Group 9: Eye-in-Hand Range Image Registration for Surgical Robot

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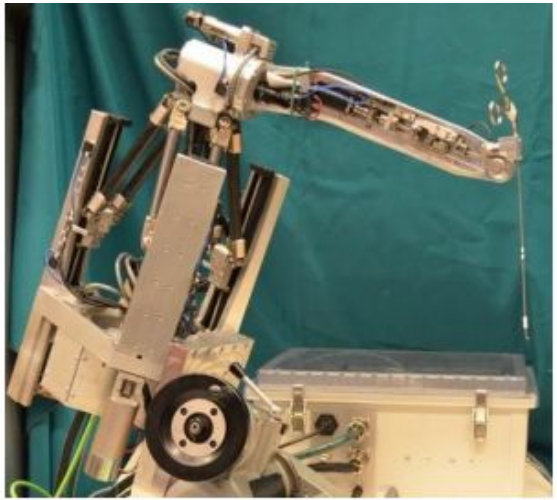
Project Summary

Register point cloud from a RGBD camera with a mesh from a CT scan to make setting up and aligning the robot easier and more accurate.



Technical Approach

Mesh

- Slicer to convert DICOM to STL
- Convert STL to standard triangle mesh

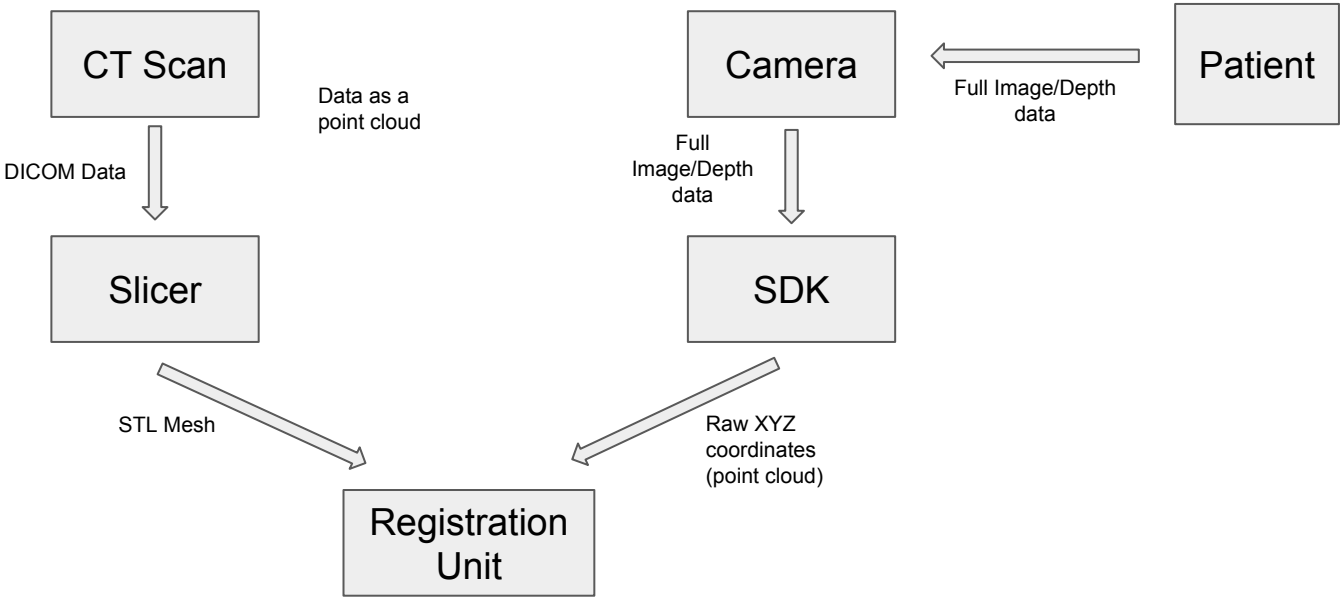
Point Cloud

- Obtain depth data as raw XYZ coordinates from camera
- Convert to PCD to visualize with PCL

Registration

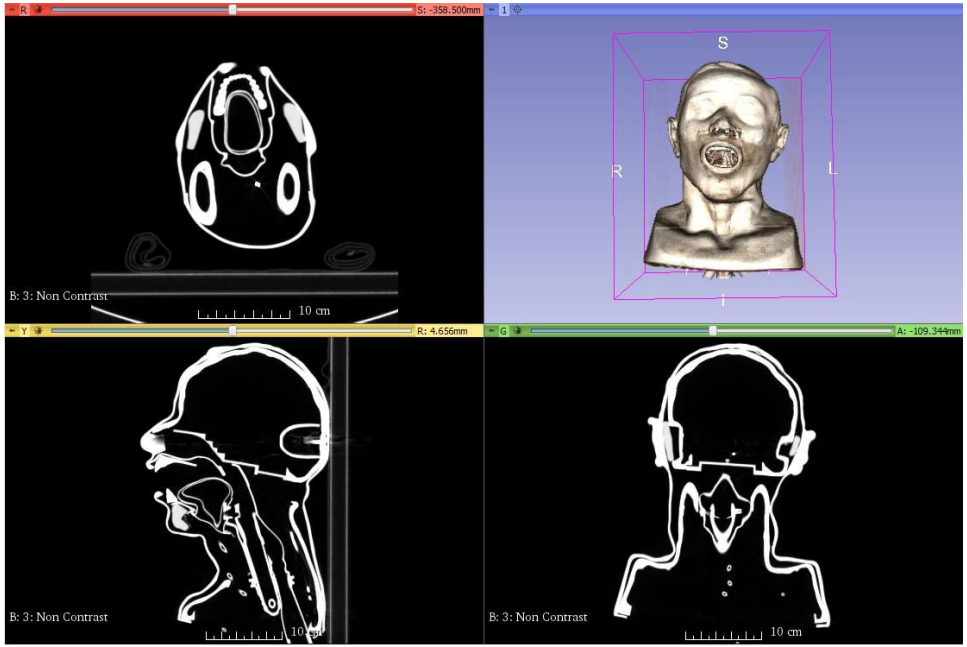
- Run robust ICP algorithm from Seth Billings

Technical Approach: Information Flow



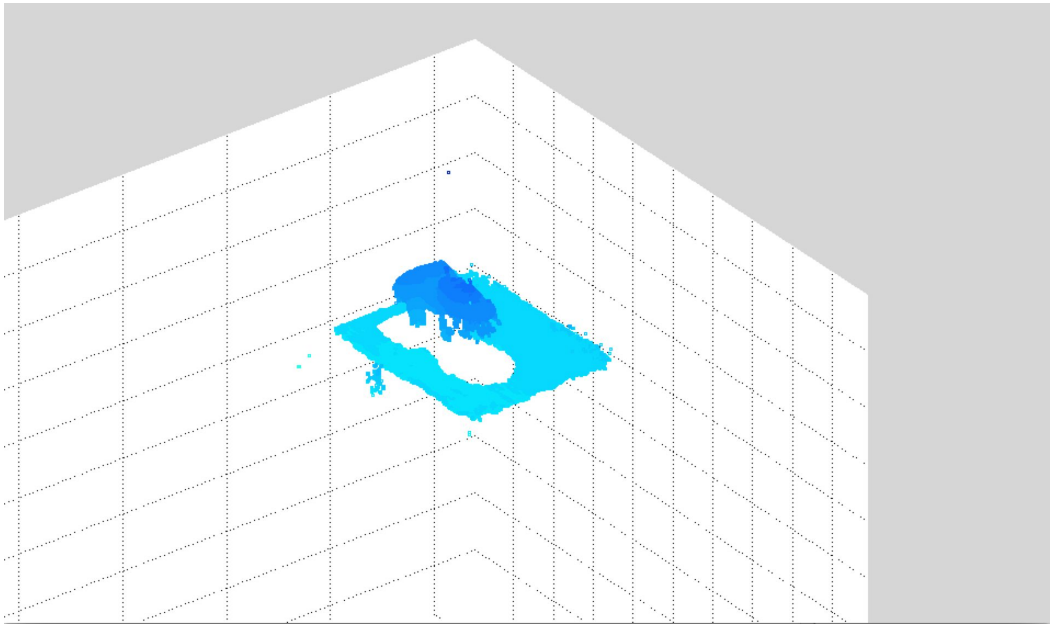
Current Progress

Conversion of DICOM data to mesh via Slicer



Current Progress

Obtaining point-cloud data from camera using librealsense SDK



Challenges

Getting Point Cloud from Intel Camera

Setting up CISST libraries

General CPP building errors/environment issues

Dependencies

Intel RealSense Camera - ✓

Camera to Robot Mount - ✓

Camera SDK (librealsense) - In Progress. We are experiencing some errors with the open-source software.

ICP and CISST libraries - Almost Complete.

Access to REMS Robot - ✓

CT Scans for Phantom - ✓

Previous Deliverables

Minimum: Register between pre-operative model and camera point cloud

Expected: Test registration accuracy on a phantom with a CT image
Provide some type of guidance to robot operator
AX = XB calibration to get camera position relative to robot

Maximum: Find ideal starting pose for robot and assist in initial setup
or Track robot motions using camera throughout operation
or Deformable registration using statistical atlas

Updated Deliverables

Minimum: Software that completes a registration between pre-operative model and camera point cloud

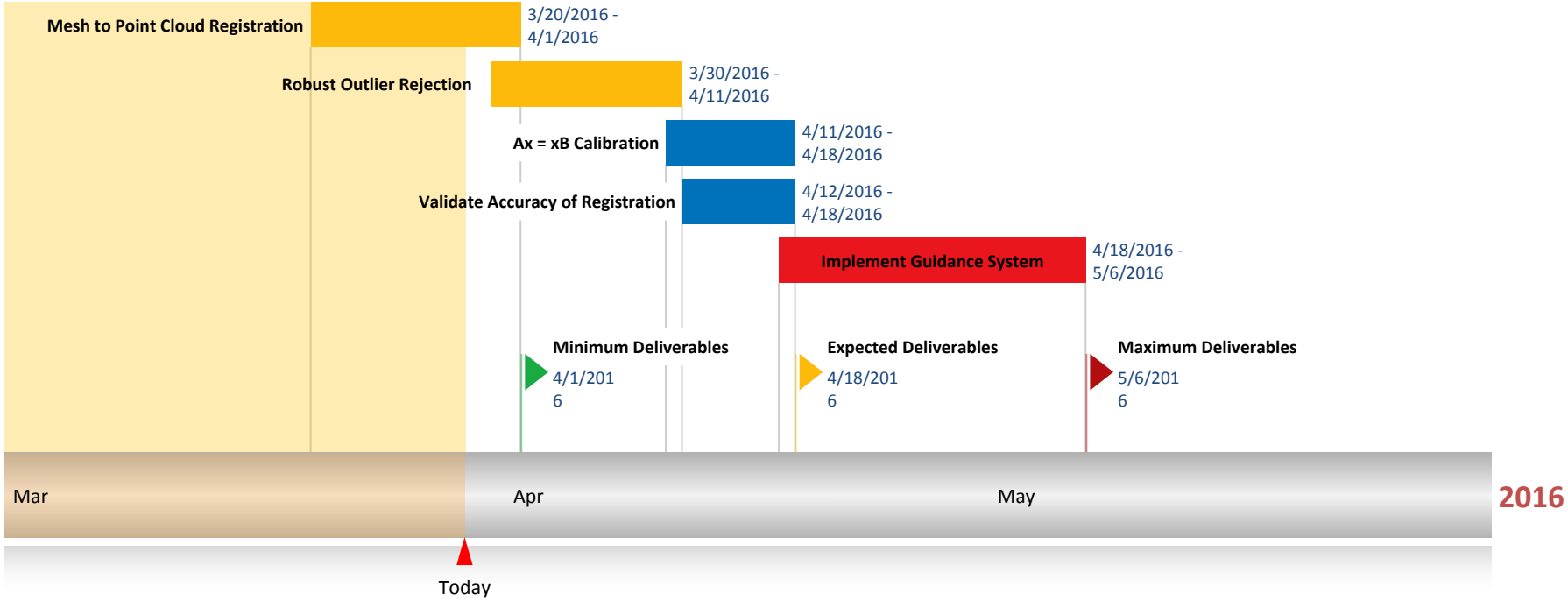
Design documentation of said software

Expected: Rigorous testing of registration accuracy

AX = XB calibration to get camera position relative to robot

Maximum: Create a guidance system for robot operator

Updated Timeline



Milestones

- Mount Camera to Robot - ✓
- Construct Phantom from CT Scans - ✓
- Perform Mesh to Point Cloud Registration - 4/1/16
- Robust Registration with Outlier Rejection - 4/11/16
- Ax = xb Calibration - 4/18
- Validate Accuracy of Registration - 4/18/16
- Implement Guidance System - 5/6/16

Project Readings

[1] S. Billings, A. Kapoor, M. Keil, B. J. Wood, and E. Boctor, "A hybrid surface/image-based approach to facilitate ultrasound/CT registration", in SPIE Medical Imaging 2011: Ultrasonic Imaging, Tomography, and Therapy, Lake Buena Vista, Florida, Feb 13, 2011. pp. 79680V-1 to 79680V-12.

[2] S. Billings, E. Boctor, and R. H. Taylor, "Iterative Most-Likely Point Registration (IMLP): A Robust Algorithm for Computing Optimal Shape Alignment", *PLOS ONE,* vol. 10- 3, pp. (e0117688) 1-45, 2015. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0117688 doi:10.1371/journal.pone.0117688

[3] S. Billings and R. Taylor, "Generalized Iterative Most-Likely Oriented Point (G-IMLOP) Registration", *Int. J. Computer Assisted Radiology and Surgery,* vol. 8- 10, pp. 1213-1226, 2015. DOI 10.1007/s11548-015-1221-2

[4] K. C. Olds, P. Chalasani, P. Pacheco-Lopez, I. Iordachita, L. M. Akst, and R. H. Taylor, "Preliminary Evaluation of a New Microsurgical Robotic System for Head and Neck Surgery", in IEEE Int. Conf on Intelligent Robots and Systems (IROS), Chicago, Sept 14-18, 2014. pp. 1276-1281.

[5] K. Olds, *Robotic Assistant Systems for Otolaryngology-Head and Neck Surgery,* PhD thesis in Biomedical Engineering, Johns Hopkins University, Baltimore, March 2015.

[6] Cignoni, P., C. Montani, and R. Scopigno. "A Comparison of Mesh Simplification Algorithms." Computers & Graphics 22.1 (1998): 37-54.Science Direct. Web. 20 Mar. 2016.