Control of Go1

And overview of first 2 weeks

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Timeline

Forward Kinematics

$$x = L_t sin(\theta_t) + L_c sin(\theta_t + \theta_c)$$

$$z = [L_t cos(\theta_t) + L_c cos(\theta_t + \theta_c)] cos(\theta_h)$$

$$y = ztan(\theta_h)$$

Where L_c = Length of Calf
L_t = Length of Thigh
θ_c = Calf Angle θ_t = Thigh Angle
θ_h = Hip Angle

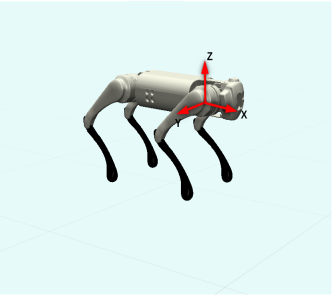


Figure: Go1 Coordinate Axes

Inverse Kinematics

L_c = Length of Calf
L_t = Length of Thigh
θ_c = Calf Angle
θ_t = Thigh Angle
θ_h = Hip Angle
;

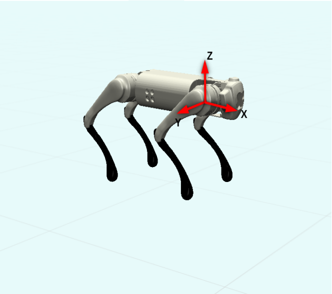


Figure: Go1 Coordinate Axes

$$\theta_h = arctan(\frac{y}{z})$$

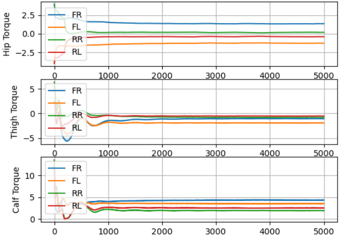
$$\theta_c = arcsin(\frac{x}{L} - sin(\theta_t)) - \theta_t$$

$$\theta_t = arccos(\frac{\sqrt{x^2 + y^2 + z^2}}{L_t + L_c}) + arctan(\frac{-x}{\sqrt{y^2 + z^2}})$$

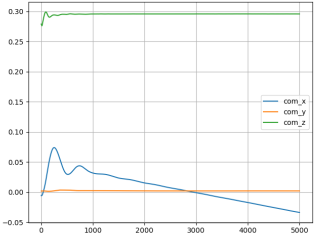
Standing Controller

Gravity Compensated PD-Controller

$$\boldsymbol{\tau} = \mathbf{J}^{\mathbf{T}}(\boldsymbol{\theta}) \cdot \mathbf{F_{gc}} + K_p \boldsymbol{\theta}_{\mathbf{e}} + K_d \dot{\boldsymbol{\theta}}_{\mathbf{d}}$$

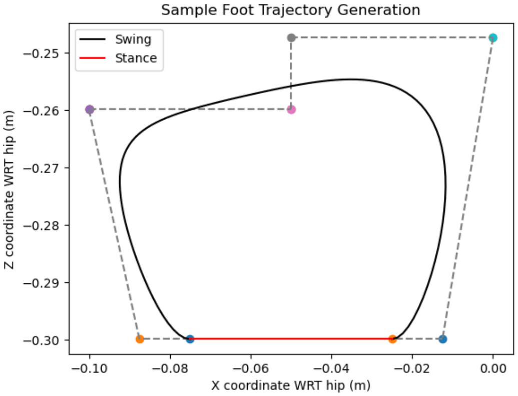


Position of feet statically set to $\vec{p} = \begin{bmatrix} -0.02 \\ 0.02 \\ -0.3 \end{bmatrix}$ With respect to coordinate system above. Gains were also set for each joint as $K_p = 30; K_d = 0.1$



Walking Controller

Feet trajectory generated using Bezier Curves.
$\mathbf{F_{gc}}$ now contains weight of body split between the two "standing" legs. And weight of the leg itself for "swinging" legs.
Gains set to $K_p = 50$ and $K_d = 1$ in walking state.



Standing Controller

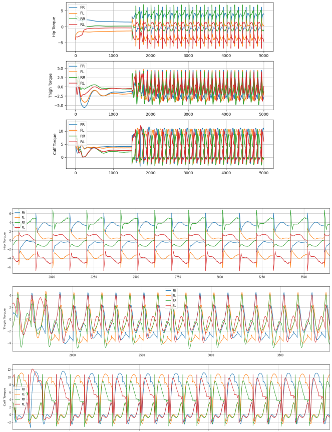


Figure: Joint Torques

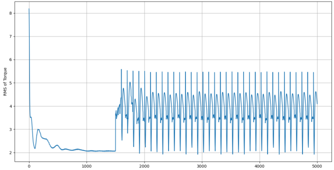


Figure: Root Mean Square of Torques

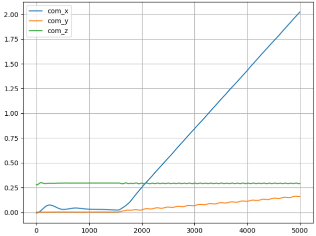


Figure: Center of Mass Position

Next Steps

- Implement standing procedure.
- Implement variable step-length of each leg so can have a controller to adjust position if path isn't straight.
- Tune gains of each individual joint and general controller improvement.
- Apply neural net to "learn" control.

Roadblocks

- Physical low-level control of Go1, hopefully fixed with new board.