Universität Siegen

Naturwissenschaftlich-Technische Fakultät

Mechatronic Systems Laboratory

Manipulator Robot- Pick and Place Task

Project Report

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Group 3

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Table of Contents

Table of Figures

1) Objectives:

The main goal is to program the manipulator in MATLAB in order to develop a behaviour for homing, picking up, and placing the ball at the desired station.

2) Introduction:

We used MATLAB software to program a manipulator and control it to perform pick and place motions.

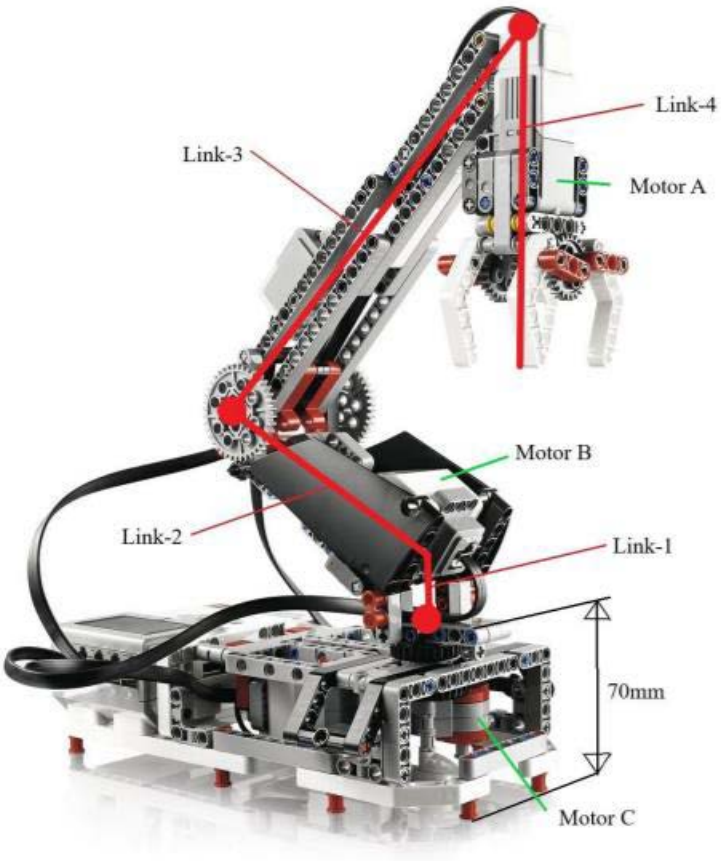
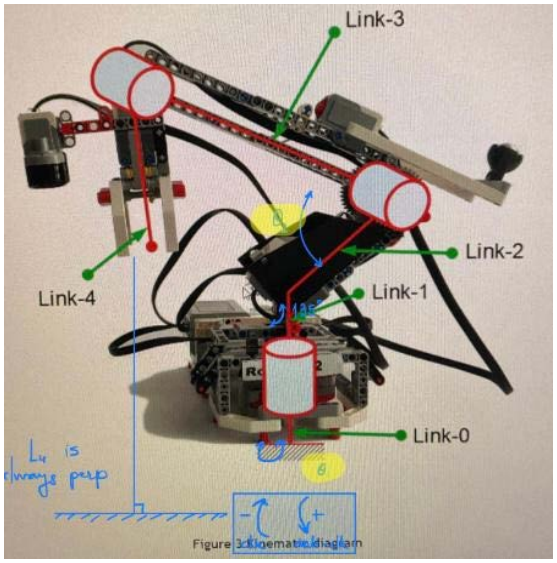


Figure 1. Robot arm configuration

The robotic arm is driven by three motors, Motor A, B, and C, that are rotary actuators. The system contains five sensors, two of which are touch sensors (Touch sensor#1 and 2), and the remaining three are encoders attached to the corresponding motors. The manipulator arm has four links, shown in Figure 1, with the following lengths: Link 1, 2, 3 and 4 are 50mm, 95mm, 185mm and 110mm respectively. Link 1 and 2 are at an angle of 135 degrees, while Link 4 is perpendicular to the ground. The rotation of Link 3 is bounded by Link 2 on the lower side and by Touch Sensor 2 on the upper side. The movement of the base is limited by Touch Sensor 1. All motors are coupled together through gearboxes. It is used to move ball, sense its surroundings, and carry out pick and place operation.

3) Inverse Kinematics equations:



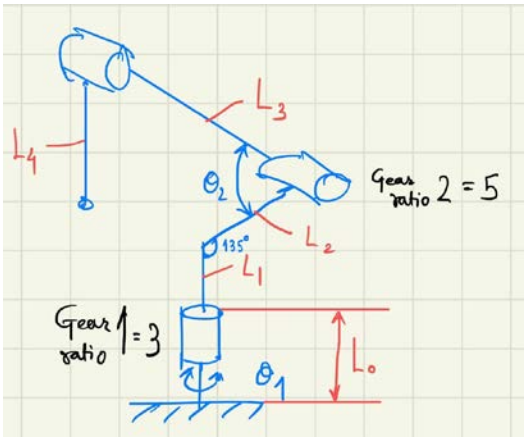
L_0 = 70mm

L_1 = 50 mm

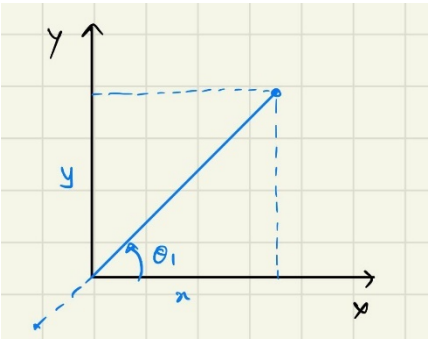
L_2 = 95 mm

L_3 = 185 mm

L_4 = 110 mm

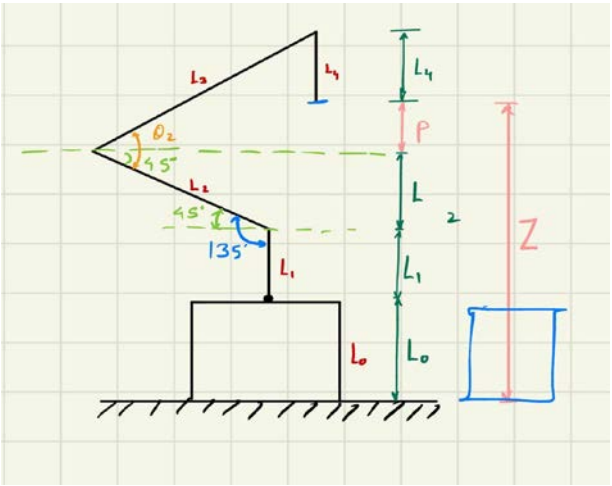


❖ **For Theta 1 :** -



$$\Theta_1 = \tan^{-1}\left(\frac{y}{x}\right)$$

❖ **For Theta 2:** -



$$\sin(\theta_2 - 45^\circ) = \frac{L_4 + p}{L_3} \quad \text{.....(1)}$$

$$p + \frac{L_{2*\sqrt{2}}}{2} + L_1 + L_0 = Z$$

$$p = Z - \frac{L_{2*\sqrt{2}}}{2} - L_1 - L_0 \text{ .....(2)}$$

From 1 & 2

$\sin(\theta_2 - 45^o) = \frac{L_4 - O + Z - L_2 * \sin 45^o - L_1 - L_0}{L_3}$

$$\theta_2 = [\sin^{-1}(\frac{L_4 - O + Z - \frac{L_2 * \sqrt{2}}{2} - L_1 - L_0}{L_3}) + 45^o] * 4$$

$$\theta_2 = [\sin^{-1}(\frac{L_4 - 55 + Z - \frac{L_2 * \sqrt{2}}{2} - L_1 - L_0}{L_3}) + 45^o] * 4$$

$$\theta_2 = [\sin^{-1}(\frac{Z * 1000 - 132.175}{L_3}) + 45^o] * 4$$

The above Equation of θ_2 is for MATLAB code

The value of Z is in meters therefore multiplying it by 1000 to convert it to mm

- Note for Offset: -
  (Offset is the height of claw = O = 55 mm)
  The height of the offset must be subtracted from the link 4 (L_4) to cope for the height of the claw (gripper)to prevent it by crashing into the station plane which may damage the gears, the body, the motors on the robot. And the offset was measured with a scale which came out as 55m

4) Working of Robot:

Step 1: Homing.

At first the robot will be at any random position. Then the robot is taken to its initial position through the homing code. Robot arm is at top most position so the (touch) sensor 2 is activated, it is rotated towards station A such that touch sensor 1 is activated and gripper in closed. To take robot to this configuration i.e., to home, the robot Arm motor is first given negative speed for upward motion and the base motor negative speed for anticlockwise motion till both the sensors are activated. Then base motor is given positive speed and rotates towards station B. Finally, encoder values of both arm and base motor are reset to zero and robot is now at home position.

Step 2: Measuring Height.

After homing robot starts to measure heights from Station to Station in order A, B, C respectively.

During measurement arm is at the topmost position and base motor C is given rotation from homing ie B to A and then B and C in respective order.

Measured heights are stored for further pick & place operation.

Step 3: Picking and Placing ball in sequence.

Pick and place sequence is B/C, C/A, A/B, B/A, A/C, A/B.

After measuring heights, ball is picked from station B and placed at station C.

For this the arm is given positive speed for downward motion and claw is open. The angle of rotation for the downward motion of arm motor is calculated according to the inverse kinematics equation.

After arm is at the measured height of station B, Gripper (claw) closes and picks the ball and arm moves upwards with negative speed till the touch sensor 2 reads 1. Then the base motor is given positive speed for rotation towards station C and the arm is again given positive speed for downwards motion till the measured height of station C is reached.

The claw opens and places the ball.

After every pick and place robot comes back to home position and encoder values resets to 0 and starts another sequence.

Similar process occurs during other sequential pick and place operation.

Only change that occurs during other sequence is the change of rotational direction of base motor and angle of rotation for arm motor.

Clockwise motion and speed is considered as positive for reference.

Step 4: Homing.

After a sequential pick and place operation Arm return to the topmost position such that touch sensor 2 is activated and motor C is rotated towards Station A such that touch sensor 1 is activated and then motor C is rotated towards station B i.e., Homing Station.