OstrichRL: A Musculoskeletal Ostrich Simulation to Study Bio-mechanical Locomotion

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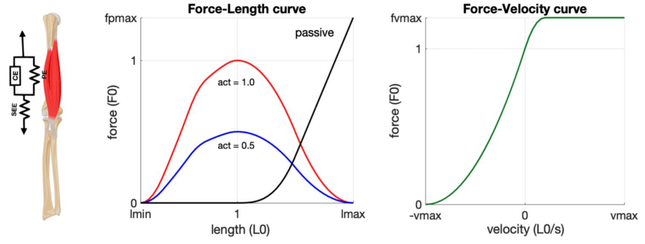
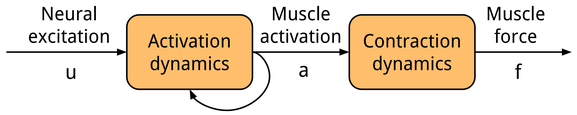
TLDR

- Muscle actuation is studied in many fields such as biomechanics, robotics and graphics.
- Existing models mostly use the OpenSim simulator that is too slow to be easily integrated into RL pipelines.
- We propose a fast and accurate 3D model of an ostrich using the MuJoCo physics engine.
- Ostriches are the fastest bipeds on earth with a top speed of over 40 km/h (25 mph).
- We release dm_control tasks including motion capture tracking.

Muscle actuation modeling

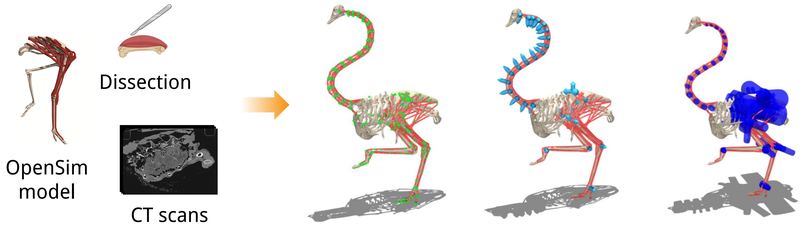
- **Hill-type muscle models** are often used in biomechanics to estimate active and passive forces with respect to length, activation and velocity.
- **OpenSim** is a popular physics engine in biomechanics.
- **MuJoCo** is a popular physics engine in RL, roughly 300 times faster than OpenSim.





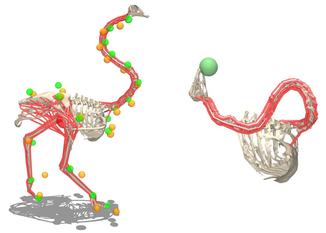
Proposed ostrich model

- **Existing OpenSim model** of the legs, adapted to have more realistic feet and converted to a MuJoCo model.
- **CT scans** to obtain the geometries for the remaining body parts (rib cage, wings, neck, head).
- **Dissection** to gather anatomical muscle data, including muscle routing and pennation angle.
- **Complex overactuated model** including 48 joints and 121 muscles.
- **Torque-controlled skeletal model** for comparison.



Proposed dm_control tasks

- **Run forward** as fast as possible.
- **MoCap tracking** of running and standing clips.
- **Foraging** random targets with the beak.

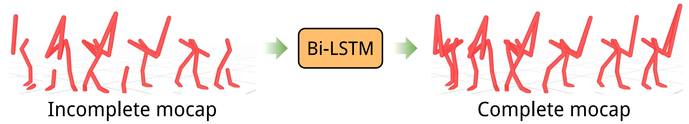


Reinforcement learning

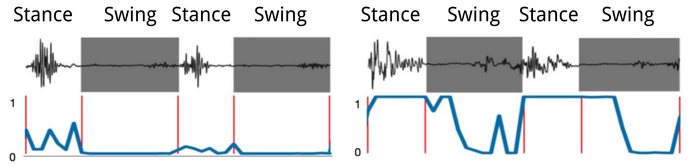
- **TD4 agent** combining TD3 and D4PG features.
- **Tonic RL library** to easily train, analyze results and explore policies.

Motion Capture

- We predicted missing marker positions in an existing ostrich MoCap dataset.
- We inferred the locations of the markers on our model and the matching joint angles.

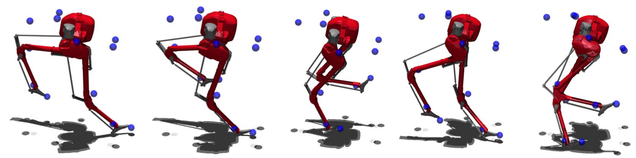


Comparison to EMG data (ILPO and ITC muscles)



Cassie

- The Cassie robot has an ostrich-like morphology.
- We applied the proposed MoCap tracking pipeline to its existing MuJoCo model.



Ressources https://github.com/vittorione94/ostrichrl

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