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**Course:** ME 639: Introduction to Robotics

**<u>Mid Sem</u>**

**Task 2 (a):**

According to me the soft gripper will be best fit for this task for the following reason:

- Since pill are small in size and have low weight, it can be picked by soft gripper
- The softness of the hands of the soft gripper will give us the advantage to hold the pill, the pill can be easily fit in the soft hand. On the other hand, hard gripper will have hard hands thus the pill will not fit properly in the gripper and can fall. [for the round, elliptical pills, etc]
- Soft gripper provides more point of contact between the pill and gripper hand compare to that of hard gripper. [for the round, elliptical pills, etc]
- If we apply force greater than needed on the pill while picking or placing it doesn't harm the object since the gripper is soft but in hard robotic gripper it can break the object.

To visualize the above mention points, imagine that you are picking a pill placed in the cup using your 2 fingures (soft gripper) making it behave as 1 DOF and then picking the same pill using straw stick (hard gripper)

**Task 2 (b)**

<u>Flexible Mechanism:</u>

Mechanism in which the elastic properties of the body are used to perform the motion, motion is transmitted through the deformation of elastic body in its elastic range.

- It have a single piece of body.
- Since it is made of single piece of body there are no joints in it and thus there will be no problem of backlash.
- Easy to produce, reduce production cost.
- Gives better performance
- Durable (depends on the material used in the mechnism)

Soft Robotic Gripper:

Soft material like rubber are used as the hands of the gripper. Doesn’t have multiple links. It can easily work as a 2R elbow manipulator with only one soft link

- It is flexible.
- It can be used to pick and place wide range of object irrespect of there size, shape and material
- If we apply force greater than needed it doesn’t harm the object since the gripper is soft but in hard robotic gripper it can break the object.
- Have high point of contact thus picking and placing the object will become much easier

Universal Gripper:

The gripper is the spherical in shape and made of the material that changes is shape and mold itself around the object. Pressure pump is used so that the object can be hold in mid air.

Apply some pressure inside the sphere.The sphere size will increase. Take the gripper to the object and apply force on the object so that the sphere will mold around the object. Here the sphere is only mold around the object but didn’t hold it. To hold the object release the pressure from the sphere.This will make the sphere to mold around the object

- Friction between the gripper and the object plays and important role
- Generally the gripper material is rubber or any material with high coefficient of friction
- The range of objects it can pick and place depends on the the following factors:
    - Size of the gripper (size of the sphere)
    - Size of the object
    - Weight of the object
    - Coefficient of friction between the object and the gripper

Paper Gripper:

As the name suggest the paper is used to make the gripper. The paper is first cut in the specific shape and from the specific key spots and then bend it to make it a gripper. Instead of paper a flexible material can also be used

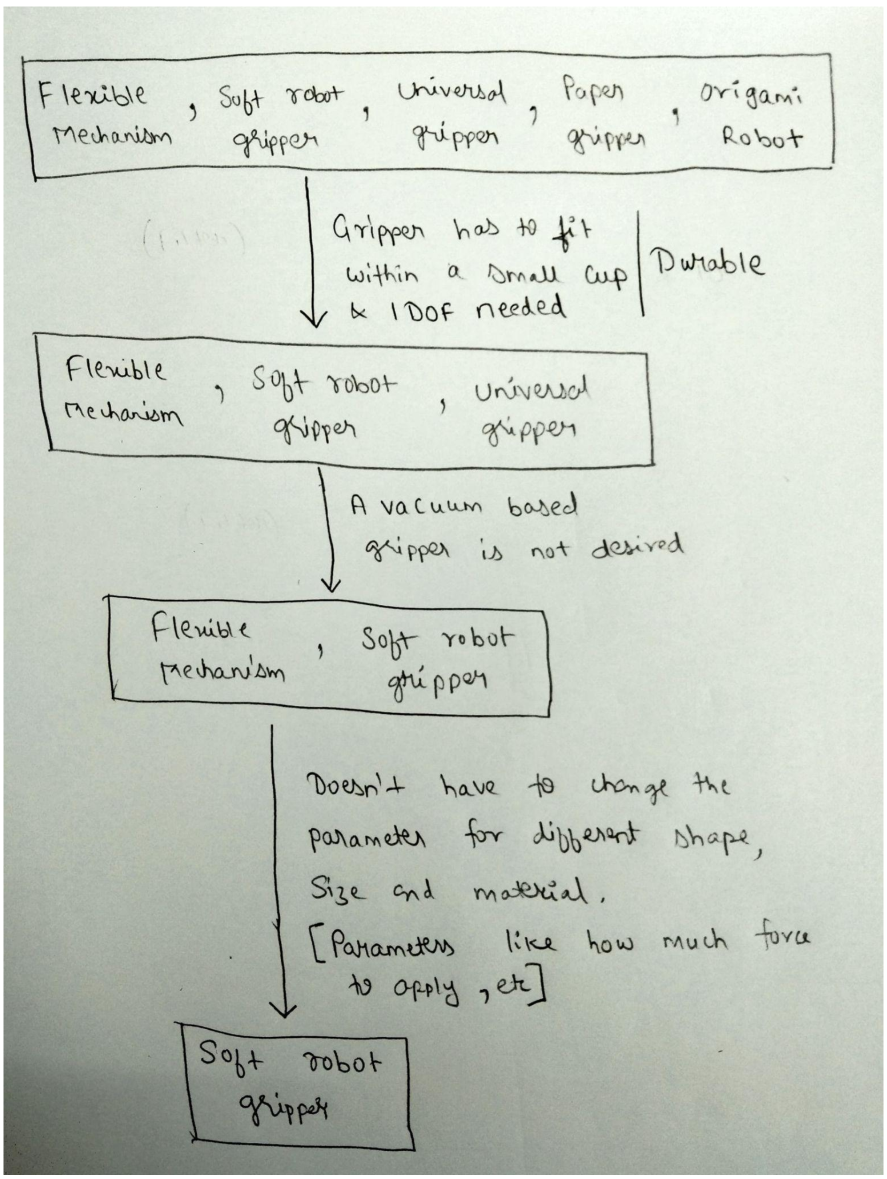
- It can pick and place the object with low weights
- Easy to manufacturer and easy to replace with other paper gripper thus have a low production cost
- Different size, shape and material objects can be pick and place easily

<u>Origami Robot:</u>

Robot which is compact due to the folds, this fold provide the function and mechanism to the robot.

- Biggest use of this is in satellite. Solar panel is been folder and compactly packed in the satellite and when satellite reaches the space these fold will open up.
- Origami robot can also be used in gripper. Initially the material will be unfold first and then to pick the object it will fold thus grab the object and to place the object it will unfold again

<u>Selection chart (selcting the best suitable gripper for the application):</u>



1. Out of all the available gripper we need to filter out the gripper which can fit in the cut, have 1 DOF and durable.
    a. Paper doesn’t seem durable it can break easily
    b. Origami may have more than 1 DOF and may not fir in the cup when its unfold.
2. Since company doesn’t desired for the vacuum based gripper we can throw out universal gripper. Since it used pressure pump to creat a vacuum to mold around the object
3. Out of the remaining 2 the problem with Flexible Mechanism is that if the object is soft or easily breakable the we need to be very careful how much force to apply. If we apply more force the object can break. Thus Soft Root gripper seems to be the best candidate

Video of soft robot gripper:

- Universal Soft Robotic Gripper
- Soft Robotics' octopus-inspired robots industrial grippers

**Task 3 (a):**

Measurements of my body:

| |
|---|
| Hip-to-Knee distance = Length of link 1 = 38 cm |

| |
|---|
| Knee-to-Ankle distance = Length of link 2 = 43 cm |

Gait Trajectory:

When we give input as a specific co-ordinate of the leg and body motion to the legged robot, the path it follow is called gait trajectory. In a simple world its the trajectory that legs follow.

Step Height:

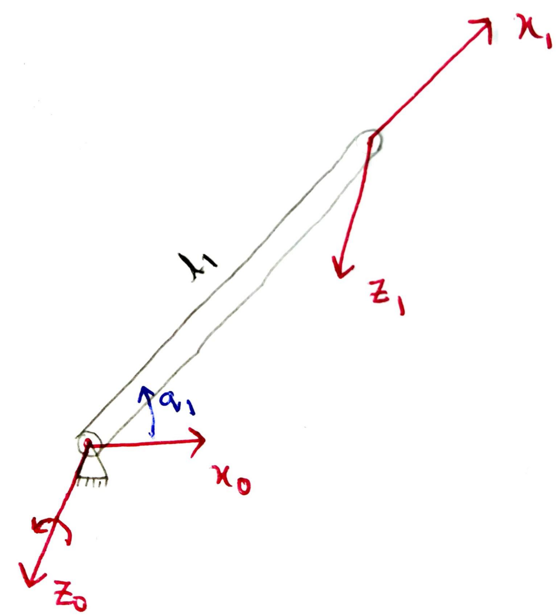
Step Height is the distance between the ankle when the whole foot is touching the ground to the ankle when the foot is in maximum height.

Step Length:

Step Length is the distance between the heel strike of one foot to the heel strike of another foot. Generally its lie in the range of 44 cm to 70 cm. It depends on person’s age, weight, height, etc.

$$Step\ Length\ =\ |\,Heel\ Strike\ of\ left\ foot\ -\ Heel\ Strike\ of\ right\ foot\,|$$

**Task 4 (a):**



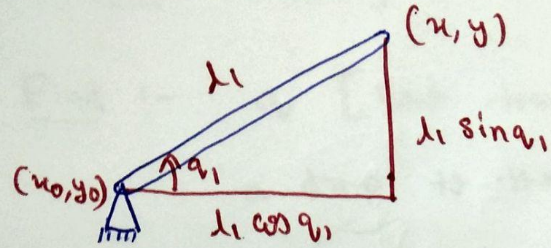

DH Parameter:

| | a | alpha | d | theta |
|---|---|---|---|---|
| Link 1 | l1 | 0 | 0 | q1 |

$$A_0^1 = \begin{bmatrix} \cos\theta & -\sin\theta\cos\alpha & \sin\theta\sin\alpha & a\cos\theta \\ \sin\theta & \cos\theta\cos\alpha & -\cos\theta\sin\alpha & a\sin\theta \\ 0 & \sin\alpha & \cos\alpha & d \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T = T_0^1 = A_0^1 = \begin{bmatrix} \cos q_1 & -\sin q_1 & 0 & l_1\cos q_1 \\ \sin q_1 & \cos q_1 & 0 & l_1\sin q_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

**Task 4 (b):**




| | |
|---|---|
| $x = l_1 \cos q_1$ | $y = l_1 \sin q_1$ |
| $\dot{x} = -l_1 \sin q_1 \, \dot{q}_1$ | $\dot{y} = l_1 \cos q_1 \, \dot{q}_1$ |
| $\ddot{x} = -l_1 \cos q_1 (\dot{q}_1)^2 - l_1 \sin q_1 \, \ddot{q}_1$ | $\ddot{y} = -l_1 \sin q_1 (\dot{q}_1)^2 + l_1 \cos q_1 \, \ddot{q}_1$ |
| $\ddot{x} = -\dot{y} \, \dot{q}_1 - y \ddot{q}_1$ | $\ddot{y} = \dot{x} \dot{q}_1 + x \ddot{q}_1$ |
| $\ddot{q}_1 = -\left(\dfrac{\ddot{x} + \dot{y} \dot{q}_1}{y}\right)$ | $\ddot{q}_1 = \left(\dfrac{\ddot{y} - \dot{x} \dot{q}_1}{x}\right)$ |

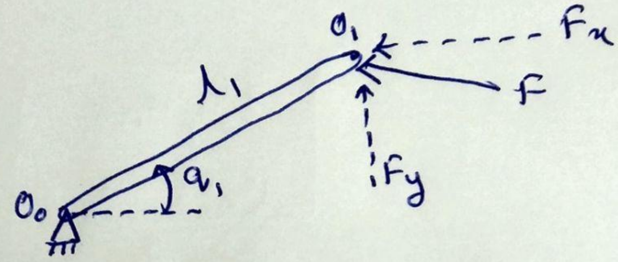
$$m l^2 \ddot{q}_1 + m g l \sin(q_1) = \tau \quad \text{—(Given)}$$

(dynamic of single link robot)

Neglecting gravity

$$\tau_1 = m l^2 \ddot{q}_1$$

## Deriving torque




Resultant torque $(\tau_R) = \vec{l}_1 \times (\vec{F}_x + \vec{F}_y)$

$$\vec{l}_1 = l_1 \cos q_1 \, \hat{i} + l_1 \sin q_1 \, \hat{j}$$

$$\vec{F}_x = m\ddot{x} \quad \hat{i}$$

$$= -m \left[ l_1 \cos q_1 (\dot{q}_1)^2 + l_1 \sin q_1 \, \ddot{q}_1 \right] \hat{i}$$

$$\vec{F}_y = m\ddot{y} \quad \hat{j}$$

$$= m \left[ -l_1 \sin q_1 (\dot{q}_1)^2 + l_1 \cos q_1 \, \ddot{q}_1 \right] \hat{j}$$

$$\tau_R = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ l_1 \cos q_1 & l_1 \sin q_1 & 0 \\ m\ddot{x} & m\ddot{y} & 0 \end{vmatrix}$$

$$= 0\,\hat{i} - 0\,\hat{j} + (m l_1 \cos q_1 \, \ddot{y} - m l_1 \sin q_1 \, \ddot{x}) \, \hat{k}$$

$$\tau_R = m l_1 \left[ \cos q_1 \ddot{y} - \sin q_1 \ddot{x} \right]$$

$$= m l_1^2 \left[ -\cancel{\sin q_1 \cos q_1 (\dot{q}_1)^2} + (\cos q_1)^2 \ddot{q}_1 \right.$$

$$\left. + \cancel{\sin q_1 \cos q_1 (\dot{q}_1)^2} + (\sin q_1)^2 \ddot{q}_1 \right]$$

$$= m l^2 \left[ \underbrace{(\sin q_1)^2 + \cos(q_1)^2}_{1} \right] \ddot{q}_1$$

$$\tau = m l^2 \ddot{q}_1$$

$$\tau = K \phi$$

$\phi = q_1$

$K$: ~~Torque~~ Torisional Stifness

$$\tau = K q_1$$

$$\tau = \frac{GJ}{L} q_1$$

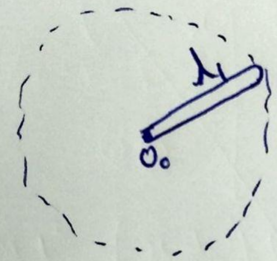
$G$: Shear modulus or modulus of rigidity

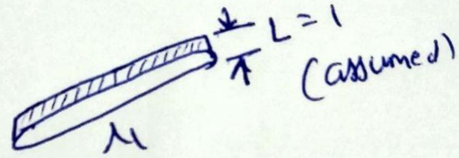
$J = \int_S \rho^2 \, dA \qquad \rho = l_1$ (here)

$L = 1$ --- (assumed)

↳ (in our case it will be thickness of rod)

$$J = \frac{\pi \lambda_1^4}{2} \quad \text{--- (virtual)}$$




$$\tau = \frac{G \pi \lambda_1^4}{2} q_1$$

Torsional stiffness

$$(K) = \frac{G \pi \lambda_1^4}{2}$$

We will take 'G' as a i/p.

**Task 5:**

Yes

**Task 6:**

Yes

**Task 7:**

Yes

**Task 8:**

Yes

**Task 9:**

Yes