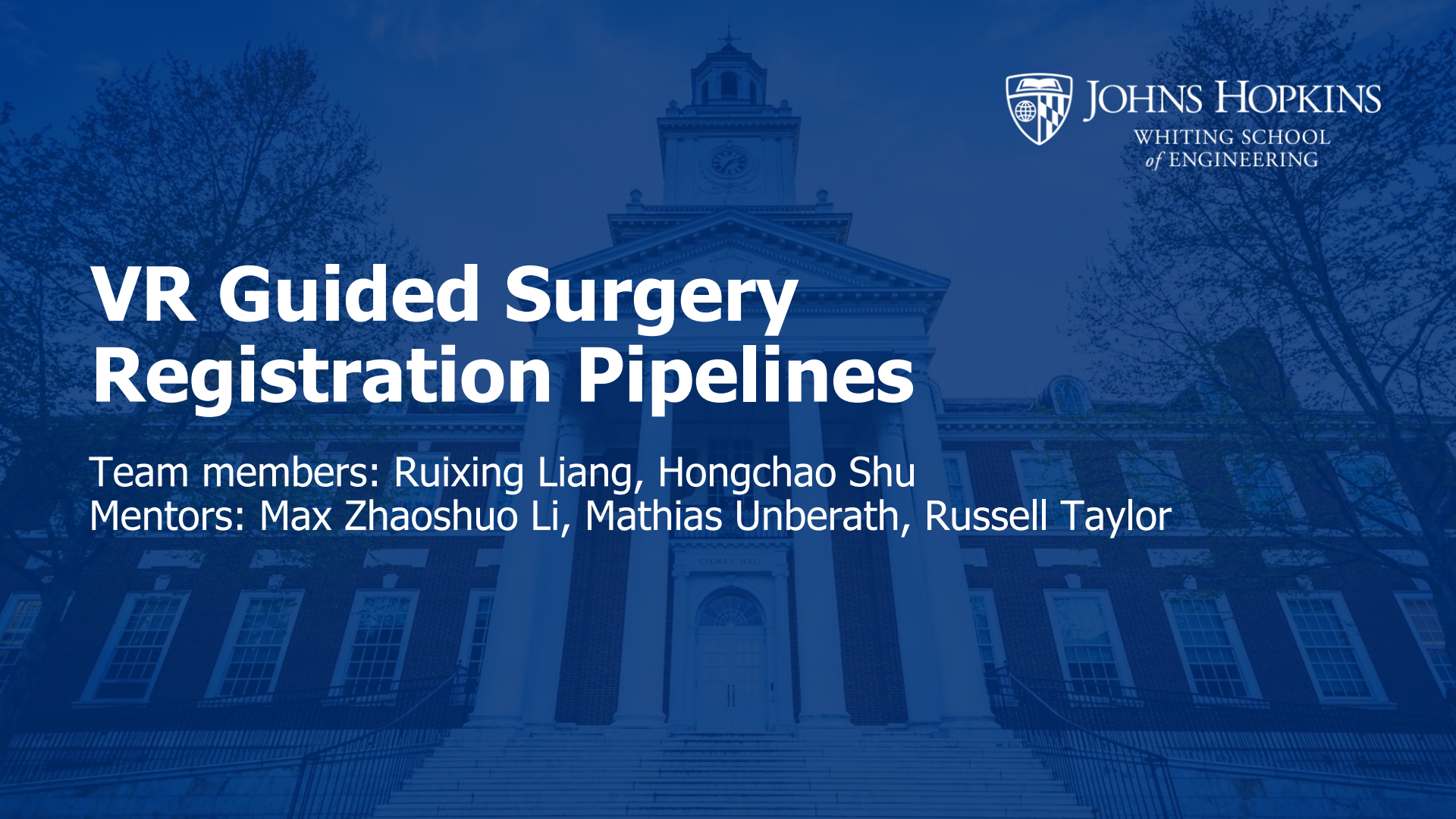


JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

VR Guided Surgery Registration Pipelines

Team members: Ruixing Liang, Hongchao Shu
Mentors: Max Zhaoshuo Li, Mathias Unberath, Russell Taylor

Overview

On Mastoid Surgery For Navigation

Background

Registration And VR Integration For Data Generation

Goal

Technical Approach
Dependencies
Deliverables
Milestones
Management

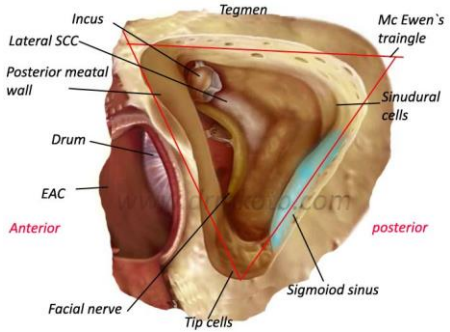
Plan

References

Reference

Background

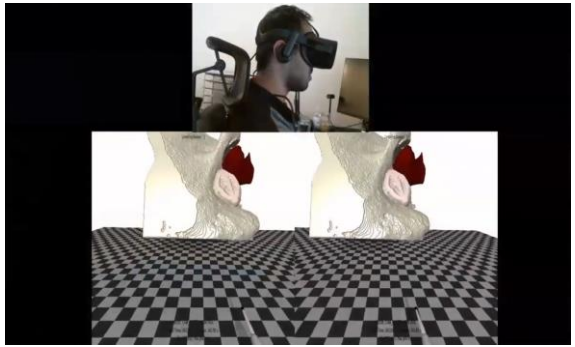
- Mastoidectomy is a common surgical procedure within otology. 30K ~ 60K patients goes through this procedure annually in US.
- Mastoidectomy with an experimental cooperatively controlled robotic system
- Surgical navigation system is needed
- Optical tracker and EM tracker can interrupt clinical workflow
- Stereo video-based motion tracking system is all we need

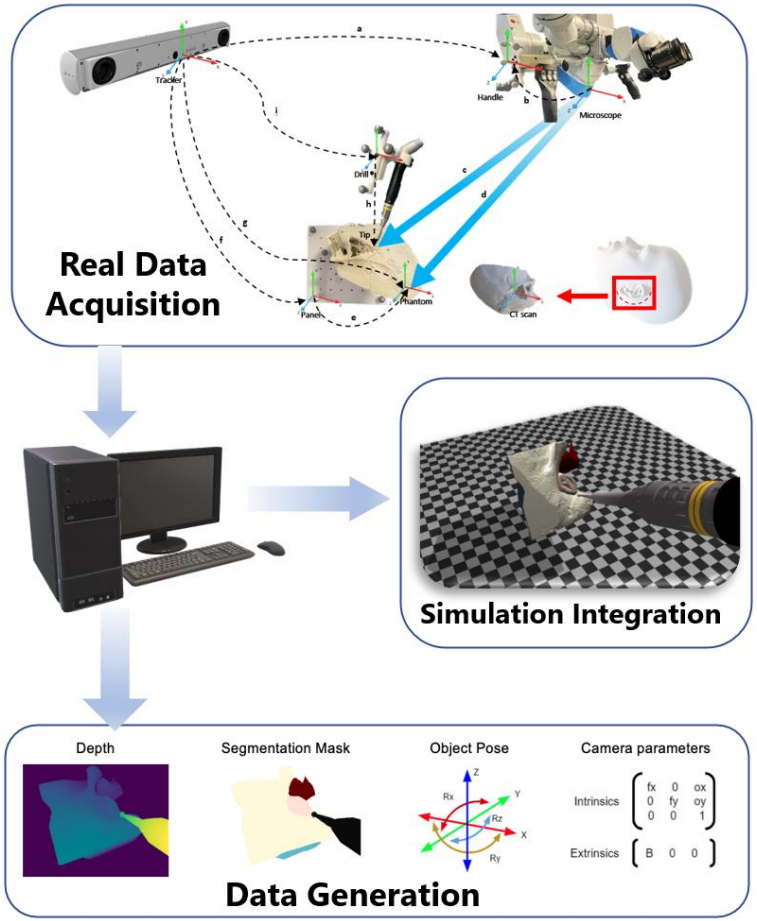


(Negi, 2015)

Goals

- Maintain accurate patient-to-tool registration for downstream applications
  - VR based surgery for Surgical training and pre-surgery planning
  - Integration of Virtual Reality and Real-world data to generate infinite and accurately-annotated images for Deep Neural Network training.



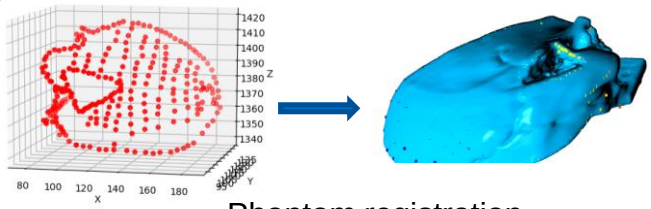


(A. Munawar et al. ,2021)

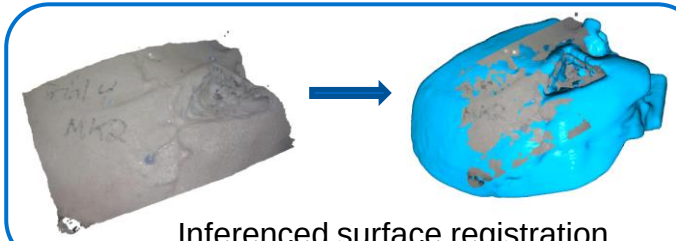
Technical Approach

- Calibration and registration between camera, tracker, drill, VR set, and phantom using open source library like Open3d
- Synchronize and time alignment using Rospy
- Integrate refined registration pipelines with VR, generate ground truth data from simulation scenarios

Stereo rectify



Phantom registration

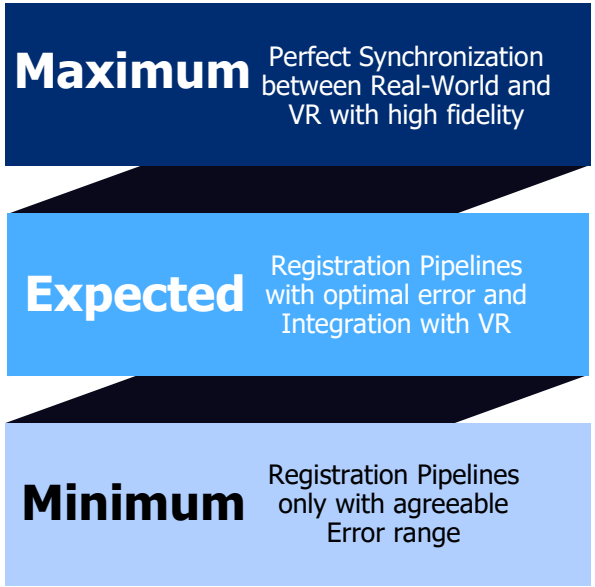


Inferenced surface registration

Dependencies

Item Name	Expected Time	Contact	Shared with	Status	Effect on milestones if not met
Atracsys Fusion track 500	1/22	Nick Greene	Nick Greene	Fulfilled	N/A
HS Allegra 500 with Desktop	1/21	Anna Goodridge	N/A	Fulfilled	N/A
Optical marker * 13	1/22	Nick Greene	N/A	Fulfilled	N/A
Phacon	1/31	Anna Goodridge	N/A	Fulfilled	N/A
Pointer	1/23	Jonas Winter	Jonas Winter	Fulfilled	N/A
J&J Driller	1/31	Anna Goodridge	Jesse Haworth	Fulfilled	N/A
VR simulation environment code	2/28	Max Li	N/A	Fulfilled	N/A
VR Headset	Before 4/9	Max Li	TBD	Pending	Time Delay, or simulate on PC only

Deliverables



As part of VR guided surgery project, we are happy to develop the integration of all if possible.

- Minimal deliverables have been developed during the MICCAI submission process. Registration pipeline ready to work now.
- Expected deliverable will be integration of VR using refined version of registration.
- Maximum deliverable will be even possibly beyond the scope of this course but partial accomplishment could be within this term
- **Form: Documentations, Demo, Paper**
  Library of Codes for CIIS, and Data

Milestones

01 Hardware Setup

Accomplished on Jan 31st.
Huge credit to Anna

02 Initial Pipeline

Accomplished on Feb 14th.
Batches of data were collected and manually labeled and evaluated by Max

03 VR Integration

After verification of accuracy and error analysis
VR will be integrated and expected to be available on Apr 10th

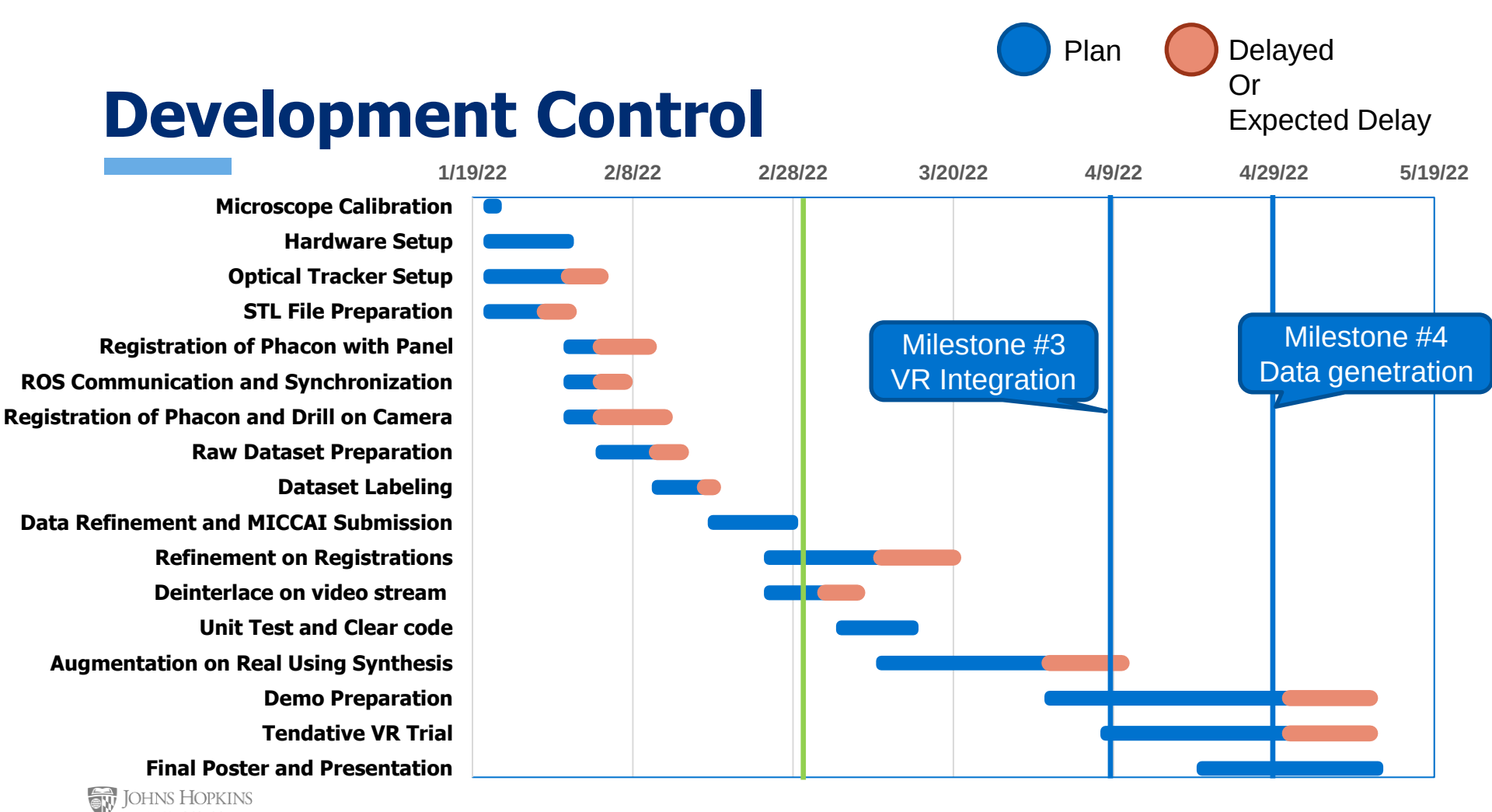
04 Data Generation

Augmentation on the dataset harnessing the registration accuracy in ROS synthesis environment will be tested at the final stage of our project in Apr 24th

(If Integration is not ideal on VR Headset, alternative to use rviz for visualization of VR is still possible.)

(If the results of the data generated for training DNN perform worse or tie with existing solution, we may downgrade our deliverable to expected rather than Maximum)

Development Control



Management

Code Management

Code will be uploaded to Github for version control and collective collaboration

Communication

Weekly Meeting via Zoom
and IM tools using Wechat Slack and Email

Dev Control

According to Gantt Schedule, progress will be evaluated routinely to optimize Dev

References

- 1. L. C. French, M. S. Dietrich, and R. F. Labadie, "An estimate of the number of mastoidectomy procedures performed annually in the United States," Ear Nose Throat J **87**(5), 267–270 (2008).
- 2. F. Furrer et al., "Evaluation of Combined Time-Offset Estimation and Hand-Eye Calibration on Robotic Datasets," in Field and Service Robotics, M. Hutter and R. Siegwart, Eds., pp. 145–159, Springer International Publishing, Cham (2018) [doi:10.1007/978-3-319-67361-5_10].
- 3. C. R. Razavi et al., "Image-Guided Mastoidectomy with a Cooperatively Controlled ENT Microsurgery Robot," Otolaryngol Head Neck Surg **161**(5), 852–855, SAGE Publications Inc (2019) [doi:10.1177/0194599819861526].
- 4. V. M. E. | 2841 N. H. R. Owensboro and K. 42303 | Office:691-6161, "Mastoid Surgery," in Midwest Ear, Nose and Throat Head & Neck Surgery.
- 5. A. Munawar et al., "Virtual Reality for Synergistic Surgical Training and Data Generation," Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization, 1–9 (2021) [doi:10.1080/21681163.2021.1999331].