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ME639 : Intro to Robotics

Midsem exam

(5) DH convention → Are all joints axis always aligned with respective z axis ?

→ Yes.

(6) DH convention → Are the origins of all the coordinate frames always at center of joints ?

→ ~~Yes~~ .NO. Mostly, origin will be at the center of joints. However, for end effector we do not have joint. still there will be origin.

(7) Is it true a homogeneous transformation consists of both a rotation and a transition?

⇒ Yes.

(8) can the Rotation matrices for each individual rotation be multiplied together to form the overall rotation matrix (capturing the sequence of rotations)?

⇒ yes.

(9) Is a composite ~~com~~ rotation matrix consisting of a sequence of several rotations still an orthogonal matrix with determinant equal to 1?

⇒ yes.

Problem ② Pill picking robot.

(a) Hard gripper or soft gripper?

→ Hard gripper might not be a good idea for pill picking robot. As we have random size and orientation for pills, it will be difficult to obtain orientation and gripping for every pill with hard gripper. However we can design hard gripper for the task but it will ~~requir~~ require high dof from manipulator.

→ soft gripper will be useful for this purpose. It will enable use to pick up all pills without worrying about size and orientation.

(b) Flexible, soft and universal gripper seems to be a good alternative for conventional gripper.

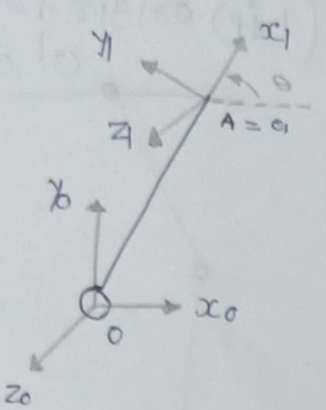
→ Universal gripper works with vaccum but it through soft end effecter. With sufficient vaccum and gripper size we can use it for pill picking.

(link: https://youtu.be/od4f8fEysf8) (also available in readme.txt file),

→ Flexible gripper can be designed to pick small pills and we do not need to worry about orientation and size.

problem-(4) (a) For a robot with a single revolute joint and a single link of length l. Work out DH parameters.

⇒



→ $x_0 y_0 z_0$ attached at joint with origin o_a at joint center.

→ $x_1 y_1 z_1$ are attached to end at joint link ($A = O_2$) as shown in figure.

→ DH parameter for given joint,

$$a = l, \quad d = 0, \quad \alpha = 0, \quad \theta = \theta(t)$$

→ Transformation matrix,

$$R_0^1 = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & l\cos\theta \\ \sin\theta & \cos\theta & 0 & l\sin\theta \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

(b) Find torque for joint to behave like a virtual torsional stiffness with linear characteristics

→ Desired torque τ_d will be provided by motor so that link can behave as a spring.

→ So desired torque should be equal to torque generated by spring.

so, $$\tau_d = -K(\theta - \theta_e)$$

→ Here, θ is measured from x_0 axis, so our one equilibrium point will be $(\cancel{\theta}\pi/2)$ (considering Gravity). So ~~it makes~~ & so, for simplicity I will take

$\theta_e = \cancel{3\pi/2}.-\pi/2.$ $\qquad \tau_d = -K(\theta_e + \pi/2).$

→ Equation of motion:

$$K = \frac{1}{2} m \dot{\theta}^2 \frac{l^2}{3}, \qquad P = \frac{mgl\sin\theta}{2}$$

$$\mathcal{L} = K - P = \frac{1}{2} m \dot{\theta}^2 l^2 - \frac{mgl\sin\theta}{2}$$

$$\therefore \frac{d}{dt}\left(\frac{\partial L}{\partial \dot{\theta}}\right) - \frac{\partial L}{\partial \theta} = \tau.$$

$$\therefore \frac{l^2 m \ddot{\theta}}{3} + \frac{mgl\cos\theta}{2} = \tau$$

↳ {given equation of motion is different from given equation, as I have taken different notation for θ}

→ Now, Dynamic simulation is done in python code, with $\tau = \frac{mgl\cos\theta}{2} + \tau_d.$

$$= \frac{mgl\cos\theta}{2} - K(\theta + \pi/2)$$

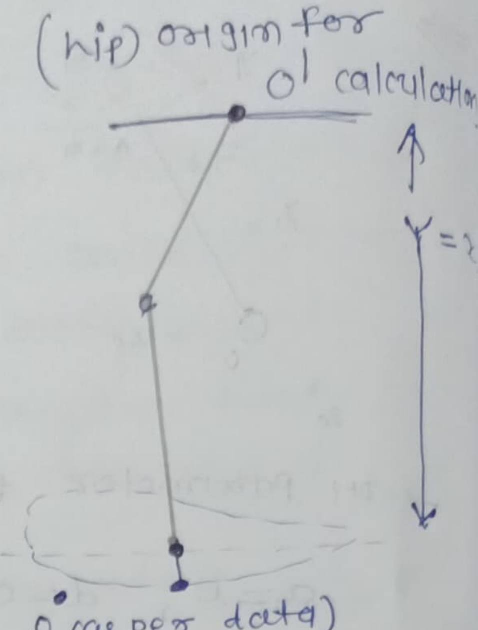
→ $\tau_i = \frac{mgl\cos\theta}{2}$ is compensating for gravity and τ_d is providing spring stiffness.

Problem: (3) Consider a planar 2R elbow manipulator.

(a) Pick reasonable link length (hip to knee and knee to ankle)

→ hip to knee length = 45 cm

→ knee to ankle length = 35 cm



gait trajectory:

→ Gait trajectory is motion of lower limbs during walking or running. This data is collected to study the motion of limbs and movement of joints:

→ step height : Maximum vertical height achived during walking.

→ step length: Length covered during walking by one step.

(b)

⇒ python code is submitted with PDF.

⇒ (c). I have written a code for forward and inverse kinematics. Py file is attached.

problem : (1) Block → 20 × 15 × 10 cm

Robot (1) → stanford (RRP)

Robot (2) → PUMA (RRR)

Robot (3) → SCARA (RRP)

↳ link lengths → 0.25 m

↳ link masses → 0.8 kg

↳ moment of inertia → 0.005 kg m^2

(a) (b) (c) codes are attached with submission

(all lengths are in cm),