Assignment 5

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You want to plan a joint space LSPB trajectory for a 2R robot for one motion segment. The starting point of the segment is $\theta_1(0) = -10°, \theta_2(0) = 25°$, and the end point is $\theta_1(t_f) = 20°$, $\theta_2(t_f) = 100°$. If the magnitude of $\ddot{\theta}_{d1}$ equals $20°/s^2$, the magnitude of $\ddot{\theta}_{d2}$ equals $80°/s^2$ and $t_f = 2.5$ s, determine:

a) t_b and $\dot{\theta}_{max}$ for each joint

b) θ for each joint when $t = 1.5$ s

$\theta_1(0) = -10°$ $\theta_2(0) = 25°$ $t_f = 2.5s$

$\theta_1(t_f) = 20°$ $\theta_2(t_f) = 100°$

$\ddot{\theta}_{d1} = 20°/s^2$ $\ddot{\theta}_{d2} = 80°/s^2$

a) $$t_b = \frac{\ddot{\theta}_d t_f - \sqrt{\ddot{\theta}_d^2 t_f^2 - 4\ddot{\theta}_d(\theta_f - \theta_i)}}{2\ddot{\theta}_d}$$

θ_1:

$$t_B = \frac{\ddot{\theta}_{d1} t_f - \sqrt{\ddot{\theta}_{d1}^2 t_f^2 - 4\ddot{\theta}_{d1}(\theta_1(t_f) - \theta_1(0))}}{2\ddot{\theta}_d}$$

$$t_B = \frac{(20°/s^2)(2.5s) - \sqrt{(20°/s^2)^2(2.5s)^2 - 4(20°/s^2)(20 + 10°)}}{2(20°/s^2)}$$

$t_B = 1s$

$\dot{\theta}_{max} = \ddot{\theta}_d t_b$

$(\dot{\theta}_1)_{max} = (20°/s^2)(1s)$

$= 20°/s$

θ_2:

$$t_b = \frac{\ddot{\theta}_d t_f - \sqrt{\ddot{\theta}_d^2 t_f^2 - 4\ddot{\theta}_d(\theta_f - \theta_i)}}{2\ddot{\theta}_d}$$

$$t_b = \frac{(80°/s^2)(2.5) - \sqrt{80^2 \cdot 2.5^2 - 4 \cdot 80\,(100° - 25°)}}{2(80)}$$

$$t_b = 0.459\,s$$

$$(\dot{\theta}_2)_{max} = \ddot{\theta}_{d2} \cdot t_b$$

$$= (80)(0.459)$$
$$= 36.75°/s$$

b) θ for each joint when $t = 1.5s$

θ_1:

$$t_f - t_b \leq t \leq t_f$$
$$2.5 - 1 \leq 1.5 \leq 2.5$$
$$1.5 \leq 1.5 \leq 2.5 \checkmark$$

$$\theta_1(t) = \theta_f - \frac{1}{2}\ddot{\theta}_d(t_f - t)^2$$

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$$= 20 - \frac{1}{2}(20)(2.5 - 1.5)^2$$

$$= 10^\circ$$

θ_2:

$$t_b \le t \le (t_f - t_b)$$

$$0.459 \le 1.5 \le 2.041$$

$$\theta_1(t) = \theta_i + \frac{1}{2}\ddot{\theta}_d t_b^2 + \dot{\theta}_d t_b (t - t_b)$$

$$= 25 + \frac{1}{2}(80)(0.459)^2 + 80(0.459)(1.5 - 0.459)^2$$

$$= 73.22^\circ$$