

ME 639 – Introduction to Robotics

MID SEM EXAM

LEVEL 0 – GRADES:

Ans 5. Yes, all joint axes are always aligned with respective to z-axis.

Ans 6. No, the origins of all the coordinate frames are not always at the centers of the joints (this can be verified from the video shown in the class for DH-conventions).

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

$$H_0^1 = \begin{bmatrix} R & \mathbf{d} \\ \mathbf{0} & 1 \end{bmatrix}, R \text{ and } \mathbf{d} \text{ are the rotation matrix and the vector from the origin } o_0 \text{ to origin } o_1.$$

Ans 8. Yes, the rotation matrices for each individual rotation can be multiplied together to form the overall rotation matrix.

Ans 9. Yes, a composite rotation matrix consisting of a sequence of several rotations is still an orthogonal matrix with its determinant equal to 1.

Let the matrix R be a product of two rotation matrices A and B.

$$R = AB$$

$$A^T A = I$$

$$B^T B = I$$

$$R^T R = (AB)^T (AB) = B^T A^T AB = B^T (A^T A) B = B^T I B = B^T B = I$$

$$\det(R) = \det(AB) = \det(A) \det(B) = 1 \cdot 1 = 1$$

LEVEL 1 – NO END SEM:

2-a. For the given task of pill picking robot (without using vacuum), a compliant or soft gripper would be more efficient. Pills are relatively small objects and can be of varied sizes. Thus, they may fall from the hard gripper if only a very small area is in contact with the gripper. On the other hand, if a soft gripper is used, it can hold the pills more efficiently as its shape can change to adjust with the shape of the pill. Also, there would be less chances of breaking the pill in the case of a soft gripper.

2-b. Soft robotics grippers – [link to the example](#)

Universal grippers – [link to the example](#)

The above two videos demonstrate how soft robotic grippers and universal grippers can be used for the specified task. These grippers can also be used for larger objects as well (larger than pills). Flexible mechanics videos seemed to state that such mechanics is better for links and joints and may not be the best solution for this task. Paper grippers use suction as a means to hold on to the paper and they might not be able to hold smaller pills properly (if the robot is made to be used

over any size of pill). Origami robots are best used for cases where a micro-level task is to be achieved and with respect to the effort that would be needed to make them, they seemed above the line for the given task. So, according to me, soft robotic grippers and universal gripper was best suited.

3-a. First link length – hip-to-knee distance = 41.1 cm

Second link length – knee-to-ankle distance = 40.5 cm (measured my own)

Gait trajectory – During a gait analysis, several markers are attached to the body of the patient. the patient then walks over a treadmill and the motion followed by the markers is recorded. This is termed as the gait trajectory (the path followed by the required marker).

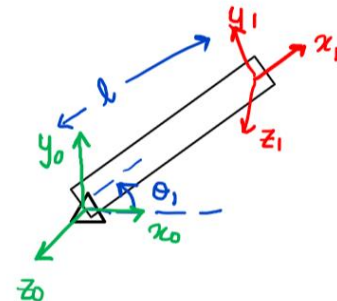
Step height – is the height of the leg lift of the patient under observation.

Step length – is the distance between the first point of contact of the first foot and the first point of contact of the second foot, while walking.

4-a. We have the following table for the DH parameters:

Link	a_i	α_i	d_i	θ_i
1	ℓ	0	0	θ_1

Refer to the diagram for the variables.



LEVEL 2: NO QUIZ 2

4.b Kinetic energy of the link can be written as $= KE = T = \frac{1}{2} I \dot{\theta}^2$

Potential energy of the link as it behaves like a torsional stiffness $= PE_{torsional} = \frac{1}{2} K \theta^2$

There will be no potential energy due to gravity as it is neglected, thus, the total potential energy is $= PE = V = \frac{1}{2} K \theta^2$

Thus,

$$L = T - V = \frac{1}{2} I \dot{\theta}^2 - \frac{1}{2} K \theta^2 = \frac{ml^2}{6} \dot{\theta}^2 - \frac{1}{2} K \theta^2$$

For calculating the desired torque

$$\begin{aligned} \tau &= \frac{d}{dt} \left(\frac{\partial L}{\partial \dot{\theta}} \right) - \frac{\partial L}{\partial \theta} \\ &= \frac{ml^2}{6} \ddot{\theta} + K \theta \end{aligned}$$

REFERENCES:

1. Stack Exchange – Mathematics: [Link](#)
2. The Free Dictionary – step length. (n.d.) *Medical Dictionary*. (2009). Retrieved October 1 2021 from <https://medical-dictionary.thefreedictionary.com/step+length>
3. Gait Analysis – Wikipedia [link](#)