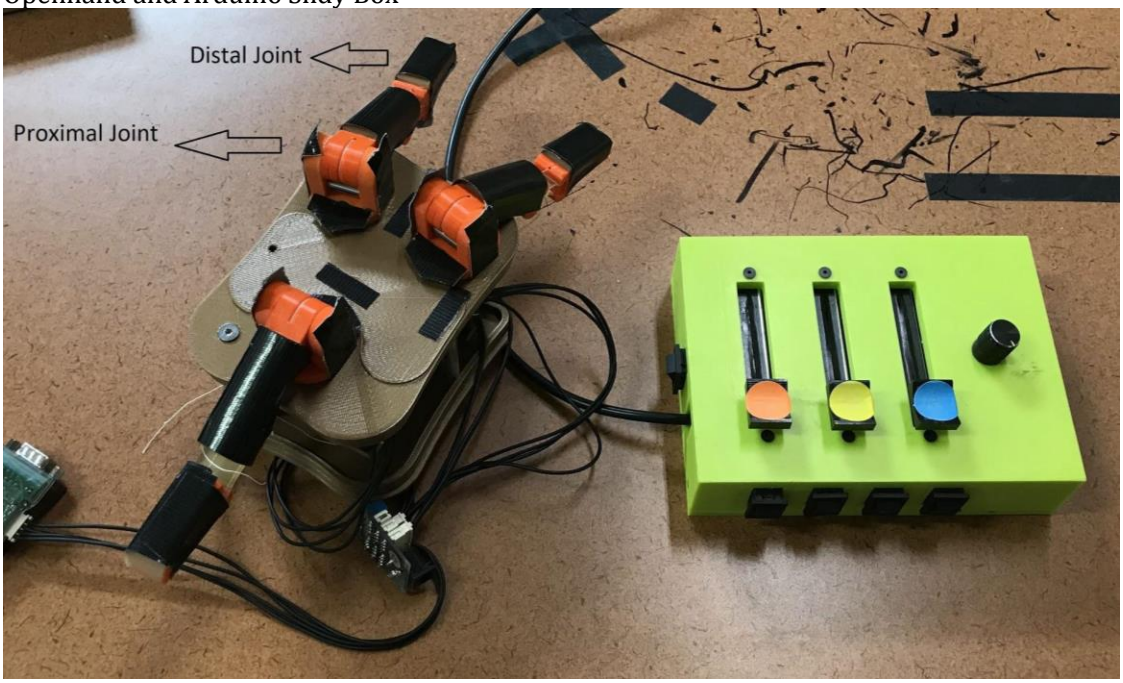
Project Purpose:

1. Write a python controller to actuate and control Openhand that contains 3 fingers by using 4 Dynamixel SDK servos, and an Arduino slider box that contains 3 sliders and 1 potentiometer.
2. Write a python script to conduct grasping analysis by taking finger position data of each grasping technique.

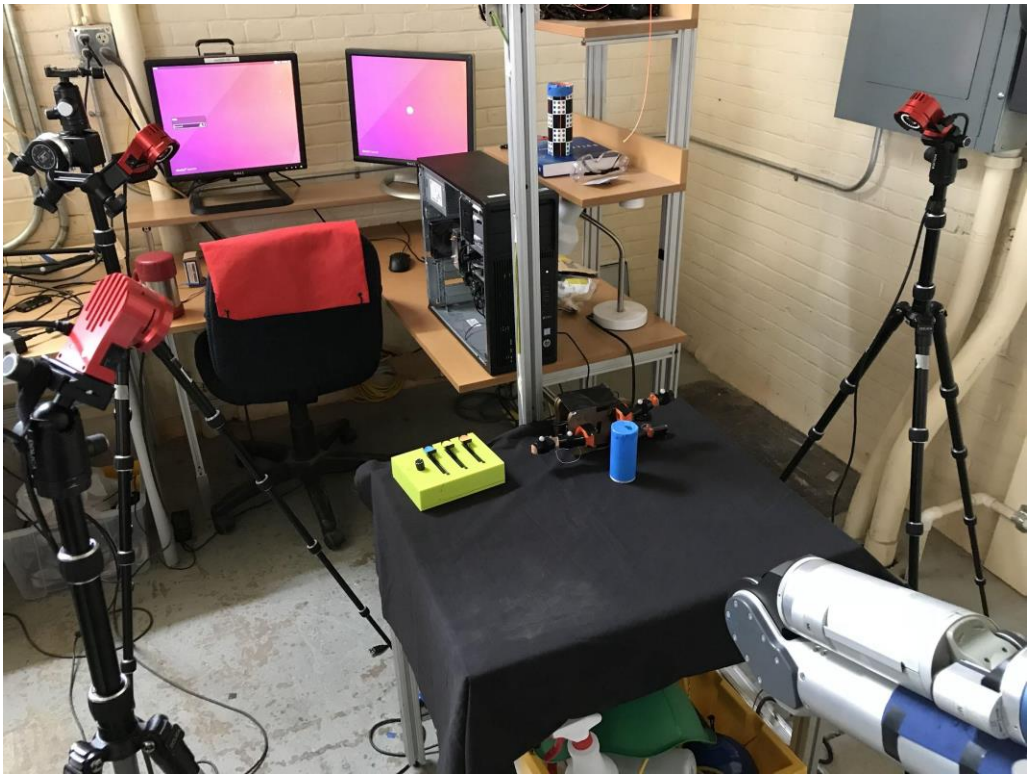
Results

Part 1. Python Controller of Openhand
Openhand and Arduino Slidy Box



Refer to the videos to validate the working Openhand, and Arduino slidy box
Refer to the python controller script to learn about controller mechanism

Part 2. Grasping Data Analysis
Refer to the videos to validate the Openhand executing three types of grasping techniques: Normal grasp, Palm grasp, Pinch grasp.



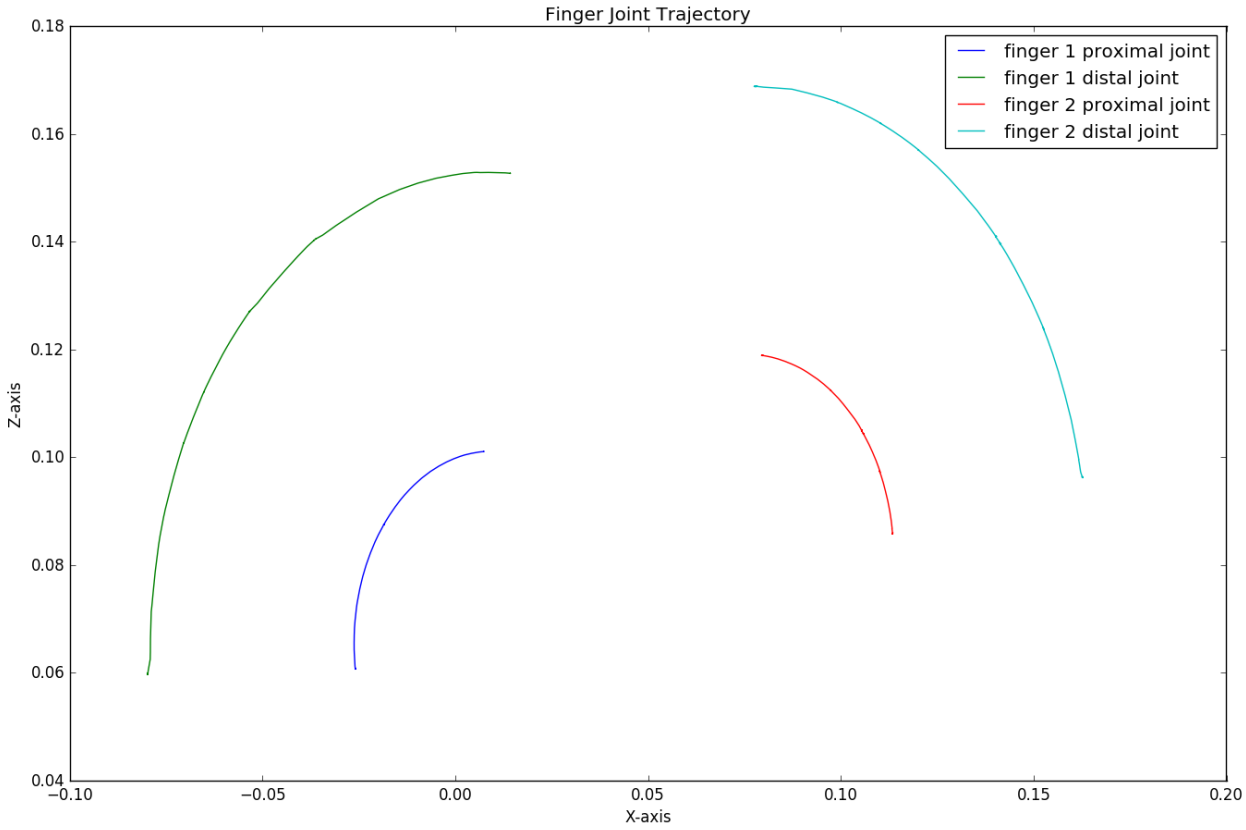
Optitrack Motion Capture:

- 3 Optitrack Cameras (red cameras in the picture) were set up around the table to capture grasping motion
- Joint positions of proximal and distal joint were collected in X (length), Z (width), Y (altitude) directions.
- For this project, only X and Z data were analyzed

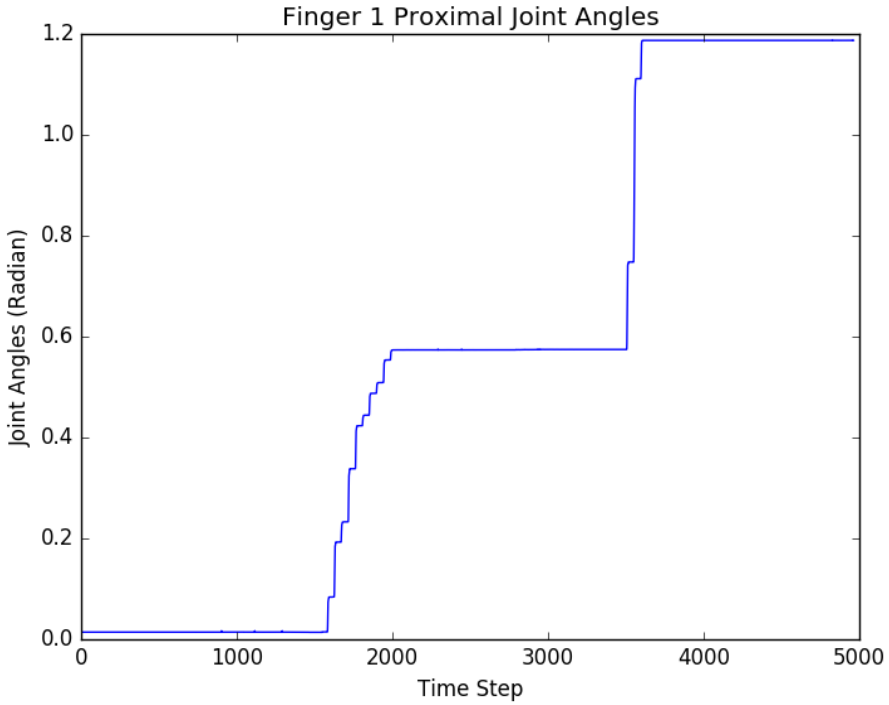
Data Analysis Results

Grasp Type / Technique: Normal Grasp

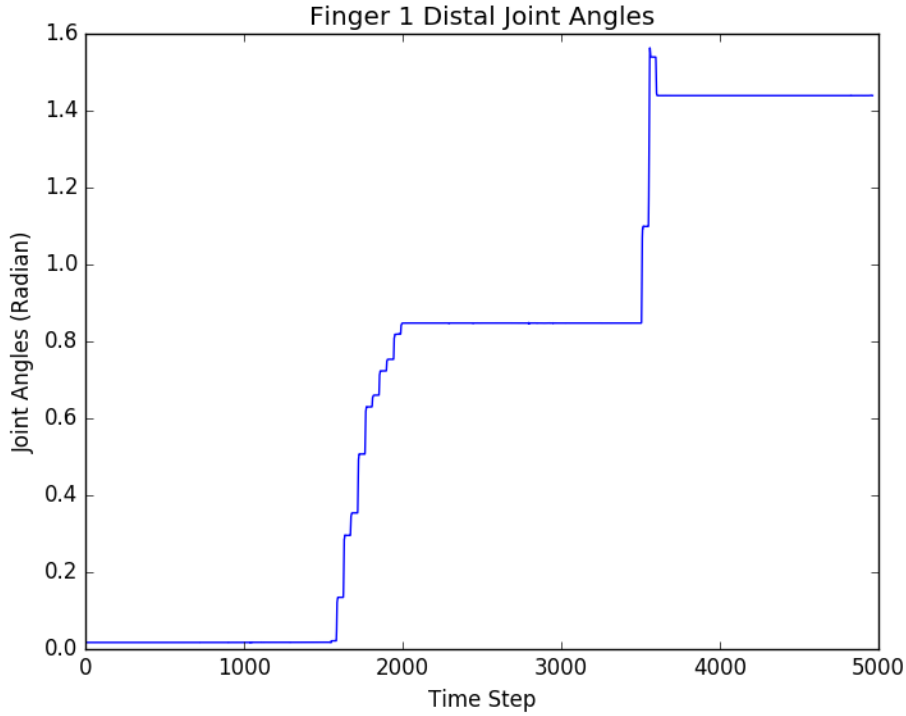
Proximal and Distal Joint Trajectory during normal grasp motion



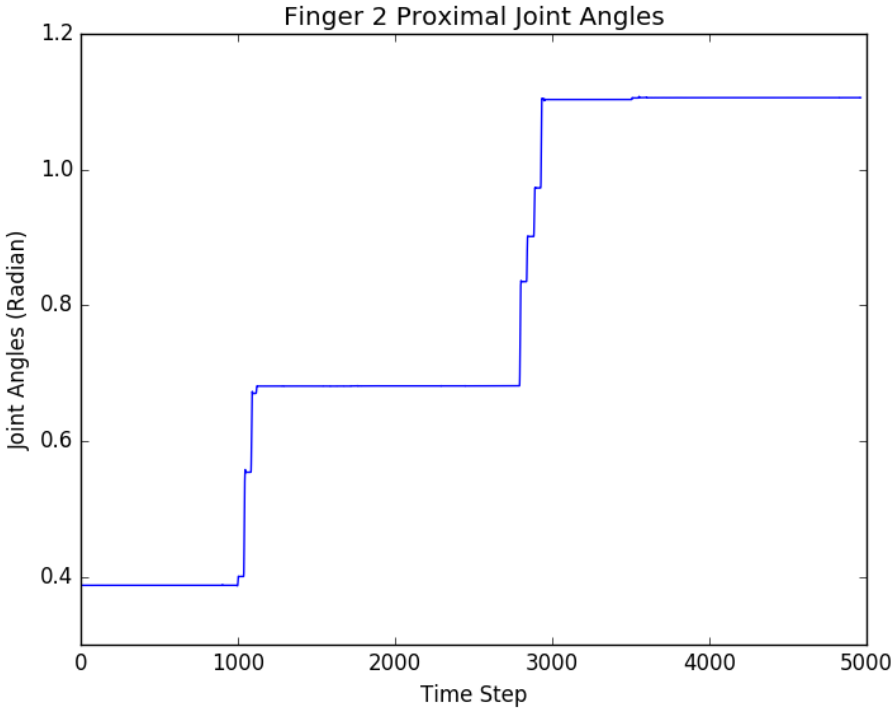
Finger 1 (left finger) Proximal Joint Angles



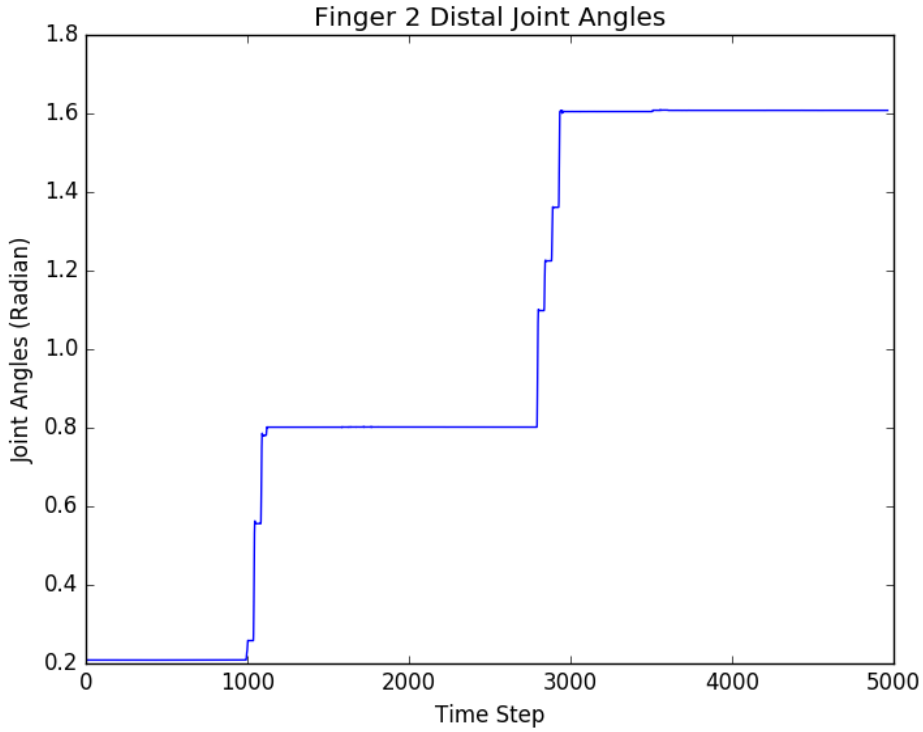
Finger 1 (left finger) Distal Joint Angles



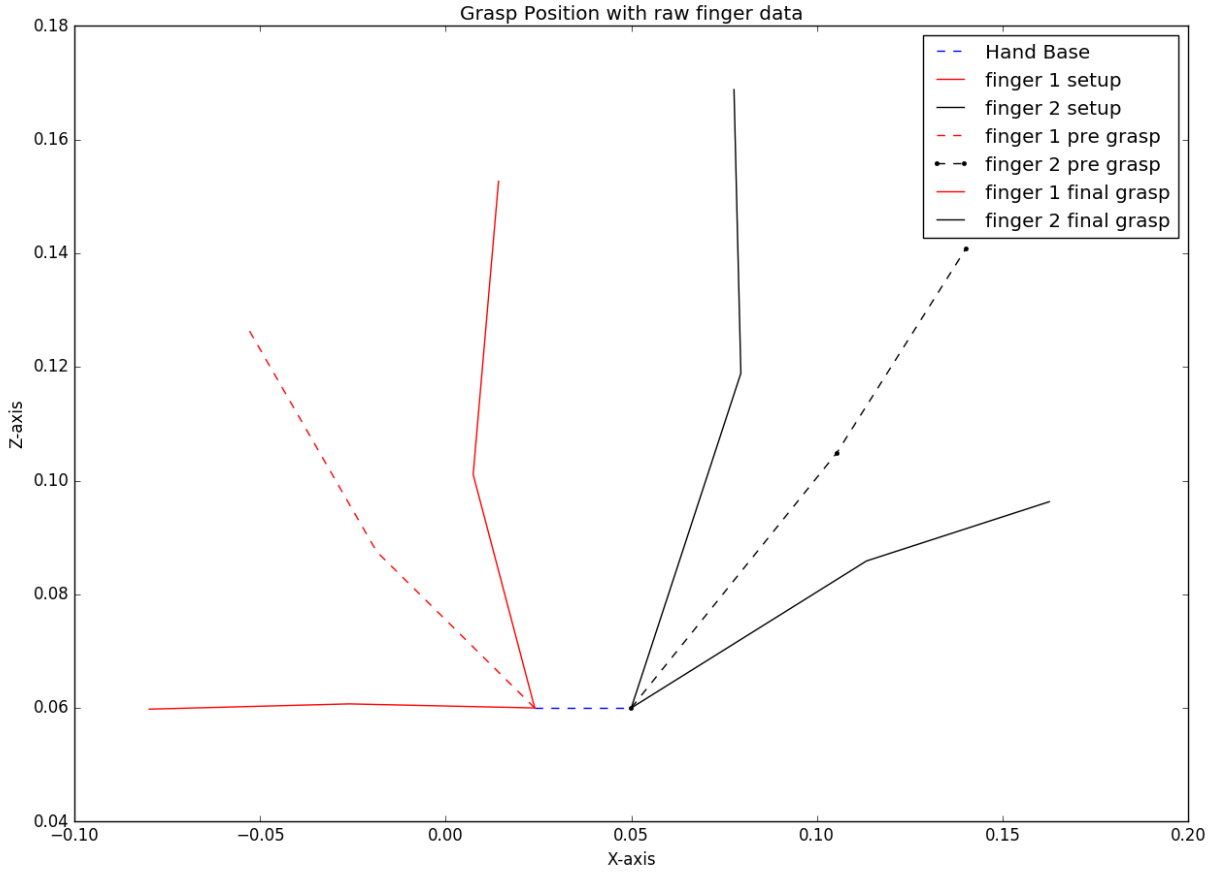
Finger 2 (right finger) Proximal Joint Angles



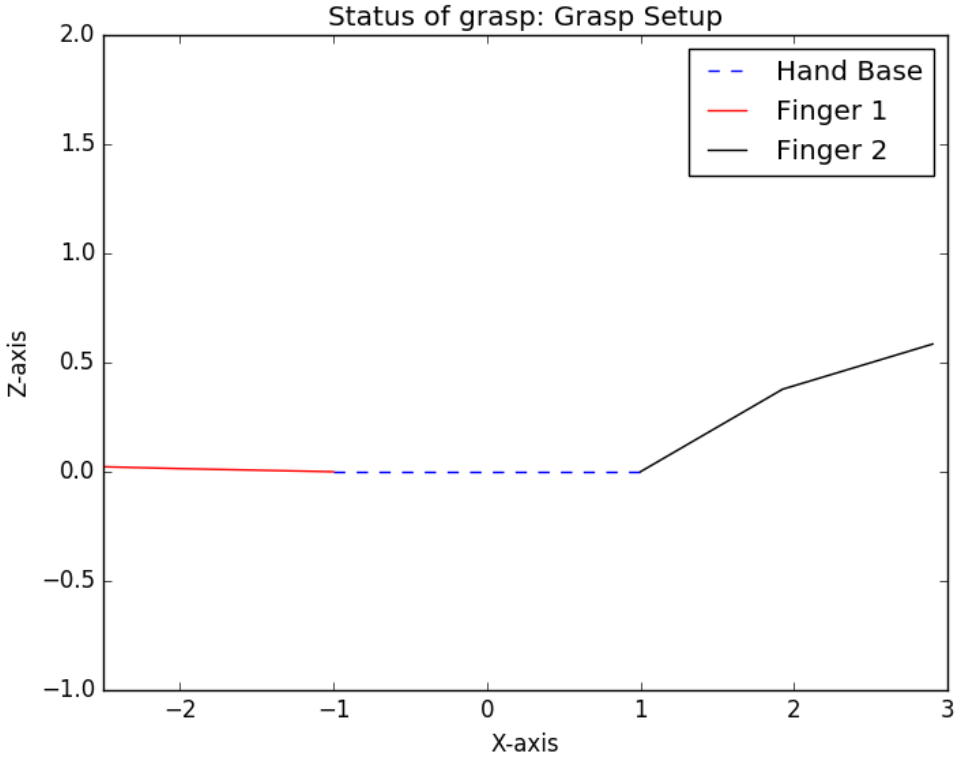
Finger 2 (right finger) Distal Joint Angles



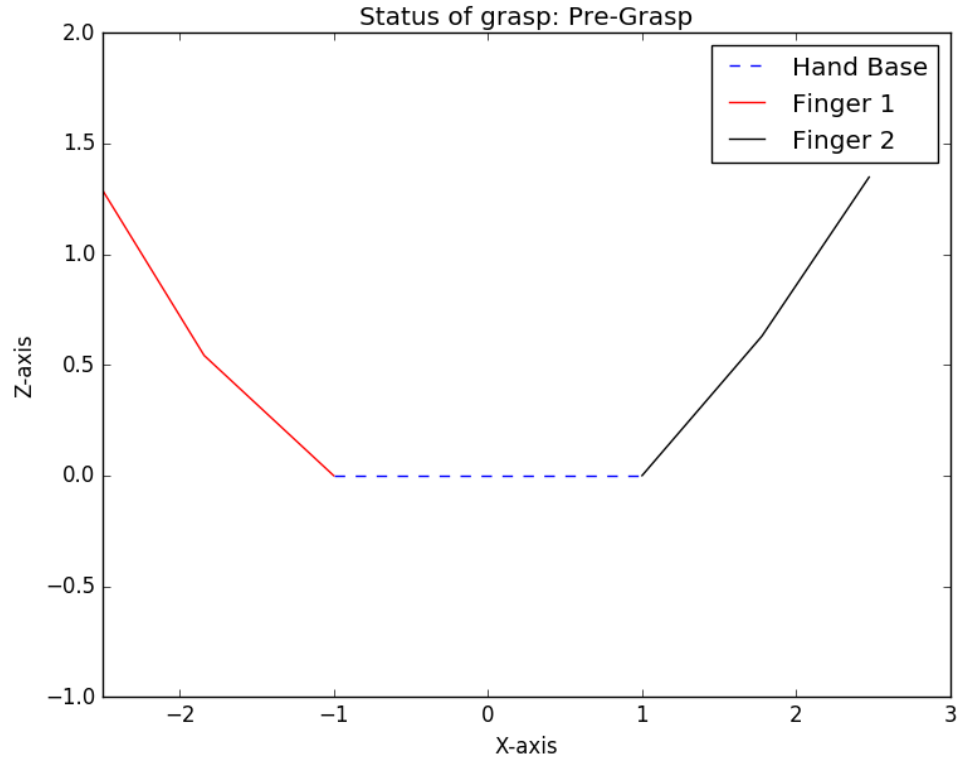
Openhand position during normal grasp motion (using collected joint position data)



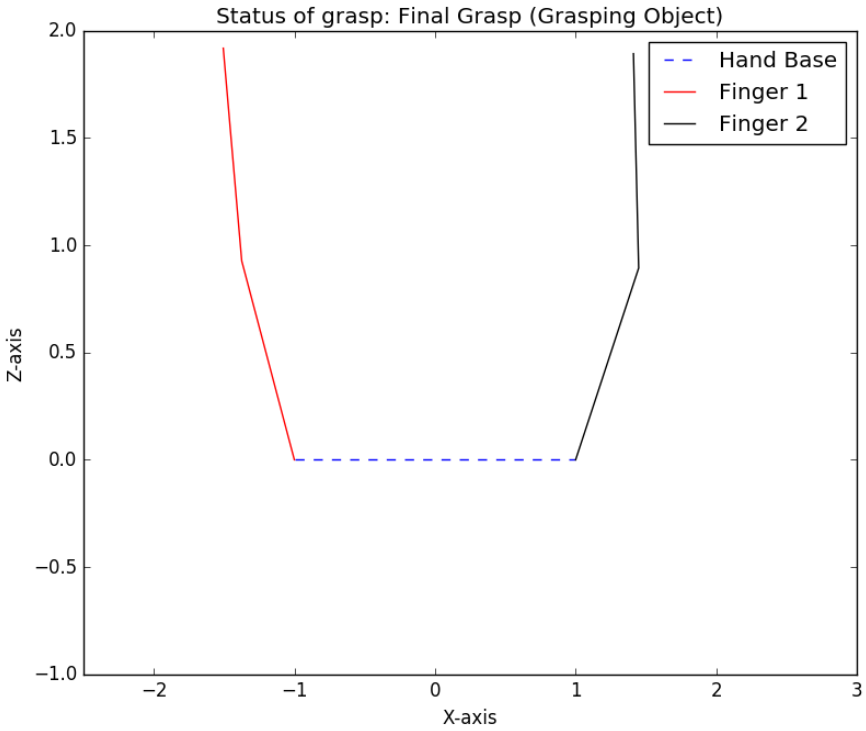
Initial Openhand position (plot using calculated joint angles)



Pre-grasp Openhand position (plot using calculated joint angles)

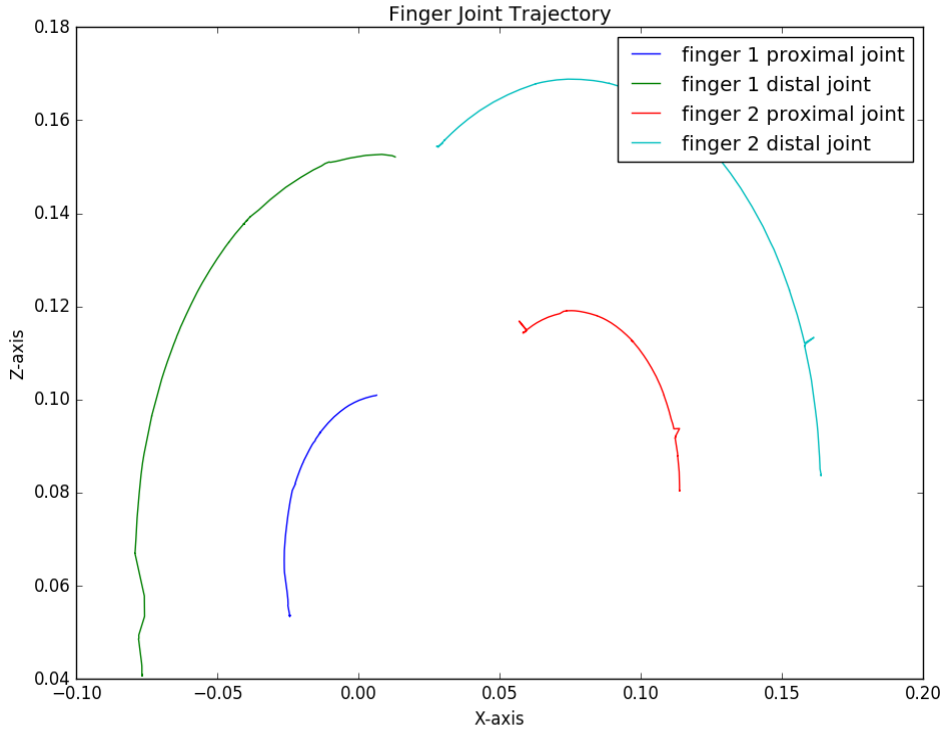


Final Openhand position (it means Openhand is grasping the object; plot using calculated joint angles)

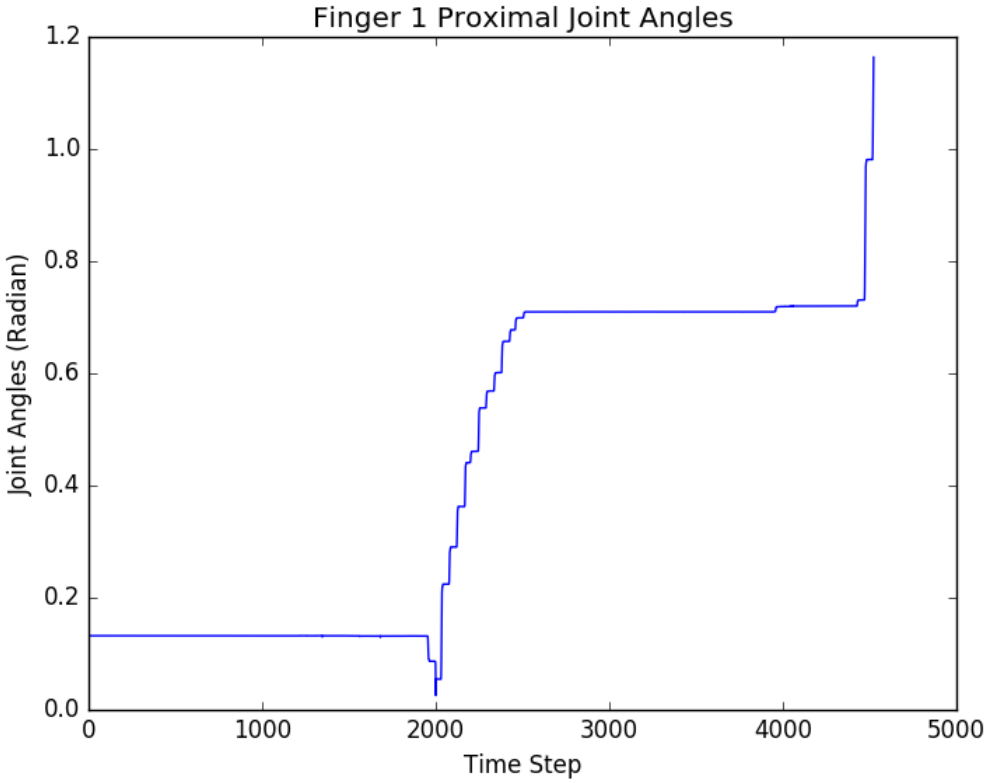


Grasp Type / Technique: Palm Grasp

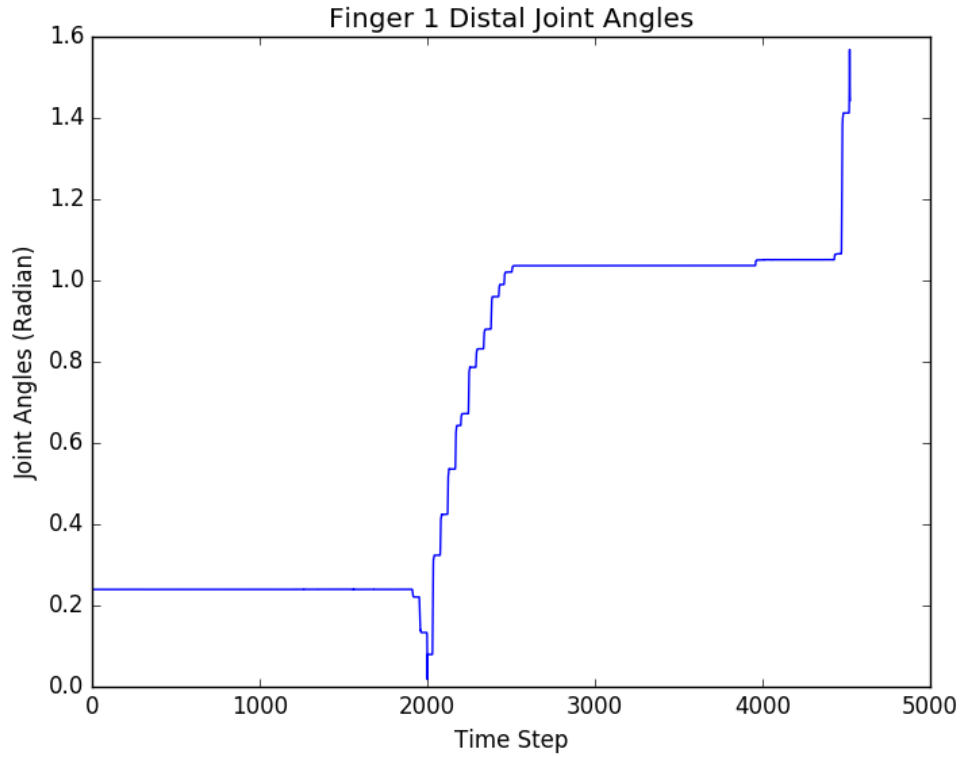
Proximal and Distal Joint Trajectory during palm grasp motion



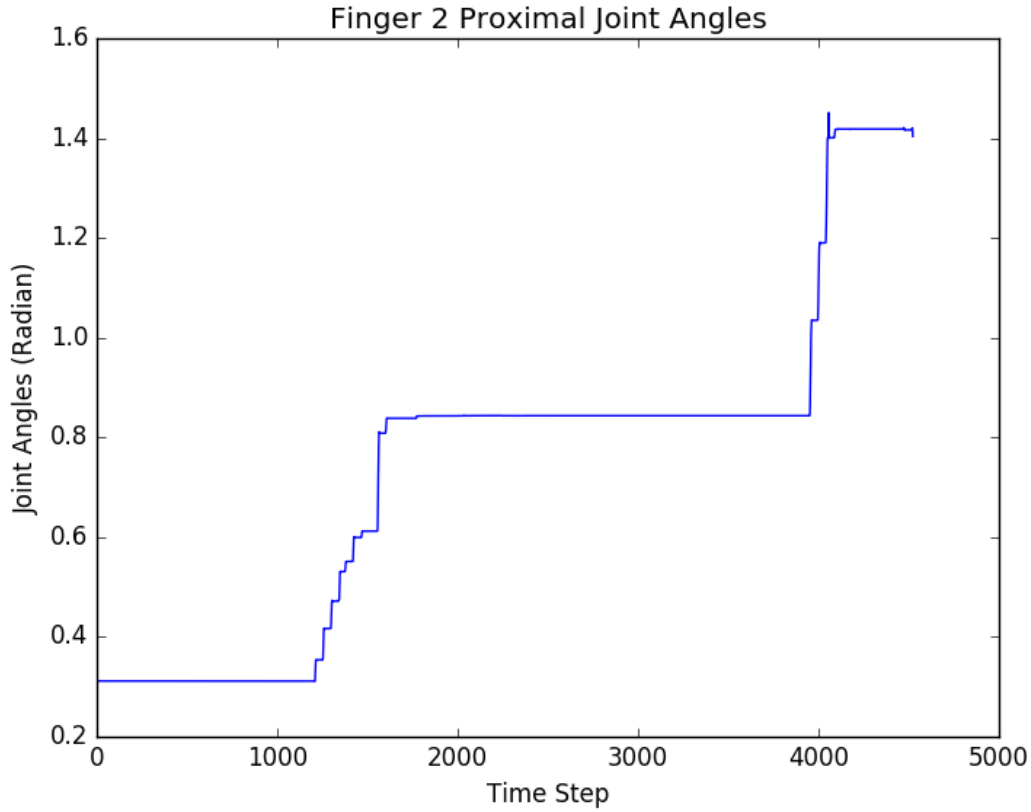
Finger 1 (left finger) Proximal Joint Angles



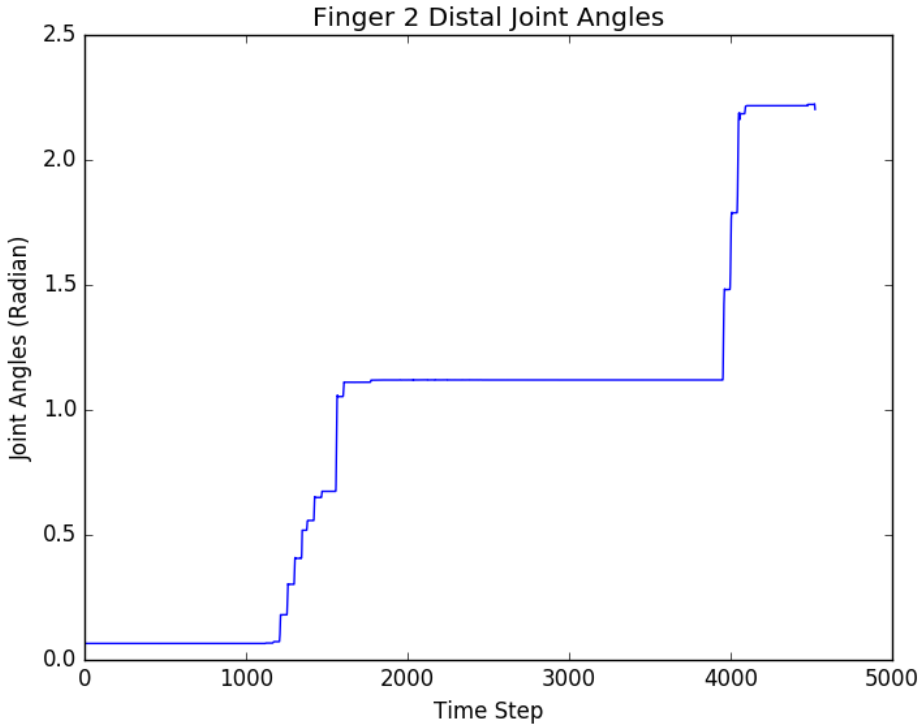
Finger 1 (left finger) Distal Joint Angles



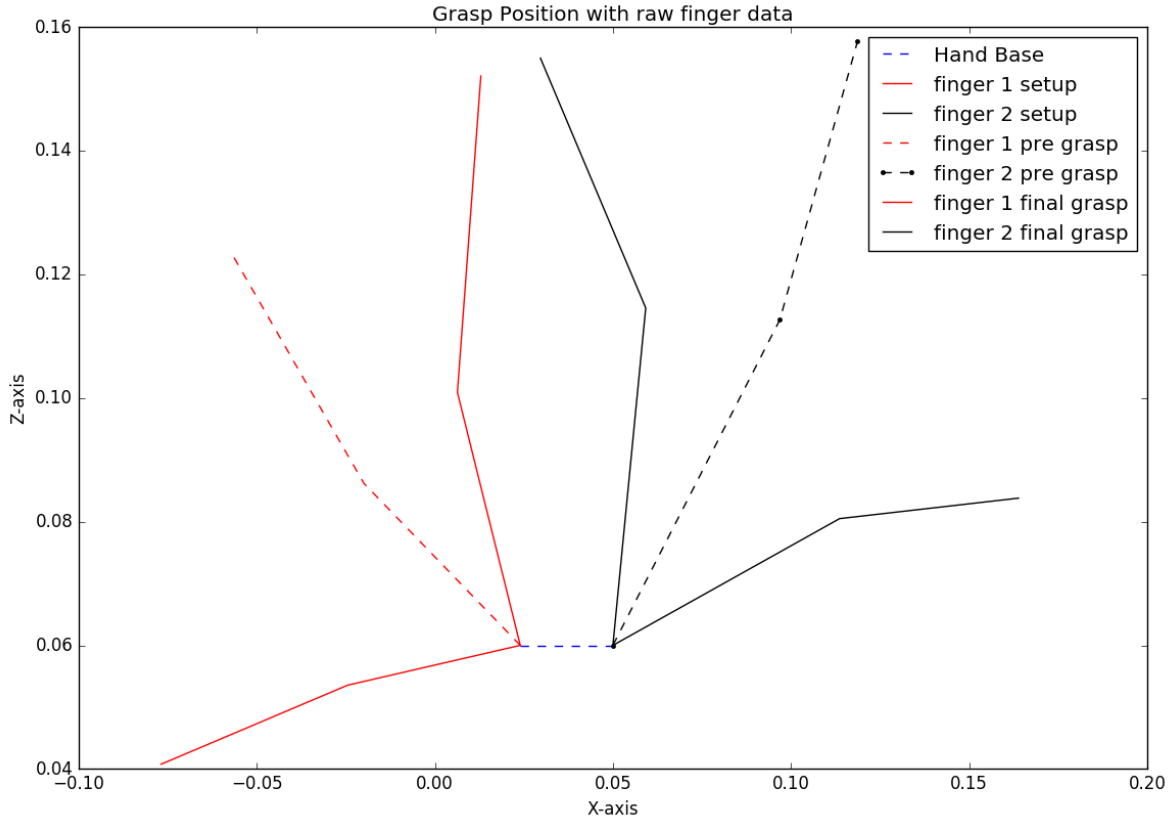
Finger 2 (right finger) Proximal Joint Angles



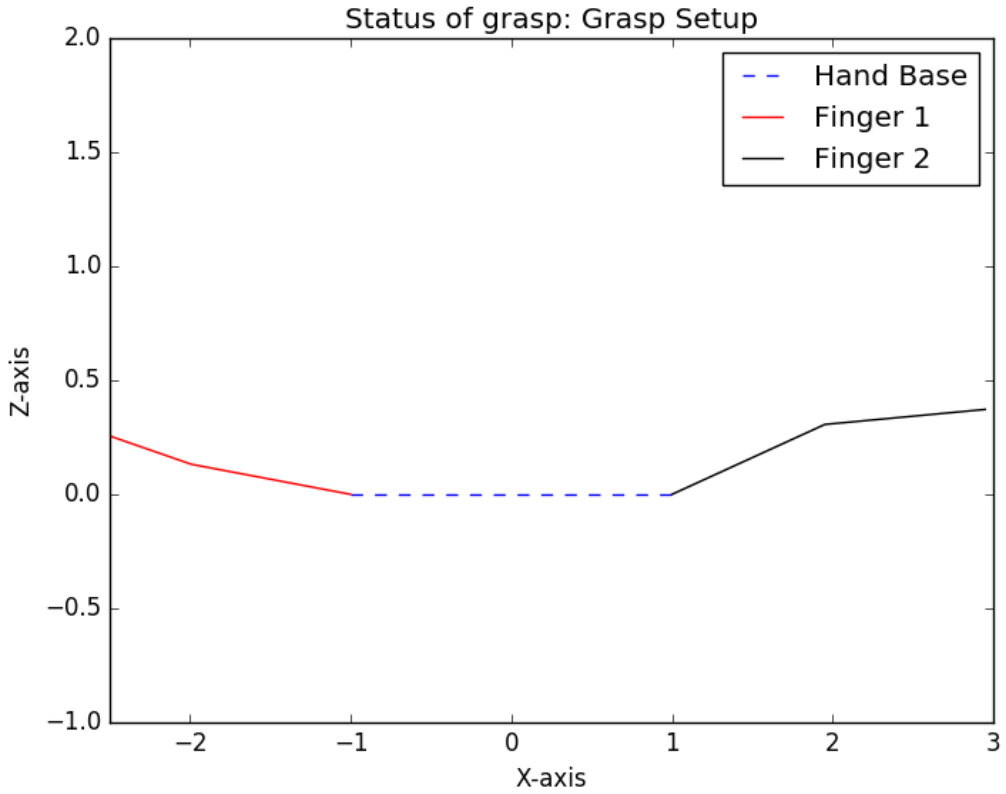
Finger 2 (right finger) Distal Joint Angles



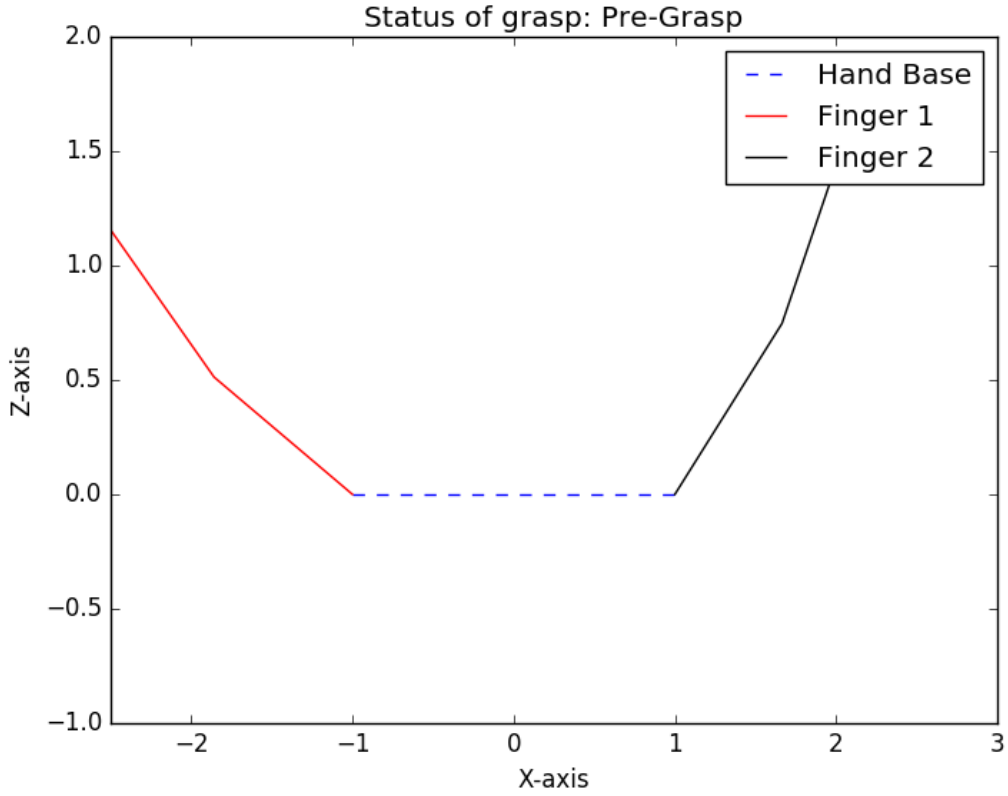
Openhand position during palm grasp motion (using collected joint position data)



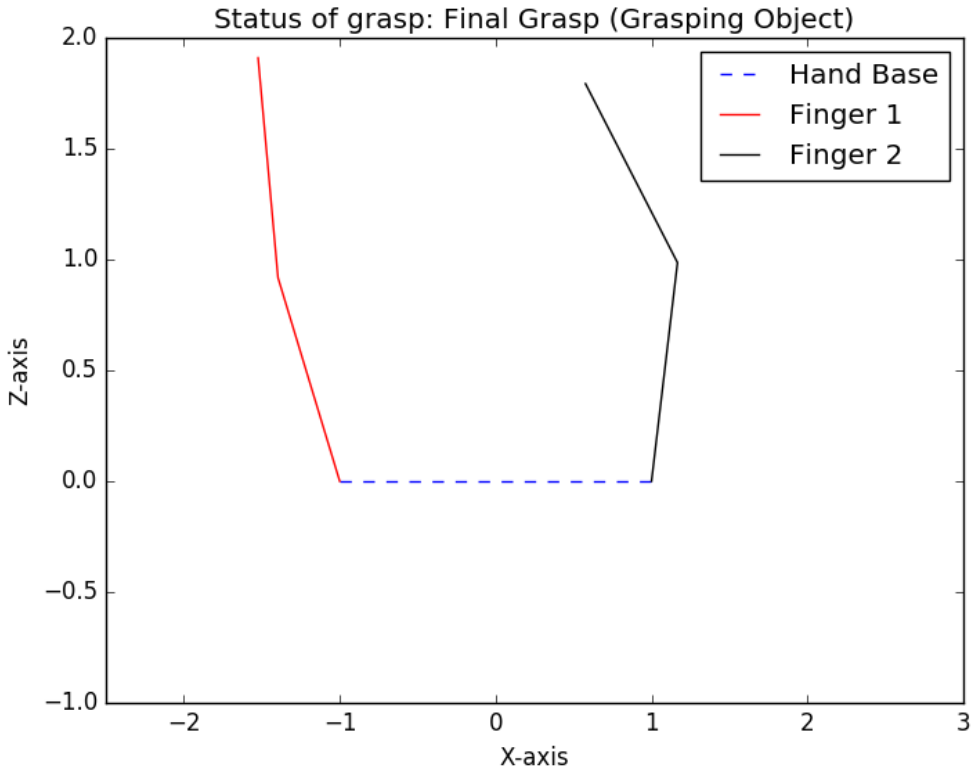
Initial Openhand position (plot using calculated joint angles)



Pre-grasp Openhand position (plot using calculated joint angles)

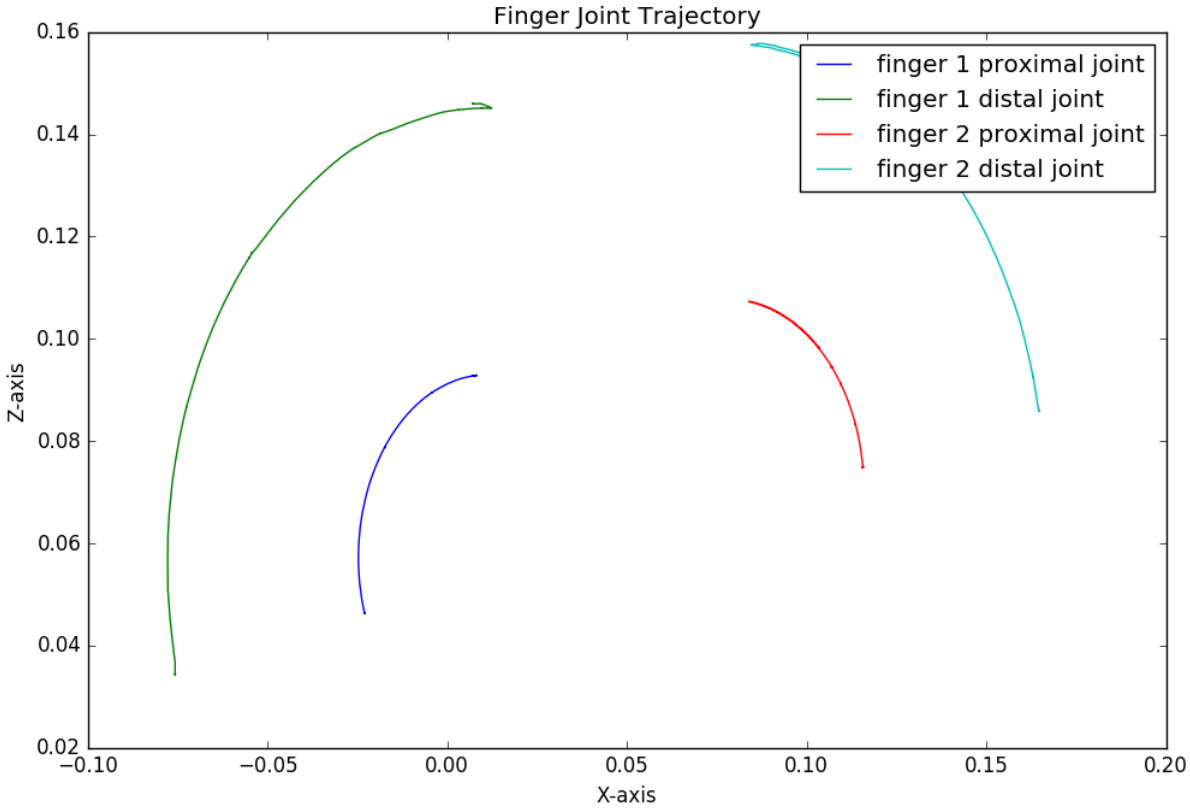


Final Openhand position (it means Openhand is grasping the object; plot using calculated joint angles)

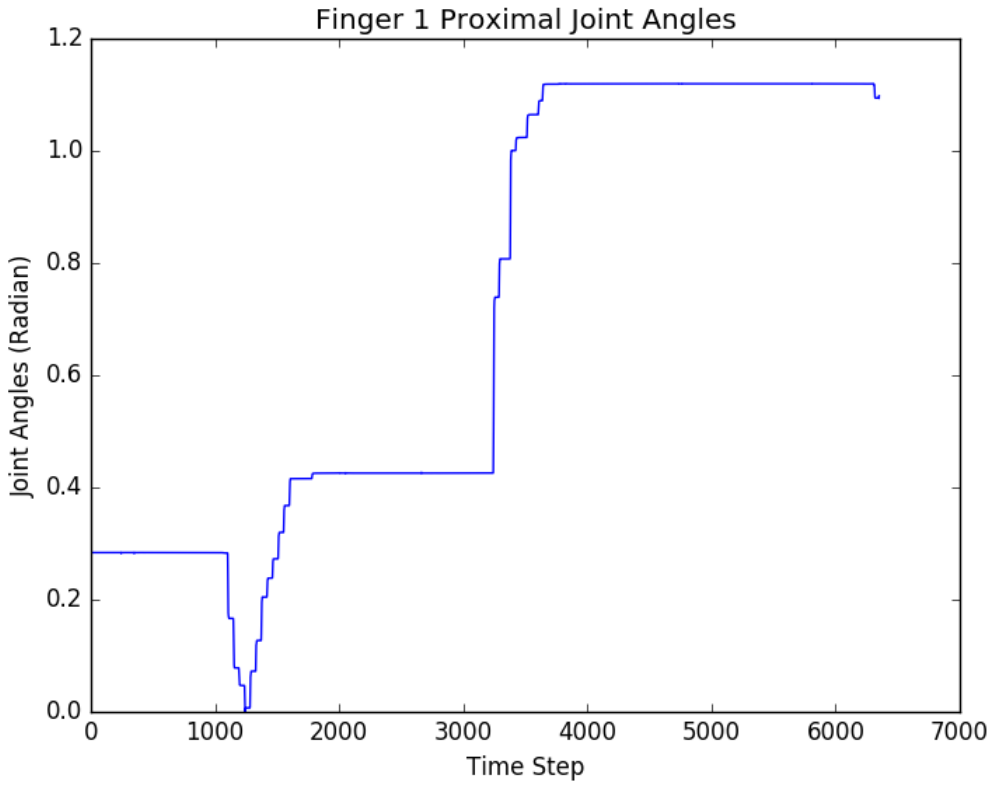


Grasp Type / Technique: Pinch Grasp

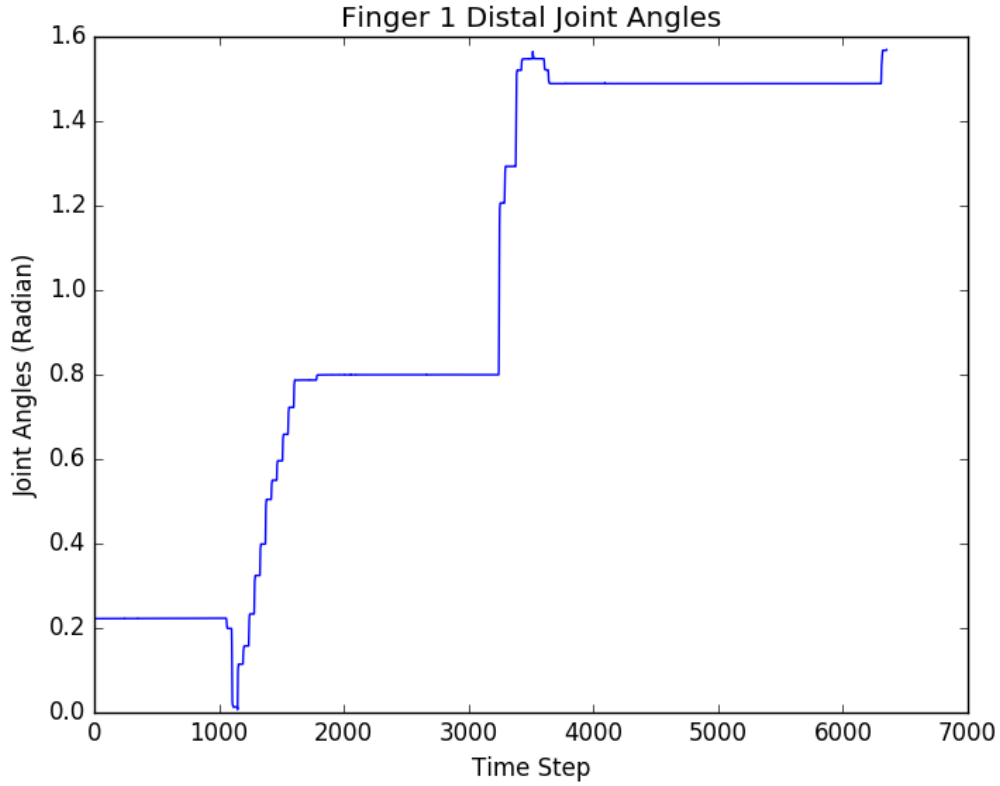
Proximal and Distal Joint Trajectory during pinch grasp motion



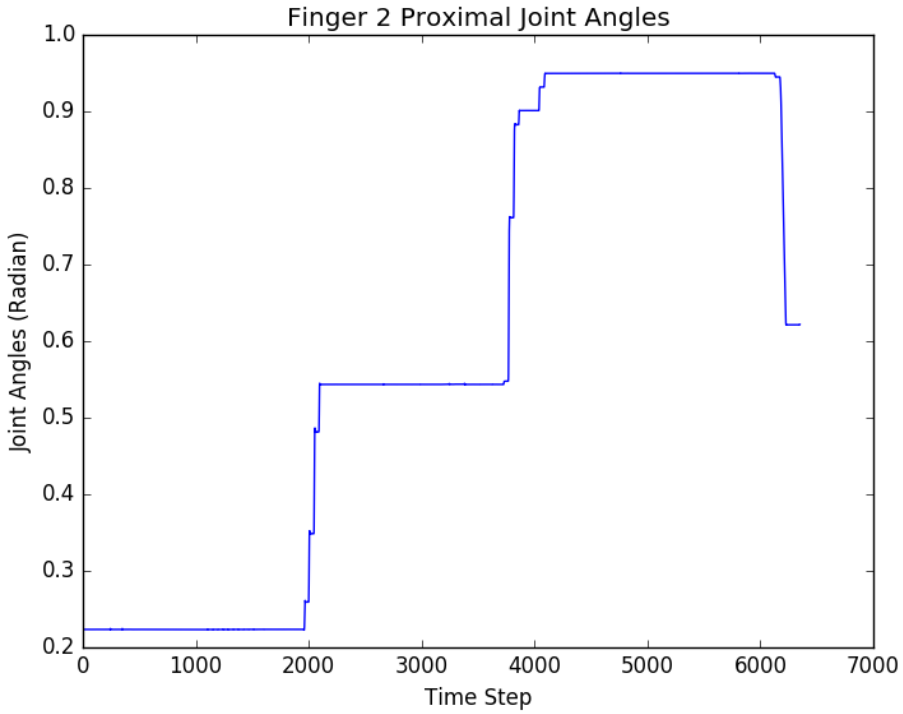
Finger 1 (left finger) Proximal Joint Angles



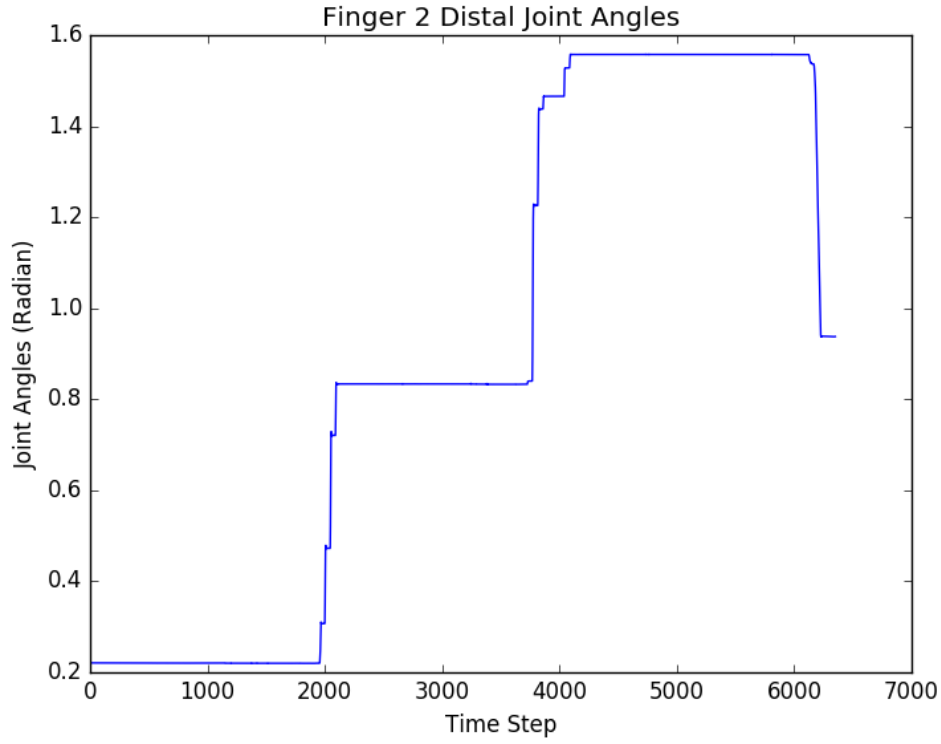
Finger 1 (left finger) Distal Joint Angles



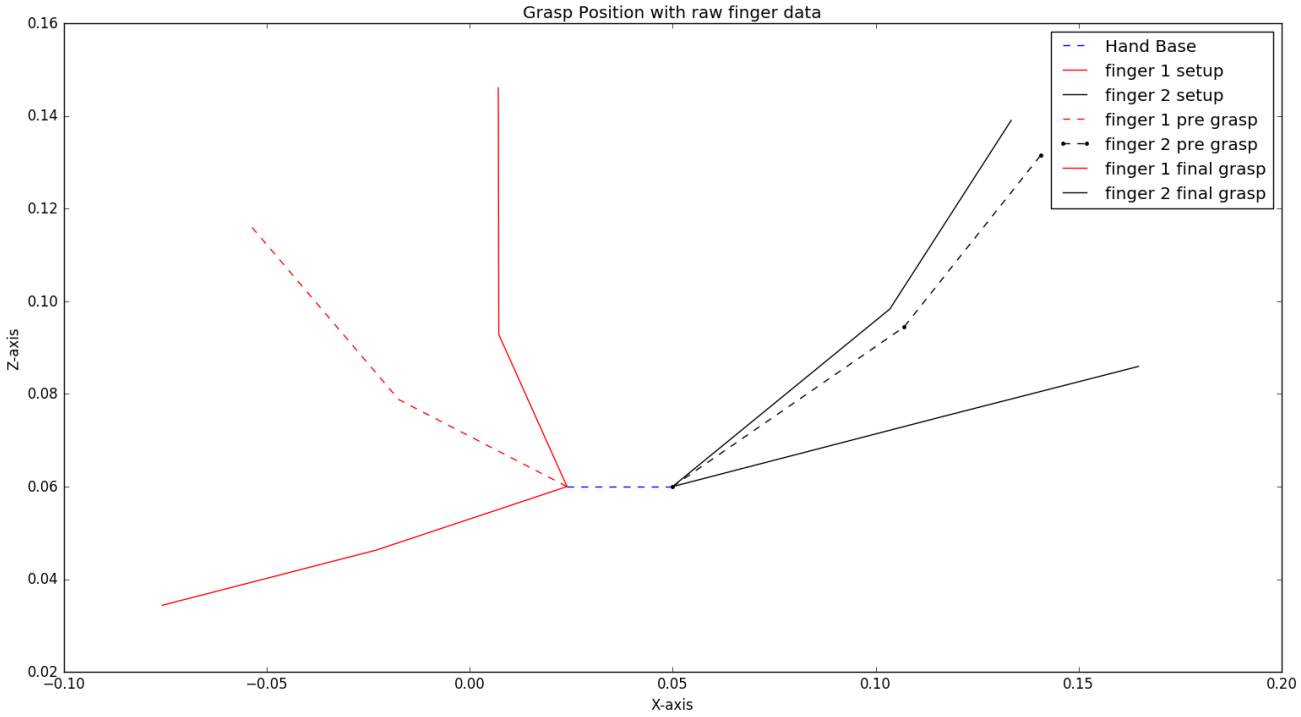
Finger 2 (right finger) Proximal Joint Angles



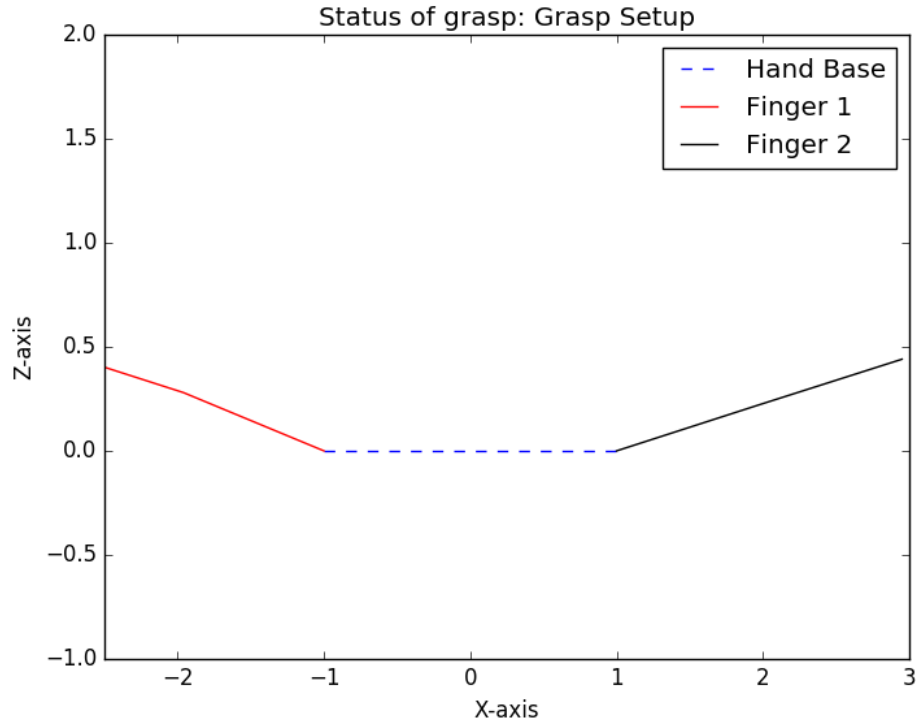
Finger 2 (right finger) Distal Joint Angles



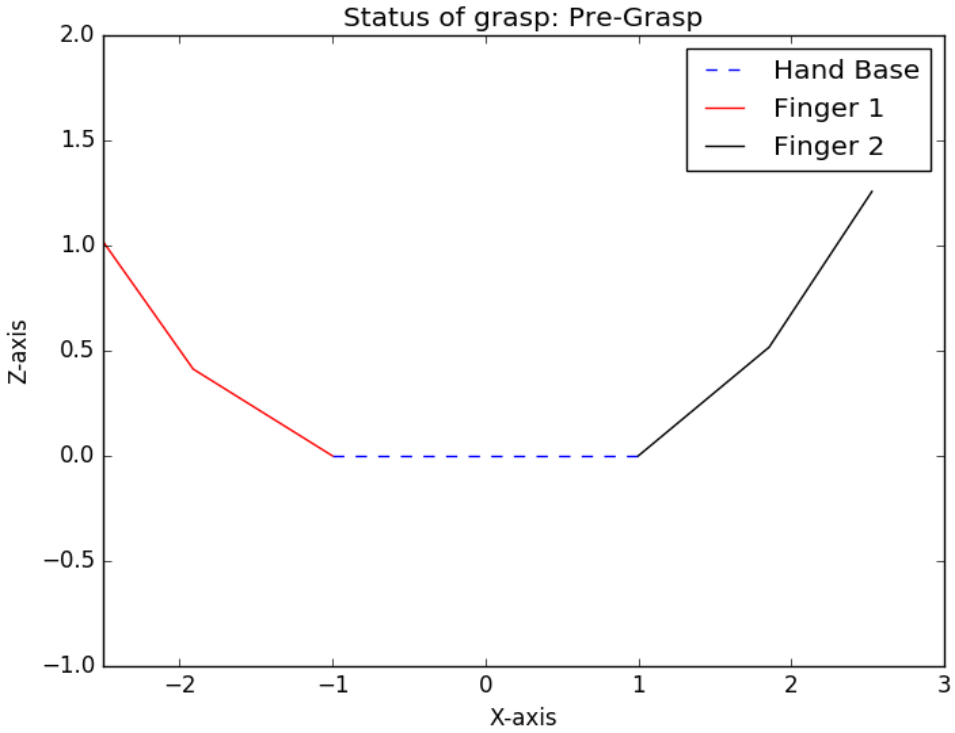
Openhand position during palm grasp motion (using collected joint position data)



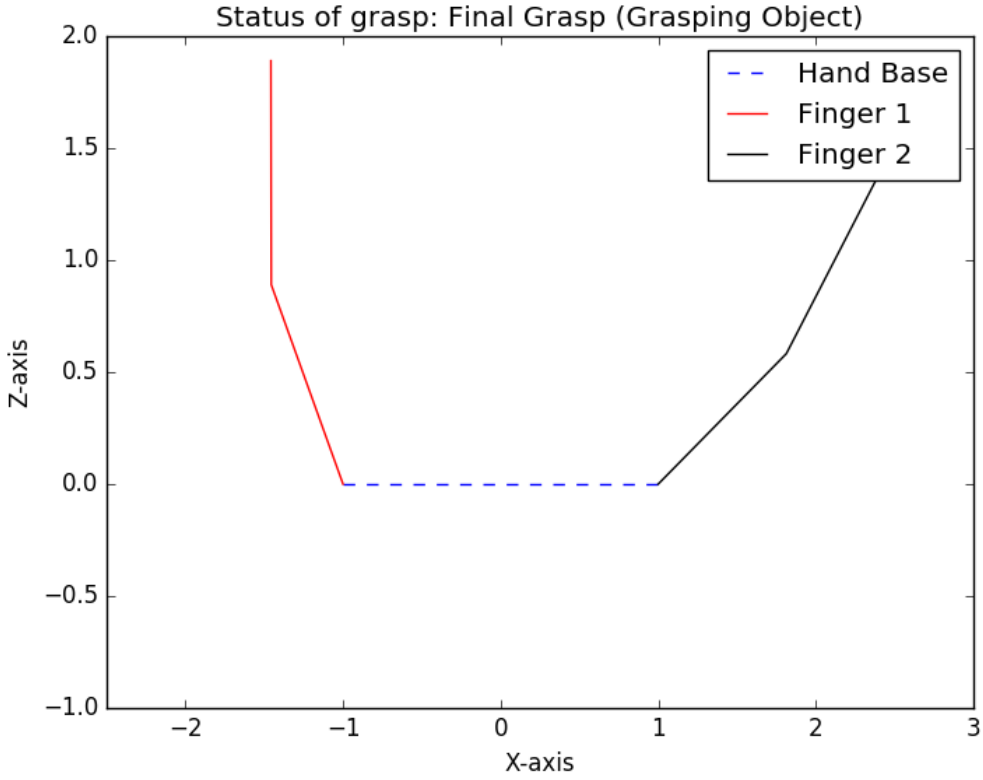
Initial Openhand position (plot using calculated joint angles)



Pre-grasp Openhand position (plot using calculated joint angles)

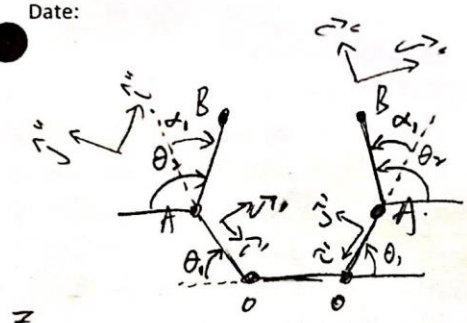


Final Openhand position (it means Openhand is grasping the object; plot using calculated joint angles)



Calculation
Joint Angle Calculation

Course:
Name: Yi Herng Ong
Date:



$\theta_1 = 0 + \theta_1$

$\theta_2 = \theta_1 + \alpha_1$

$\vec{r}_O = \vec{0}$

$\vec{r}_A = \vec{r}_O + \vec{r}_{A/O} = 0 + L_1 \hat{i}'$

$\vec{r}_B = \vec{r}_A + \vec{r}_{B/A} = L_1 \hat{i}' + L_2 \hat{i}''$

$\vec{r}_A = \begin{bmatrix} L_1 \\ 0 \\ 0 \end{bmatrix}' = \begin{bmatrix} L_1 \cos\theta_1 \\ L_1 \sin\theta_1 \\ 0 \end{bmatrix}$

$L_1 = OA.$

$L_2 = AB.$

$\vec{r}_B = \begin{bmatrix} L_1 \cos\theta_1 \\ L_1 \sin\theta_1 \\ 0 \end{bmatrix} + \begin{bmatrix} L_2 \\ 0 \\ 0 \end{bmatrix}''$

$\vec{r}_B = \begin{bmatrix} L_1 \cos\theta_1 \\ L_1 \sin\theta_1 \\ 0 \end{bmatrix} + \begin{bmatrix} L_2 \cos\theta_2 \\ L_2 \sin\theta_2 \\ 0 \end{bmatrix}$

For each finger, $\vec{r}_A = \begin{bmatrix} x_A \\ z_A \end{bmatrix}$ $\vec{r}_B = \begin{bmatrix} x_B \\ z_B \end{bmatrix}$.

$x_A = L_1 \cos\theta_1$ $\quad x_B = L_1 \cos\theta_1 + L_2 \cos\theta_2$

$z_A = L_1 \sin\theta_1$ $\quad z_B = L_1 \sin\theta_1 + L_2 \sin\theta_2$

Joint Angle of A

$\theta_1 = \cos^{-1}\left(\frac{x_A}{L_1}\right)$

Joint Angle of B.

$\theta_2 = \cos^{-1}\left(\frac{x_B - L_1 \cos\theta_1}{L_2}\right)$

Note: x_A, z_A, x_B, z_B will be collected from motion capture using Optitrack.

L_1 & L_2 are the length from O to A, and A to B of each finger.

Future Work

Finger position data with other grasping techniques and approaches will be collected by varying the distance between object and Openhand. Successful and Failure grasp will be recorded for each grasping technique, and a distance range that guarantees successful grasps will be determined.