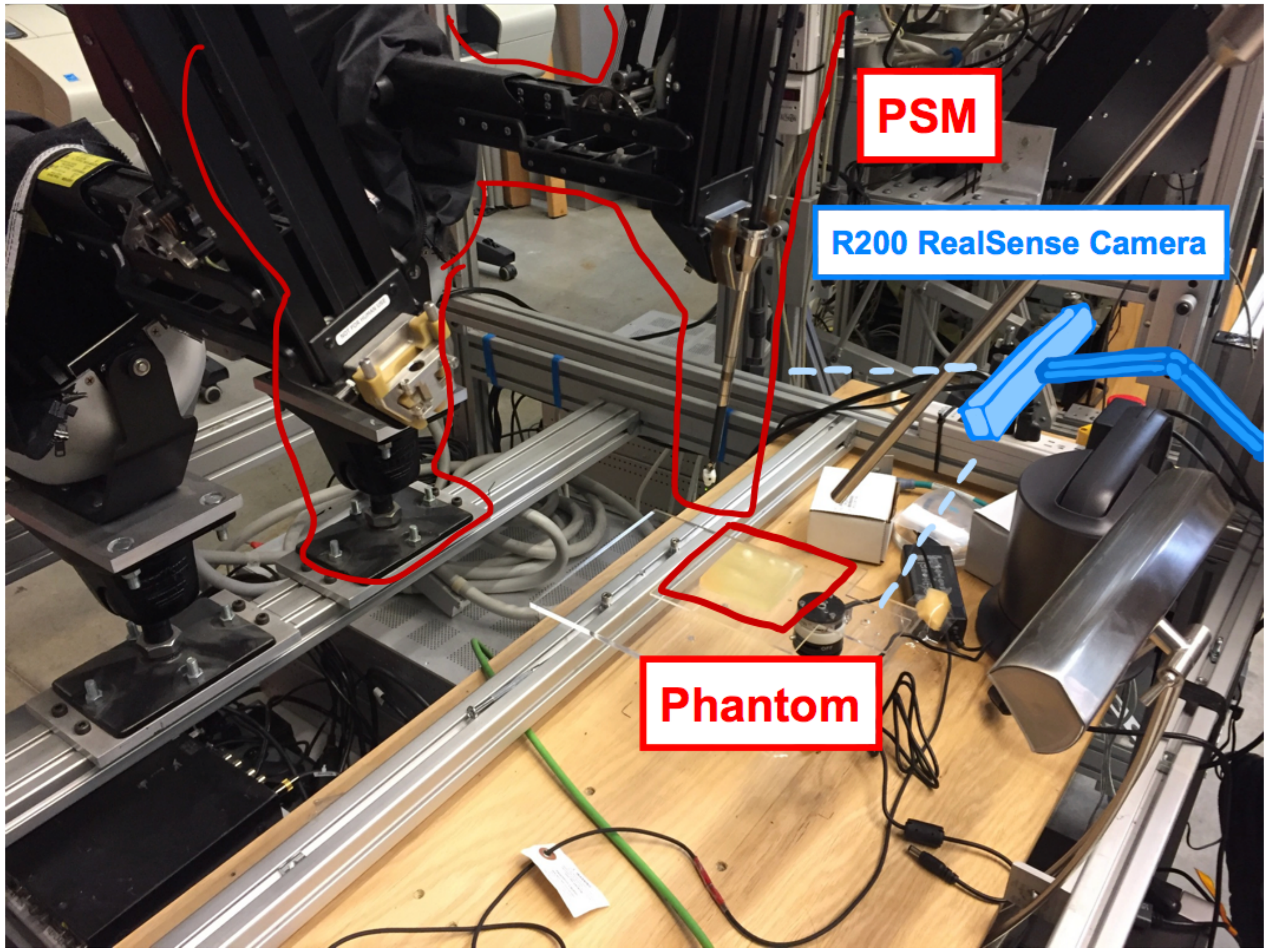
DVRK Stereo Camera Calibration and Model Registration

Group12: Petern Ahn and Mengze Xu
Mentors: Preetham Chalasani and Anton Deguet
March 14, 2017

Project Introduction



- Complete registration between camera and PSM
- Detect phantom surface in camera image

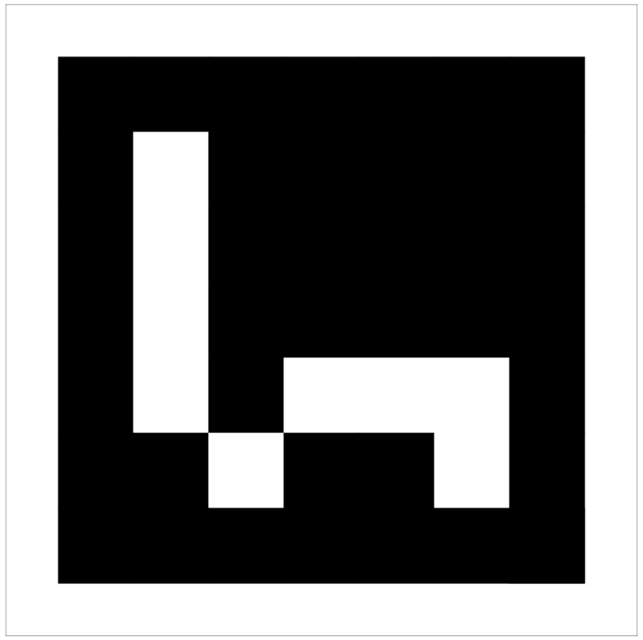
Paper Selected

- [1] Garrido-Jurado S, Muñoz-Salinas R, Madrid-Cuevas F J, et al. Automatic generation and detection of highly reliable fiducial markers under occlusion[J]. Pattern Recognition, 2014, 47(6): 2280-2292.

- [2] M. Shah, Solving the Robot-World/Hand-Eye Calibration Problem Using the Kronecker Product, ASME Journal of Mechanisms and Robotics, Volume 5, Issue 3 (2013).

ArUco Library

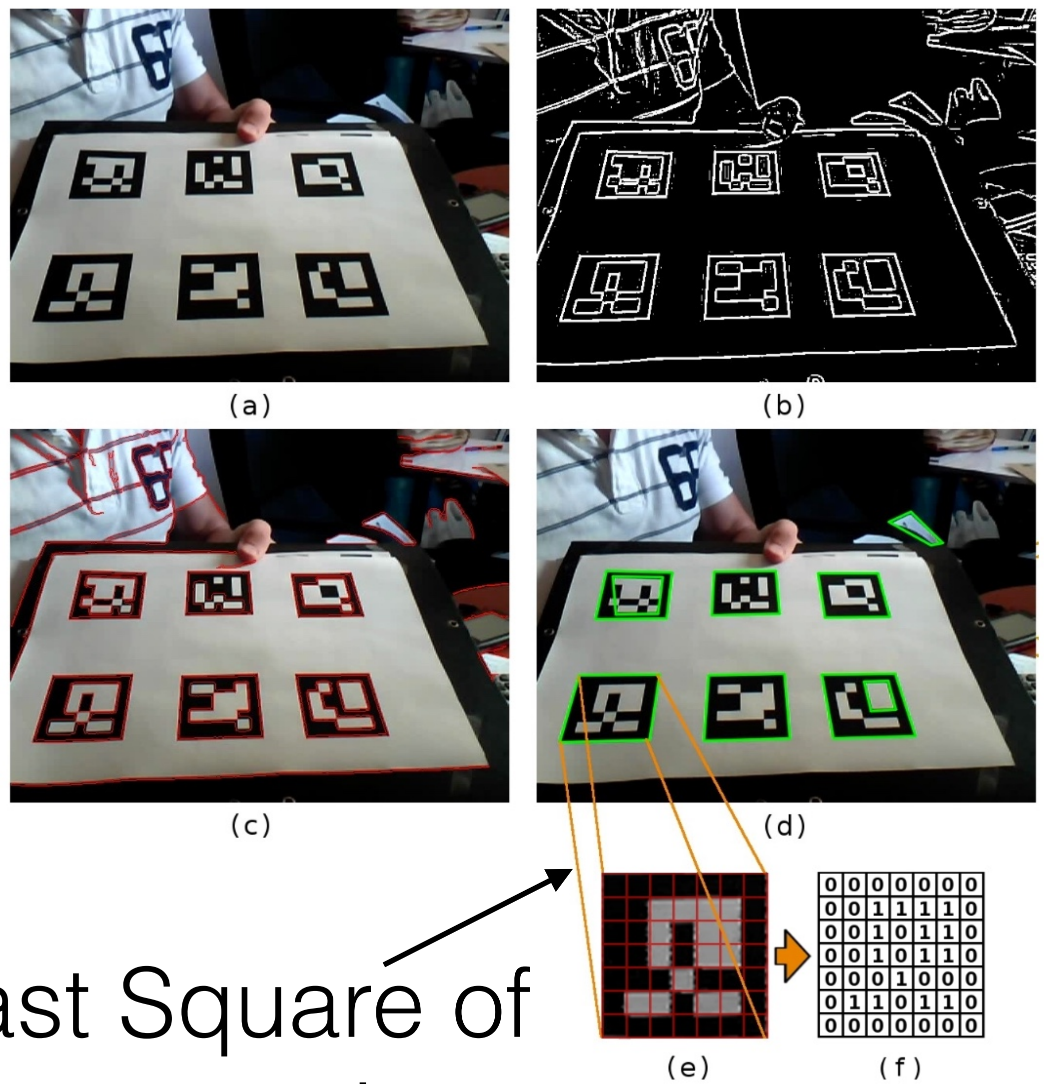
- Main problem: How to estimate the pose of stereo camera to the world?
- Natural key points or fiducial markers
- ArUco tag: easy to complete and use in ROS



Paper Summary

- Method to encode and decode the marker
- Detect markers from the image
- Solve occlusion problem

Detect Markers



Least Square of contour points is used to estimate pose

image(a)

edge(b)

contour(c)

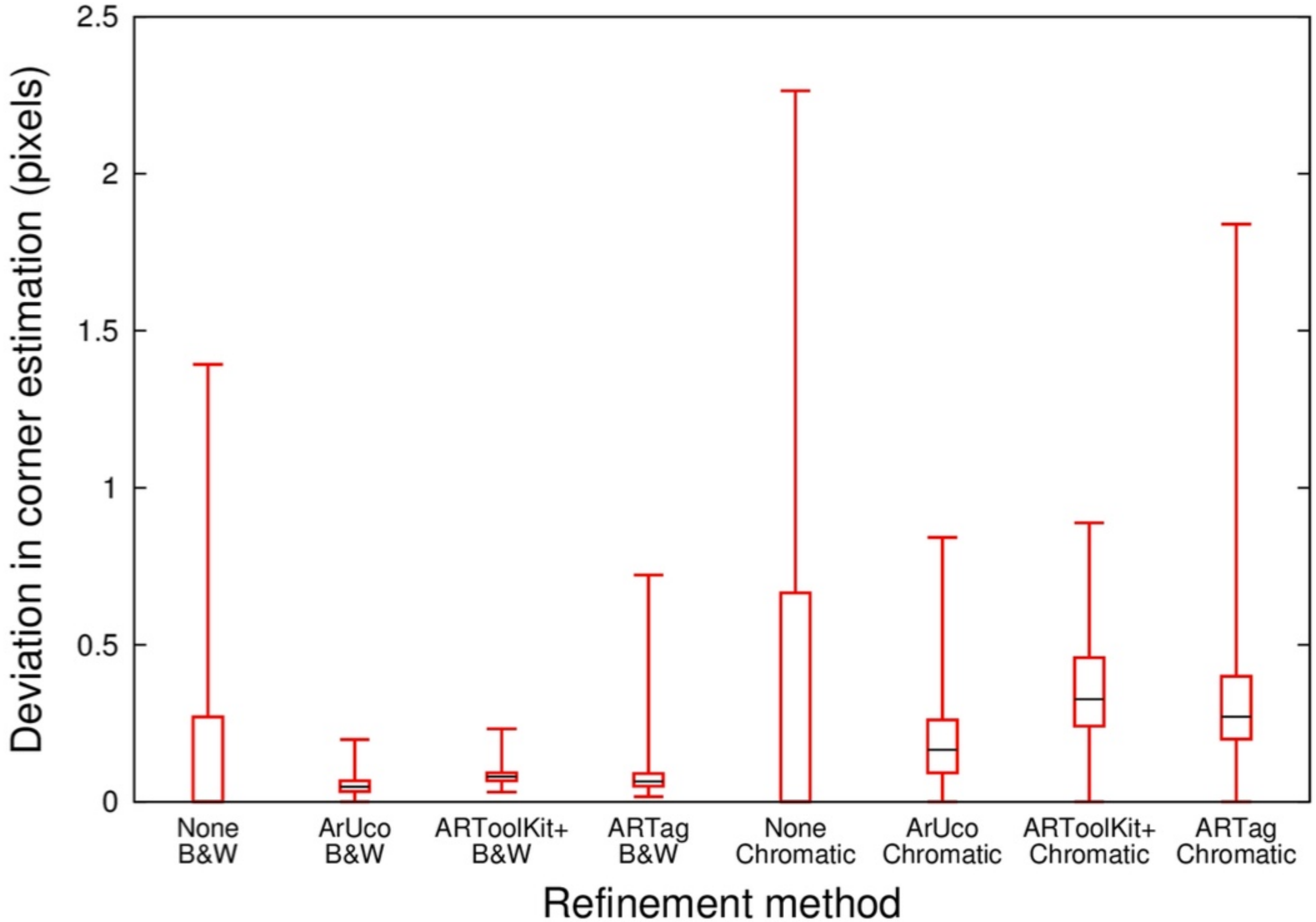
marker (d) (known size)

project (e)

pose

code(f)

Accuracy



2.5
2
1.5
1
0.5
0
Deviation in corner estimation (pixels)
None B&W
ArUco B&W
ARToolKit+ B&W
ARTag B&W
None Chromatic
ArUco Chromatic
ARToolKit+ Chromatic
ARTag Chromatic
Refinement method

Summary

- A very convenient tool
- Robust to environment and light condition
- Lack of error estimation and analysis of the pose
- Might be useful for you
  - http://wiki.ros.org/aruco
  - http://terpconnect.umd.edu/~jwelsh12/enes100/markergen.html

Solving AX=ZB

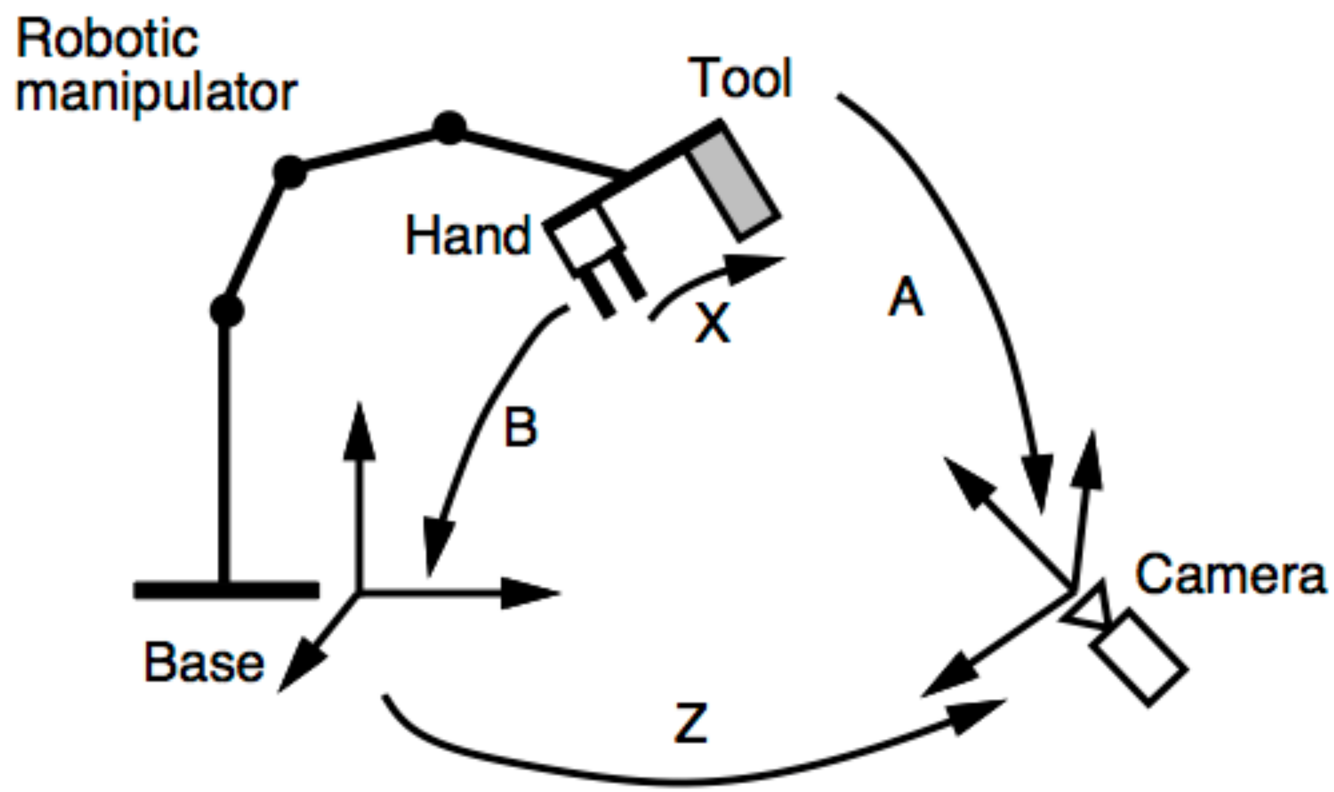


Fig. 2. Robot/eye (**Z**) and hand/tool (**X**) calibration. The tool is mounted onto the gripper and tool motions are determined by observing tool feature points with a camera. The world frame is, in this case, identical with the camera frame.

Matrix A: Provided by ArUco library

Matrix B: Provided by DVRK API

- Main problem: “AX=YB” hand-eye calibration

Paper Summary

- Provide closed form of solution
- Error estimation of simulated data
- Error estimation of real data
- Comparison to other major methods

Closed Solution

- At least $n>=3$ pair of A and B are required
- Kronecker Product $K = \sum_i R_B \otimes R_A$
- SVD: $K=U\Sigma V$
- u and v are singular vector correspond to singular value n
- v → RX and n → RY
- tX and tY is easy to solve by least square

Simulate Experiment

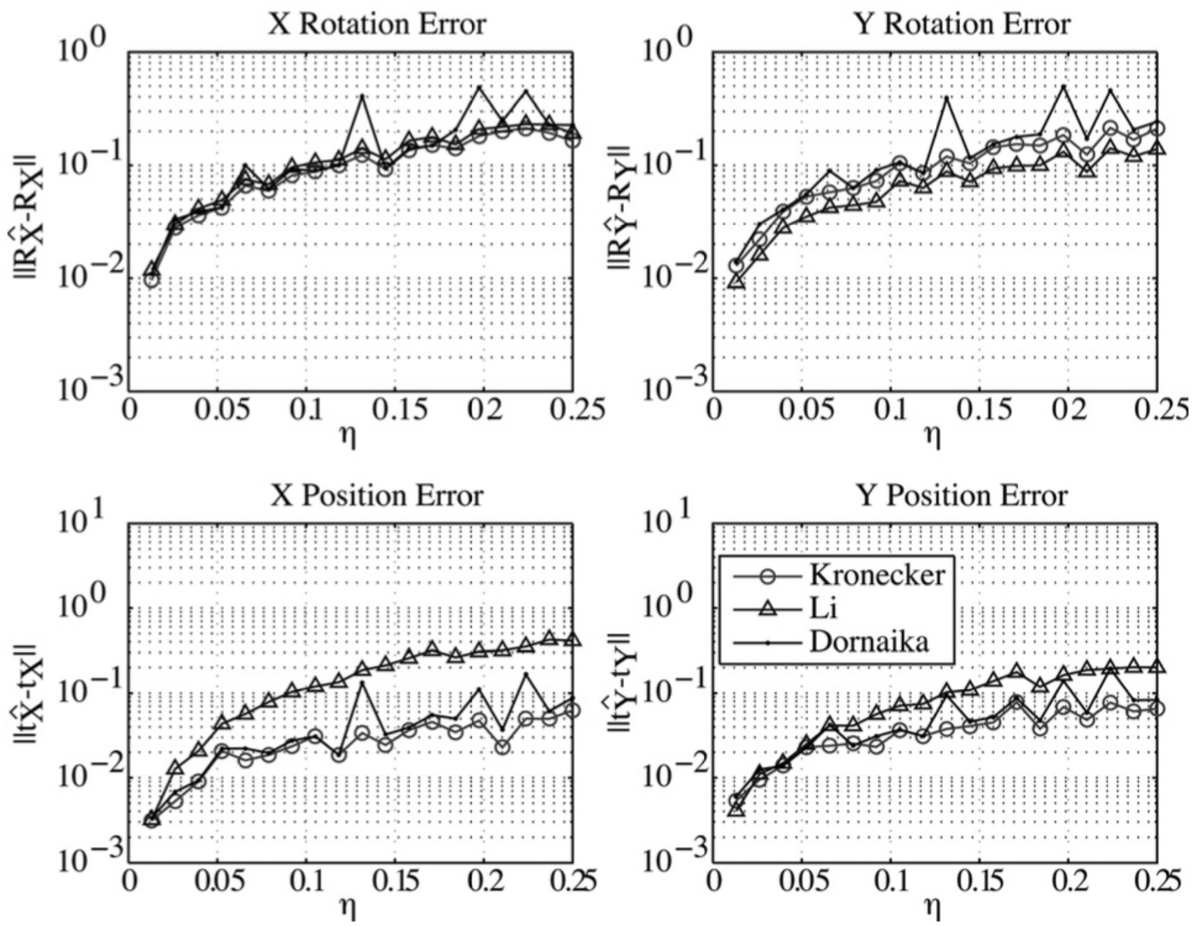


Fig. 2 Comparison of the Kronecker product method described in this paper (circles), the Li et al. Kronecker product method described in Ref. [9] (triangles), and the Dornaika and Horaud closed-form quaternion method described in Ref. [4] (solid line) on simulated data.

- First generate ground truth of X & Y
- Then generate A & B and add noise
- Calculate X & Y from A & B
- (sensitivity)

Real Data

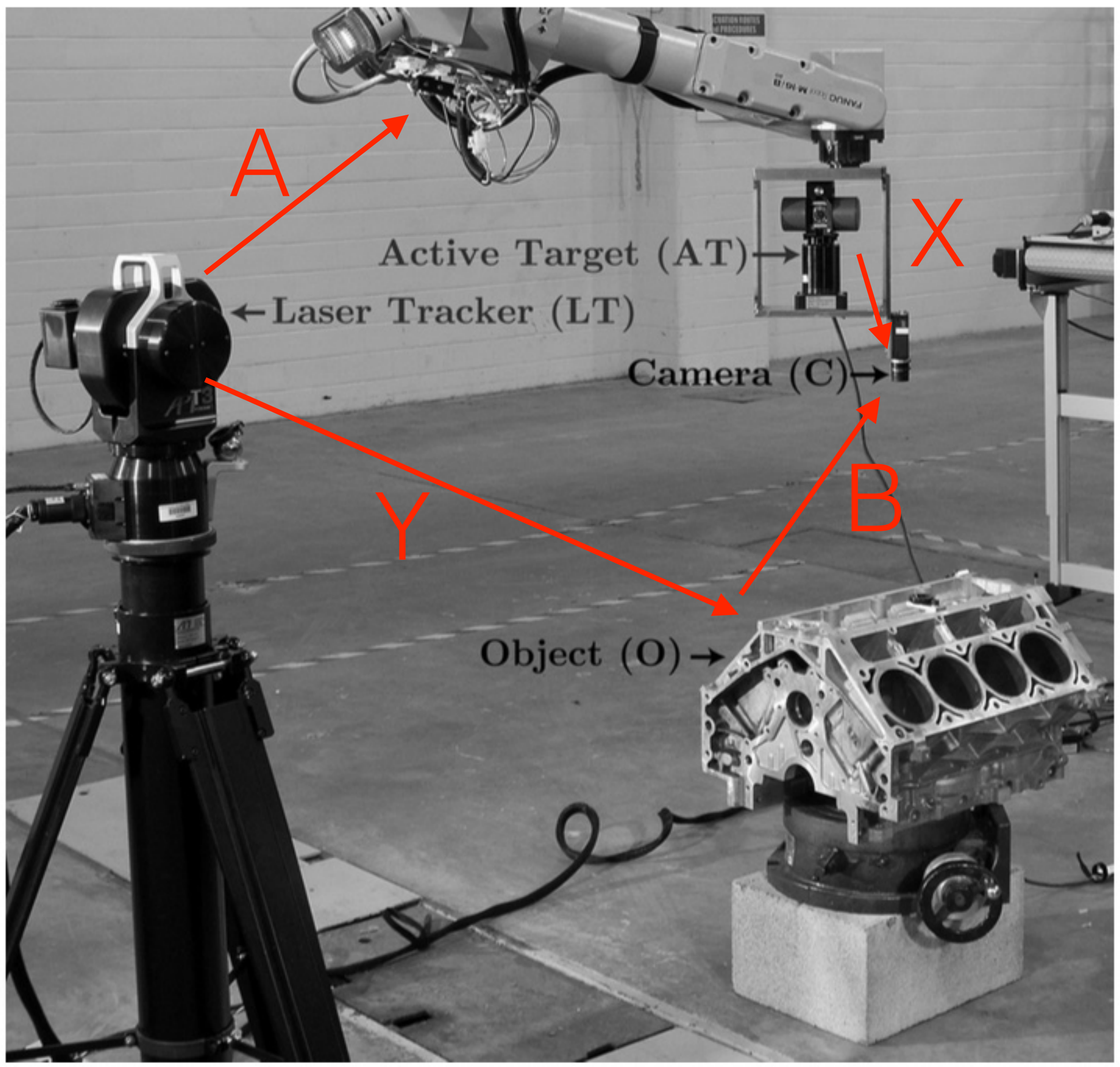


Fig. 3 Experimental setup of the commercial system with the laser tracker system

- Another measure of Y is considered as ground truth
- Rotation ~ 0.1%
- Translation ~ 2 - 5mm

Summary

- Closed Form: Fast and easy to completed
- Lack of analysis of factors that influence error
- Maybe helpful: http://math.loyola.edu/~mili/Calibration/AXYB/shah.m

An interesting Problem

- How we get correspond A & B
- Method 1: Time Stamp
- Method 2: using static pose?
- Method 3: Hard to complete and they don't give me the code
- Li H, Ma Q, Wang T, et al. Simultaneous Hand-Eye and Robot-World Calibration by Solving the $ AX= YB $ Problem Without Correspondence[J]. IEEE Robotics and Automation Letters, 2016, 1(1): 145-152.

Another interesting problem

- How to choose the n pair of poses
- Will moving a little several times influence the accuracy?

Thanks

- Any Question?