Introduction to Robotics

ME 639

Mid Sem Exam

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M.Tech (Mechanical)

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Task-1: (a), (b), (c) Code and output along with verification submitted as Google Colab file.

Task-2:

(a) I think a compliant/soft gripper would be more suitable for this task. As the task is to pick up the pill from the cup, assuming the cup can be of any size and pill can be lying in any orientation. With a compliant mechanism, the gripper can be configured in a better way for the task. Also, the force with which it has to pick the pill will be different, depending on type & shape of pill to be picked. Thus, with compliant gripper we can have flexibility of gripping force.
If we assume that the gripper has to pick only one type of pill from a cup of known dimensions, we can use a hard gripper provided that the force of picking has been configured according to the compressive strength of the pill, so that it will not crush the pill with its gripping force.

(b) Successfully reviewed the Flexible Mechanisms, Soft robotic grippers, Universal Grippers, Paper grippers and Origami grippers have been successfully reviewed.
After reviewing all of them, I felt that the type of gripper worth considering can be categorized into these two categories depending on the type of solution and precision:

- **Cheap & Reliable Solution:** Paper grippers can be considered.

  Youtube links:

  https://www.youtube.com/watch?v=UerxNyu147g
  https://www.youtube.com/watch?v=gI0tzsO8xwc&t=58s

- **If more precise solution needed:** Origami robots can be considered but these are little expensive.

  Youtube links:

https://www.youtube.com/watch?v=L_9BDZ6ZBwk

https://www.youtube.com/watch?v=P_f0BmmNTGc

Task-3 (a)

Link Lengths:

- First Link (Hip to knee): 47 cm
- Second Link (Knee to Ankle): 44cm

- **Gait Trajectory:**

  It is the path followed by the leg of a person in a Gait cycle while walking. When approaching an obstacle, visual information about the size and location of the object is used to adapt the stepping pattern. These adjustments involve change in the Gait trajectory of leg movement and the associated postural adjustments required to maintain the balance. Thus Gait trajectory will be different for different situations/environment.

- **Step Height:**

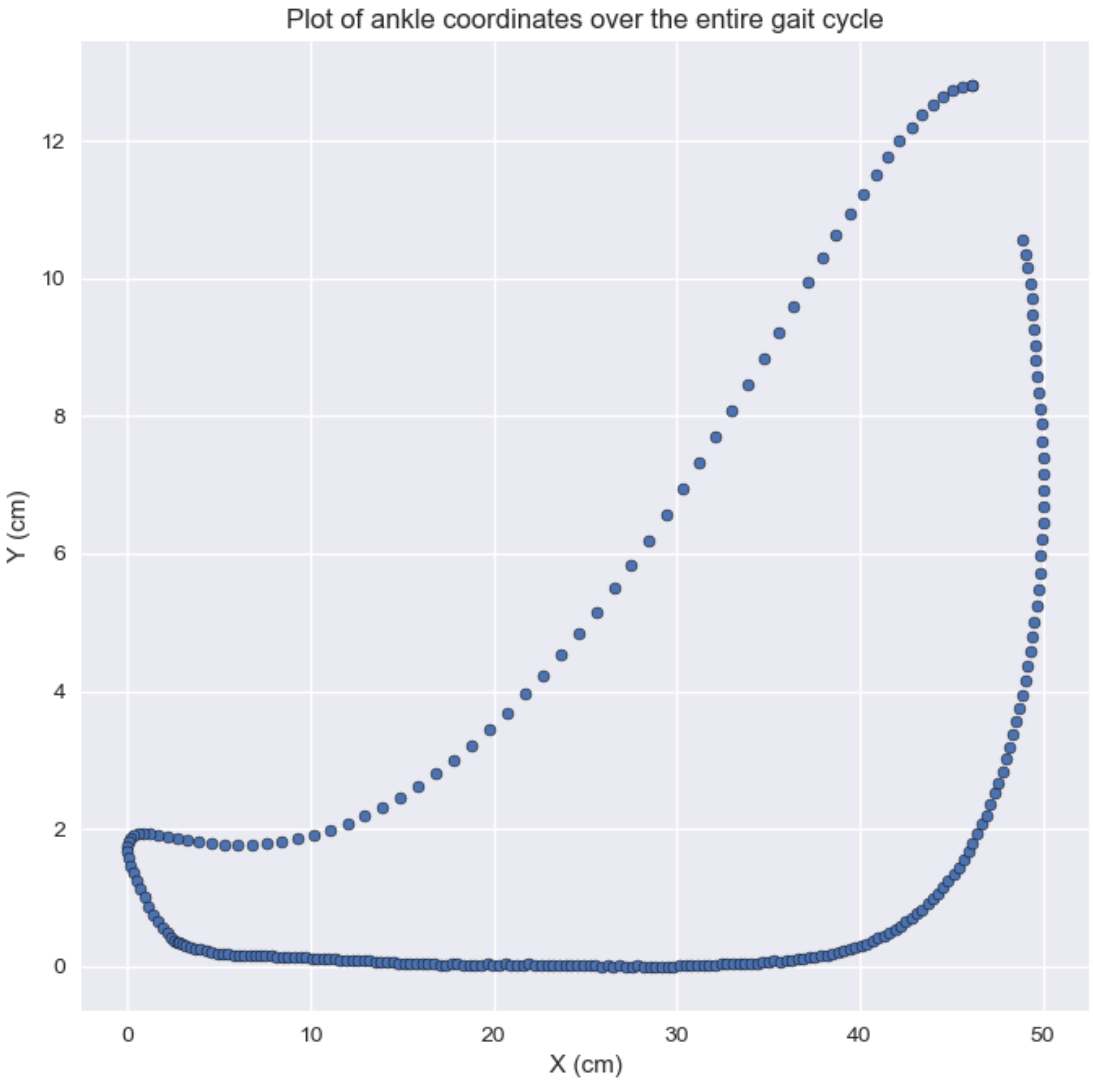
  The distance from the bottom of the floor to the maximum height achieved in a leg lift by the foot in each period.

- **Step Length:**

  The distance from a point of contact with the ground of one foot to the following occurrence of the same point of contact with the other foot. The right step length is the distance from the left heel to the right heel when both feet are in contact with the ground, expressed in meters (m). In simple words, the distance your left foot travelled (from the toe of our right foot to the toe of our left foot, or from the heel of your right foot to the heel of our left foot) is your step length. There might be a difference between our left step length and our right step length.

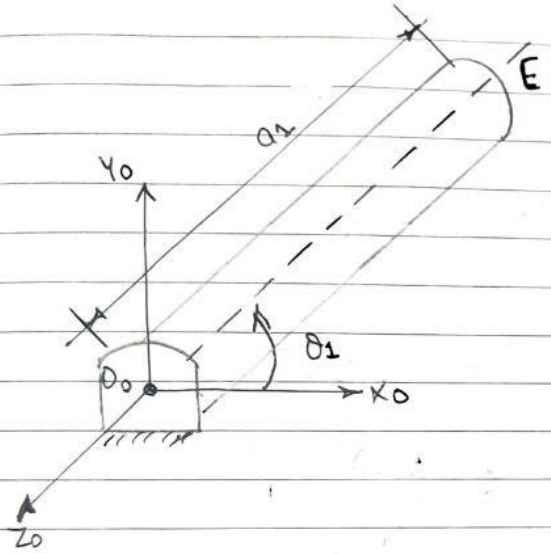
3 (b) Code has been submitted with the folder.

Plot of the ankle Coordinates over the entire gait cycle is shown below;



Task-4

(1) (a) Single Link Robot without Compliance
- Single revolute Joint
- Single link of length l_1



DH Parameters :-

Link	a_i	α_i	d_i	θ_i
1	q_1	0	0	θ_1

(Length of link = $q_1 = l_1$ & $\theta_1 = q_1$)

(b) → Desired torque to be provided by the motor Connected at the joint, if the joint to behave like a Viscous damper system with linear characteristics.

Using Lagrange's equations;

$$L = K - V$$

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_1}\right) - \frac{\partial L}{\partial q_1} = \tau_1$$

Kinetic energy $(K) = \frac{1}{2} I \dot{q}_1^2$

$$= \frac{1}{2}\left\{\frac{1}{3} m l^2\right\} \dot{q}_1^2$$

$$= \frac{1}{6} m l^2 \dot{q}_1^2$$

Potential energy $(V) =$

$$= m_1 g l_1 \sin q_1$$

$$\therefore L = \frac{1}{6} m l_1^2 \dot{q}_1^2 - m g l_1 \sin q_1$$

$$\frac{\partial L}{\partial \dot{q}_1} = \frac{2}{6} m l_1^2 \dot{q}_1 - m g l_1 \cos q_1$$

Now, ~~$\frac{d}{dt}\left[\frac{2}{6} m l^2 \dot{q}_1 - m g l \cos q_1\right] - \frac{2}{6} m l^2 \dot{q}_1 - m g l \cos$~~

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_1}\right) = \frac{1}{3} m l_1^2 \ddot{q}_1$$

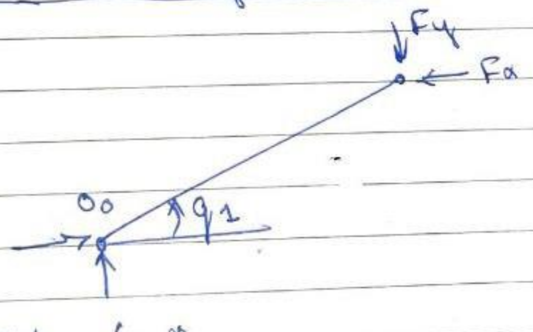
$\therefore$ $$\boxed{\tau = \frac{1}{3} m l_1^2 \ddot{q}_1 + m g l_1 \cos q_1} \quad -(1)$$

Now;

$$\left.\begin{aligned} F_x &= K_x \delta x \\ F_y &= K_y \delta y \end{aligned}\right] \quad -(2)$$

where, $\delta x = [x - x_0]$
$\delta y = [y - y_0]$

$\therefore$ From FBD of link;



$\Sigma M_{O_0} = 0$

$F_y l \cos q_1$ & F_x ...

for x & y;

$$\left.\begin{aligned} x &= l_1 \cos q_1 \\ y &= l_1 \sin q_1 \end{aligned}\right] \quad -(3)$$

$$\therefore \left.\begin{aligned} F_x &= K[l_1 \cos q_1 - l_1] \\ F_y &= K[l_1 \sin q_1] \end{aligned}\right] \quad -(4)$$

From the FBD of link 1

$$\Sigma M_O = 0$$

$$\therefore F_y l_1 \cos q_1 - F_x l_1 \sin q_2 = \tau_1 \quad \text{--- (5)}$$

$\therefore$ Substituting the values from (4) in (5);

$$\boxed{K[l_1 \sin q_1][l_1 \cos q_1] - [K l_1 [\cos q_1 - 1][l_1 \sin q_1] = \tau_1}$$

— (6)

$\therefore$ Motor Torque $\tau_T = \tau + \tau_1$

$$\therefore \boxed{\tau_T = \tau + \tau_1}$$

Where τ comes from eq-(1)

τ_1 comes from eq - 6.

Task-5 Yes,

All joint axes are always aligned with the respective Z axis in the DH Convention. Z axis is always along the rotation direction for revolute joints and along the translation direction for prismatic joints.

Task-6 No,

The origin of all coordinate frames is not always at the centre of joints.

Task-7 Yes,

The Homogeneous transformation consist of both rotation and translation.

Task-8 Yes,

For a sequence of rotations performed one after the other, rotation matrix for each individual rotation can be multiplied together to form the overall rotation matrix, capturing the sequence of rotations.

Task-9 Yes,

A composite rotation matrix consisting of sequence of several rotations is still an orthogonal matrix and its determinant will be equal to 1 according to Right handed coordinate system.