LAB 02-GETTING FAMILIAR WITH ARM HARDWARE

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EE366L/CE366L: Introduction to Robotics Lab

1. TASK 2.1 Model of the arm (20 points)

(a) Links and Joints are annotated in the below figure.

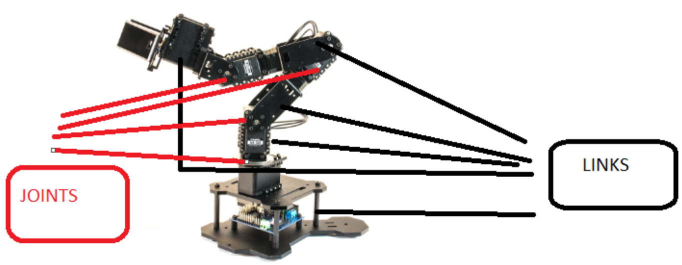
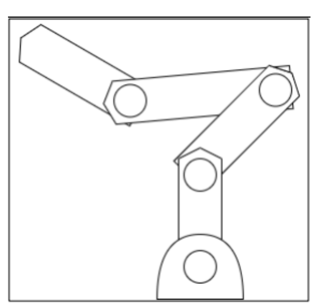


Figure 2.1: Phantom X Pincher Arm

(b) There are Four Joints and Five Links in the above arm.

(c) All of the Four Joints are Revolute Joint. There is an open-loop kinematic chain mechanism, RRRR means the chain has 4 revolute joints.



(d) Degrees of Freedom = m(N-1)-(JxC)

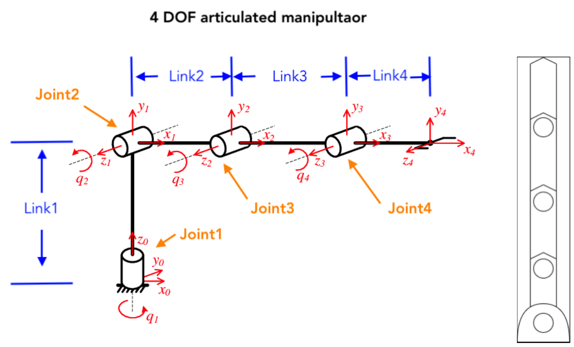
$$(m = 3, C = 2, N = 5, J = 4)$$

Degrees of Freedom = 3(5-1)-(4x2)

Degrees of Freedom = 4.

2. TASK 2.2 Configurations Exploration (20 points)

(a) The robot to a configuration with maximal horizontal reach = 340 mm and vertical reach = 360 mm



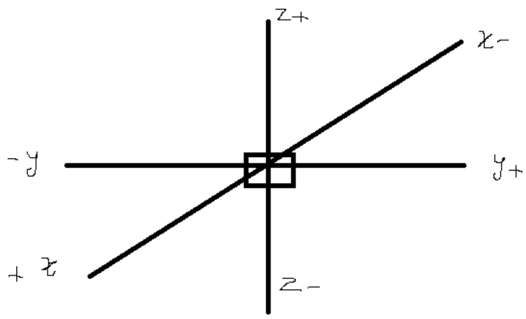
(b) We noticed that the wrist angle could only move within a certain degree i.e., from -30° to 30°. This limit was to make sure the safety of the robot also other joints move as well along with the wrist.

(c) In the real world there is some resistance factor that affects the robot manipulator. Which can be solved by the sensors and Feedback control system in the robot. But still, there is some error that remains which is called "Machine Error" or the least error. During this activity, the real-world environment is sensed and the arm motion is adjusted based on the received sensing data and actual data which is inserted through ArmLink software. The Processing happening in the Micro Controller board which is adjusting the error rate. https://www.sciencedirect.com/topics/engineering/environmental-sensor

(d) A task suitable to describe in the cartesian coordinates can be a picking and placing of an object on a certain location. A task suitable to describe in the cartesian coordinates can be 3D printing or drawing something

3. TASK 2.3 Coordinate Axes (10 points)

(a) The directions of positive x, y, and z axes and mark them on paper, in relation to the shape of the black base.



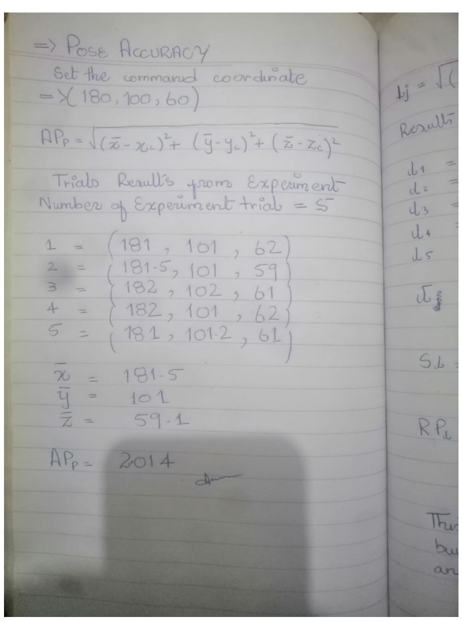
(b) 1 unit on the Armlink software corresponds to 0.95 mm on the sheet in the real world.The point we chose to measure the distance from is Grasper's terminal point.

Direction	Arm Link Coordinates		Physical Units		Resolution
	Lower	Upper	Lower	Upper	
X	0mm	200mm	0mm	180mm	$\frac{180-0}{200-0+1} = 0.9$
Y	50mm	240mm	52mm	230mm	$\frac{230-52}{240-50+1} = 0.98$
Z	10mm	150mm	20mm	140mm	$\frac{140-20}{150-10+1} = 0.85$

4. TASK 2.4 Accuracy and Repeatability (50 points)

(a) We have designed an experiment for determining the accuracy and repeatability of the robot. We first take a reference point in the workspace of the robotic arm and mark the point on the sheet with its coordinates (x,y,z) or coordinates of the command pose and conducted five trials in order to find repeatability and accuracy because we know that the Accuracy is how close a stage can position to the actual (true) value. Repeatability is a measure of the stage's ability to sequentially position to the same target value.

(b) Calculations and Results



=> Pose Accuracy

Set the command coordinate

= X(180, 100, 60)

$AP_P = \sqrt{(\bar{x}-x_c)^2 + (\bar{y}-y_c)^2 + (\bar{z}-z_c)^2}$

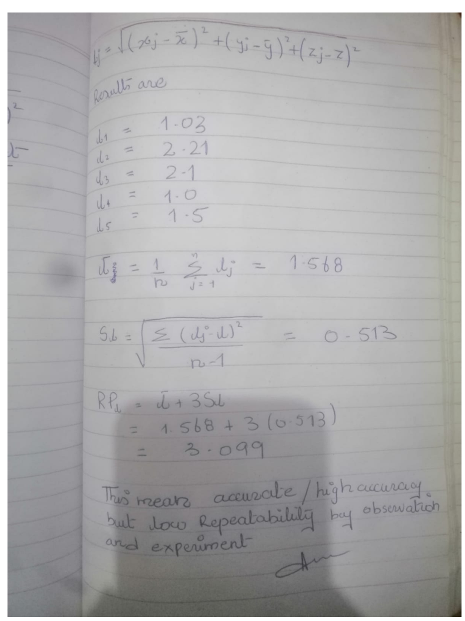
Trials Results from Experiment

Number of Experiment trials = 5

1 = (181, 101, 62)
2 = (181.5, 101, 59)
3 = (182, 102, 61)
4 = (182, 101, 62)
5 = (181, 101.2, 61)

$\bar{x}$ = 181.5
$\bar{y}$ = 101
$\bar{z}$ = 59.1

AP_P = 2014



$l_j = \sqrt{(x_j-\bar{x})^2 + (y_j-\bar{y})^2 + (z_j-z)^2}$

Results are

d_1 = 1.03
d_2 = 2.21
d_3 = 2.1
d_4 = 1.0
d_5 = 1.5

$\bar{l}_j = \frac{1}{n}\sum_{j=1}^{n} l_j = 1.568$

$S_l = \sqrt{\frac{\sum (l_j - \bar{l})^2}{n-1}} = 0.513$

$RP_l = \bar{l} + 3S_l$
$= 1.568 + 3(0.513)$
$= 3.099$

This means accurate / high accuracy but low Repeatability by observation and experiment

(c) We took three points in different regions with point 1 nearest to the origin and point 2 middle and point 3 furthest. We see that as we move away from the origin the error increases esp for the z-axis. So yes as we move away from the base accuracy decreases.

(d) The repeatability and accuracy are likely to be important to evaluate: path, position and orientation. These are the factors that you want to assure you are achieving each and every time you set your robot and end-effector in motion. The combination of position and orientation with the robot's end-effector is called a pose. Absolute position accuracy is the ability of the robot to reach a specific programmed position with minimum error. If the accuracy and/or repeatability of our robot arm is lower in pick and place operation then the operation will not be more accurate and precise because there will be a high error or precision rate. The position reached by the robot arm will differ from the desired position, and the robot will be unable to pick and place the object perfectly. The pose repeatability of an industrial robotic arm studied ranges from 0.9 to 2.5, while the repeatability ranges from 4.5 to 5.9. The calculations of these values include an important delay factor known as delta in the Armlink software, which refers to how quickly the arm moves to a specific position. Our results lie in the high accuracy and low repeatability condition that is calculated in the above part

$https://blog.robotiq.com/what-are-accuracy-and-repeatability-in-industrial-robots$

(e) Answered in the above part(d).

https://www.kth.se/polopoly$_{f}s/1.1078075.1622113235!/gr22rapport2021-02.pdf$

https://www.mdpi.com/2218-6581/11/3/54

5. TASK 2.5 Bonus (20 points)

(a) The number of savepoints depends on the complexity of your task. more complicated case Letters/shapes required more savepoints, but for simple shapes and letters Fewer savepoints required. Save points increased each time. I had to lift the end effector and put it back on the paper. pose must be saved Be the one to help you draw letters/shapes wherever there is a change Anywhere the trajectory and end effector need to be lifted and returned.The end-effector has to be lifted at each point where we do not want the robotic arm to place a stroke/write on the paper. The best orientation to grab the pen was with the endeffector at 90 to the surface, as this allowed more area of the pen/marker to be gripped by the robot, thus increasing its stability when writing. For our letter, we made the robot write the letter U, which was done by drawing three strokes as shown in the video and lifting/placing the marker at relevant positions. Video Link: https://youtu.be/HlQwyJx0Fv1