??
??
??
$\dot{\theta}_1 =$
$-\frac{(\theta_2+\pi)}{2}$
$\dot{\theta}_2 =$
$-2\dot{\theta}_1$
??
$\dot{\theta}_2$
??
??
??
??
$_m anipulator.pngThemanipulatorcorrespondingtoaverticaloneleg jump.$

$x_{end} = L_1 \cos(\theta_1) + L_2 \cos(\theta_1+\theta_2) y_{end} = L_1 \sin(\theta_1) + L_2 \sin(\theta_1+\theta_2)$
(1)
$_1 \sin(\theta_1) -$
$L_2 \sin(\theta_1 +$
$\theta_2) -$
$L_2 \sin(\theta_1 +$
$\theta_2)$
$L_1 \cos(\theta_1) +$
$L_2 \cos(\theta_1 +$
$\theta_2) L_2 \cos(\theta_1 +$
$\theta_2)$
$_j acobian_v elocity.eps Vertical Paw velocity as a function of knee angle.$
??
??
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Robot Jumping Controller Logic

Friction Scaling:

$$N_\mu \leftarrow 0.8\, N_\mu$$

Angle Conversions (Degrees to Radians):

$$\theta_1 = \frac{\pi}{180}\theta_{\text{hip\_deg}}, \quad \theta_2 = \frac{\pi}{180}\theta_{\text{knee\_deg}}$$

$$w_1 = \frac{\pi}{180}w_{\text{hip\_deg}}, \quad w_2 = \frac{\pi}{180}w_{\text{knee\_deg}}$$

Link Lengths:

$$l_1 = \text{thigh\_l\_m}, \quad l_2 = \text{calf\_l\_m}$$

Capping Angular Velocities:

$$w_{1,\text{abs}} = \min(|w_1|, w_{\text{hip\_max}}), \quad w_{2,\text{abs}} = \min(|w_2|, w_{\text{knee\_max}})$$

Maximum Torque Based on Speed:

$$\tau_{1,\text{max\_abs}} = \tau_{\text{hip\_stall}} \left(1 - \frac{w_{1,\text{abs}}}{w_{\text{hip\_max}}}\right)$$

$$\tau_{2,\text{max\_abs}} = \tau_{\text{knee\_stall}} \left(1 - \frac{w_{2,\text{abs}}}{w_{\text{knee\_max}}}\right)$$

Assigning Torques:

$$\tau_2 = \tau_{2,\text{max\_abs}}, \quad \tau_{1,\text{motor\_dyn\_limit}} = -\tau_{1,\text{max\_abs}}$$

Friction Cone Constraint:

$$\tau_{1,\text{friction\_cone\_limit}} = \frac{-\,l_1\, l_2\, \sin(\theta_2)\, N_\mu \;+\; \big(l_1 \sin(\theta_1) + l_2 \sin(\theta_1 + \theta_2)\big)\tau_2}{l_2\, \sin(\theta_1 + \theta_2)}$$

Final Hip Torque Selection:

$$\tau_1 = \max\big(\tau_{1,\text{motor\_dyn\_limit}},\, \tau_{1,\text{friction\_cone\_limit}}\big)$$

Direction-Dependent Torque Output:

$$\tau_{\text{hip}} = (\text{front1\_backneg1})\, \tau_1, \quad \tau_{\text{knee}} = (\text{front1\_backneg1})\, \tau_2$$