



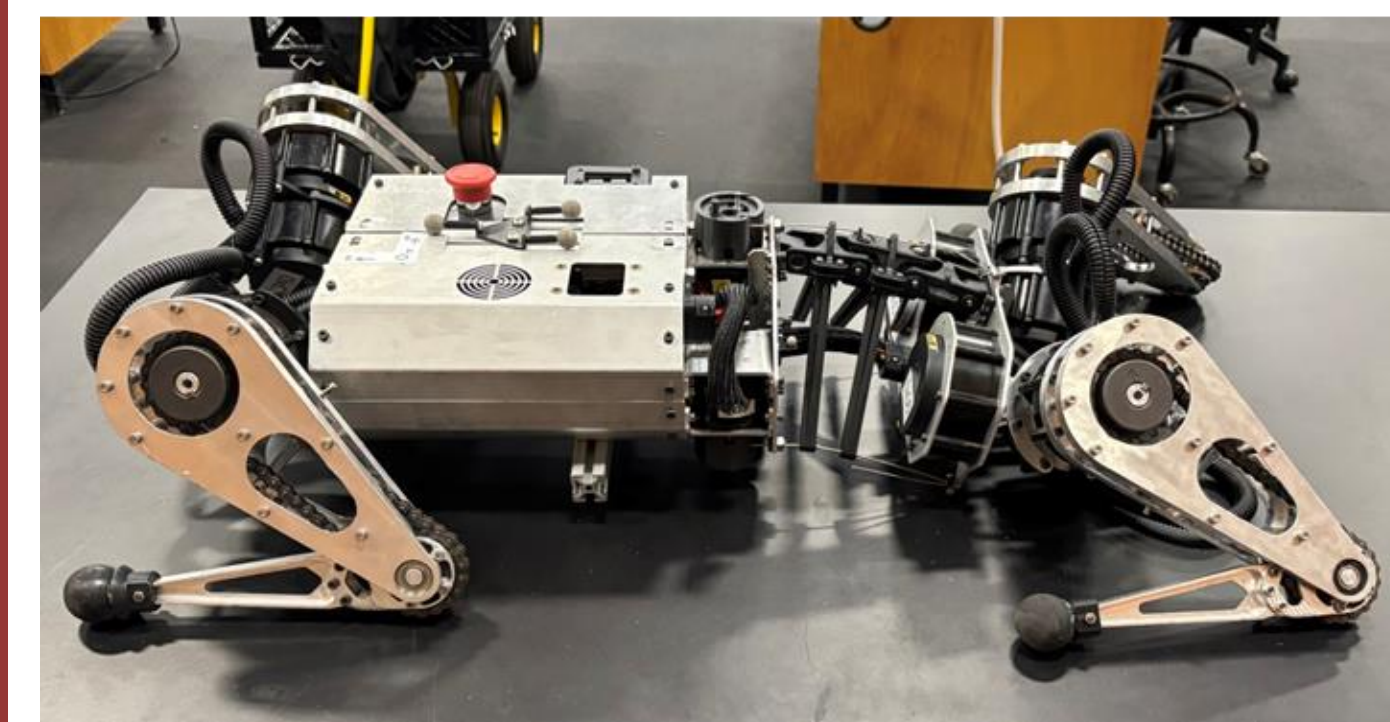
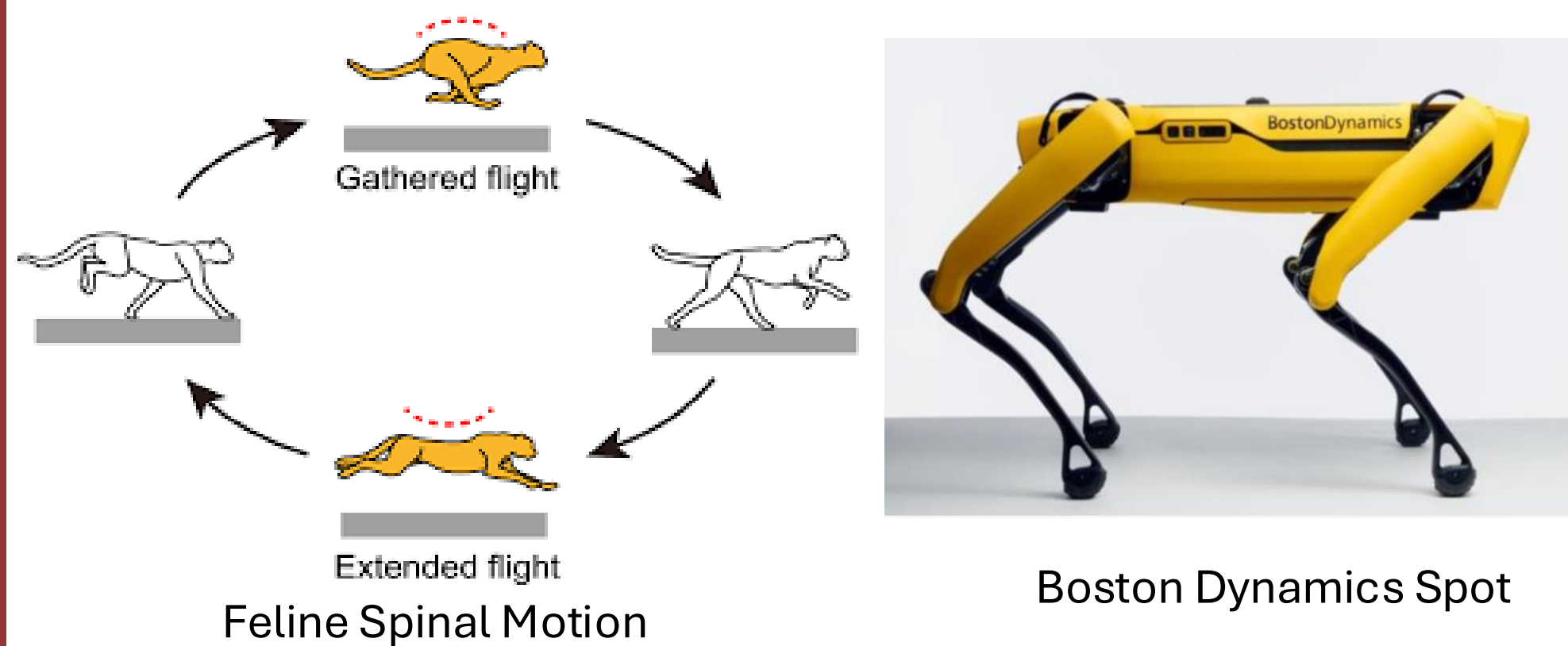
Learning Spine-Assisted Locomotion: A Reinforcement Learning Comparison of Spined and Rigid Quadruped Robots

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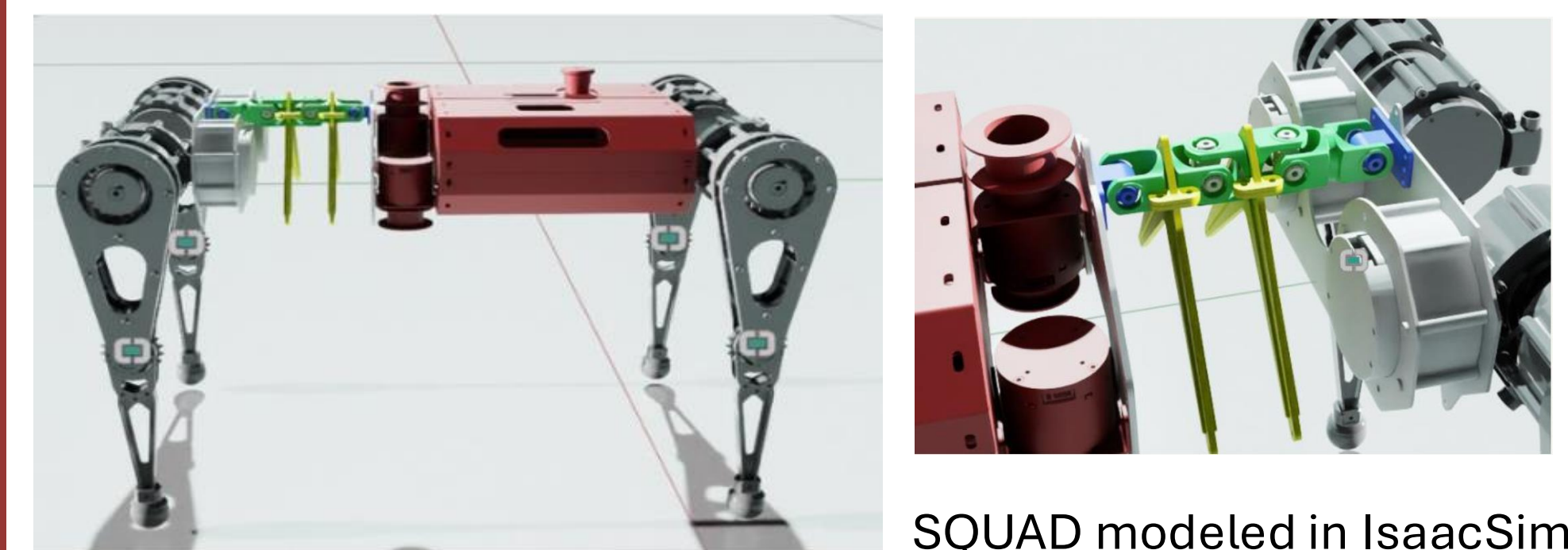


Background and Motivation

- Research Question:** How does a flexible spine affect reinforcement learning performance and locomotion efficiency in a simulated quadruped robot?
- Quadruped robots typically use rigid bodies, but animals rely on flexible spines for efficient motion.
- The goal is to determine whether spine flexibility improves speed, stability, and efficiency.



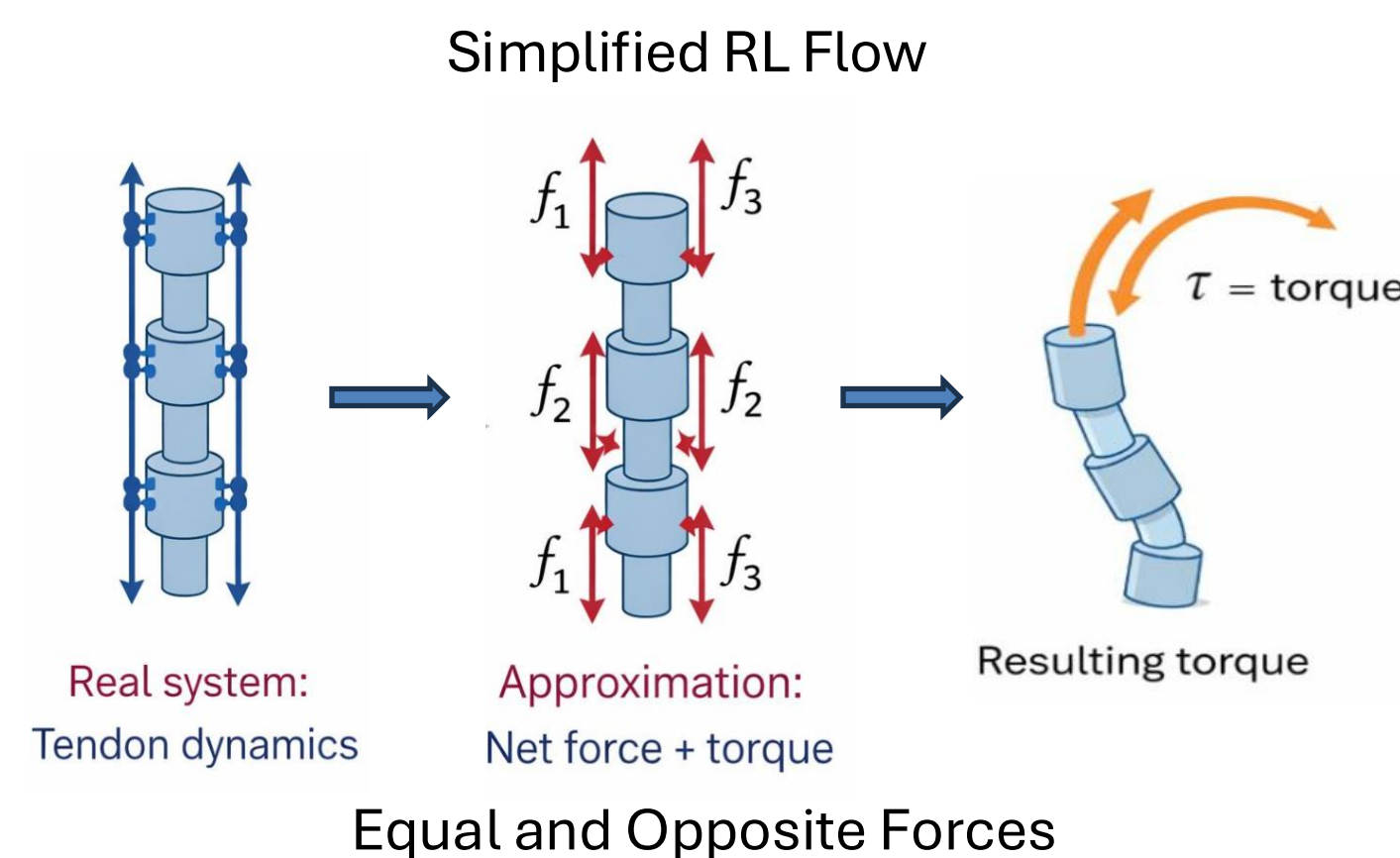
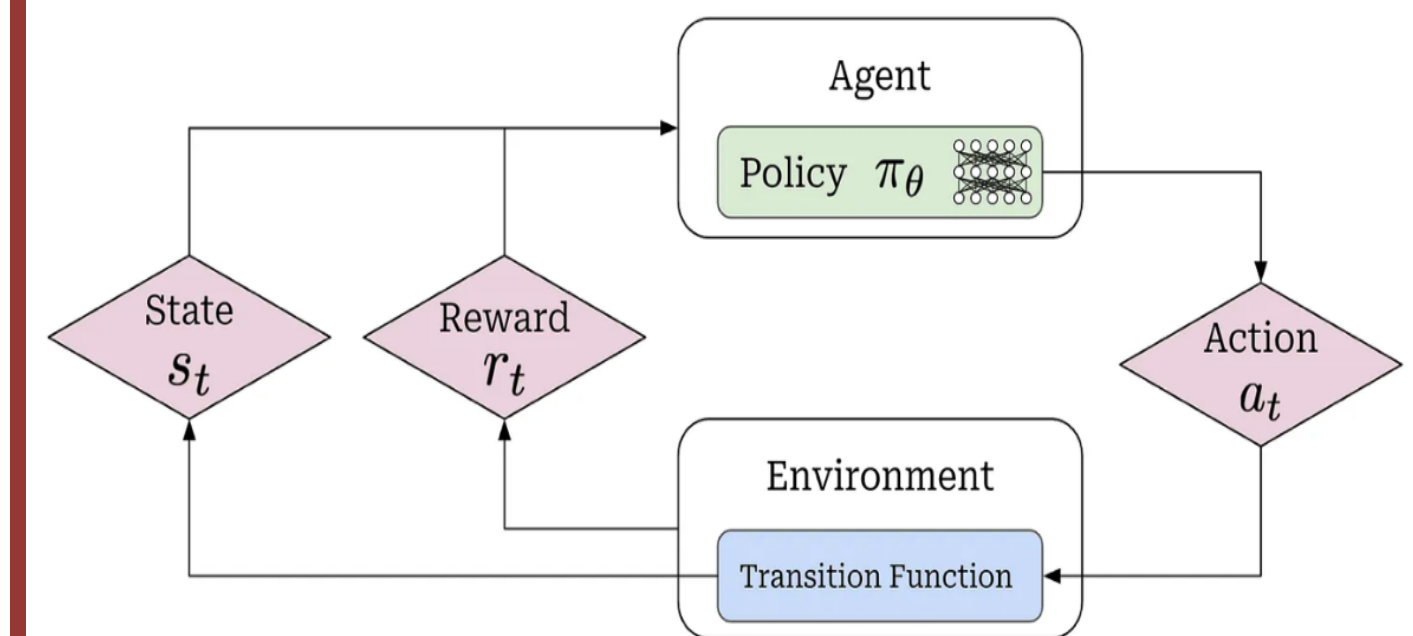
Sun Labs Spined Quadruped (SQUAD)



SQUAD modeled in IsaacSim

Methodology

- RL trains policies through trial and error to learn actions that maximize a reward signal over time.
- PPO (Proximal Policy Optimization) is a stable RL algorithm that updates the policy gradually to handle noisy, contact-rich locomotion. Modeled and trained in IsaacSim/IsaacLab using physics-based simulation, with actions controlling joint positions and spine forces.
- Spine actuation implemented using an equal-and-opposite force approximation to maintain physical consistency, and rewards/observations were carefully designed to encourage stable, efficient locomotion.



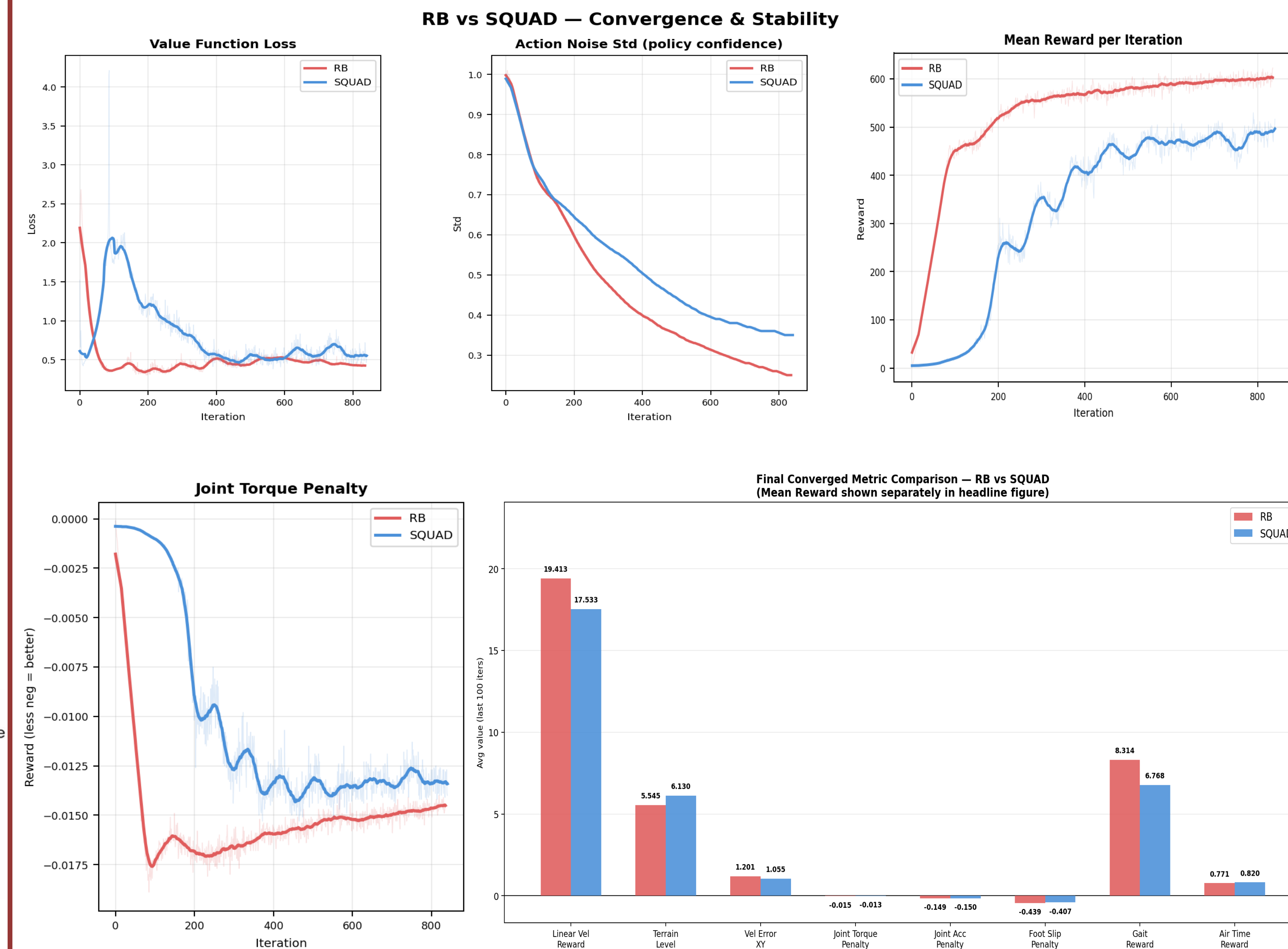
Results & Conclusion

- The rigid-body : better verall reward, episode length, gait consistency, fall rate.
- The spined model : smoother motion, lower torque usage, lower XY velocity tracking error.

A flexible spine improves:

- Motion quality
- Efficiency

However, spine is also adding instability and harder optimization problem



Acknowledgements

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