



University of Stuttgart
Germany

**Data-
Integrated
Simulation
Science**

cbb
Computational
Biophysics
and Biorobotics

SimTech

Biophysics Simulation of a One-legged Skier

**Sebastian Schulz,
Thilo Paul,
Riccardo Frenner**

February 7, 2024

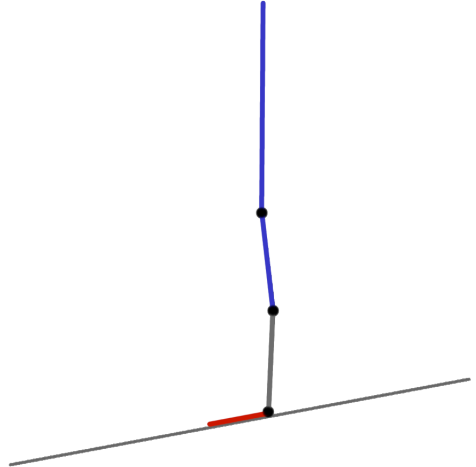
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Overview

- 1 Motivation
- 2 Model
- 3 Theory
- 4 Control
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- 6 Conclusion and Outlook

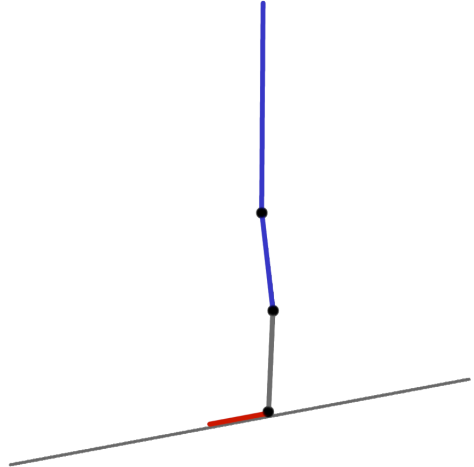
Motivation

- Is balancing on a ski with one leg possible without arms?

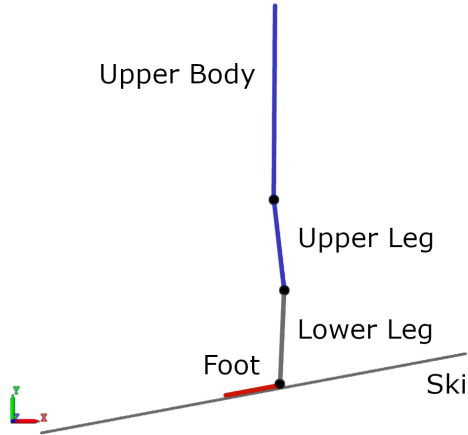


Motivation

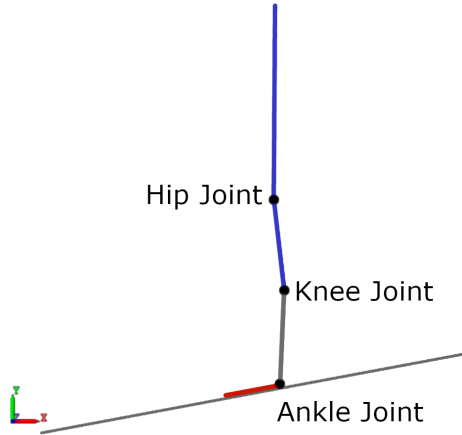
- Is balancing on a ski with one leg possible without arms?
- What information is needed to control the model?



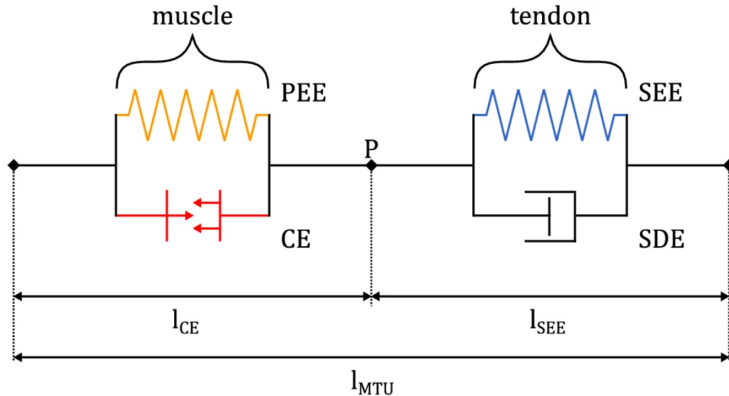
Model



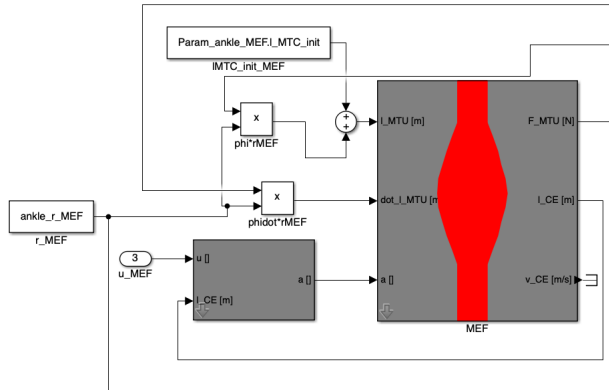
Model



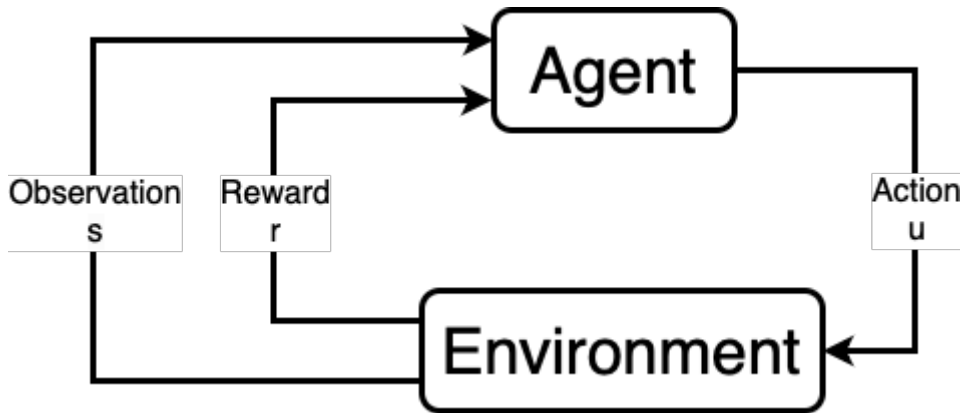
Hill-Type Muscle Model



Hill-Type Muscle Model



Reinforcement Learning Agent



RL Algorithm - DDPG

Deep deterministic policy gradient (DDPG):

- Neuronal Net based policy
- Action-State History
- Actor-Critic architecture

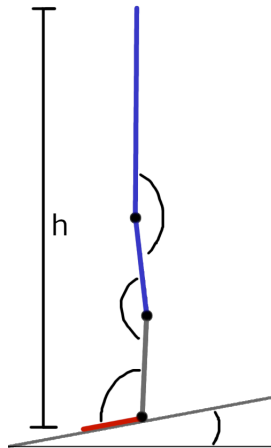
Actions and Observations

Observations:

- height
- angles
- angular velocity
- angular acceleration

Actions:

- activations u

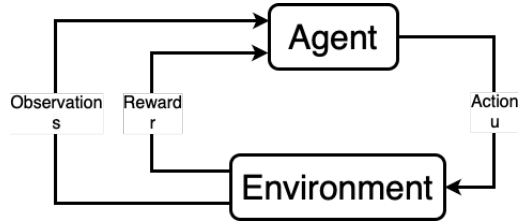


Reward Function

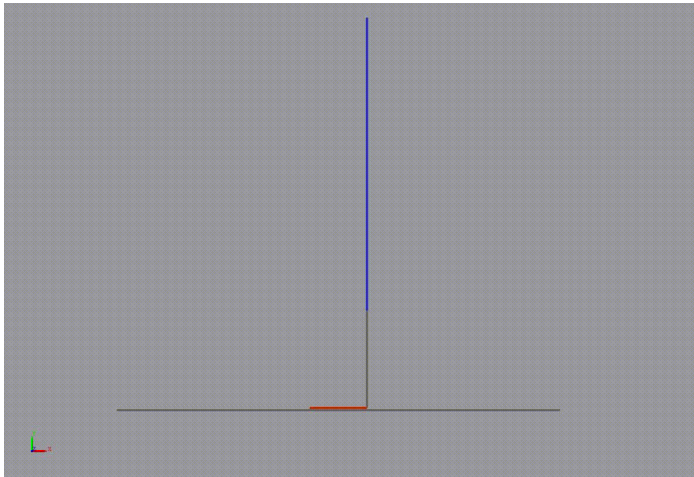
$$r = \underbrace{h^2}_{\text{height reward}} + \underbrace{1}_{\text{duration reward}} - \underbrace{0.1 \cdot u^2}_{\text{regulation reward}} - \underbrace{0.075 \cdot (w_{\text{ankle}}^2 + w_{\text{knee}}^2 + w_{\text{hip}}^2)}_{\text{speed reward}}$$

Stopping Criteria

- Maximum simulation time
- Exceeding joint angle limits
- Height below board



Results



Conclusion and Outlook

Conclusion:

- Balancing is possible

Conclusion and Outlook

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- Almost every observable is needed

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Outlook:

- Remove board slope from observations

Conclusion and Outlook

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- Balancing is possible
- Almost every observable is needed
- Reward function has large impact

Outlook:

- Remove board slope from observations
- Adding arms

Thank you for your attention!

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