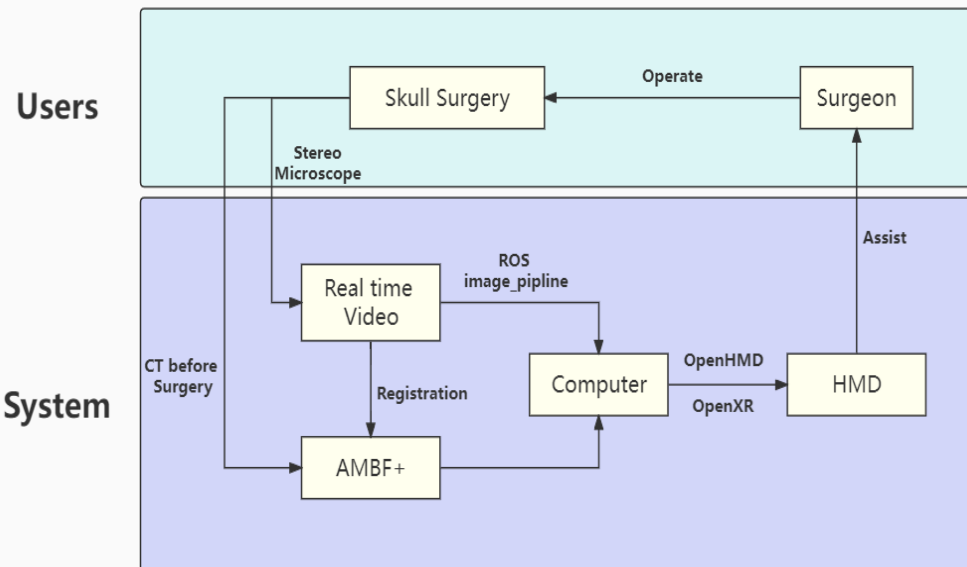
Project Summary

Problems of skull base surgery:

- Different anatomy of patients [1].
- Delicate and complex surgical procedures [2].

Goals:

- Provide immersive, detailed, and real-time navigation for surgeons.
- Develop a pipeline for augmenting stereo microscope video with AMBF simulation.



Dependencies

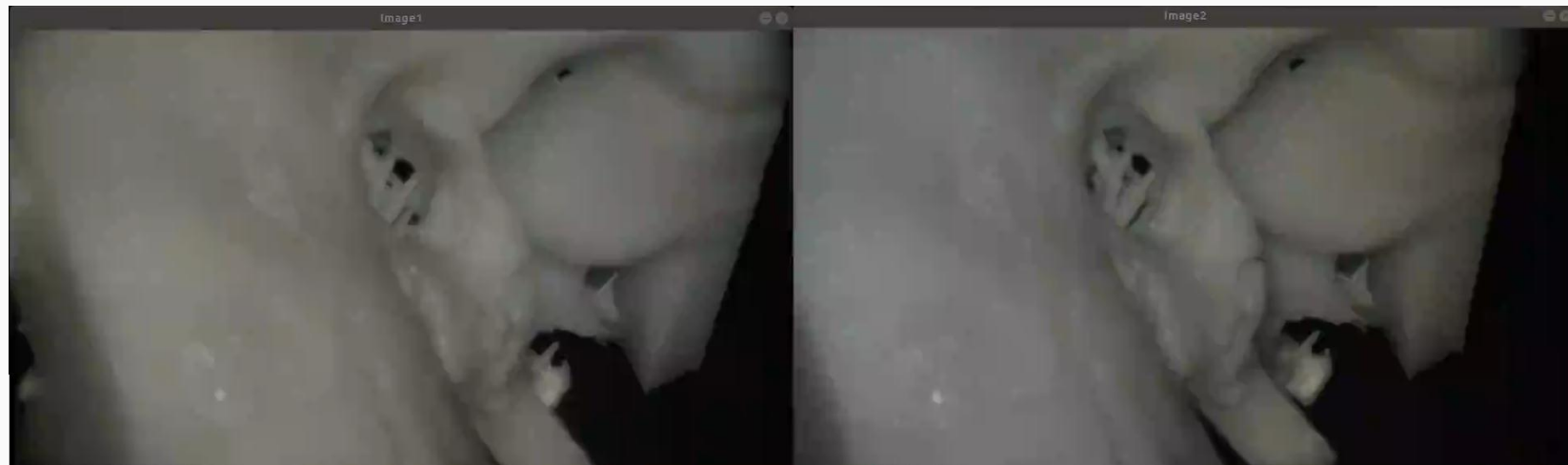
Dependency	Status	Contingency Plan	Planned DDL	Hard DDL
Install ROS on computer	Completed	Already Done	2/13/2023	2/13/2023
Install AMBF on computer	Completed	Already Done	2/13/2023	2/13/2023
Install OpenXR, OpenHDM, OpenCV on computer	Completed	Use computer in lab, or ask mentors for help.	2/20/2023	2/24/2023
Access to MockOR	Completed	Ask mentors to have access to other labs.	2/20/2023	2/24/2023
Hardware Check (HMD, Phantom Omni, Haag Streit Microscope)	Completed	Try to fix them if fails ask mentors to buy a new one.	Continuous	Continuous
IRB Approval	Not Start	N/A	7/1/2023	7/15/2023

Milestones and Status

	Deliverables	Key Milestones	Status
Minimum	A environment that can run AMBF codes.	Set up environment and learn AMBF codes.	100%
	An AMBF plugin that can read the video from stereo microscope.	Read the video from stereo microscope to computer in proper format.	100%
	An AMBF plugin that can process the stereo microscopic video for HMD.	Process the stereo microscopic video in the computer.	100%
Expected	A system with small latency time.	Minimize the delay of showing videos.	80%
	A system can display both simulation and anatomy videos in HMD.	Display all videos in HMD	30%
	An user interface for switch and control two videos.	Develop an user interface for the system.	70%
	An updated system with registration.	Perform anatomy registration.	0%
Maximum	An user study report.	Conduct user study with surgeons.	Plan to work in summer holiday
	A system can be applied in real skull-base surgery.	Update from the real operation to the simulation.	Plan to work in summer holiday

Completed Work - Read the video

- Set the host from MockOR computer to our laptop.
- Write AMBF Plugin to subscribe microscopic video topic and display it.



Completed Work - Process the video

CV images

CHAI3D Image

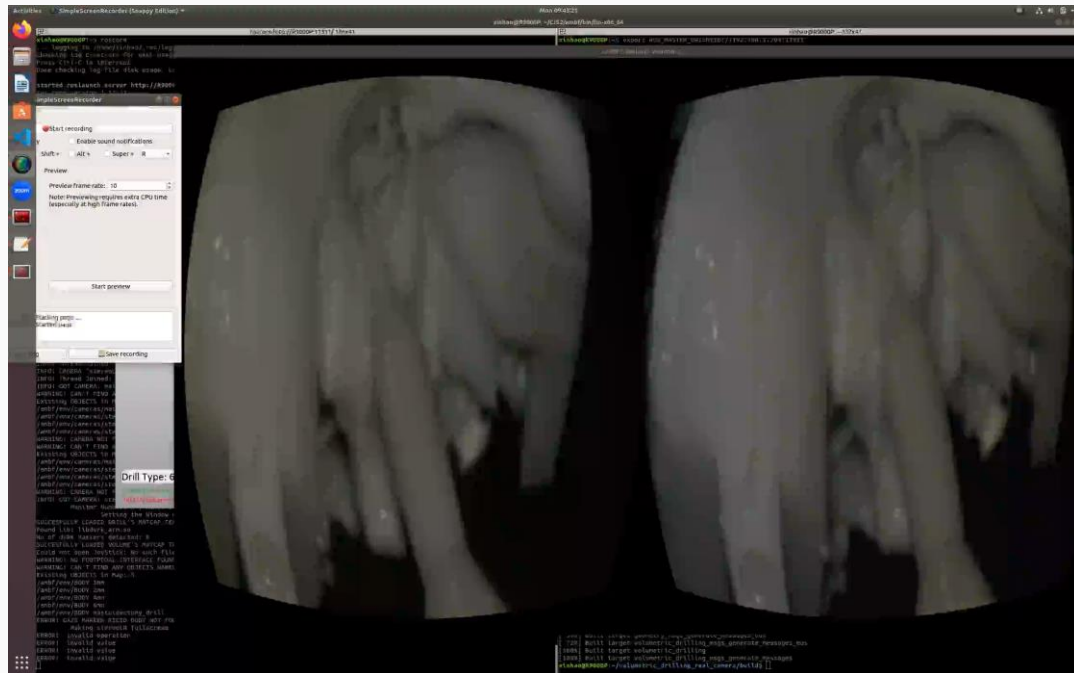
CHAI3D Texture

HMD processing
steps

Viewport Scale
Distortion Coefficient
Center of Right and Left Lens
.....

CHAI3D: an open-source set of C++ libraries for computer haptics, visualization and interactive real-time simulation.

OpenCV: a library of programming functions mainly for real-time computer vision



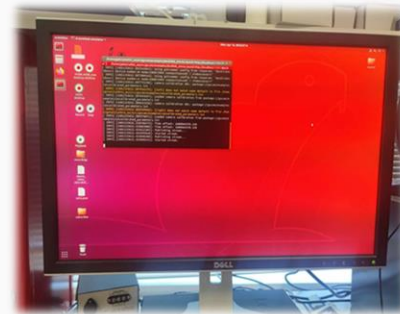
Completed Work - Measure the delay



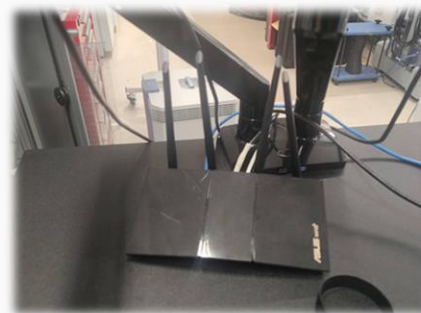
Stereo microscope



Camera



Lab computer

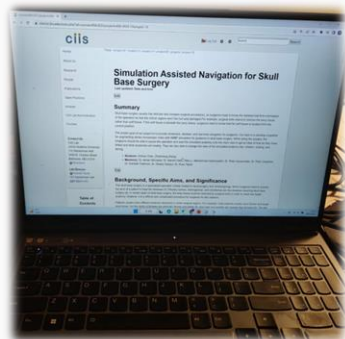


Router



HDF5,
ROSBags,
ROStopic

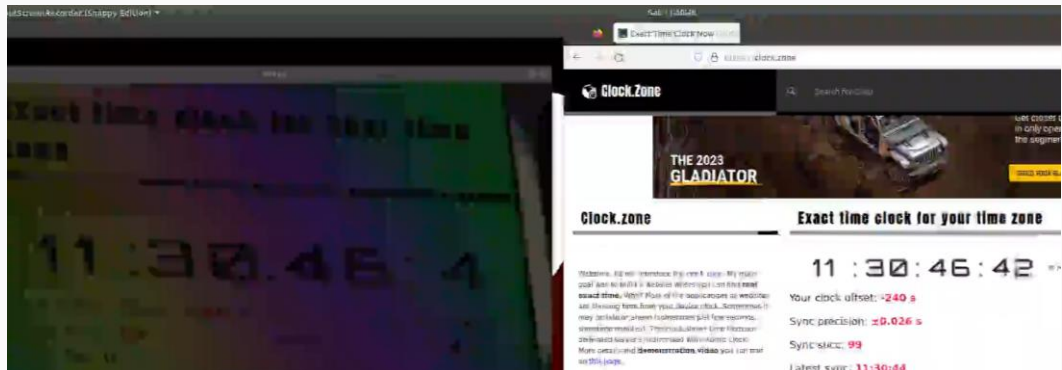
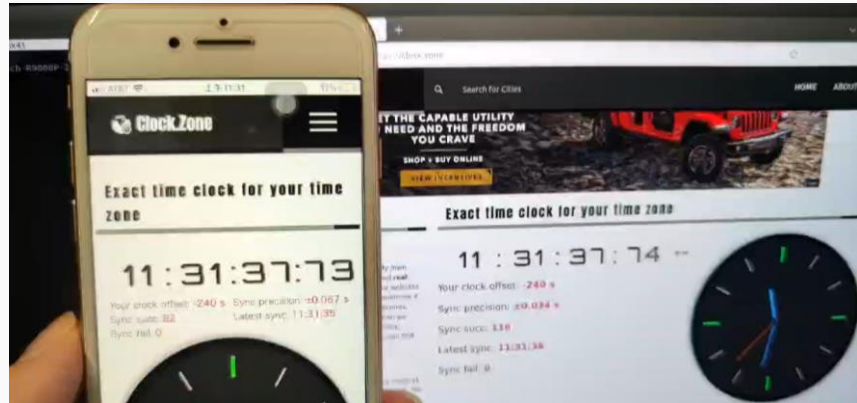
Compressed or **not**



Our computer

Completed Work - Measure the delay

- Find a website showing current time in millisecond
- Display that website on cell phone and computer
- Using the camera to record cell phone and show the video in computer



Completed Work - Measure the delay



→ -0.01~0.01 second offset

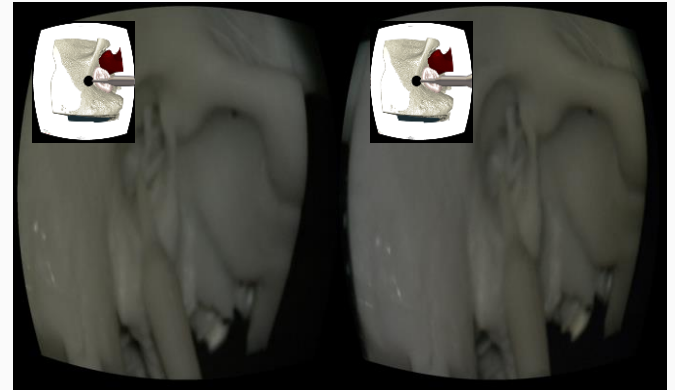
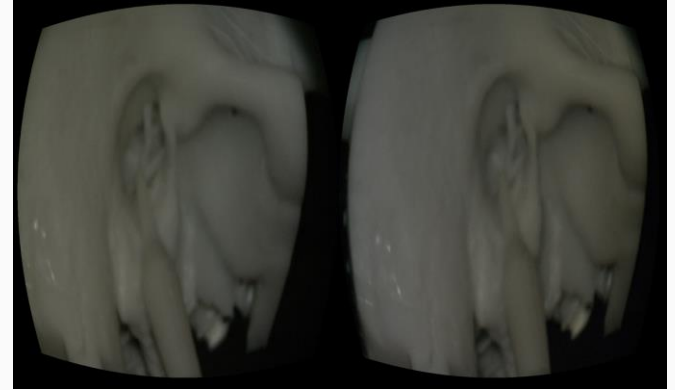
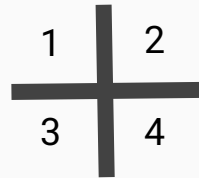
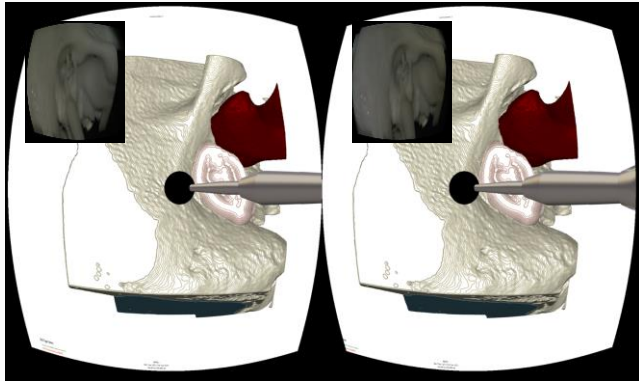
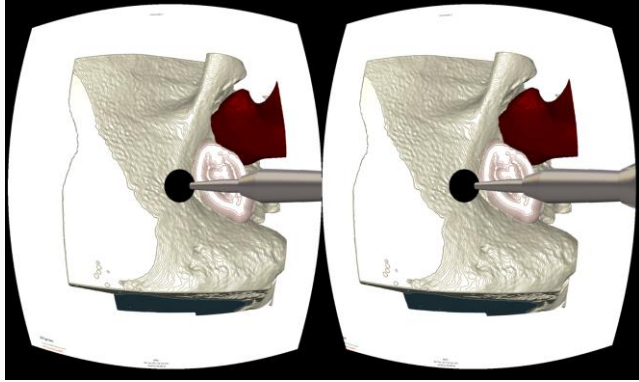
Latency time:
About 0.3 second



→ 0.27~0.32 second delay

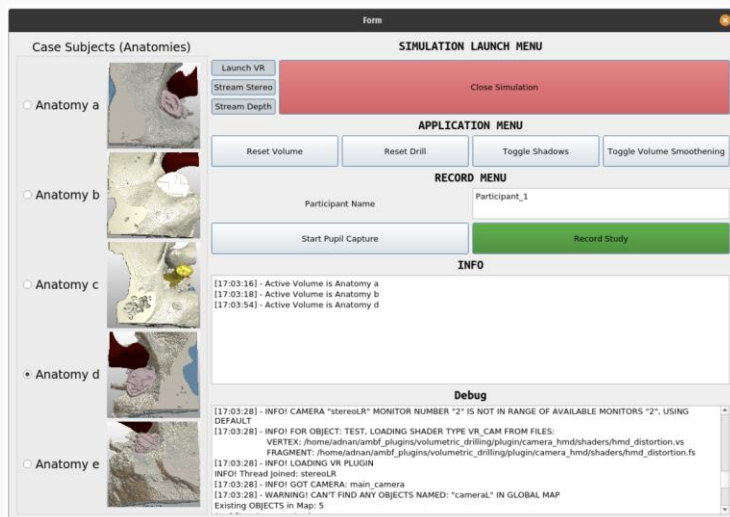
Completed Work - Develop user interface

Video modes to display



In-progress Work - Develop user interface

Ways to switch videos



Modify AMBF GUI [3]



Set shortcuts

1. Instruction documentation for codes (Uploaded in Github page)

Instruction documentation for codes

Overview

This fork adds the function that reading videos from real camera and displaying it in HMD together with videos from AMBF. To achieve this, we changes the 6 files based on original volumetric_drilling project. They are `~/ADF/world/world.yaml`, `~/launch.yaml`, `~/CMakeLists.txt`, `~/ADF/single_stereo_camera.yaml`, `~/plugin/camera_hmd/hmd.h` and `~/plugin/camera_hmd/hmd.cpp`. We will introduce these changes in detail.

"~/ADF/world/world.yaml"

World.yaml file determines the lights and cameras in AMBF simulation environment. We uncommnt all "publish image: true" for main camera, left camera and right camera to enable them to publish the video as rostopics. Then, we can subscribe these rostopics to read whichever video we want.

"~/launch.yaml"

launch.yaml file determines the meaning of number when start the AMBF in command. We may later wrap all the things into a new plugin for AMBF and add it in the launch.yaml.

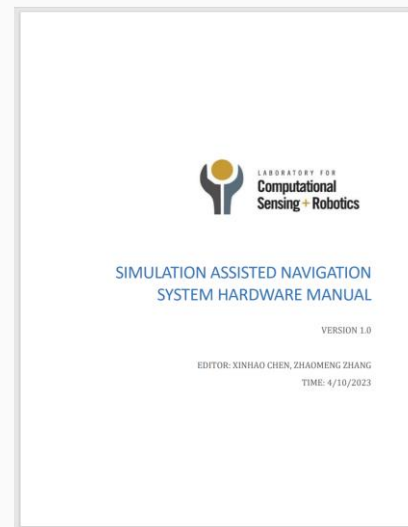
"~/CMakeLists.txt"

CMakeLists.txt determines the required environment for the whole program. We use several package which the original volumetric_drilling project does not need. So, we add them into `find_packages` and `catkin_packages` such as `ROS` package `sensor_msgs`.

"~/ADF/single_stereo_camera.yaml"

This file is launched when running 6 in the command. It only contains stereoLR camera in `volumetric_drilling` project. We add two more camera (`stereoL` and `stereoR`) so as to read stereo videos for HMD. The format for adding camera refers to `~/ADF/stereo_cameras.yaml`.

2. Hardware setup instruction (Uploaded in Wiki page)



- **Measure latency time: (Finished)**

- **Test whole system on model:**

Camera Calibration Accuracy, Drilling Simulation Accuracy[4]

- **Test whole system with surgeons: (Summer holiday)**

User study

Management Plan

- **Group meeting:**

Once a week with Dr. Adnan and other mentors on Wednesday

- **Communication:**

Microsoft Teams, Zoom, In person

- **Documentation:**

Microsoft Teams, Google Drive, Github



Roles and Responsibilities

Xinhao Chen: Read videos from microscope, Minimize the delay

Zhaomeng Zhang: Process videos to fit HMD

Together: Set up environment, Design user interface



- [1] Cousins, V.: Lateral skull base surgery: a complicated pursuit? *The Journal of Laryngology & Otology* 122(3), 221–229 (2008)
- [2] Munawar, A., Li, Z., Kunjam, P., Nagururu, N., Ding, A.S., Kazanzides, P., Looi, T., Creighton, F.X., Taylor, R.H., Unberath, M.: Virtual Reality for Synergistic Surgical Training and Data Generation. *Comp. Meth. in Biomech. and Biomed. Eng.: Imaging & Visualization* (2021)
- [3] Munawar, A., Li, Z., Nagururu, N., Trakimas, D, Kazanzides, P., Taylor, R.H., Creighton, F.X.: Fully Immersive Virtual Reality for Skull-base Surgery: Surgical Training and Beyond (2023)
- [4] 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*.



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Thank You