DVRK stereo camera calibration and model registration

-Checkpoint Presentation-

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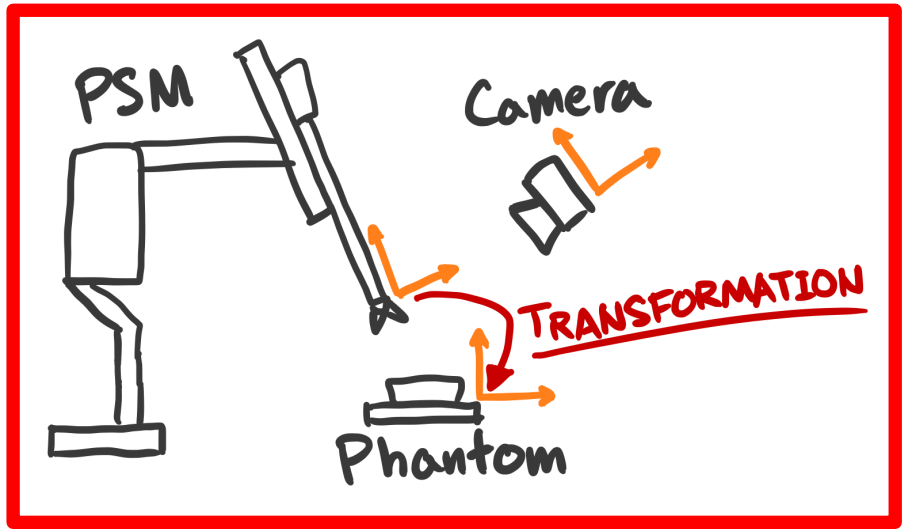
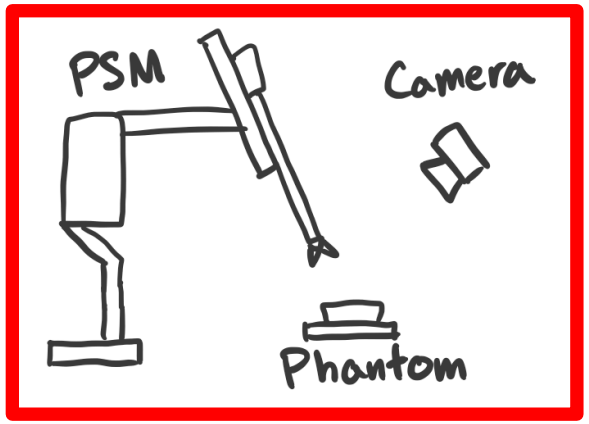
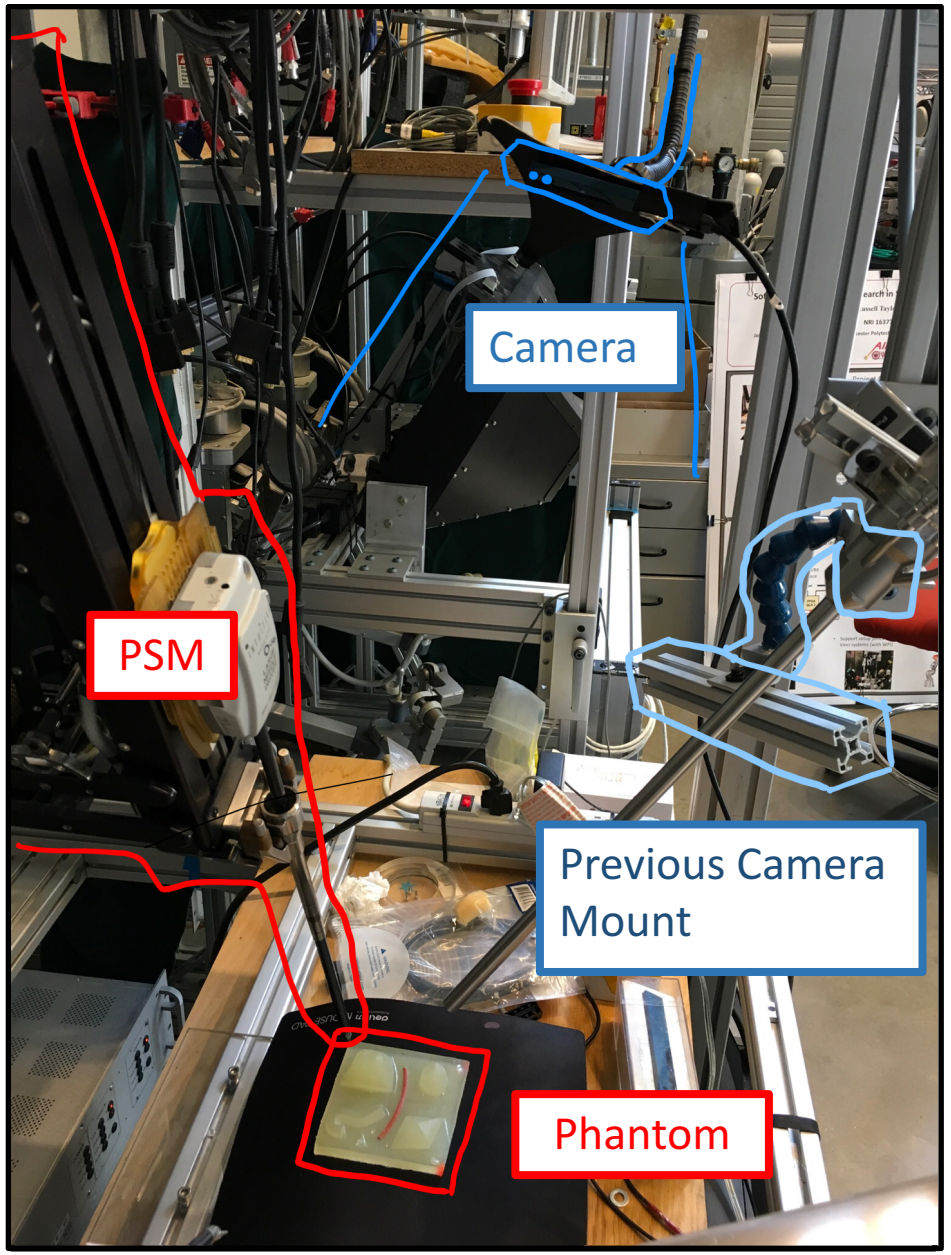
Background

- Goal: Register surfaces to the robot (Patient Side Manipulator, PSM)
- Current Method: Move robot to touch the surface
- What we want to do: Using calibrated stereo camera to substitute touching



Background





- Complete Hand-Eye Calibration
- Detect and register phantom surface to PSM
- Desired accuracy in several *millimeters*

Current Deliverables

Minimum

- Hand-Eye Calibration and Accuracy Test
- [Completed on March 31]

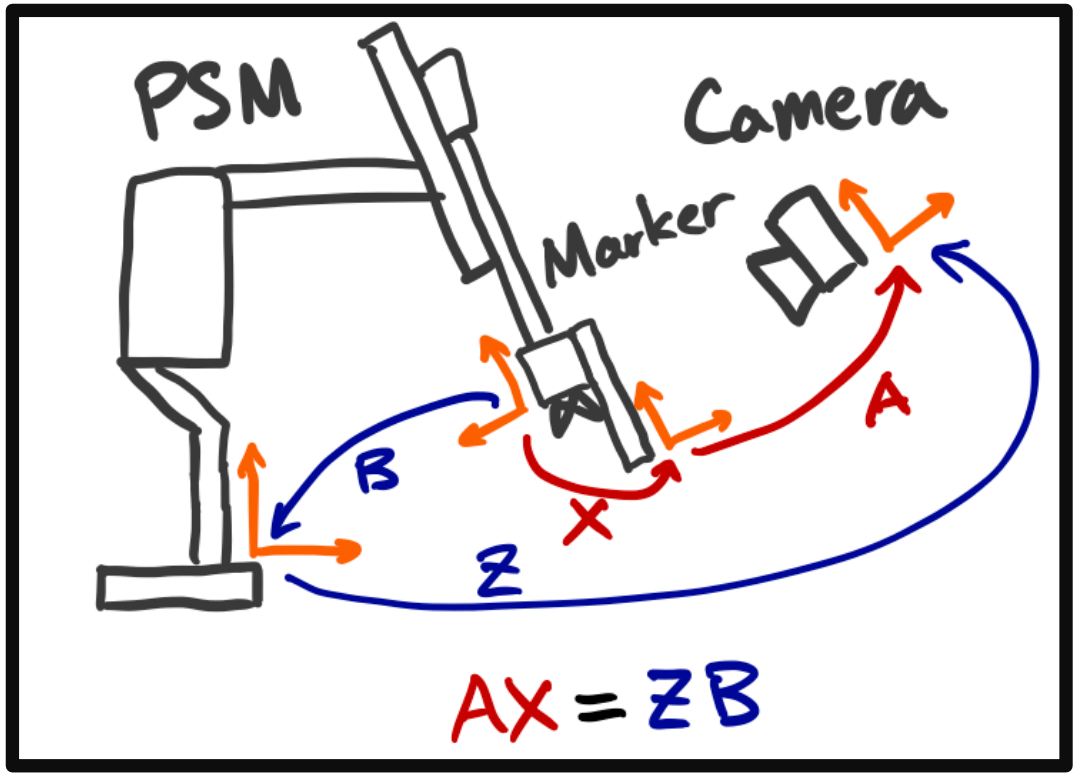
Expected

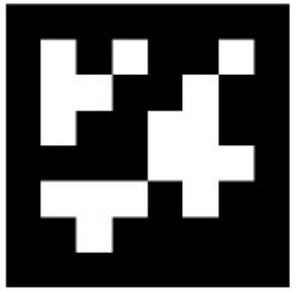
- Predefined Surface Detection and Accuracy Test
- [In Progress]

Maximum

- Unknown Surface Detection and Accuracy Test
- [Not Started]

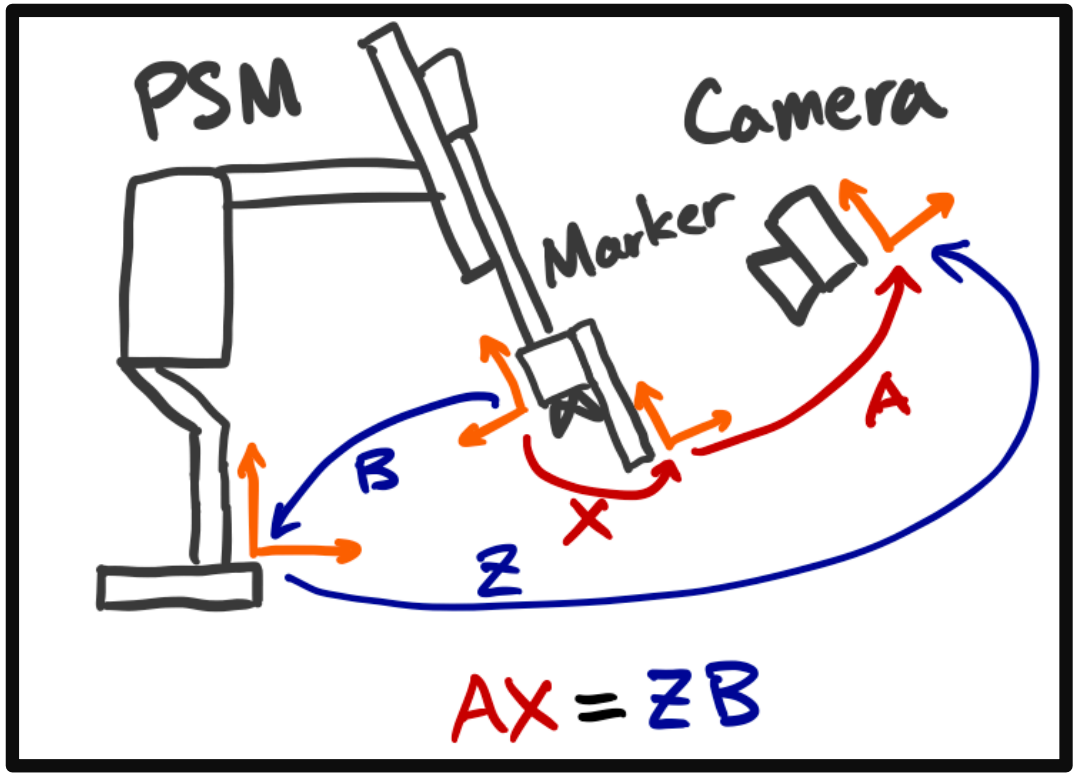
Progress – Hand Eye Calibration

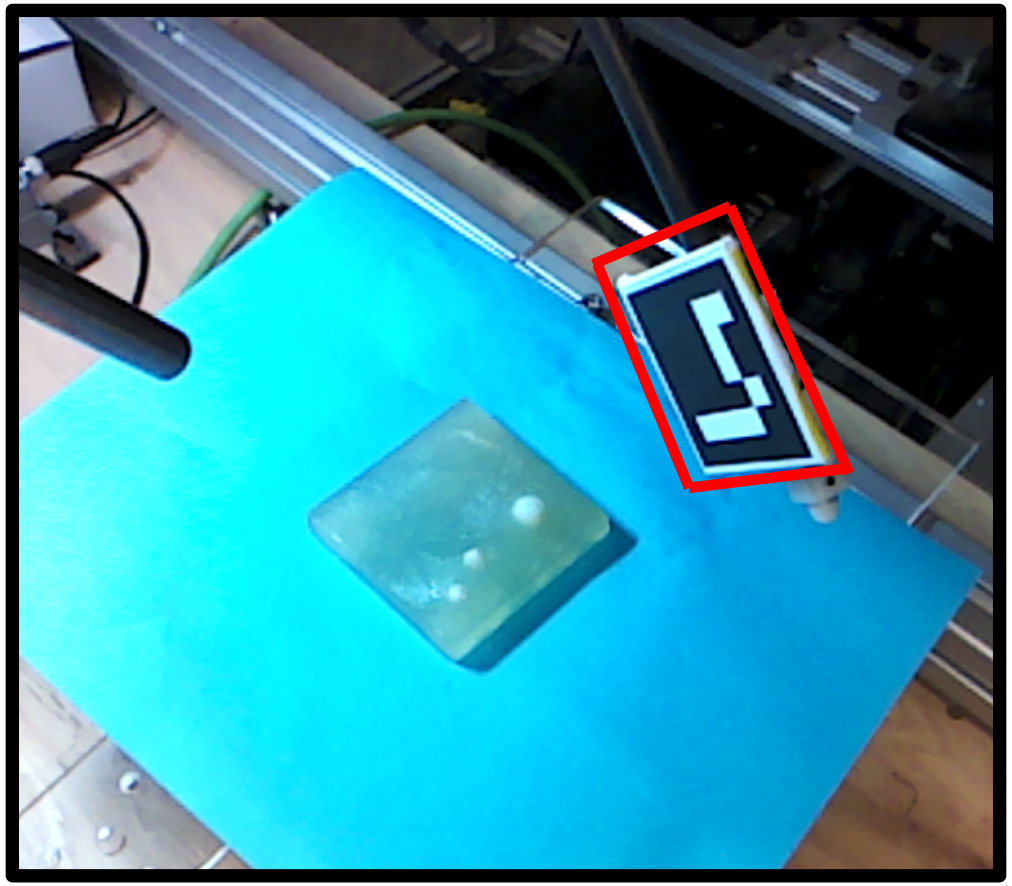


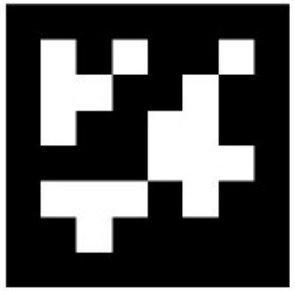


- A: Marker pose to camera frame (ArUco package)
- X: Marker pose to end effector
- B: End effector pose to PSM base (DVRK API)
- Z: Camera Pose to PSM Base

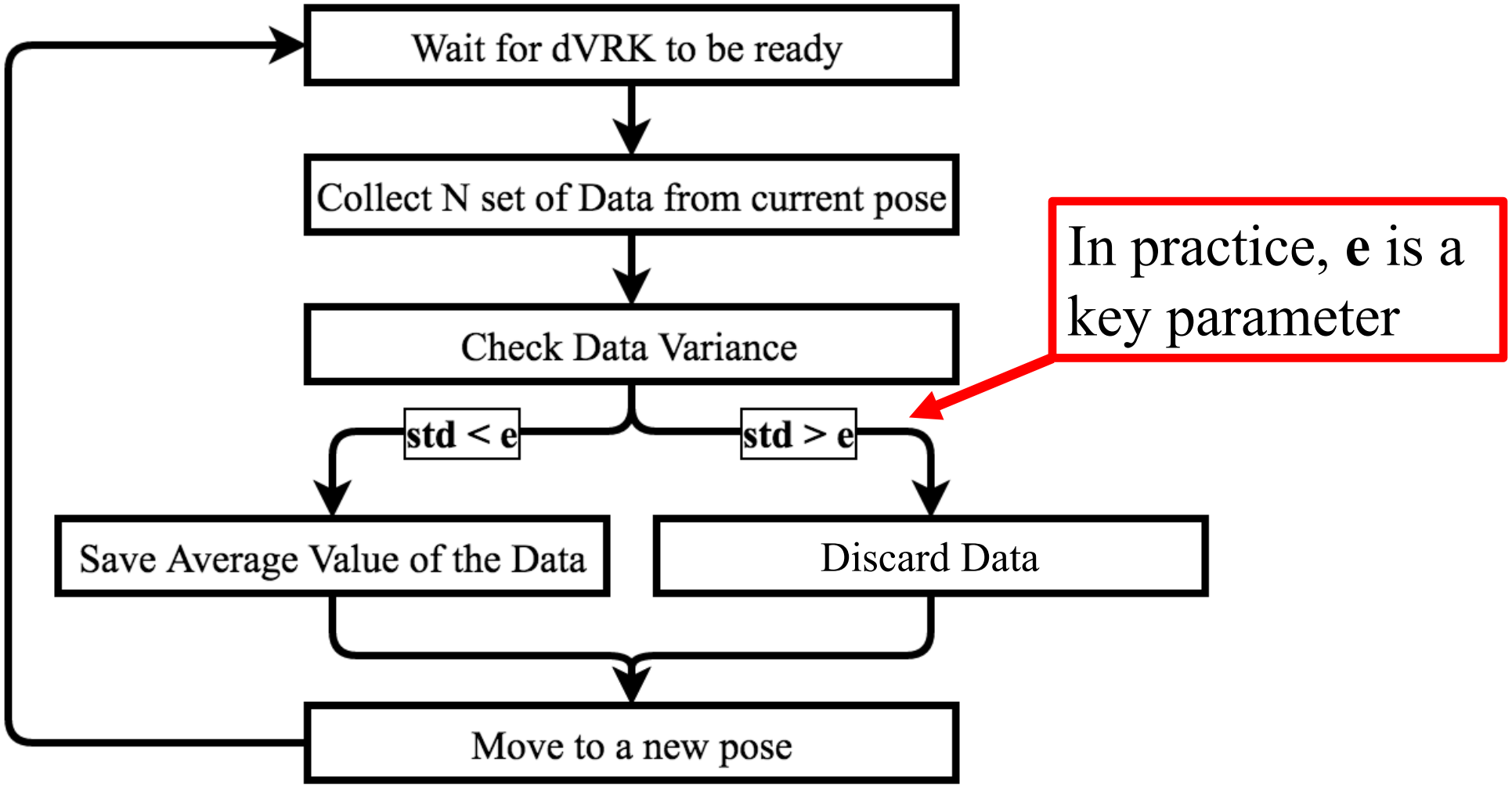
Progress – Hand Eye Calibration Setup







Progress – Data Collection Process



Calibration Consistency

Consistency of Same X and Y

	RX/rad	tX/mm	RY/rad	tY/mm
e = 0.01	0.042	20.4	0.048	19.6
e = 0.001	0.043	3.5	0.023	2.7

- Result of e = 0.001 is not bad, but it's very hard to collect data
- e = 0.003 is used later
- Convenience vs. Better Accuracy

Calibration Consistency

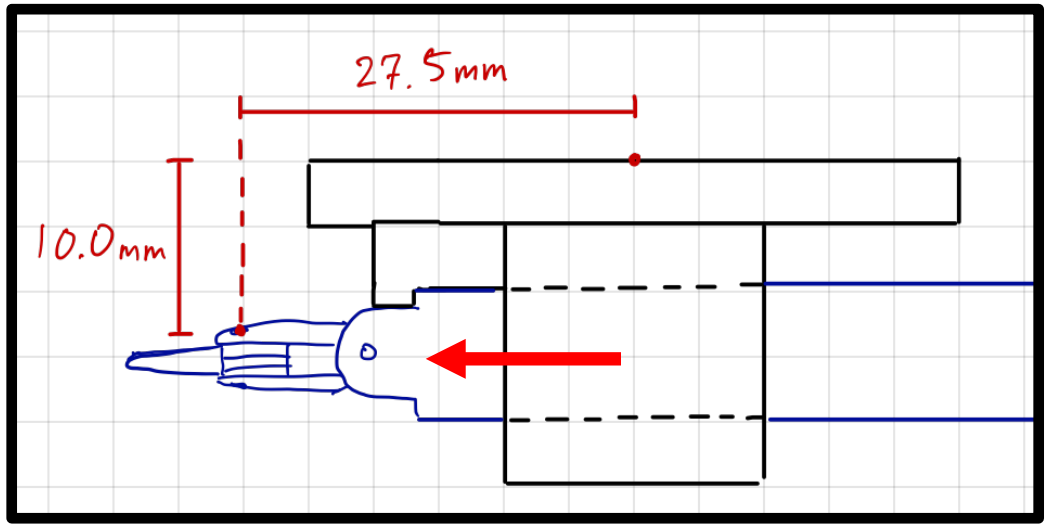
Consistency of Same X with different Y

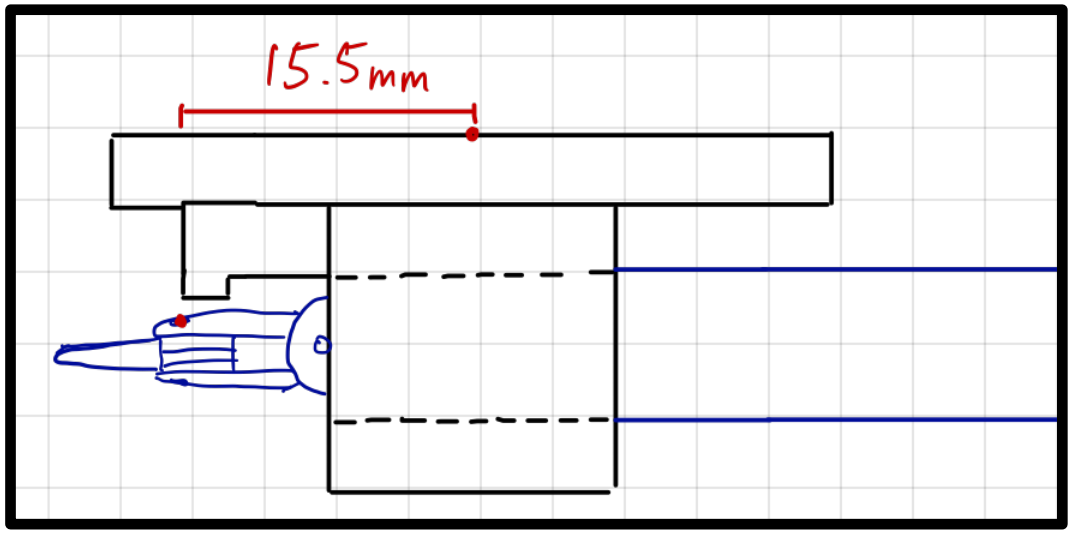
Error	RX/rad	tX/mm
e = 0.003	0.054	10.5

Consistency of Same Y with different X

Error	RY/rad	tY/mm
e = 0.003	0.025	3.1

Calibration Consistency

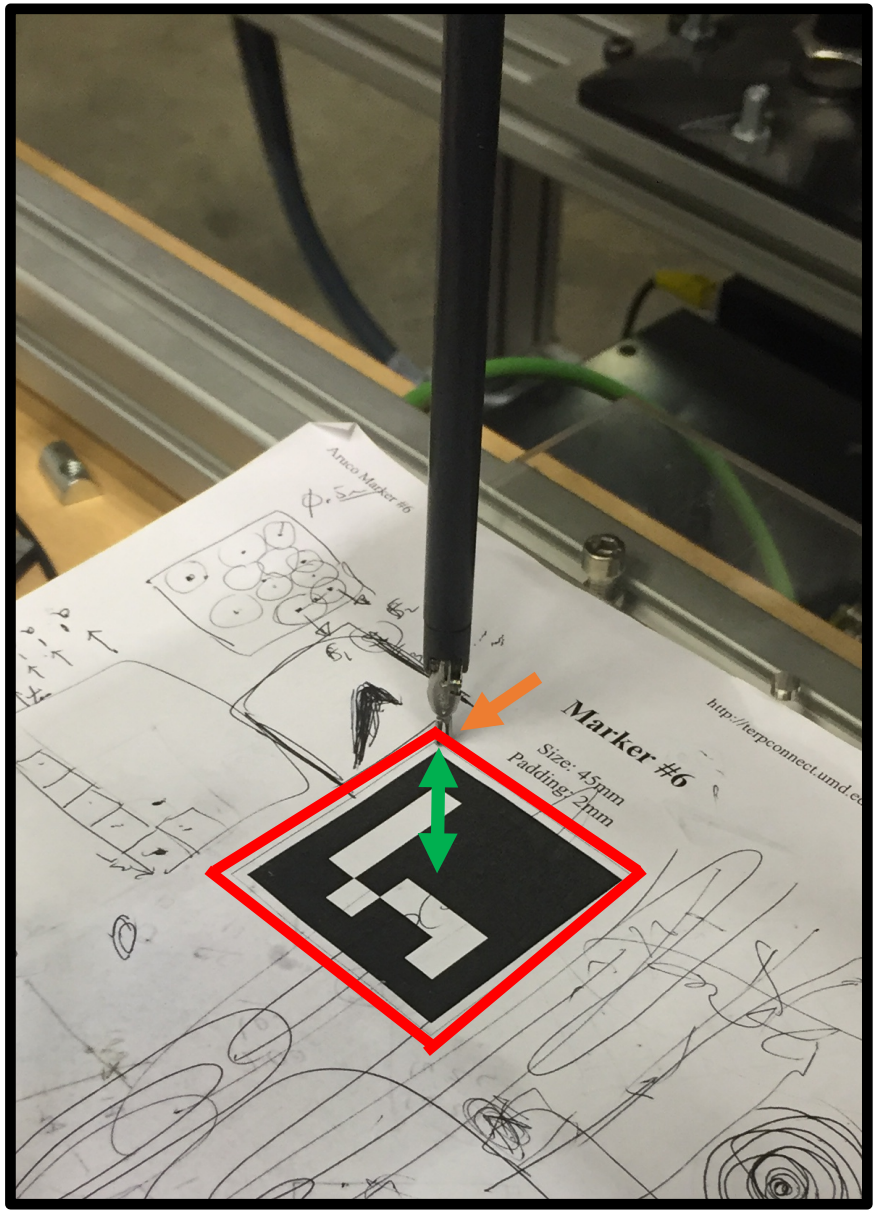




- For the case of same Y, we move the adapter (X) for about 12mm and the change of tX is 12.7 mm

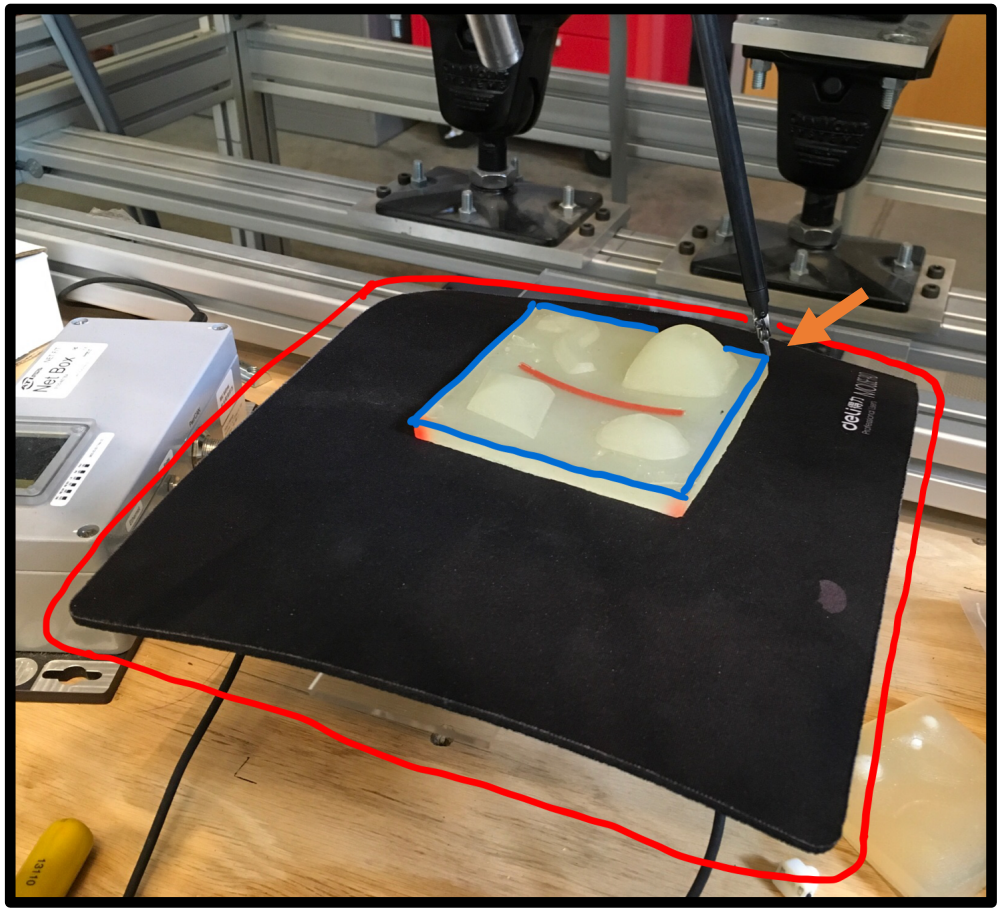
Calibration Accuracy

- error = [-0.4, 2.8, -1.3] mm
- || error || = 3.1 mm

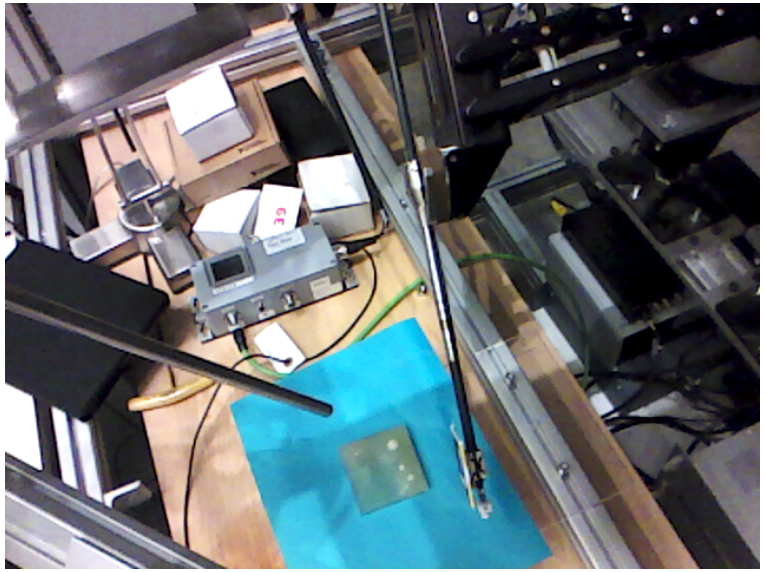


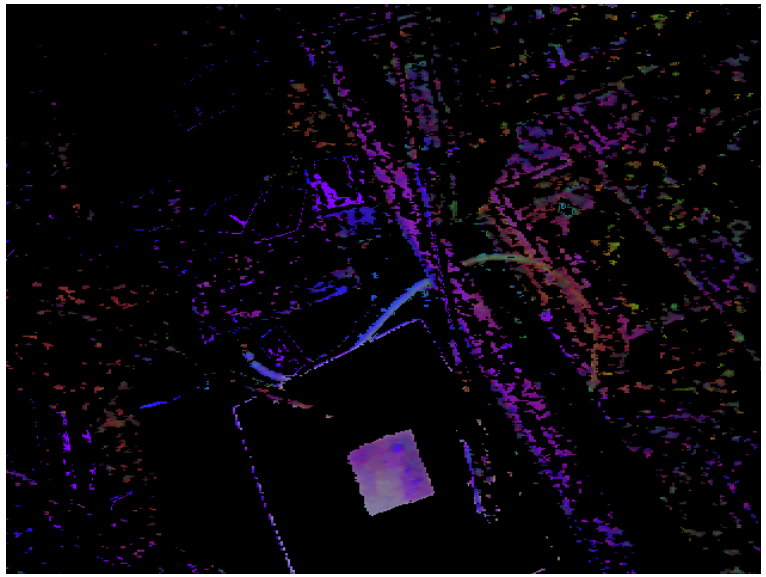
Phantom Detection Accuracy (via Touching)

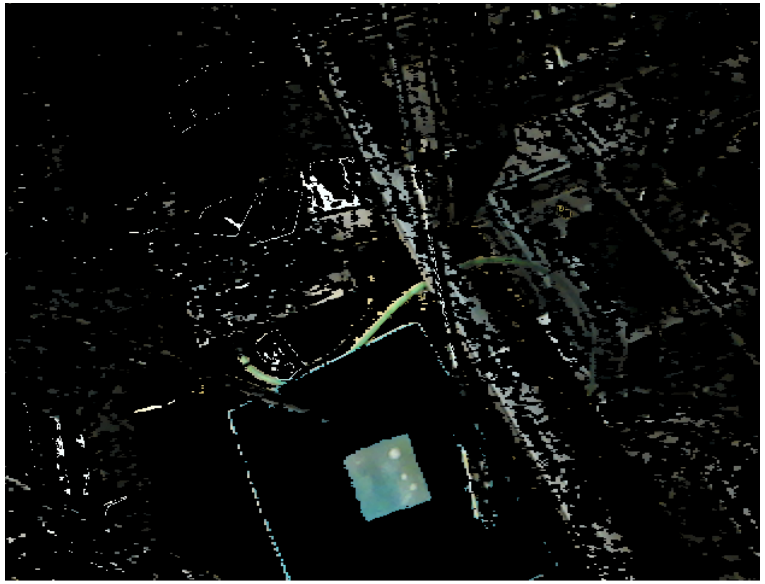
- error = [34.6, 55.7, -13.7] mm
- || error || = 67 mm
- Mainly due to the poor result of depth information

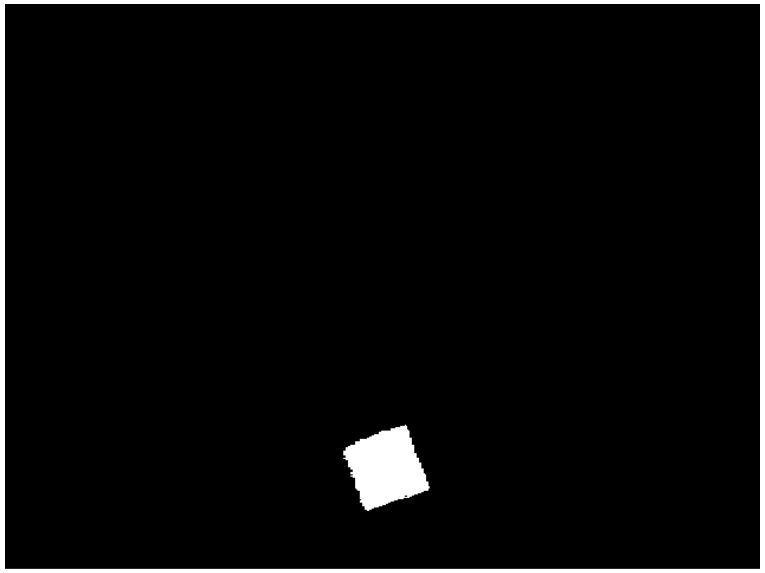


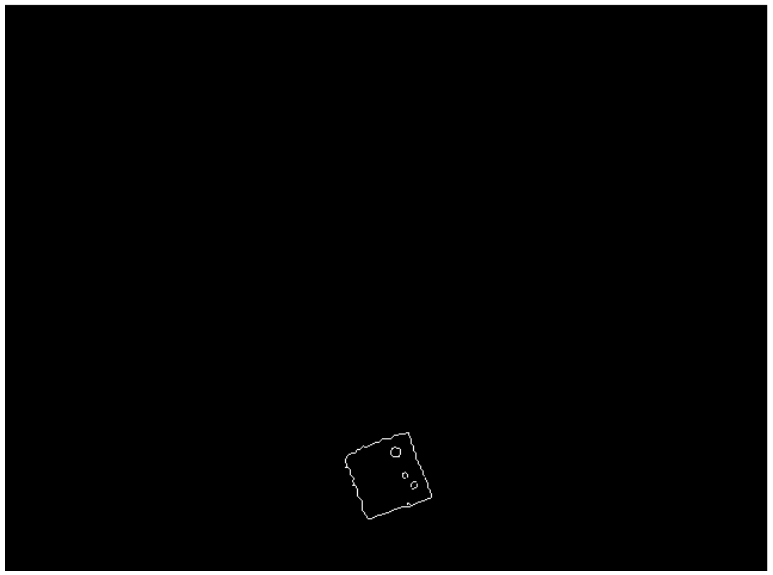
Result of Edge Detection

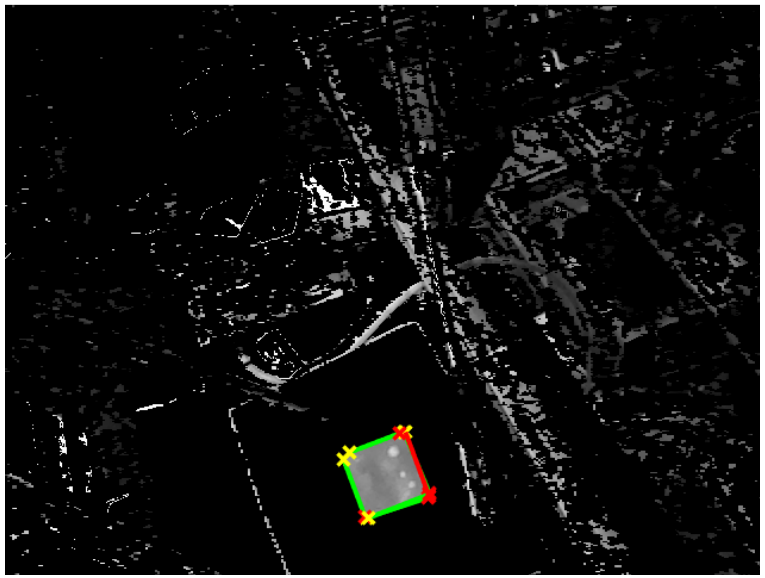




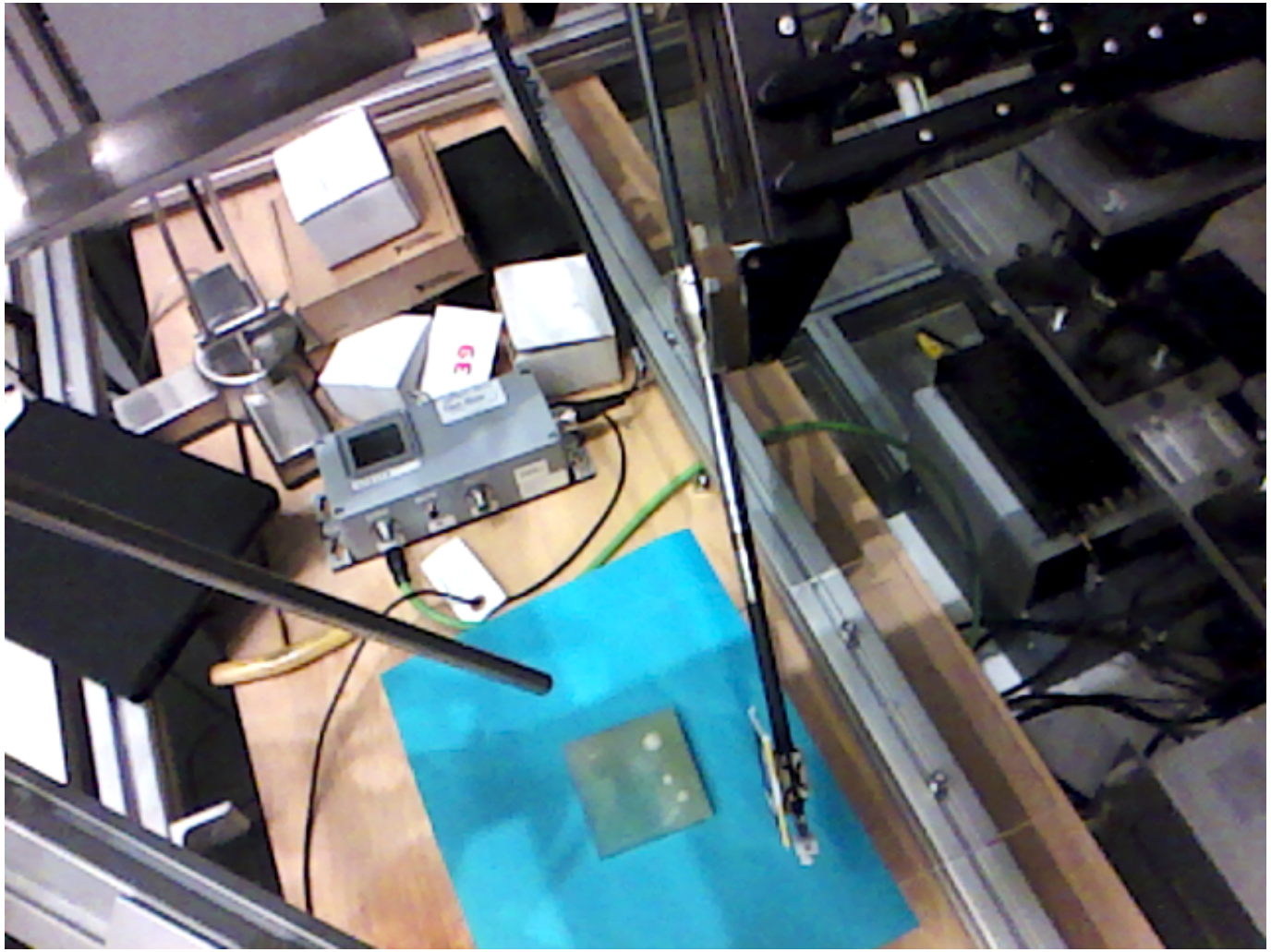






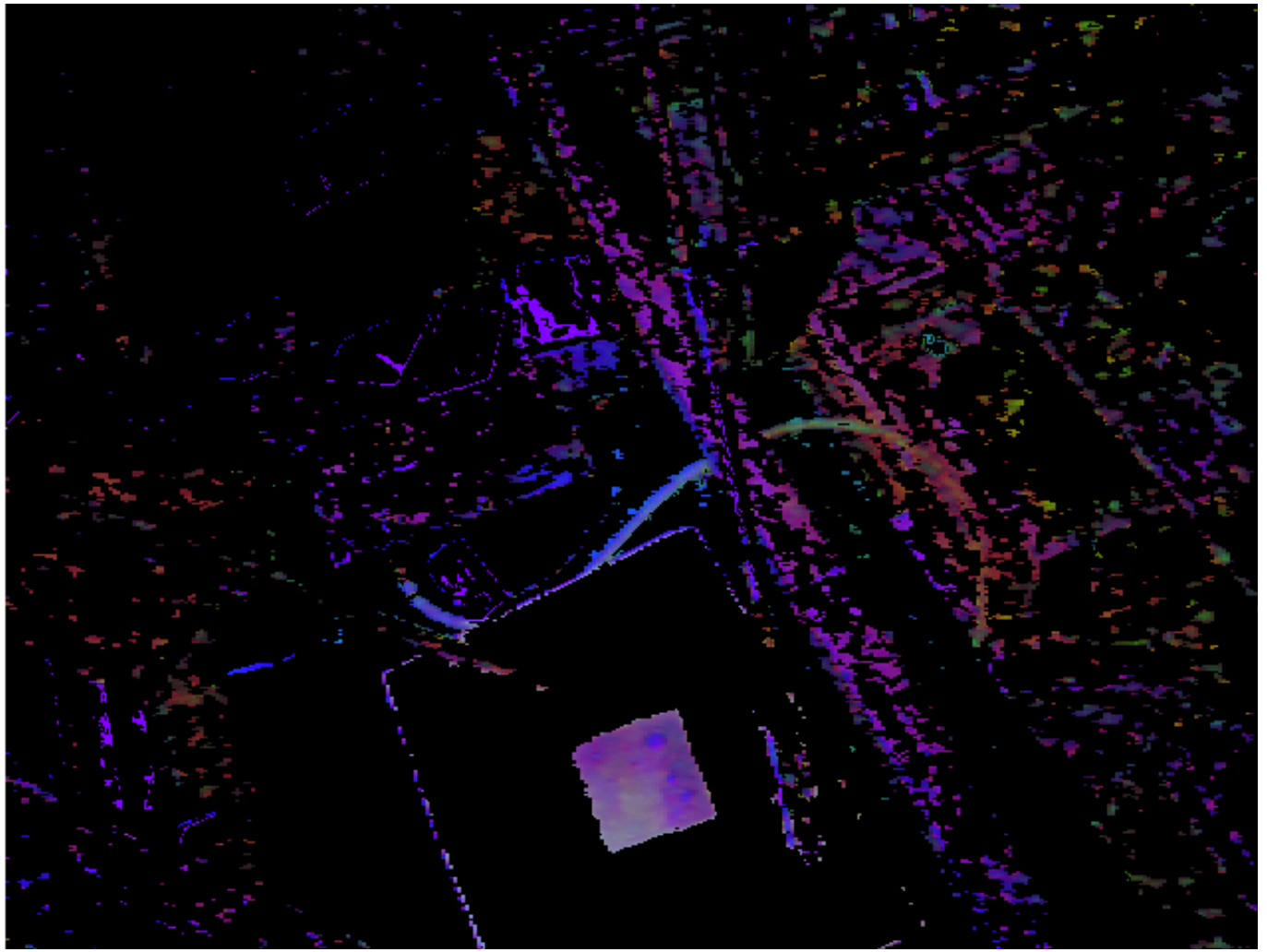


Result of Edge Detection



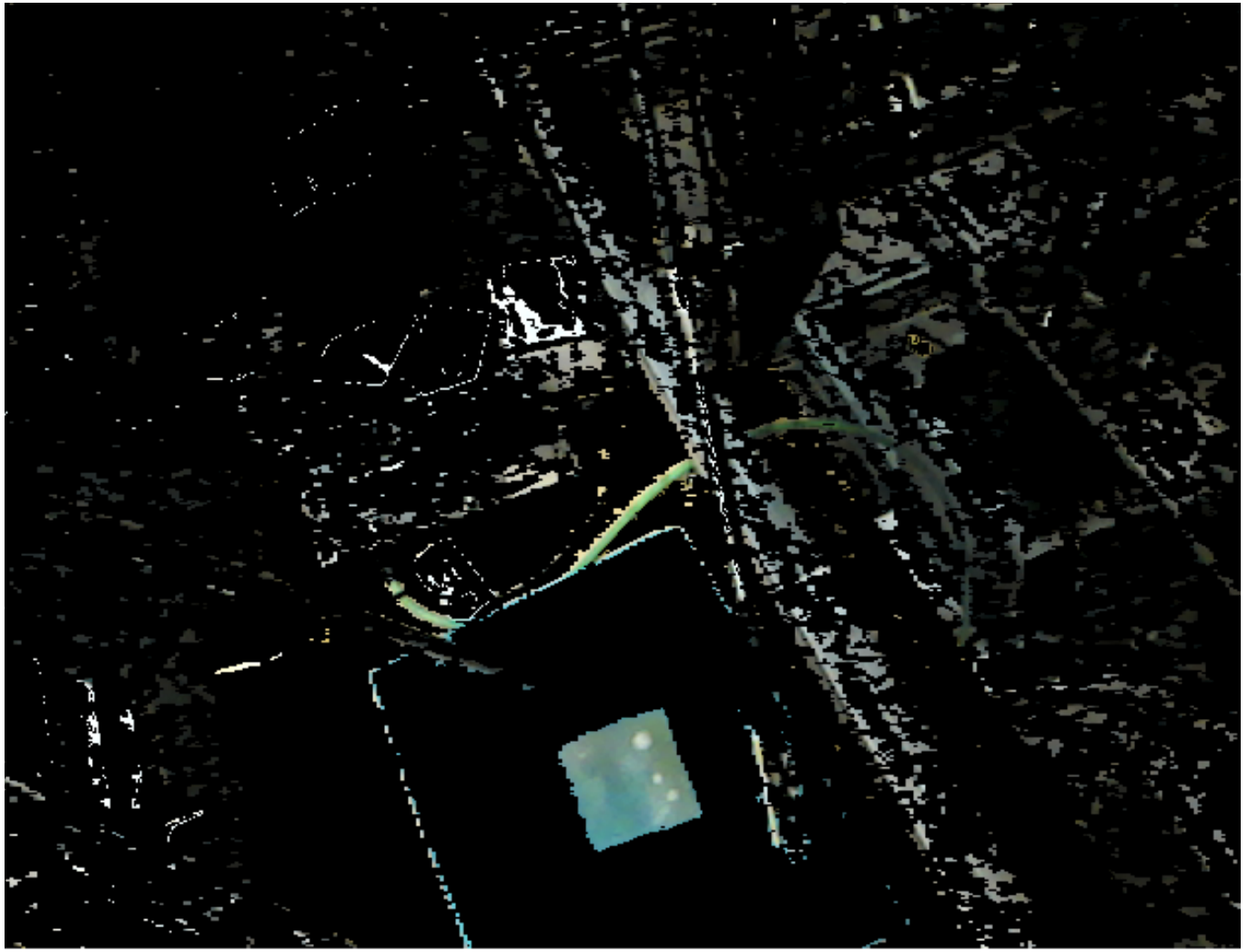
RGB Image

Result of Edge Detection



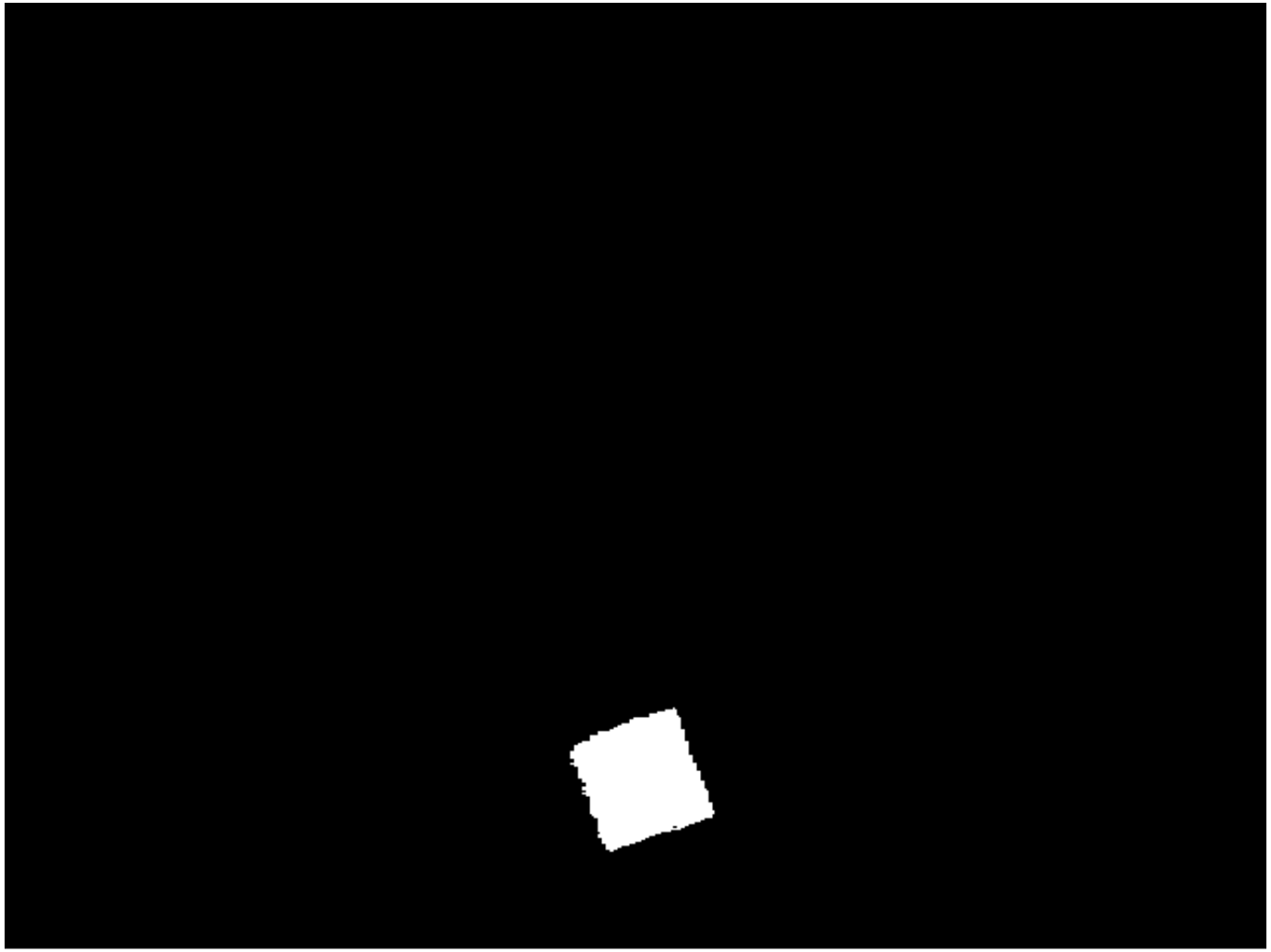
HSV Image (color threshold to eliminate background)

Result of Edge Detection



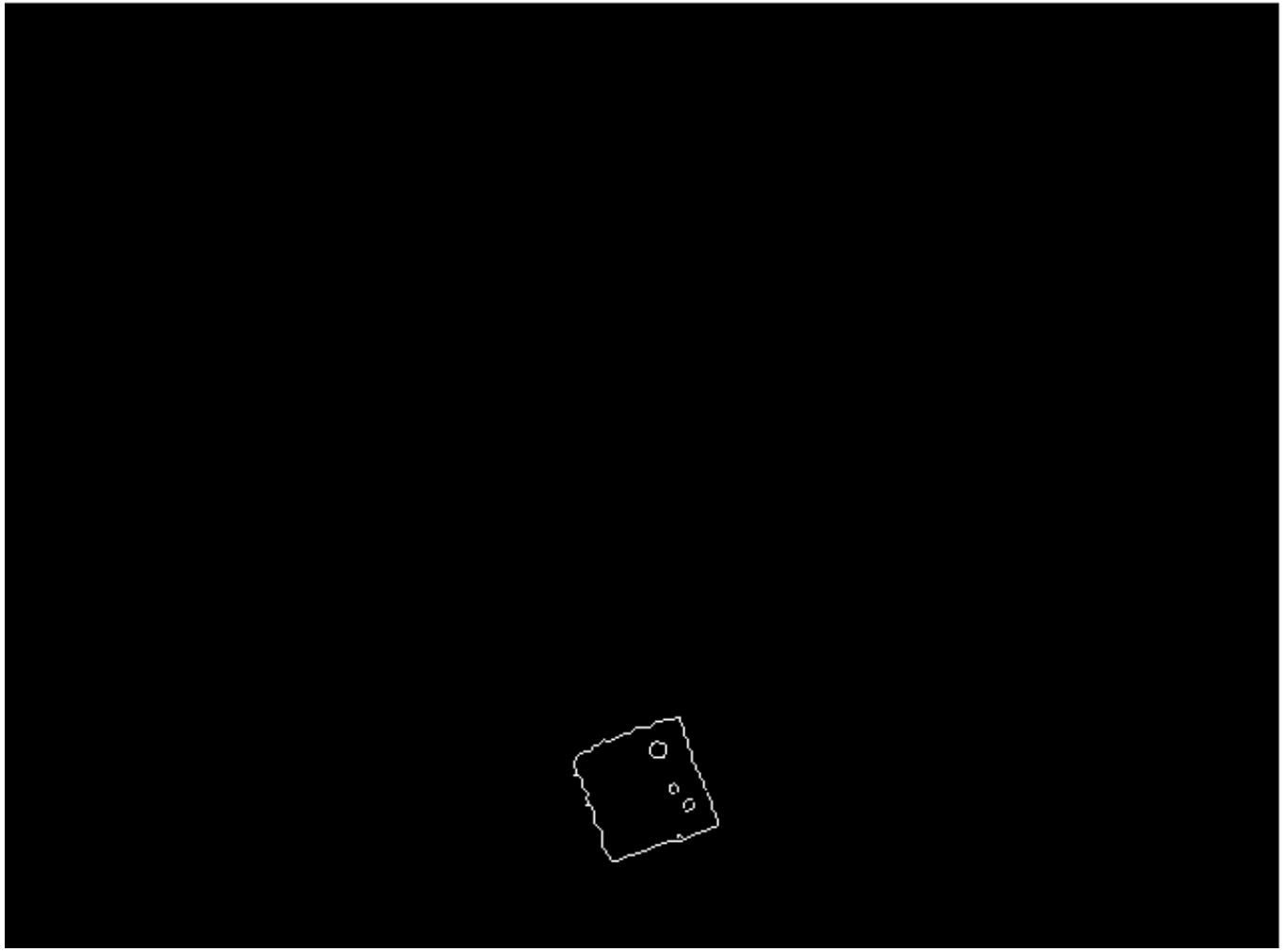
Converted back to RGB Image

Result of Edge Detection



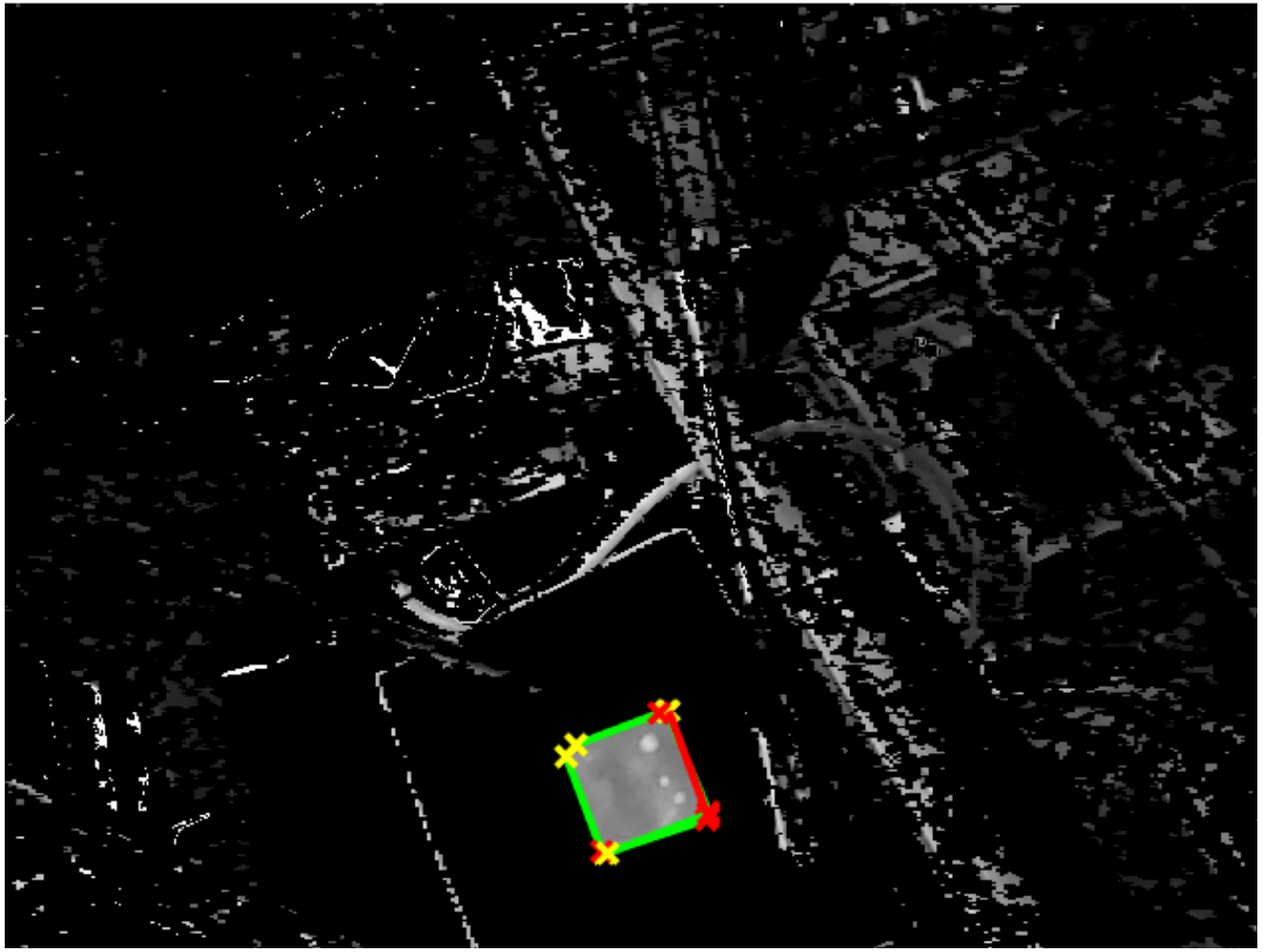
Sectioned Binary Image

Result of Edge Detection



Edge Image (Sobel Filter)

Result of Edge Detection



Line Image (Hough Transform)

Technical Approach Changed

Expected Deliverable

- Detect the edge of phantom with single stereo camera and register with model
- Set up two R200 RealSense camera to build a stereo camera system and detect edge points

Maximum Deliverable

- Find correspond surface points in two camera

Future Work

- Set up two calibrated camera systems
- Complete ICP algorithm for detected edge points and test for accuracy
- Complete algorithm to find correspond points to estimate point cloud of unknown surface

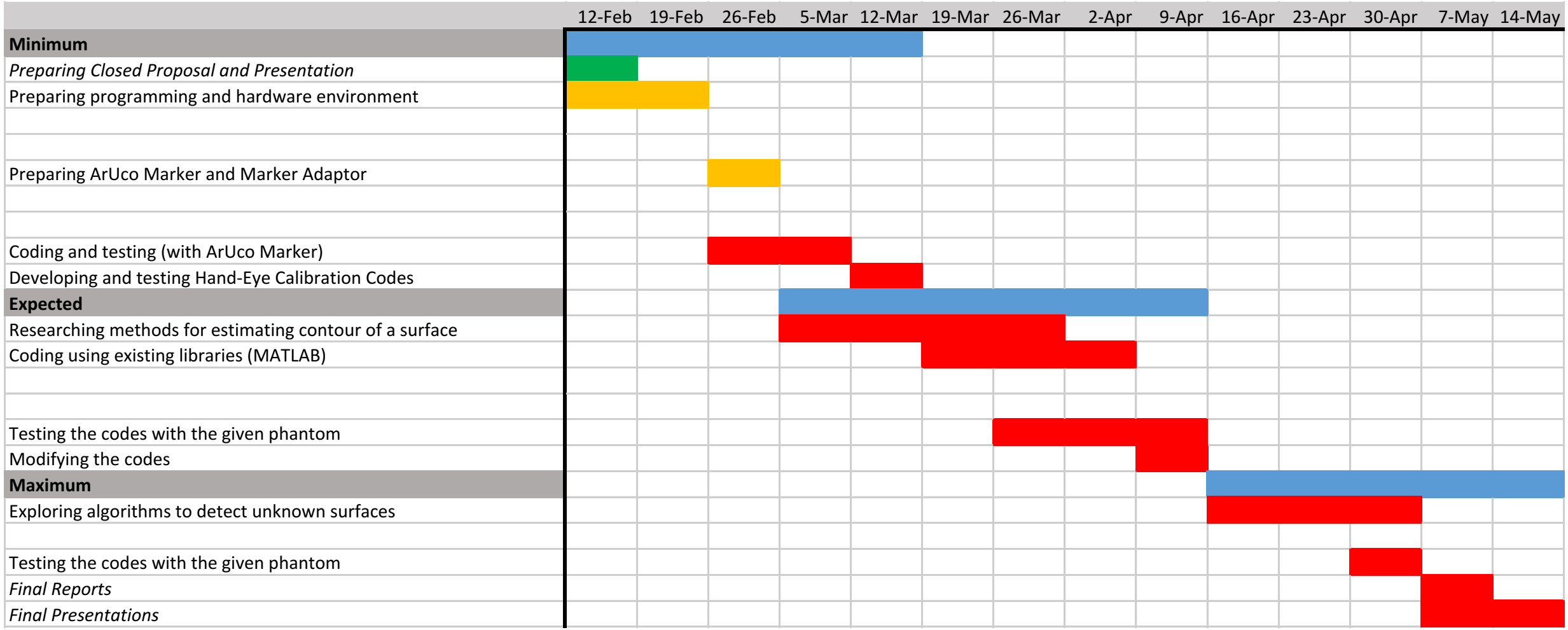
Updated Dependencies

Dependencies		How to Resolve	Status
Hardware	dVRK System	Access to LCSR Lab	Resolved
	~~Stereo / Depth Camera~~	~~Access to LCSR Lab~~	~~Resolved~~
	Two R200 Realsense Cameras	Find a way to connect two stereo cameras into one USB hub	Pending
	3D Printer	Access to 3D Printer Room	Resolved (Peter)
	~~Opaque Phantom~~	~~Develop another phantom with different coloring dye~~	~~Pending [Not immediate concern]~~
Software	ROS	Open source codes	Resolved
	ArUco / OpenCV Package	Open source codes	Resolved
	Solidworks (CAD)	WSE IT website	Resolved (Peter)
	MATLAB	WSE IT website	Resolved

Updated Timeline

Plan Date	Progress	Actual Complete Date
2/18	Finish proposal and presentation	2/18
2/25	Prepare hardware and environment	3/05
3/11	Complete codes for hand-eye calibration	3/14
3/18	Test codes and estimate accuracy	3/31
4/01	Complete contour detection	3/25
4/08	Set up 2 camera system and calibrate	
4/11	Test codes and estimate accuracy for expected deliverables	
4/15	Complete codes for finding correspond points	
4/22	Test codes and estimate accuracy for expected deliverables	
	Leave time for other methods	

Original Timeline



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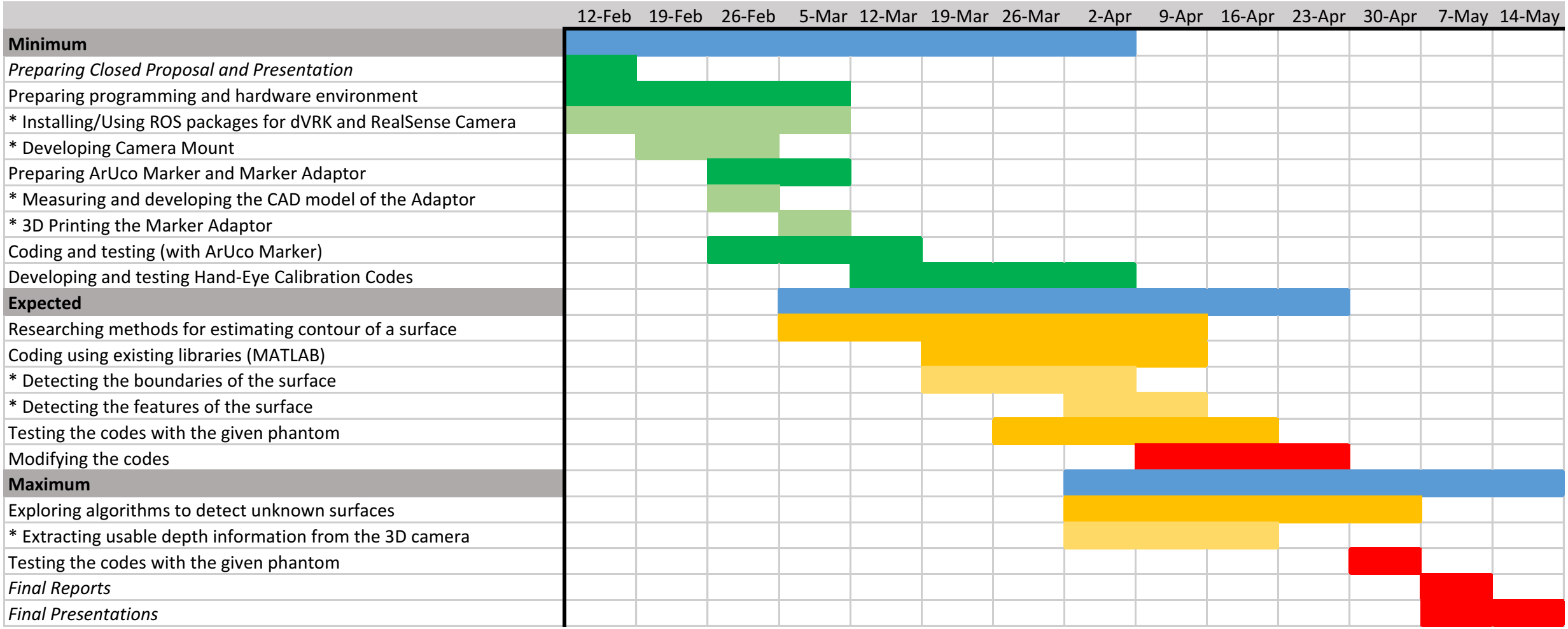

Updated Timeline