Hybrid Zero Dynamics Inspired Feedback Motion Planning for 3D Bipedal Locomotion Using Reinforcement Learning

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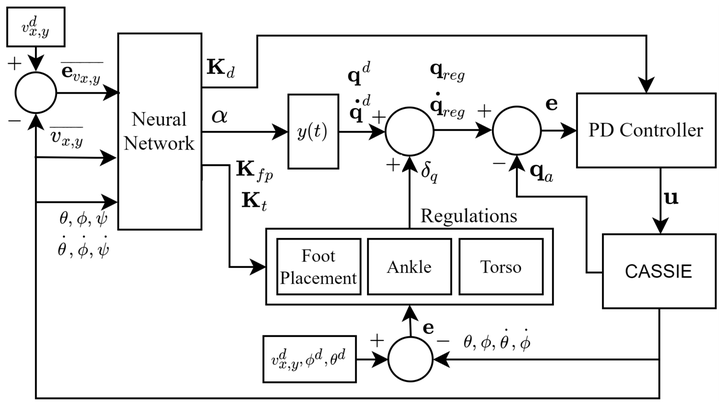
❑ Problem Formulation

- Bipedal walking is challenging due to the hybrid nature of its dynamics and the complexity imposed by high-dimensional models.
- Current RL methods are data inefficient or depend on prior knowledge of reference trajectories.
- **Target:** Design of feedback controllers for bipedal robots using a non-traditional RL structure that embeds formal control methods (HZD) and intuitive feedback regulations into the policy learning.

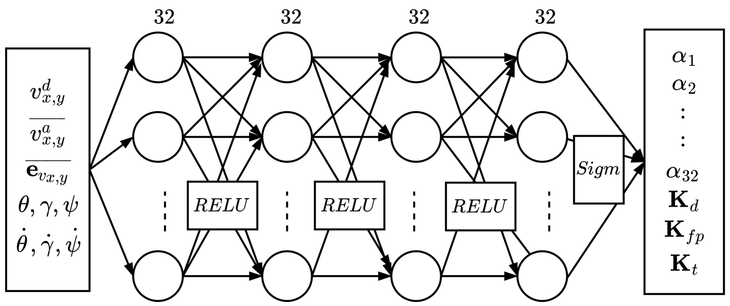
❖ HZD-based RL

- Light weight structure - data efficient.

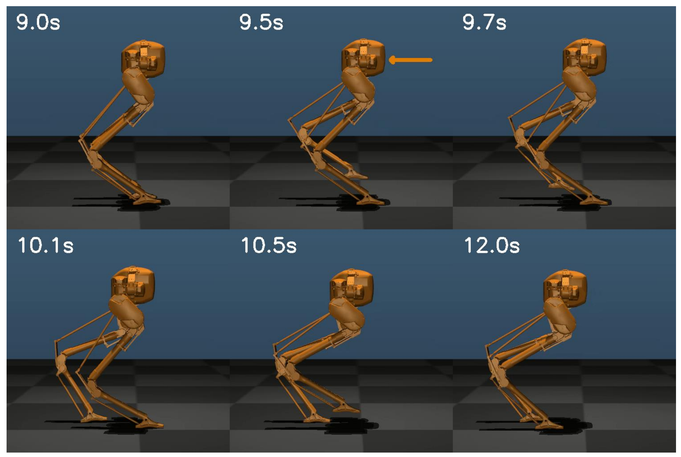


❖ Neural Network (NN) Structure

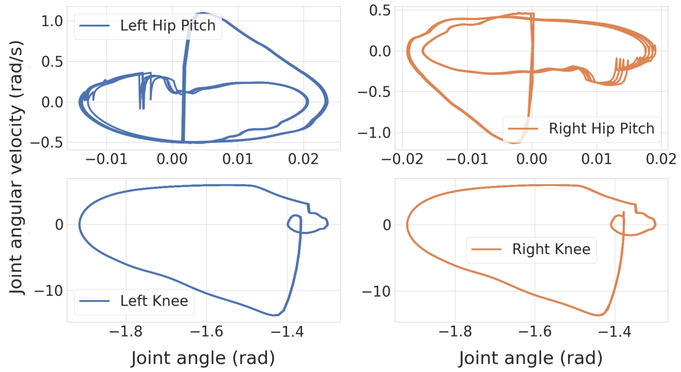
- Light weight structure - data efficient.



❑ Simulation Results on Cassie

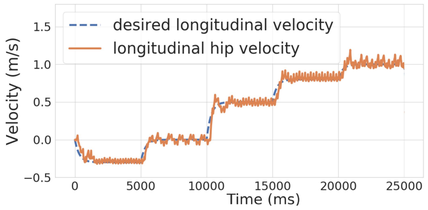


❖ Tracking fixed desired velocity



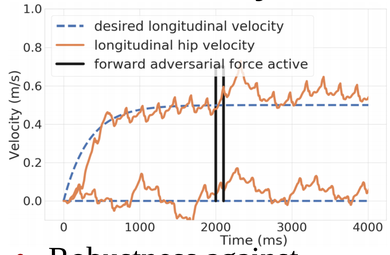
- Controller renders stable walking limit cycle.

❖ Speed tracking



- Good performance when tracking varying longitudinal and lateral desired velocities.

❖ Disturbance rejection



- Robustness against external disturbances applied in the forward and backward directions.

❑ Future Work: Exoskeleton

❖ Atalante

- Robotic hands-free and self-balancing exoskeleton for walking rehabilitation.
- 12 actuated joints: near-physiological motion.
- Bio compatible braces.
- On board computer.
- Weight: 75 kg.
- Designed by WANDERCRAFT for patients with locomotor disability resulting from spinal cord injury, neuromuscular diseases or stroke
- Used on clinical research.

❖ Objectives

- Translating current framework (formal control methods + RL) to our fully actuated lower-limb exoskeleton, ATALANTE in simulation and real experiments.
- Clinically realize hands-free dynamic walking for paraplegic individuals.
- Harness the power of RL algorithms to improve limitations on maneuverability, robust velocity regulation, and perturbation rejection.