ME 639: Introduction to Robotics
IIT Gandhinagar

Midsem Exam

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1 Task 1

2 Task 2

2.1 2a

- **Hard gripper**:
  - If we consider a hard gripper attempting for a stable grip, the very act of picking the pill will change the dynamics from two open chains with n_1 and n_2 links to a single closed chain manipulator with $n_1 + n_2 - 1$ links(usual approach), or from closed chain with n links to closed chain with $n - m$ links which are now constrained to apply a certain precise range of force to avoid crushing as well as avoid dropping the pill. This is a very complex task and will have a drastic change in dynamics during the task performance, which makes it tough to model the complete actuation procedure repeatably for different orientations in the container.
  - However, a sliding loose encompassing grip with some leeway using multiple-closed chains or even open chains can help avoid this issue if the pill dimensions/shape are known before-hand(looks like a simple option with pure motion control, if we need to have a 1-DOF system with a small risk of the pill rolling off/falling off).
- **Soft gripper**:
  - If we are to try for compliance/soft gripping, chances of the pill getting crushed are greater than chances of dropping as the non-suction based soft/compliant mechanism will usually try to achieve a certain level of force control to achieve a stable grip.It is very tough to implement such accurate force control with 1-DOF or even 2-DOF systems.

- Again here, if the stable grip approach were sacrificed for an encompassing shape based motion control approach, this avoids damage to the pill as long as the gripper orientation does not need to change drastically causing the pill to tip over.This system will have the advantage of versatility of easily adapting to different pill dimensions/shapes through a simple software update.

- In this case, I would go for a motion-planning based hard gripper configuration, due to its simplicity in implementation, once the mechanics mature.

2.2 2b

- Stable grip based mechanisms i.e. involving accurate force control for grip stability:
  - Stable grip using hard gripper
  - VERSABALL Pill Pick n Place - Empire Robotics: a universal gripper using jamming principles
  - Universal soft robotic pill picker
  - Soft Robotics Octopus inspired grippers
  - Closed chain robot with force control
  - Origami gripper with force control
- Encompassing grip based mechanisms i.e. mainly involving accurate motion control for grip stability:
  - DIY Soft Robotic Gripper demonstrating motion control based grip with dumbbells
  - Kirigami gripper with motion control: This seems to be the best in terms of repeatable performance and simplicity.

3 Task 3

3.1 3a

- Hip-to-knee length for link 1: $46cm$
- Knee-to-ankle length for link 2: $37cm$
- Gait trajectory: Displacement trajectory over time for various limb positions(usually, ankle, knee and hip positions) to analyse the pattern of limb movements made during locomotion(natural walking).
- Step height: Maximum height of foot above ground achieved in ”swing” phase of walking.

- Step length: Distance between successive landing points of alternate feet i.e. opposite symmetry while walking.Not to be confused with stride length, which is distance between consecutive landing points of same foot while walking.Step length helps analyse gait symmetry on left and right side.

3.2 3b

3.3 3c

4 Task 4

4.1 4a

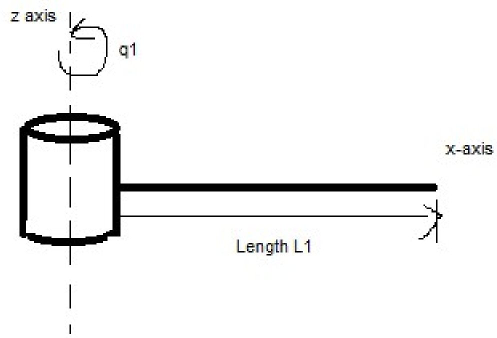

Figure 1: DH parameters for single link and single revolute joint system

From the figure, we can find that the normal distance between current $z - axis$ and any imaginary $z - axis$ in the same plane will be same as link length L_1 and angle θ is the revolution angle of the single revolute joint, given by q_1. Hence the DH parameters are $[d, \theta, a, \alpha] = [0, q_1, L_1, 0]$.

4.2 4b

For a virtual torsional stiffness with linear characteristics about a particular angle, the desired torque of the actuator will be:

$$\tau_{desired} = K(q_1 - q_0) \tag{1}$$

4.3 4c

5 Task 5

Yes, they are.

6 Task 6

No, origins do not depend on particular joint positions and could also be located outside the physical link i.e. in open space

7 Task 7

Yes it is true.

8 Task 8

Yes,usually and the product is not commutative in general. Also, there might be a gimbal-lock-like situation(all three axes get in a parallel planar frame) which may not be accounted for in sequence.

9 Task 9

Yes, as it is a rigid transformation(i.e. no amplification/attenuation of component/link sizes).