Assignment-2
(ITR)

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Q1 Prove $RS(a)R^T = S(Ra)$, R is Rotation matrix

let b is any vector,

So, $RS(a)R^Tb = R(a \times R^Tb)$ $\{as\ S(m)p = m \times p\}$

$= (Ra) \times (RR^Tb)$ $\{as\ R(a \times b) = Ra \times Rb\}$

$= (Ra) \times b$

$= S(Ra)b$

So, $RS(a)R^Tb = S(Ra)b$

As, this equality holds for all $b \in R^3$.

$\therefore \boxed{RS(a)R^T = S(Ra)}$

Q6: Types of Gearboxes:

a) Planetary Gearbox:

Pro:
↳ High torque output, compact size, high efficiency, & good precision.

Con:
↳ Complex design, which can lead to higher manufacturing costs.

Use:
↳ Robotic arms & CNC machines where ~~position~~ precision & torque transmission are crucial.

2) Spur Gearbox:

Pro:

↳ Simple design, efficient, cost effective, suitable for moderate torque applications.

Con:

↳ Can be noisy & less compact compared to other types of gearboxes.

Use:

↳ Robotic vehicles, conveyor systems & manufacturing equipment.

3) Cycloidal Gearbox:

Pro:

↳ High Torque transmission, compact size, and excellent shock load resistance. They offer exceptional accuracy.

Con:

↳ Can be less efficient due to multiple gear contacts, making them more suitable for high-torque low speed applications.

Use:

↳ Industrial Robots for material handling & welding.

4) Harmonic drive Gearbox:

↳ High Precision, zero backlash & compact design.

↳ Limited torque capacity & they are expensive.

↳ Robotic arms for tasks like surgery & precise assembly.

↳ In drone applications, the use of a gearbox depends on the specific design and requirements of drone.

Pros of using Gearbox in Drones:

Increased torque, Efficiency & Noise Reduction

Cons of Using a Gearbox in Drones:

Added weight & complexity, Reduced Responsiveness

Q7- Manipulator Jacobian for the RRP SCARA configuration.

$$x = l_1 \cos\theta_1 + l_2 \cos(\theta_1+\theta_2)$$

$$y = l_1 \sin\theta_1 + l_2 \sin(\theta_1+\theta_2)$$

$$z = d_3$$

$$\frac{\partial x}{\partial \theta_1} = -l_1 \sin\theta_1 - l_2 \sin(\theta_1+\theta_2)$$

$$\frac{\partial x}{\partial \theta_2} = -l_2 \sin(\theta_1+\theta_2)$$

$$\frac{\partial x}{\partial d_3} = 0$$

$$\frac{\partial y}{\partial \theta_1} = l_1 \cos\theta_1 + l_2 \cos(\theta_1+\theta_2)$$

$$\frac{\partial y}{\partial \theta_2} = l_2 \cos(\theta_1+\theta_2)$$

$$\frac{\partial y}{\partial d_3} = 0, \quad \frac{\partial z}{\partial \theta_1} = 0, \quad \frac{\partial z}{\partial \theta_2} = 0, \quad \frac{\partial z}{\partial d_3} = 1$$

Now, assemble the Jacobian matrix:

$$\begin{bmatrix} -l_1\sin\theta_1 & -l_2\sin(\theta_1+\theta_2) & -l_2\sin(\theta_1+\theta_2) & 0 \\ l_1\cos\theta_1 & +l_2\cos(\theta_1+\theta_2) & l_2\cos(\theta_1+\theta_2) & 0 \\ 0 & & 0 & 1 \end{bmatrix}$$

Q4. Manipulator Jacobian for RRR configuration

$$x = l_1\cos\theta_1 + l_2\cos(\theta_1+\theta_2) + l_3\cos(\theta_1+\theta_2+\theta_3)$$

$$y = l_1\sin\theta_1 + l_2\sin(\theta_1+\theta_2) + l_3\sin(\theta_1+\theta_2+\theta_3)$$

$$\frac{\partial x}{\partial\theta_1} = -l_1\sin\theta_1 - l_2\sin(\theta_1+\theta_2) - l_3\sin(\theta_1+\theta_2+\theta_3)$$

$$\frac{\partial x}{\partial\theta_2} = -l_2\sin(\theta_1+\theta_2) - l_3\sin(\theta_1+\theta_2+\theta_3)$$

$$\frac{\partial x}{\partial\theta_3} = -l_3\sin(\theta_1+\theta_2+\theta_3)$$

$$\frac{\partial y}{\partial\theta_1} = l_1\cos\theta_1 + l_2\cos(\theta_1+\theta_2) + l_3\cos(\theta_1+\theta_2+\theta_3)$$

$$\frac{\partial y}{\partial\theta_2} = l_2\cos(\theta_1+\theta_2) + l_3\cos(\theta_1+\theta_2+\theta_3)$$

$$\frac{\partial y}{\partial\theta_3} = l_3\cos(\theta_1+\theta_2+\theta_3)$$

Jacobian matrix J:

$$\begin{bmatrix} \frac{\partial x}{\partial\theta_1} & \frac{\partial x}{\partial\theta_2} & \frac{\partial x}{\partial\theta_3} \\ \frac{\partial y}{\partial\theta_1} & \frac{\partial y}{\partial\theta_2} & \frac{\partial y}{\partial\theta_3} \end{bmatrix}$$