JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

Simulation Assisted Navigation for Skull base Surgery

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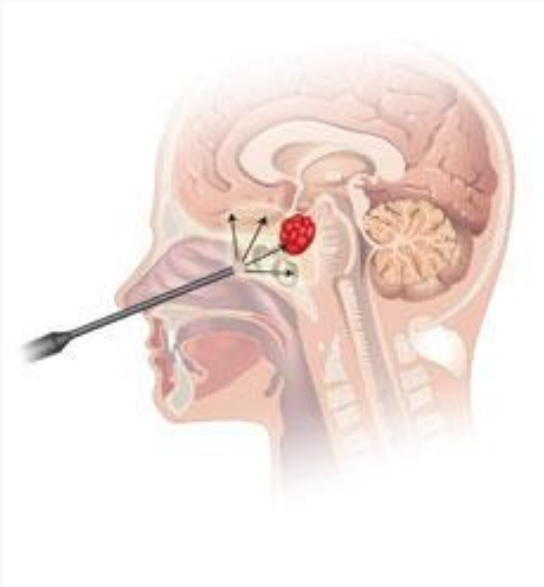
Project Background
Skull base Surgery

What's skull base Surgery?

- "Skull base surgery is a surgical subspecialty in neurosurgery and otolaryngology for surgical intervention of pathology within the base of the skull" [1].
- Remove the bony tissue and gain access to relevant anatomy by surgical drill [1].



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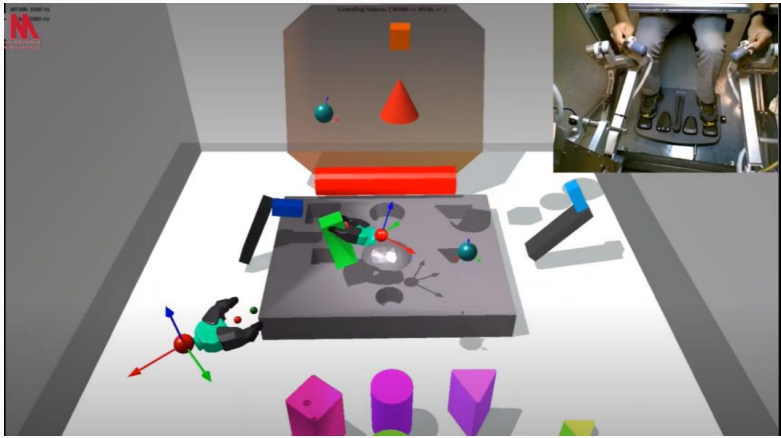
Project Background
AMBF

What's AMBF?

- Asynchronous multi-body framework (AMBF) is an open-source 3D versatile simulator for robots [5].
- This multi-body framework provides a real-time dynamic simulation of multi-bodies such as robots, paired with real-time haptic interaction with various input devices [5].



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Motivation

What are surgeon needs?

- **Stereo anatomy model**: Patients have different anatomy structures.
- **Real-time and Detailed information**: surgeons also hope to know the detailed real-time information so that the critical regions won't be hurt and damaged [1].

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Project Description

- Develop a pipeline for augmenting stereo-endoscope video with AMBF simulation for guidance in skull base surgery.
- Pause the operation and load the simulated anatomy to get real-time detailed information.
- Change the view of the simulated anatomy (rotation, scaling, and slicing).

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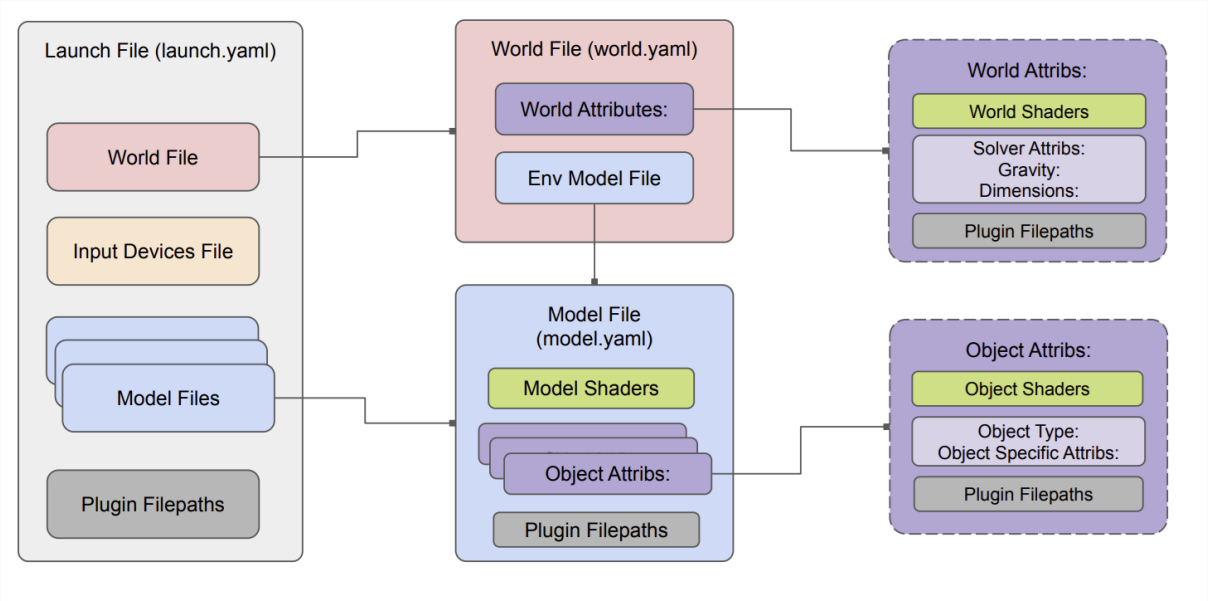
AMBF+

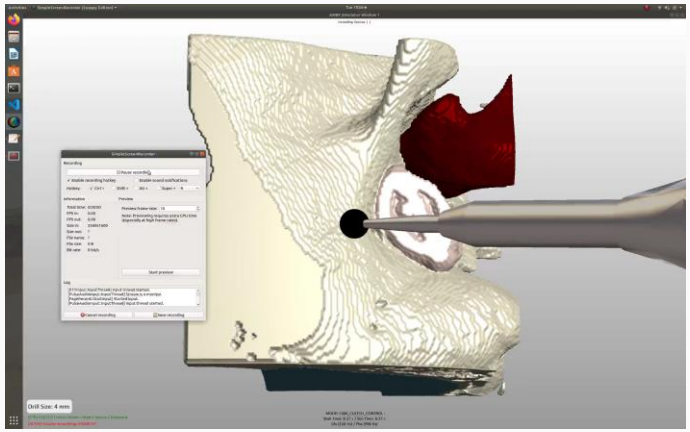
- Extended the rendering pipeline and AMBF Description Format (ADF) [1]
- ADF Files (three types): World files, Input devices files, and Model files.
- Modular plugin handling interface: custom application development [1].



Prior Work
Volumetric drilling

Fully Immersive Virtual Reality System (FIVRS)

- An immersive volumetric drilling simulator can load actual patient CT
- A haptic device to control a virtual drill
- a VR headset for an immersive stereoscopic view.



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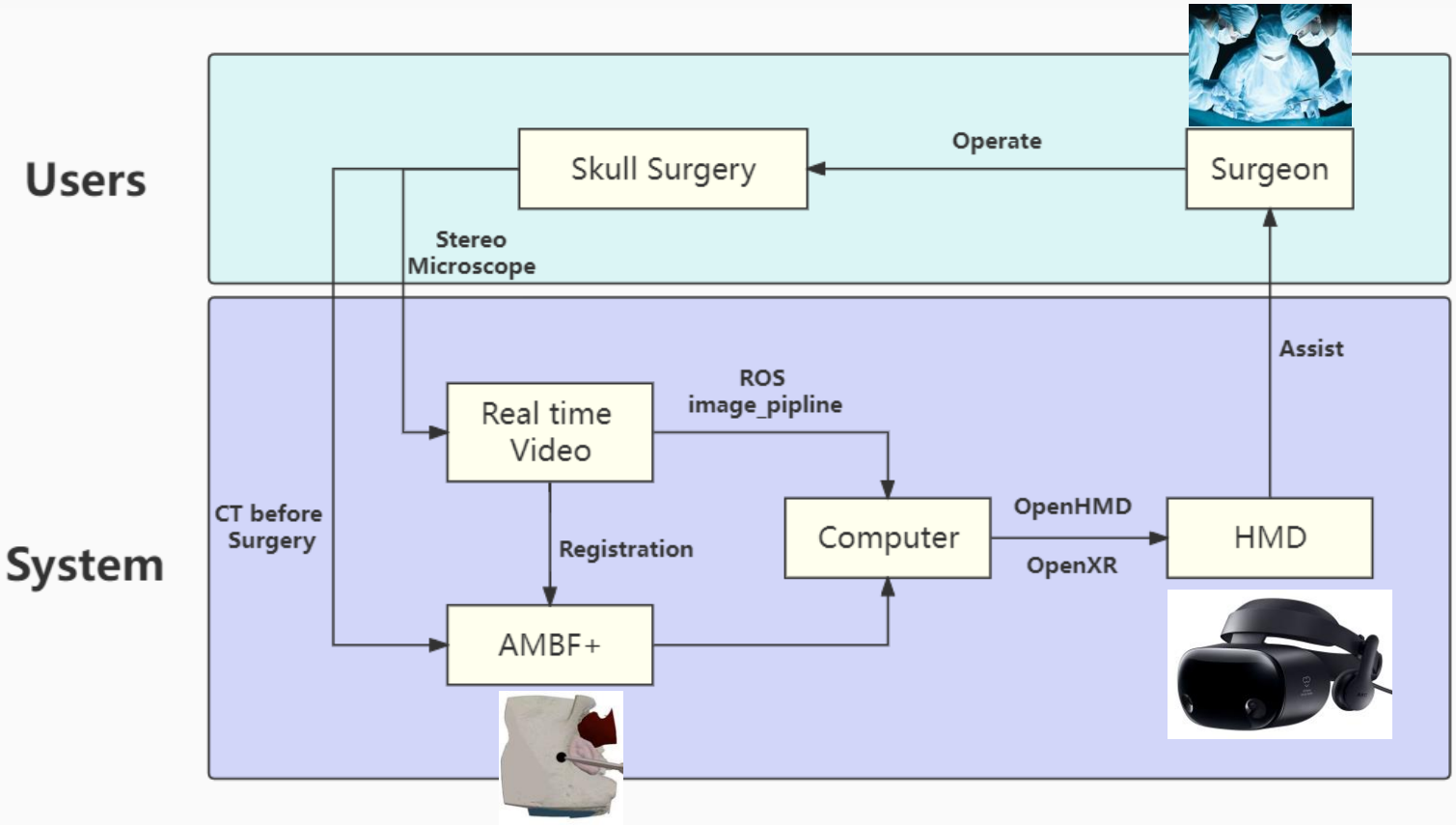
Technical Approach Overview



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Technical Approach
ROS Image_pipeline

“image_pipeline” fills the gap between getting raw images from a camera driver and higher-level vision processing. It can process raw camera images into useful inputs to vision algorithms.

ament_cmake

camera_calibration

depth_image_proc

image_proc

image_publisher

image_rotate

image_view

stereo_image_proc

ament_lint_auto

ament_cmake_lint_cmake

ament_cmake_xmllint

Technical Approach
OpenXR & OpenHMD

OpenXR seeks to simplify AR/VR software development, enabling applications to reach a wider array of hardware platforms without having to port or re-write their code.

OpenHMD can provide drivers for immersive technology, such as head mounted displays with built in head tracking.

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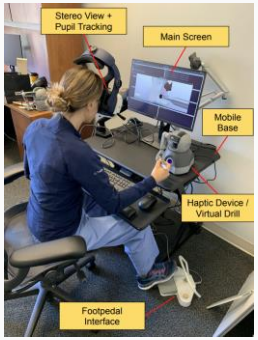
Dependencies

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 and OpenHDM on computer	On Going	Use computer in lab, or ask mentors for help.	2/20/2023	2/24/2023
Access to lab	On Going	Ask mentors to have access to other labs.	2/20/2023	2/24/2023
Hardware Check (HMD and Phantom Omni)	On Going	Try to fix them if fails ask mentors to buy a new one.	Continuous	Continuous

Testing Plan

- Test the whole system by ourselves on model (Latency time, Errors in registration)



- Conduct survey, take feedback from surgeons, focus on which video to display and how to display.

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Deliverables:

Minimum: Develop the pipeline to augment stereo endoscopic video with the AMBF simulation in an HMD and conduct surveys for UI development.

> Deliverables: A new version of the system which show simulation & real video in HMD, User study report about UI design

Expected: Perform anatomy registration and update from the real setup to the simulation.

> Deliverables: A new version of the system that can show real time simulation & real video in HMD

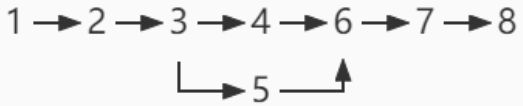
Maximum: Conduct user study with surgeons and present the system and findings in a paper.

> Deliverables: User study report

Milestones

1. Process the stereo microscopic video in the computer.
2. Display the video in HMD while operating.
3. Minimize the delay of showing video in HMD.
4. Integrate the video in HMD with AMBF.
5. Develop an user interface for the system.
6. Perform anatomy registration.
7. Update from the real operation to the simulation.
8. Conduct user study with surgeons.

Relationship:



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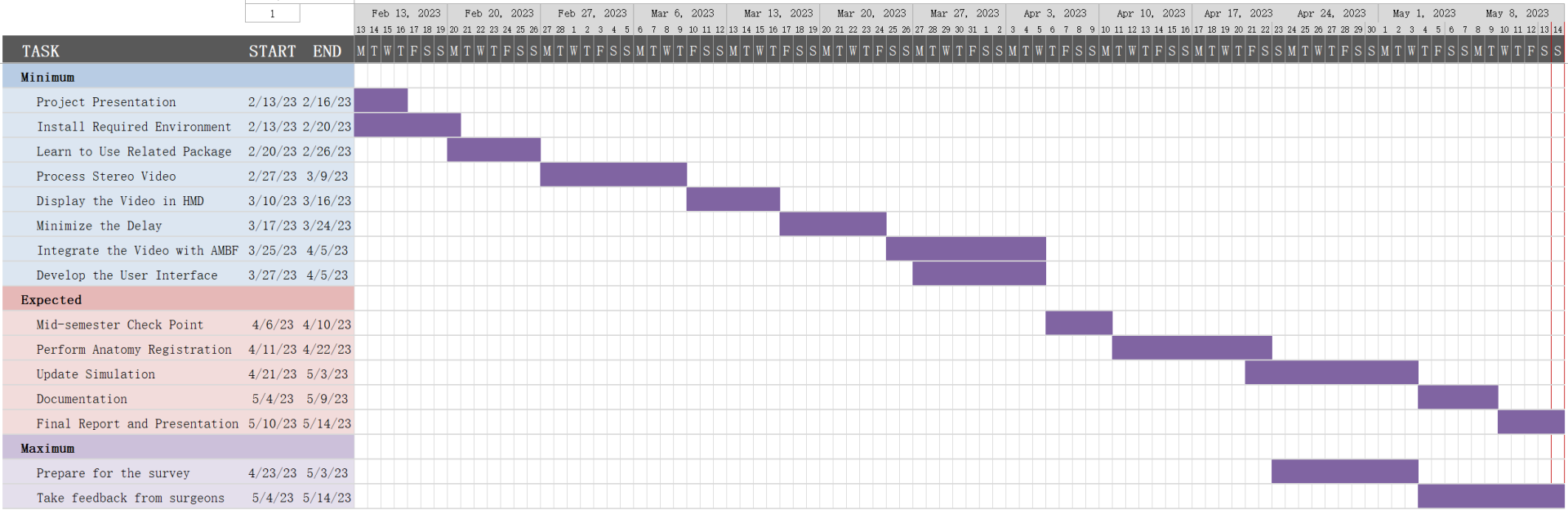
Timeline:

Simulation Assisted Navigation for Skull-base Surgery

Group 13

Mon, 2/13/2023
Sun, 5/14/2023
1



TASK	START	END
Minimum		
Project Presentation	2/13/23	2/16/23
Install Required Environment	2/13/23	2/20/23
Learn to Use Related Package	2/20/23	2/26/23
Process Stereo Video	2/27/23	3/9/23
Display the Video in HMD	3/10/23	3/16/23
Minimize the Delay	3/17/23	3/24/23
Integrate the Video with AMBF	3/25/23	4/5/23
Develop the User Interface	3/27/23	4/5/23
Expected		
Mid-semester Check Point	4/6/23	4/10/23
Perform Anatomy Registration	4/11/23	4/22/23
Update Simulation	4/21/23	5/3/23
Documentation	5/4/23	5/9/23
Final Report and Presentation	5/10/23	5/14/23
Maximum		
Prepare for the survey	4/23/23	5/3/23
Take feedback from surgeons	5/4/23	5/14/23

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Roles and Responsibilities

Xinhao Chen: Display videos in HMD, Minimize the delay, Perform anatomy registration

Zhaomeng Zhang: Processing and integrate video, Update based on real operation

Together: Design UI, Conduct survey

Management Plan

- **Group meeting:**

  Once a week with Dr. Adnan and other mentors

- **Communication:**

  Microsoft Teams, Zoom, In person

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References and Reading List

[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] Scholz M, Parvin R, Thissen J, Löhnert C, Harders A, Blaeser K. Skull base approaches in neurosurgery. Head Neck Oncol. 2010 Jul 5;2:16. doi: 10.1186/1758-3284-2-16. PMID: 20602753; PMCID: PMC2913918.

[3] Locketz GD, Lui JT, Chan S, Salisbury K, Dort JC, Youngblood P, Blevins NH. Anatomy-Specific Virtual Reality Simulation in Temporal Bone Dissection: Perceived Utility and Impact on Surgeon Confidence. Otolaryngol Head Neck Surg. 2017 Jun;156(6):1142-1149. doi: 10.1177/0194599817691474. Epub 2017 Mar 21. PMID: 28322125.

[4] Skull base surgery. Skull Base Surgery | Johns Hopkins Medicine. (2019, November 19). Retrieved February 14, 2023, from https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/skull-base-surgery

[5] Wikimedia Foundation. (2022, July 13). Asynchronous multi-body framework. Wikipedia. Retrieved February 14, 2023, from https://en.wikipedia.org/wiki/Asynchronous_multi-body_framework

Thank You