



Motion Control of High-Dimensional Musculoskeletal System with Hierarchical Model-Based Planning

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Insgroup.cc/research/MPC2.html



Video results

Goal

We aim to control high-dimensional musculoskeletal systems to achieve a variety of challenging movement tasks.

Our method has the following advantages:

- **(near) real-time** control
- **training-free generalization** over tasks, morphologies and perturbations
- **Automatic** and efficient reward engineering

Background

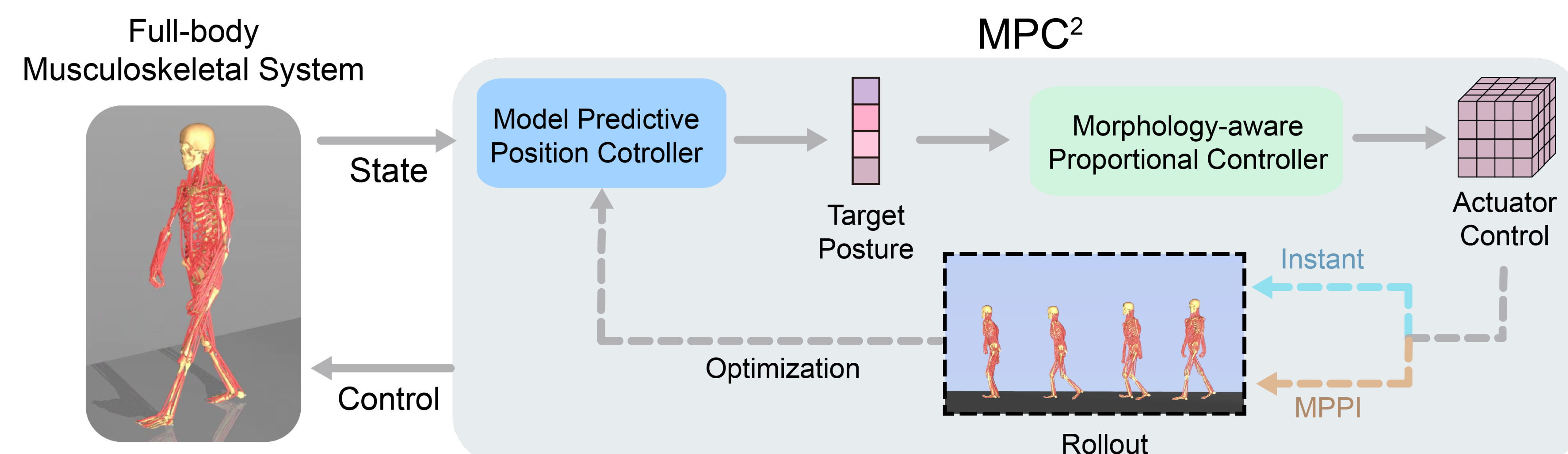
Our primary morphology is a comprehensive whole body human musculoskeletal model

- 90 rigid body segments, 206 joints, 700 muscle-tendon units
- high-dimensional state space and control space
- highly non-linear dynamical system

Current deep reinforcement learning methods for musculoskeletal control

- require long training time
- cannot generalize over tasks and morphologies

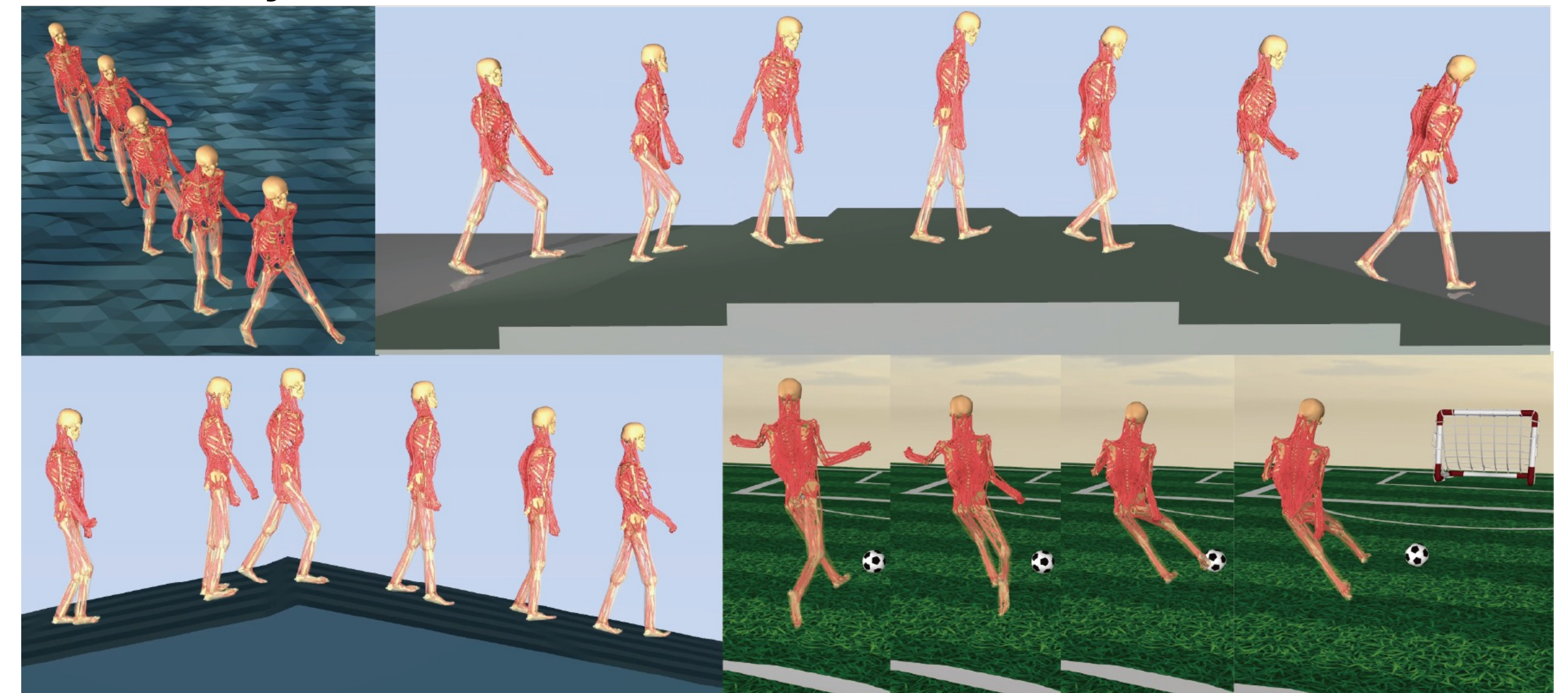
Algorithm: Model Predictive Control with Morphology-aware Proportional Control (MPC²)



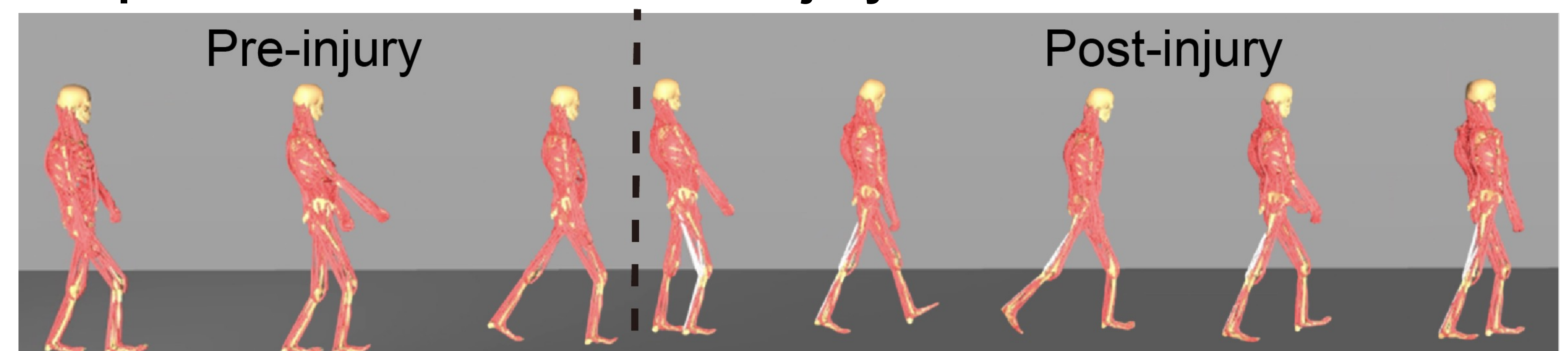
- **sampling-based planning**: avoid high-dimensional state exploration
- **hierarchical morphology-aware pipeline**: enable high-dimensional control planning
- **training free control**: facilitate automatic and efficient reward design

Musculoskeletal Control with MPC²

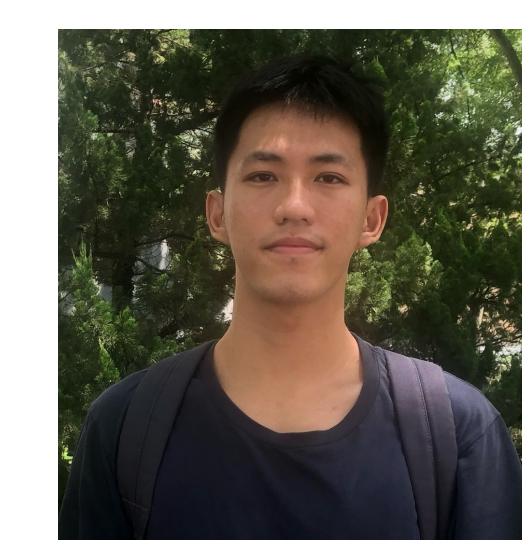
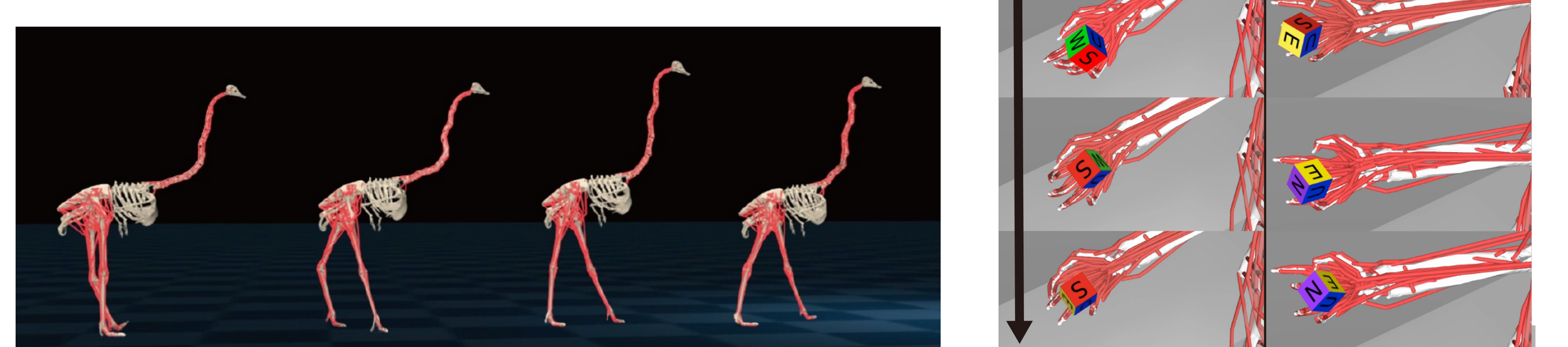
Whole body movement control



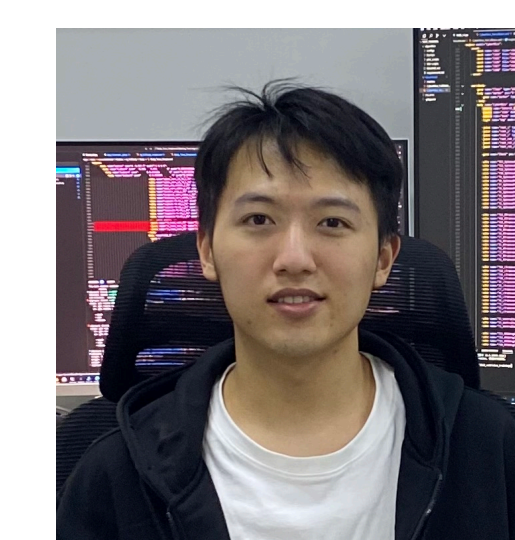
Adaption under sudden muscle injury



Zero-shot cross-embodiment control



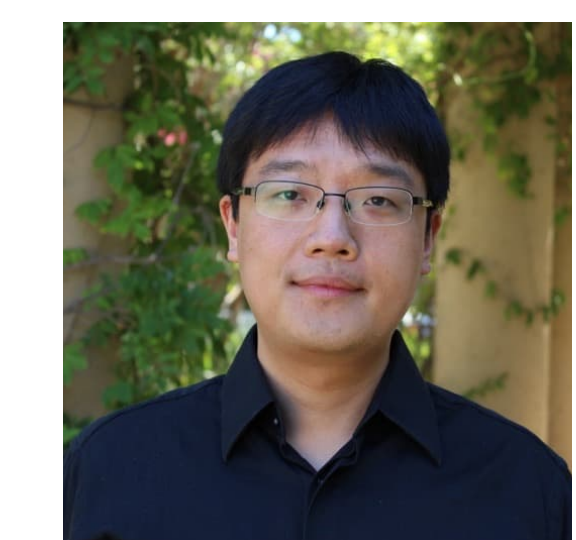
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