DVRK stereo camera calibration and model registration

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1 Introduction

To register unknown surfaces to the robot in dVRK system, we need to move robot arms to touch the surface which need to be done every time the surfaces move. Also touching the surface is unfeasible in some cases (organ surface).

One possible solution is to use a calibrated stereo camera and detect the surface from the image. The stereo camera is registered to the robot with markers and remain static. Once we detect the surface in the camera frame, we know its position to the robot.

Stereo camera has not been widely used in dVRK system and there's few established codes. Our first goal is to complete hand-eye calibration between camera and robot with markers. Then we will detect the surface from the RGBD images. Several methods are considered including edge detection and ICP.

2 Technical Approach

For hand-eye calibration, the scene is that the stereo camera remains static and the robot moves with a tag attached to the tips. ArUco package can recognize the frame of the tip from the tag. Then the calibration problem turns to solve for AX=ZB which is solvable.

For detection of surface, we will first try to get the contour of the surface. Edge detection combined with depth image will detect the edge of the deformed phantom and the contour surface can be estimated.

Then we will reconstruct the point clouds of the surface from RGBD images. RGBD images from different sights will be accumulate to get the surface. For this part, an opaque phantom and a better camera is needed.

3 Deliverables

Minimum:Codes and error estimation for hand-eye calibration.

Expected : Codes for tracking and estimating the contour of the surface

Maximum : Algorithm to detect the unknown surface

4 Milestones and Schedule

2/12 - 2/18 : Finish Closed Proposal and presentation.
2/19 - 2/25 : Prepare programming and hardware environment
2/26 - 3/04 : Prepare ArUco Marker and Marker Adaptor
3/05 - 3/11 : Coding and testing (with ArUco Marker)
Milestone : Completed hand-eye calibration codes

3/12 - 3/18 : coding using existing library (OpenCV)
3/19 - 3/25 : continue coding and prepare seminar presentation
3/26 - 4/01 : testing with real case and modifying
4/01 - 4/07 : testing and modifying
4/07 - 4/13 : testing and modifying
Milestone : Codes for estimating the contour of the surface

4/14 - 4/20 : Exploring algorithms
4/21 - 4/27 : Exploring algorithms and testing
4/28 - 5/04 : Final testing and Documentation
Milestone : Algorithm to detect the unknown surface

5/05 - 5/11 : Final reports
5/12 - 5/18 : Final Presentation

5 Dependencies

	Dependencies	How to Resolve	Status
Hardware	dVRK System	Access to LCSR Lab	Resolved
	Stereo / Depth Camera	Access to LCSR Lab	Resolved
	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

6 Management Plan

Weekly meeting with Preetham and Anton (Every Wednesday 1:00 PM).

Person	Work	Timeline
Joonghyun (Peter) Ahn	Research and setup R200 RealSense Camera on personal laptop	Done (2/20/17)
	Development of CAD model for the ArUco Marker Adapter	In progress (by 2/25/17)
	3D printing of the CAD model	In progress (by 3/1/17)
Mengze Xu	Research in Calibration methods	Done (2/19/17)
	Learn ROS dVRK	In progress (by 2/28/17)
	Learn ArUco / OpenCV package	In progress (by 3/3/17)

7 Reading List

Mili Shah, Roger D Eastman, and Tsai Hong. An overview of robot-sensor calibration methods for evaluation of perception systems. In: Proceedings of the Workshop on Performance Metrics for Intelligent Systems. ACM, 2012, pp. 1520. isbn: 1450311261.

https://www.uco.es/investiga/grupos/ava/node/26

http://wiki.ros.org/aruco

http://robotics.stackexchange.com/questions/7163/hand-eye-calibration

https://hal.inria.fr/inria-00590087/file/DornaikaHoraud-tra.pdf

More reading about detecting unknown surfaces will be decided later.