Mechatronics Systems

Project Report

Winter Semester 2022-2023

Group 12

NAME	MATRICULATION NUMBER
SHREYAS SANJAY KORDE	1653768
ANURAG SHUKLA	1634251
SWARNIM MANOJ BHATTAD	1638952
MUKUL LAMBAT	1653755

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Objective

The main objective of this project is to remotely or physically access the manipulator shown in the figure below and program it on MATLAB to complete a set of given tasks.

Introduction

Manipulator consists of three rotary actuating motors and five touch sensors in which 2 are touch sensors and 3 are encoders placed corresponding to the motors.

1. Motor A
2. Motor B
3. Motor C
4. Touch sensor #1
5. Touch sensor #2
6. Motor A encoder
7. Motor B encoder
8. Motor (MATLAB and SIMULINK, n.d.) (MATHWORKS, n.d.) (MATHWORKS, n.d.) (Mathworks, n.d.)C encoder

Labelled figure of the manipulator is given below:

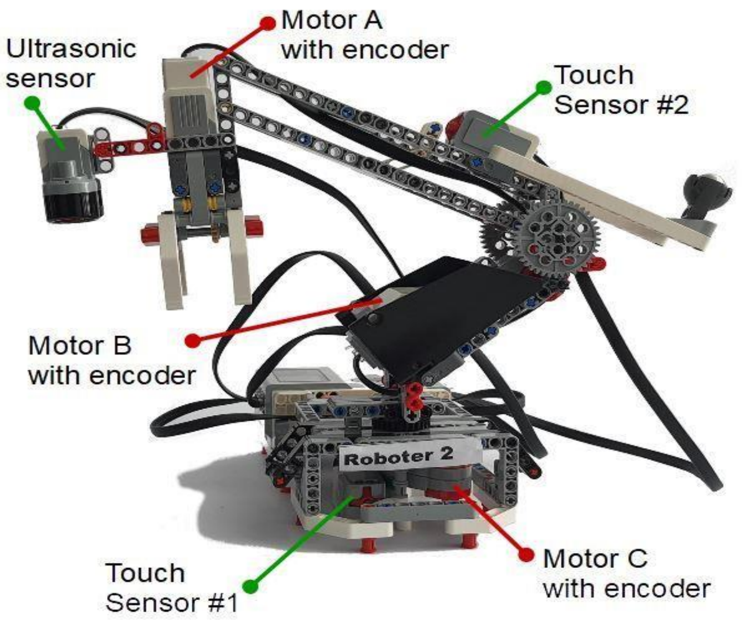


Figure 1 Robot Description

The manipulator consists of 4 links with following descriptions:

- Link 0 is 70, which is measured by user.
- Link 1 is 50mm length and is firmly connected to link-2 at an obtuse angle of 135°
- Link 2 is 95mm
- Link 3 is 185mm and the rotation of the link is bounded by link 2 and by touch sensor #3 on the lower side
- Link 4 is 110mm and it is perpendicular to the ground plane • Base rotation is bounded by touch sensor #1.

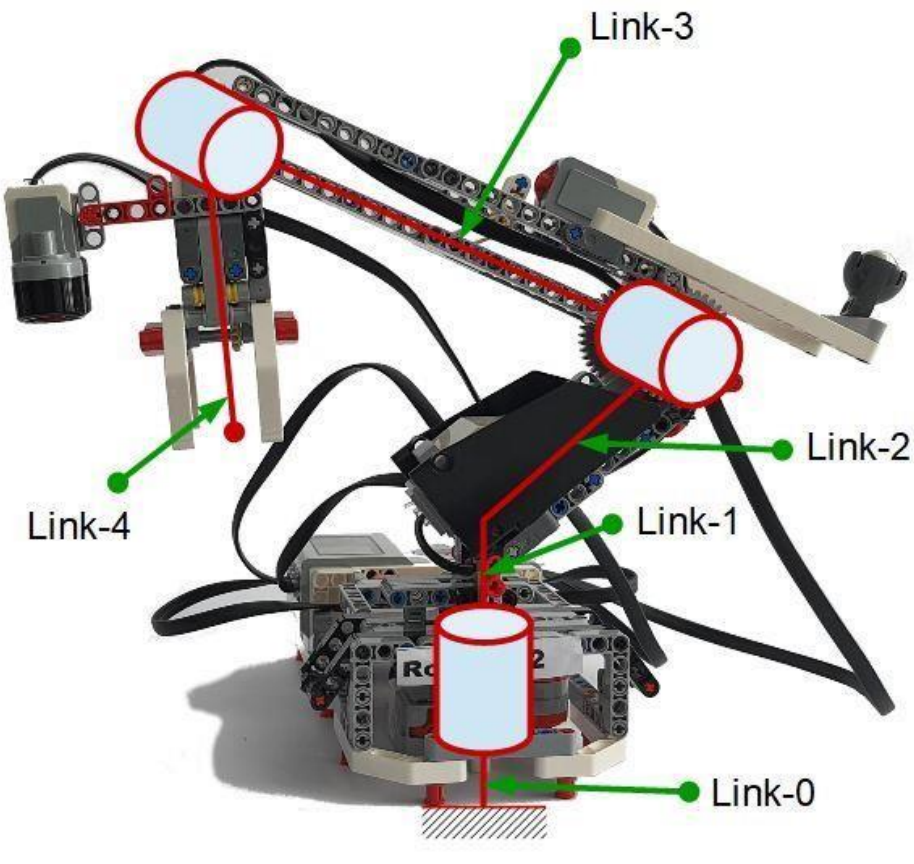
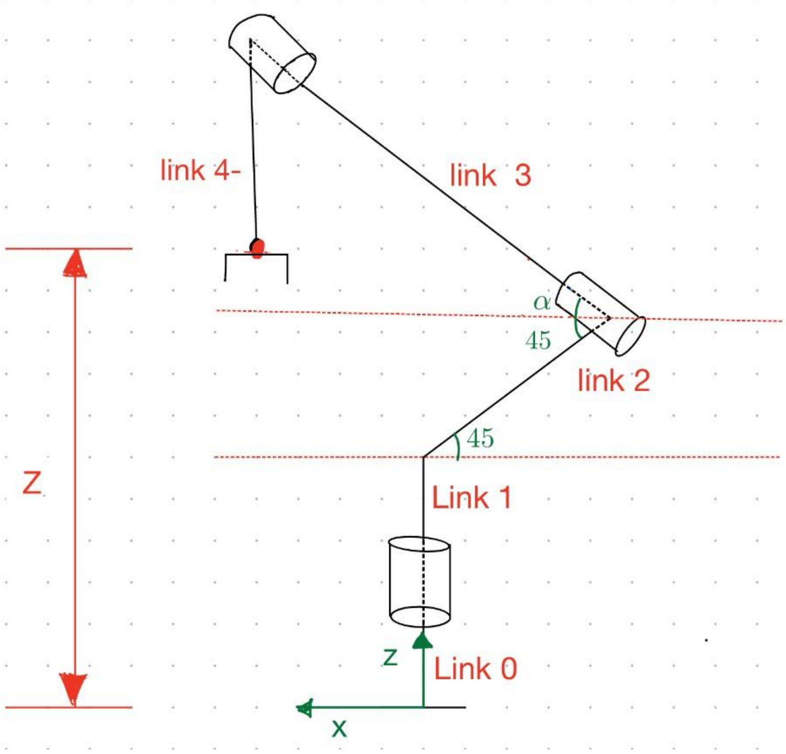


Figure 2 Manipulator Description.

Inverse kinematics Calculations

To develop inverse kinematic equations for manipulator using geometric approach.



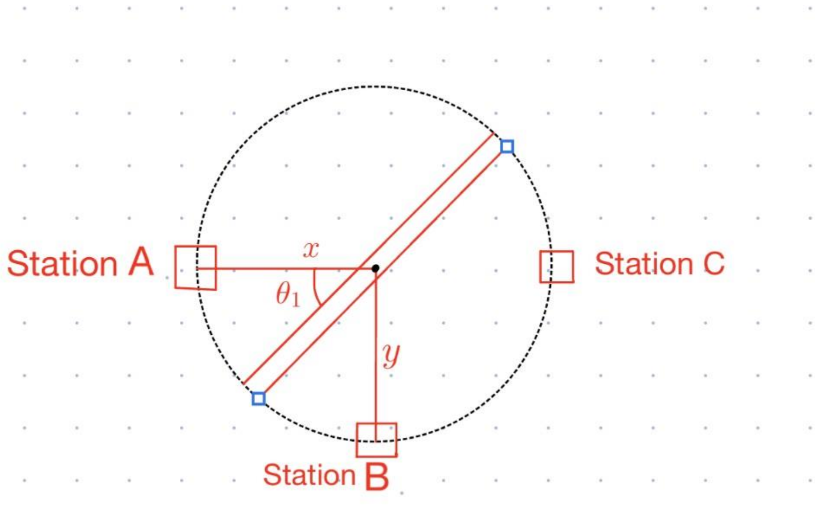


Figure 3 Inverse kinematics of Robot

Gear ratio

Base m: 36/12 = 3

Link m: 40/8 = 5

Link measurements given are as follows:

Link 0 = 70mm, Link 1 = 50mm, Link 2 = 95mm, Link 3 = 185mm, Link 4 = 110mm

Calculation

Z = Distance between Ground and end Effector

$Z = L_0 + L_1 + L_2 \sin 45 + L_3 \sin \alpha - L_4$

$\sin \alpha = \frac{Z - L_0 - L_1 - L_2 \sin 45 + L_4}{L_3}$

$$\alpha = \sin^{-1}\left(\frac{Z - L_0 - L_1 - L_2 \sin 45 + L_4}{L_3}\right)$$

θ_2 = Angle between and $L_3$and L_2 = 45° + α

$\theta_2 = 45° + \sin^{-1}\left(\frac{Z - L_0 - L_1 - L_2 \sin 45 + L_4}{L_3}\right)$

$x = (L_3 \cos \alpha - L_2 \cos 45) \cos \theta_1$

$y = (L_3 \cos \alpha - L_2 \cos 45) \sin \theta_1$

$$\theta_1 = \tan^{-1}\left(\frac{y}{x}\right)$$

where θ_1 = Angle for base motor

Stations Coordinate table

The values of x and y are calculated by measuring the height of objects given in the moodle. On station A there was rectangle having height 35mm and on station C there was cylinder having height as 65mm. By considering this we had calculated the x and y values given in table. Thus if height is changing then x and y position for every station will change.

Stations	Base motor angle	Arm motor angle	x	y	z
A	0°	To be calculated	111.7094	0	Read by Sample
B	90°	To be calculated	0	111.7094	Read by Sample
C	180°	To be calculated	-111.7094	-111.7094	Read by Sample

Table 1 Station Dimensions

Working of the Robot

The robot will initially be in an unknown position. The code is designed to direct the robot back to its starting position, or homing position. Robot arm is at its highest position, activating sensor 3, exactly above station A, activating sensor 1, and gripper is in the open condition, indicating that the gripper is in the home configuration. The encoder values of both the arm and base motor is reset to zero which is now the home position. This is achieved by understanding the robot by initially giving positive and later by negative speed to the stage gripper motor.

At home, the robot is in its ideal position. The robot has now been tasked of retrieving a ball from station X. To achieve this, we instruct the robot to move away from its current position to station X. Once the robot has picked up an object, the gripper is finally closed. The necessary values are achieved above. Yet the depth sensors are used to locate an object/obstacle and the distance between an object/obstacle to that of a gripper. The gripper is then requested to raise its arm to its highest position again after grasping an object. The robot is then instructed to move to station Y and place the object at the respected station by releasing the gripper.

Scenarios:

- Pick up an object from station B and place it to station C
- Pick up an object from station C and place it to station A
- Pick up an object from station A and place it to station B
- Pick up an object from station B and place it to station A
- Pick up an object from station A and place it to station C
- Pick up an object from station C and place it to station B

The respected scenarios are performed by setting the values of arm, link and base motor as achieved by Inverse Kinematics. The task performed by the robot can be viewed by the link given below.

Links

- https://uni-siegen.sciebo.de/s/R7fbcWTYY2jfAyy → Link to Sciebo Folder.
- https://drive.google.com/file/d/1SKAvgtYjlhjyYji8WMXLkXfDf6yj7DPt/view?usp=sharing → Link to Robot Performing all the scenarios.

References

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