

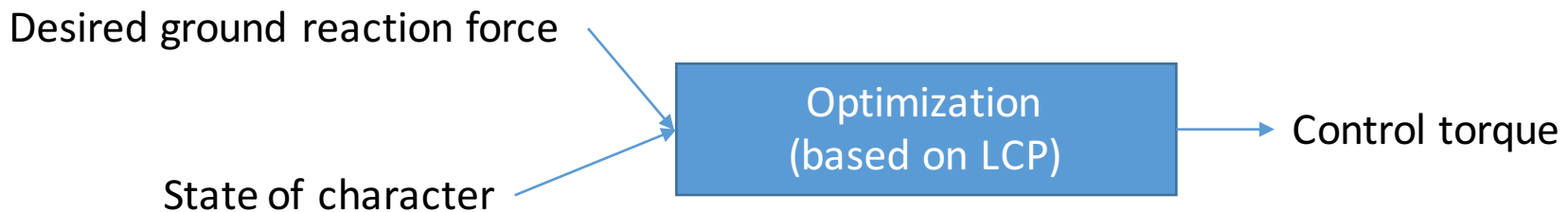
Control of lower limb

박황필

Linear complementarity problem



Linear complementarity problem



Linear complementarity problem

1. Non-penetration

- Normal force and normal velocity should be positive.

2. Direction of friction

- Direction of friction should be opposite to velocity.

3. Magnitude of friction

- GRF should lie on the friction cone.

Linear complementarity problem

1. Non-penetration

- $0 \leq \theta_i \perp \mathbf{n}_i \cdot \mathbf{v}_c \geq 0$

2. Direction of friction

- $0 \leq \phi_{ij} \perp d_{ij} \cdot \mathbf{v}_c + \lambda_i \geq 0$

3. Magnitude of friction

- $0 \leq \lambda_i \perp \mu\theta_i - \sum_j \phi_{ij} \geq 0$

Linear complementarity problem

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$$\Rightarrow x \geq 0, \quad Wx + p \geq 0, \quad x^T(Wx + p) = 0$$

LCP Formulation

- $\min_{\theta, \phi, \lambda} x^T (Wx + p)$
- S.t. $Wx + p \geq 0$
- $x \geq 0$

Optimization Formulation

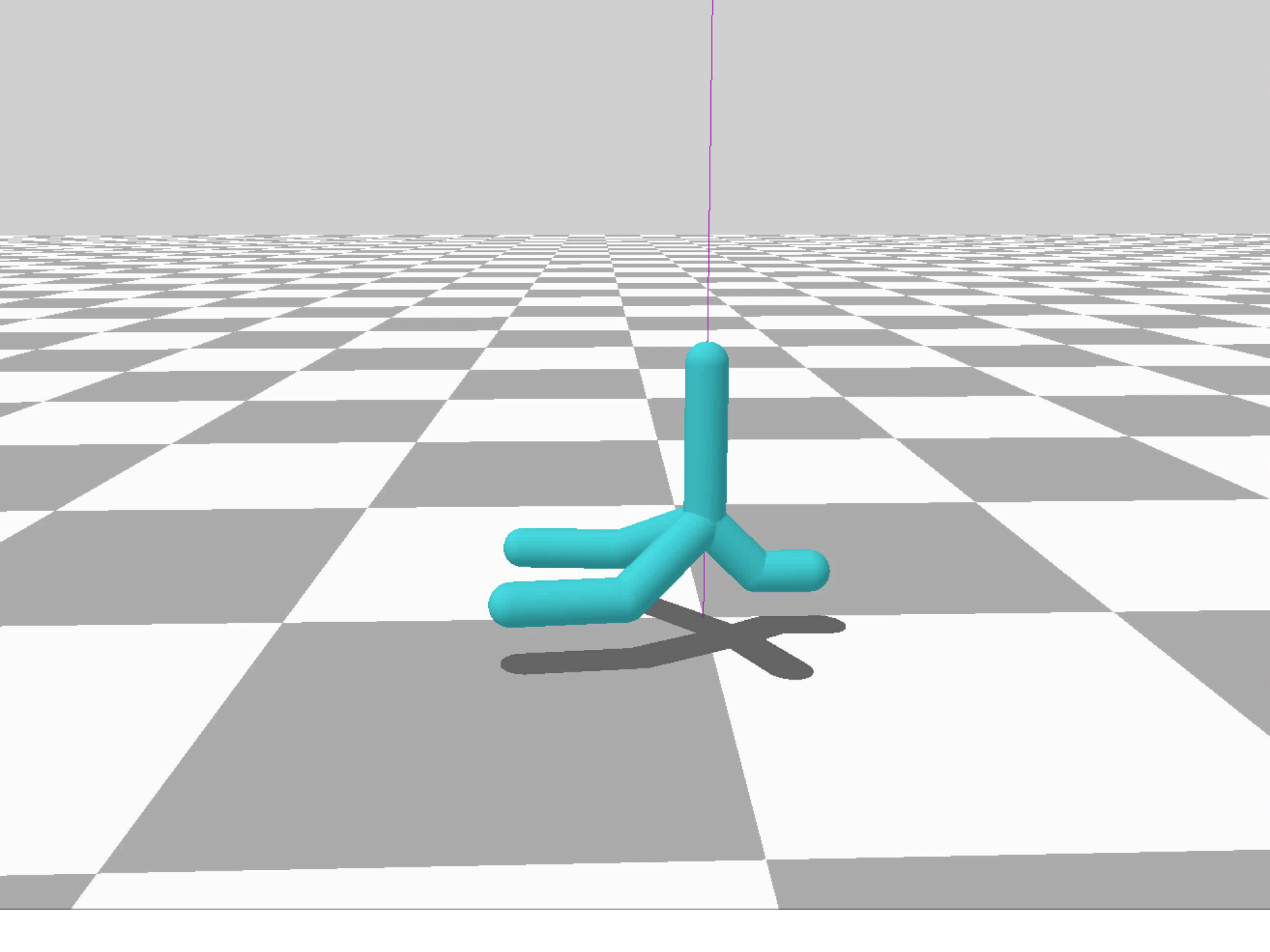
- $\min_{\theta, \phi, \lambda} x^T (Wx + p) + \omega_F |F - F_{des}|^2 + \omega_\tau |\tau|^2$
- S.t. $Wx + p \geq 0$
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Optimization Formulation

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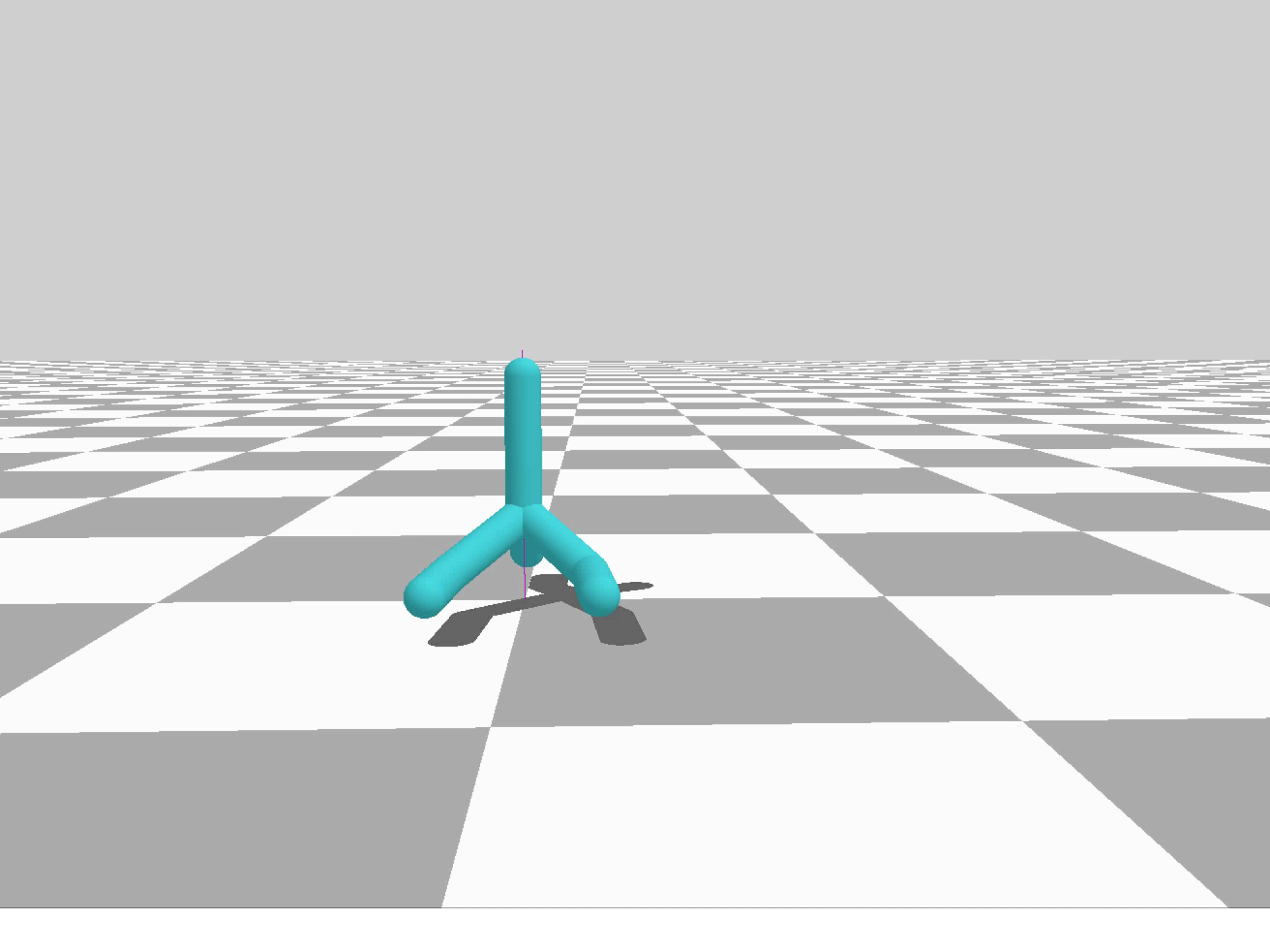
Experiments(normal direction)

- Set desired normal force F_{des} to
 - 100N
 - 150N
 - 200N
 - 250N
 - 300N
 - 350N
- Weight of the object is 35N
- For 0.2 seconds



Experiments(tangential direction)

- Set desired normal force to its weight 35N
- Set desired tangential force to
 - 40N
 - 80N
 - 100N
 - 120N
 - 140N
- For 0.2 seconds



Problem

- $F \ll F_{des}$
- LCP conditions are not satisfied in optimization
 - $x^T(Wx + p) \neq 0$