# Assignment - 2

(I)

(a) The screw axes $S_i$ in {0} are

| | $\omega_i$ | $v_i$ |
|---|---|---|
| {0} | (0,0,0) | (0,0,0) |
| {1} | (0,0,1) | (0,0,0) |
| {2} | (0,0,1) | ($\ell_1$,0,0) |
| {3} | (0,0,1) | ($\ell_1+\ell_2$,0,0) |
| {b} | (0,0,0) | (0,0,1). |

M is

$$M = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & \ell_1+\ell_2 \\ 0 & 0 & 1 & \ell_0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The screw axes in {b} are

| | $\omega_i$ | $v_i$ |
|---|---|---|
| {b} | (0,0,0) | (0,0,1) |
| {3} | (0,0,1) | (0,0,0) |
| {2} | (0,0,1) | ($-\ell_2$,0,0) |
| {1} | (0,0,1) | ($-\ell_1-\ell_2$,0,0) |
| {0} | (0,0,0) | ($-\ell_1-\ell_2$,0,0) |

(b) The final answer obtained using matlab is

$$T = \begin{bmatrix} 1 & 0 & 0 & -1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

2

(a) The screw axes for the RRP robot are

| | $\omega_i$ | $v_i$ |
|---|---|---|
| {1} | (0, 0, 1) | (0, 0, 0) |
| {2} | (1, 0, 0) | (0, 2, 0) |
| {3} | (0, 0, 0) | (0, 1, 0) |

By inspection
$$M = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 3 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad \text{—(1)}$$

The forward kinematics computed are.

when $\theta = (90, 90, 1)$ the forward kinematics are

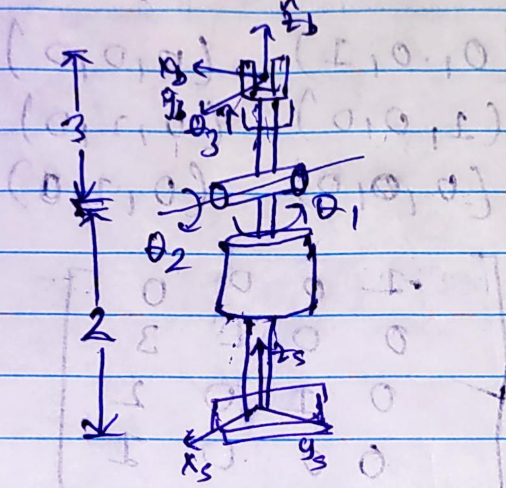
$$T(\theta) = e^{[S_1]\theta} e^{[S_2]\theta} e^{[S_3]\theta} M$$

evaluating this expression in matlab gives

$$T(\theta) = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 6 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

(a)

The Space Jacobian for this configuration is the screw axes when the robot is in the configuration




for $J_s(\theta)$:

| | $\omega_i$ | $v_i$ |
|---|---|---|
| {1} | (0,0,1) | (0,0,0) |
| {2} | (0,1,0) | (-2,0,0) |
| {3} | (0,0,0) | (0,0,1) |

$$J_s(\theta) = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

(b) The forward kinematics at $\theta = (90, 90, 1$ in the body frame are

$$\omega_i \qquad v_i = \vec{q} \times \vec{\omega}$$

| | $\omega_i$ | $v_i$ |
|---|---|---|
| {1} | (0, 1, 0) | (3, 0, 0) |
| {2} | (-1, 0, 0) | (0, 3, 0) |
| {3} | (0, 0, 0) | (0, 0, 1) |

The forward kinematics computed on matlab are $\theta = (90, 90, 1)$

$$T(\theta) = M e^{[B_1]\theta_1} e^{[B_2]\theta_2} e^{[B_3]\theta_3}$$

$$T(\theta) = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 6 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$ for M in (2)

The space Jacobian $J_b$ is

| | | $\omega_i$ | $v_i$ |
|---|---|---|---|
| $V_{b_i}(\theta)$ | {1} | (0, 0, 1) | (0, 0, 0) |
| | {2} | (-1, 0, 0) | (0, 3, 0) |
| | {3} | (0, 0, 0) | (0, 0, 1) |

$$\therefore J_b(\theta) = \begin{bmatrix} 0 & -1 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \\ 6 & 3 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

8. Member of Project
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