ME 639 - INTRODUCTION TO ROBOTICS

Mid Sem Exam

Name : Jaydeep Ramnani
Roll Number : 18110071

2.

a. I think that a compliant/soft gripper will be more suitable when compared to a hard gripper for this task as they have more general compliance, are easy to adapt to various shapes, can be manufactured at low cost and have a simple manufacturing process. All pills may be of the same shape but if there are multiple pills with different shape and size, we can even command the gripper to pick the pill with a particular shape and size. The only disadvantage they have is they cannot lift heavy objects and pills are not something that is heavy, so thus, I consider them above hard grippers for pill picking robots.

b. i) Flexible mechanism grippers -
They can be quite useful. These grippers can adapt to the shape and size of the object according to the specifications needed. These changes take less time too since the grippers are highly flexible and thus, they would be amongst one of the most suitable robotics grippers for the pill picking robot.
Reference : Design and construction of a variable-aperture gripper for flexible automated assembly" by Giulio Rosati
https://www.sciencedirect.com/science/article/pii/S0736584516301818

ii) Soft robotic grippers -
I found this gripper to be useful particularly for this application. Although with the use of its palm it can lift somewhat heavy weights, the three bending fingers seem ideal to pick objects like pills. Further, since it has to go inside a small cup and pick the pill, the fingers will easily be able to perform this job as they can even bend.A good reference will be the paper below for this.
Reference - "A Soft-Robotic Gripper with Enhanced Object Adaptation and Grasping Reliability" by Jianshu Zhou, Shu Chen, Zheng Wang
https://ieeexplore.ieee.org/abstract/document/7950912

iii) Universal grippers -
I don't think this gripper would be suitable for our task. We are required to pick up a single pill lying in the cup, but the mechanism for gripping objects is based on creating a vacuum by contracting the granular material and harden quickly to take hold of the material. This may lead to picking up more than one pill and thus, would not be suitable according to me.
Reference - https://www.wevolver.com/wevolver.staff/universal.robotic.gripper
(The video shows the mechanism clearly)

iv) Paper grippers -
Again, I don't think this gripper is suitable for our task as it too has a sucking mechanism to pick objects. There are high possibilities that multiple pills might be sucked up at the same time from the cup. This would not solve our purpose.
Reference - https://www.youtube.com/watch?v=0oqqXxeGVDg
Please mute the audio :)

v) Origami robots
The origami robot gripper seems amazing but I doubt that it will not be able to pick up such a small object as a pill. Hence, this may not be useful for our purpose. But while surfing for origami robot grippers, I found an amazing robot gripper made by a professor from Boston university which may solve our purpose. This robot gripper is inspired by Kirigami (similar to origami but is still a bit different). I have provided a reference link for the video of that and to me, it looks good for our purpose. (It is shown in the video that it can pick small marbles so I guess it may be able to pick a pill too)

Origami Robot gripper - https://www.youtube.com/watch?v=byqGFH6AZuk

Kirigami Robot gripper - https://www.youtube.com/watch?v=UerxNyu147g

3.

a. The link lengths for the exoskeleton scruffing problem can be considered as :
(my own measurements - both a bit approximated)

First link length = hip-to-knee distance
= 40 cm
Second link length = knee-to-ankle distance
= 40 cm

i) Gait Trajectory
Gait refers to the style of walking or a pattern that a person follows while walking. Thus, Gait trajectory is the path that must be followed by the links of the robot in order to resemble a normal person's gait.

ii) Step height
Step height is defined as the height that can be gained by the exoskeleton in a single step. According to the planned gait trajectory, only a certain level of flexibility may be present which highly affects the height a person can gain in a single step while wearing the exoskeleton.

iii) Step length

Step length is similar to step height with a small difference that it is the length that an exoskeleton will allow to move forward in a single step. The exoskeleton does not actually limit it but the gait trajectory is planned such that it would not cause any strain on the body and thus, allow it to move forward.

5. Yes, according to the DH convention, the joint axes are always aligned with the respective z-axis.

6. No, the origins of all coordinate frames do not always lie at the centre of joints. For instance, if z_i and z_{i-1} are parallel then the origin can lie at any position along the z_i. So, it does not always lie at the centre of joints.

7. Yes, a homogeneous transformation consists of both a rotation and a translation.

8. Yes, the overall rotation matrix can be calculated by multiplying the individual rotation matrices for each rotation (capturing the sequence of rotations).

9. Yes, the composite rotation matrix is still an orthogonal matrix and with a determinant equal to 1. We can prove this as follows :

   Let R_c be the composite rotation matrix consisting of a sequence of n rotations.

   $R_c = R_1 R_2 ..... R_n$

   Now the transpose of this matrix will be,

   $R_c^T = (R_1 R_2 ..... R_n)^T = R_n^T R_{n-1}^T ..... R_1^T$

   Thus, $R_c R_c^T = R_1 R_2 ..... R_n R_n^T R_{n-1}^T ..... R_1^T = I_3$

   Hence, the composite rotation matrix will be orthogonal.

   Now,

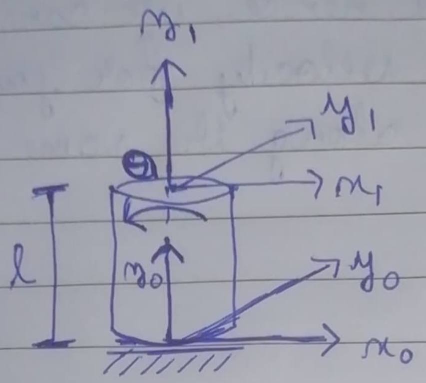
   $det(R_c) = det(R_1 R_2 ..... R_n) = det(R_1) det(R_2) .... det(R_n) = 1$

   Therefore, its determinant is equal to 1.

   Hence, proved.

Problem 4.

a. Given,
a single revolute joint with link length l



$x_0 y_0 z_0$ - base frame

SINGLE REVOLUTE JOINT

Thus, we will have the DH parameters as,

$\theta_i = \theta$
$\alpha_i = 0$
$a_i = l$
$d_i = 0$

Ans

b. The desired torque value for it to behave like a virtual torsional stiffness joint is,

$$\tau = k(q_0 - q_1)$$

where k is the torsional stiffness constant
q_0 is equilibrium position (angular)
and, q_1 is the current angular position

Page No.
Date

Problem 1 d.

We travel with constant velocity along each edge of the path to be traversed. But here the joint angles may be changing with uncertainities and hence, we cannot say that the angular velocity for joints will be constant, even along the same line of path.

(I have included my approach in the code file, please check it. Thanks !!!)