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A stability locomotion-control strategy for quadruped robots with center-of-mass dynamic planning

Keywords:

Center-of-mass (CoM) planning, Quadruped robot, Cooperative scheme, Ground reaction forces, Stability margin



Backgrounds



Advantage:

Bionic structure

Flexible mobility

Terrain adaptability

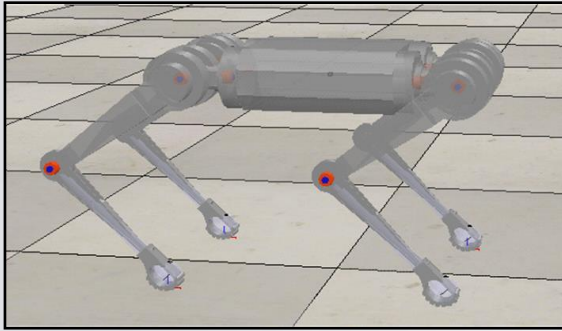
Quadruped robots at home and abroad

Locomotion stability is **essential** and a **prerequisite** for adapting to unstructured terrains.

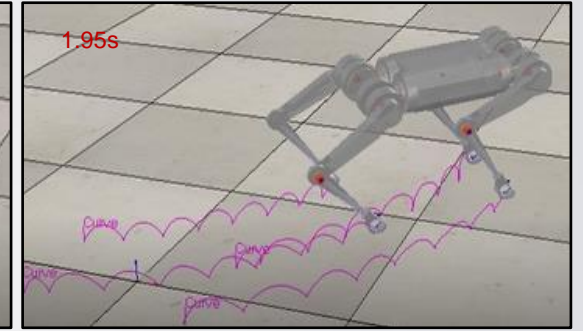
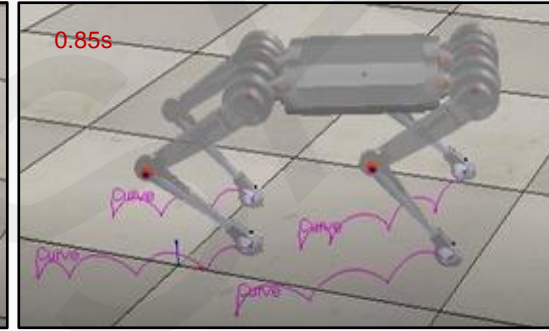
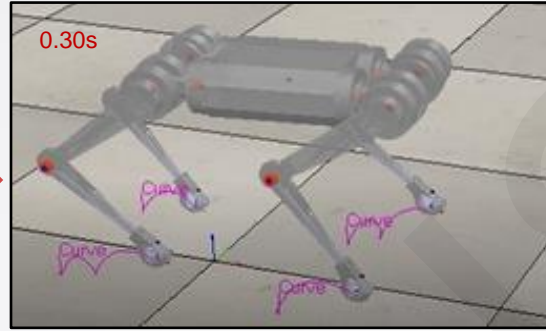


Abstract

Simulation model



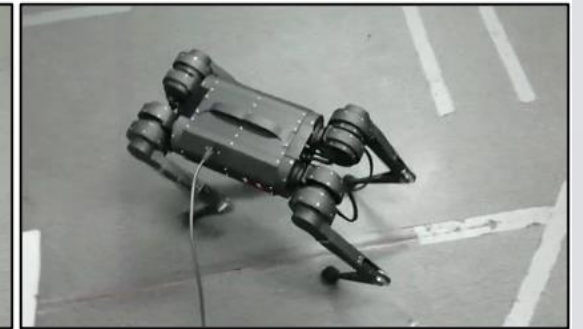
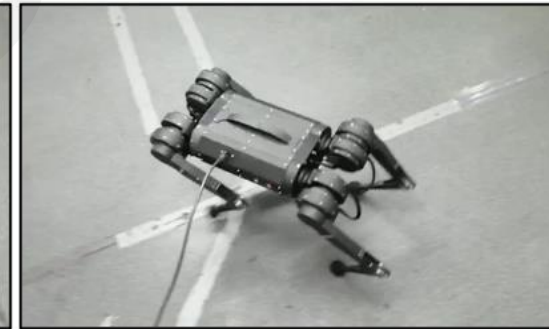
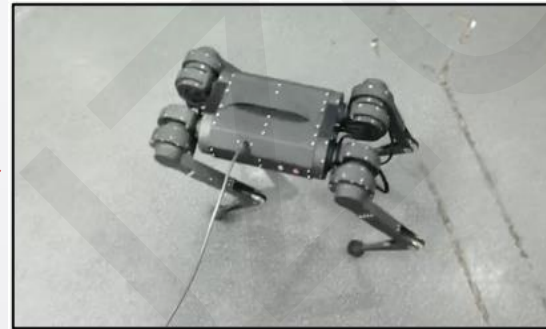
Simulation snapshots of omnidirectional locomotion



Experimental prototype



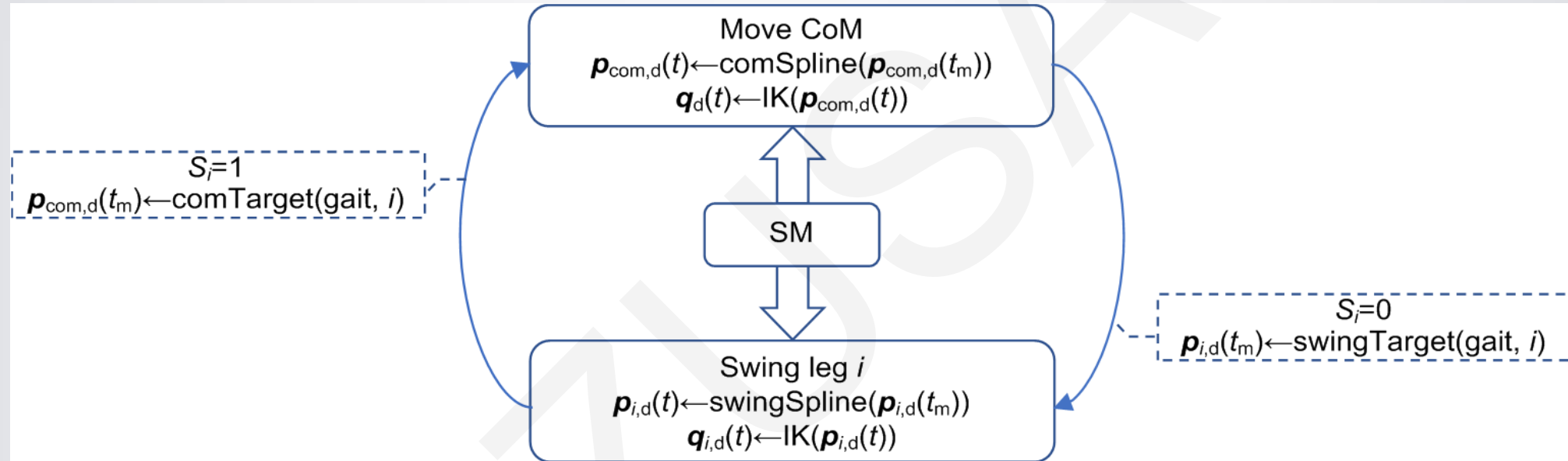
Experimental snapshots of omnidirectional locomotion



In order to **improve the locomotion stability** of quadruped robots for adapting them to unstructured terrain. We propose a control strategy with **center-of-mass (CoM) dynamic planning** for the robot's stable locomotion.

Innovation

Logic diagram of the state machine (SM)



03

Locomotion stability and energy consumption are simultaneously considered with a constant desired velocity.

02

The center-of-mass (CoM) and swing legs of the robot are synchronized to optimize coordination during locomotion.

01

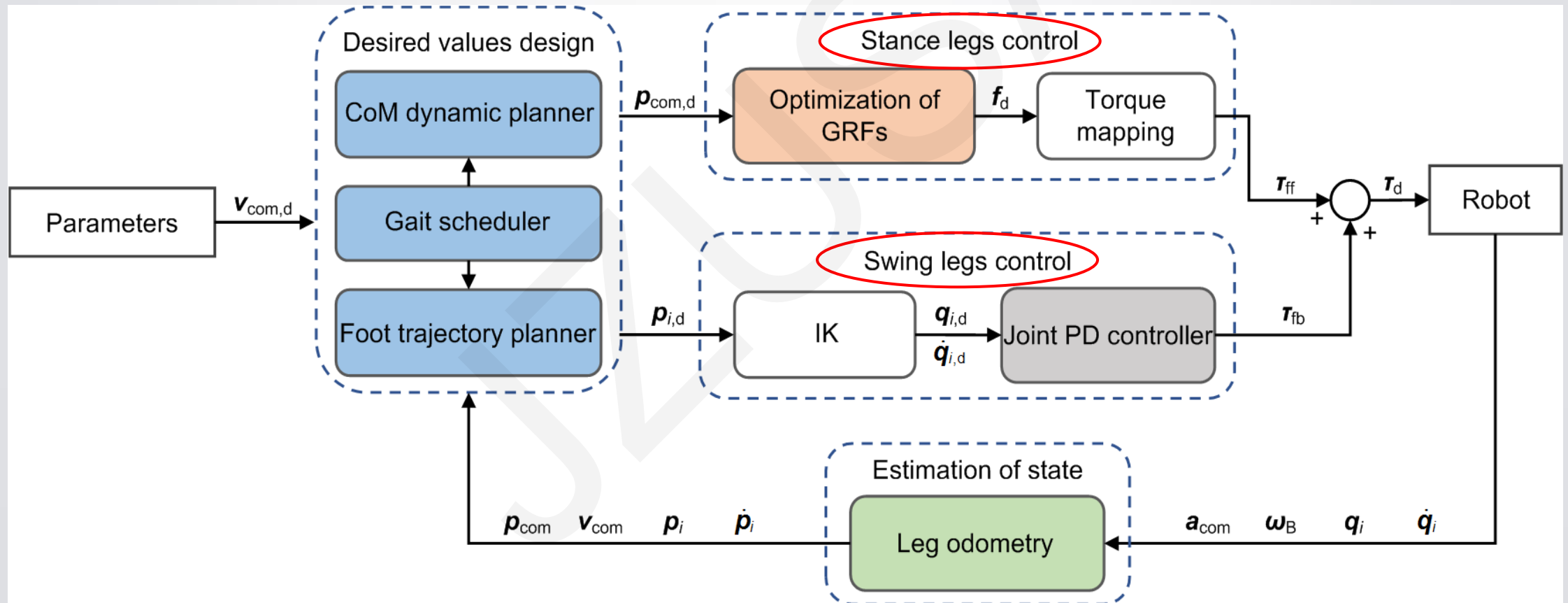
As the forces on the robot legs differ between the stance and swing phases, they are handled under different control strategies.

Innovation



01

As the forces on the robot legs differ between **the stance and swing phases**, they are handled under **different control strategies**.



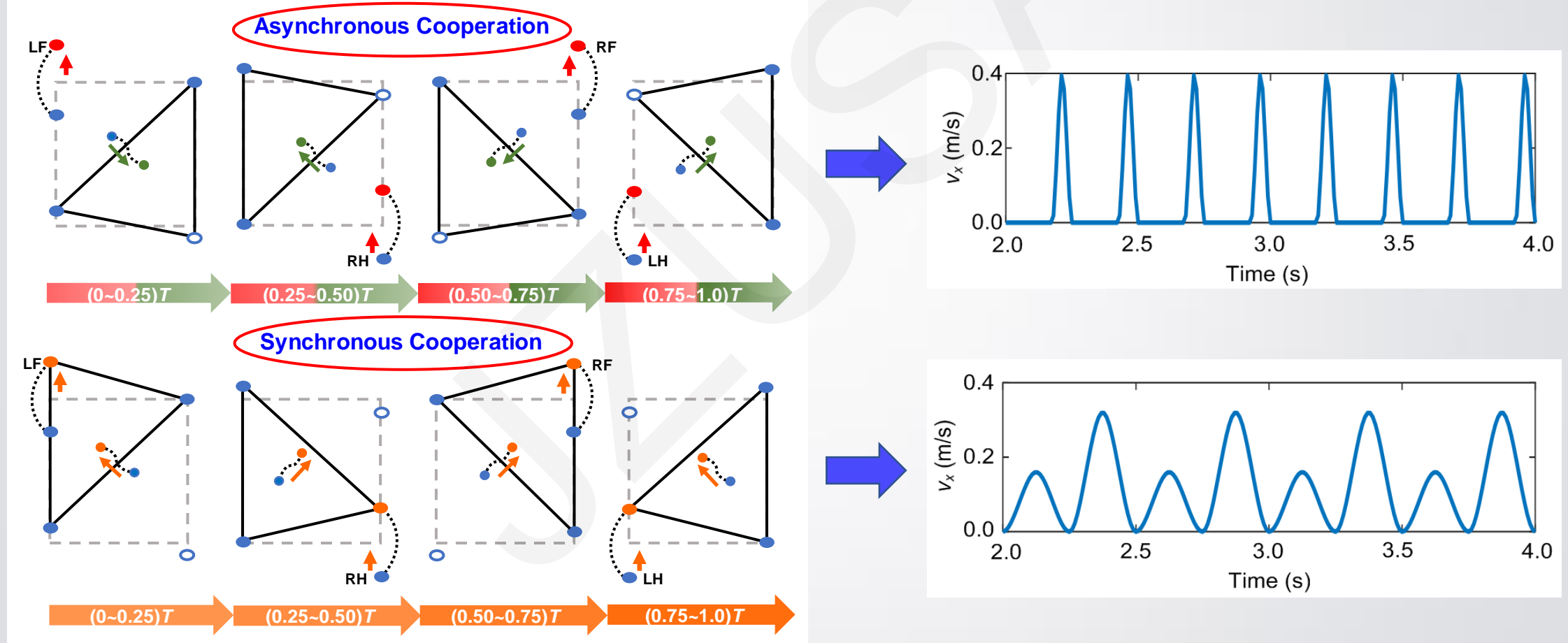
Block diagram of control system

Innovation



02

The center-of-mass (CoM) and swing legs of the robot are **synchronized** to optimize coordination during locomotion.



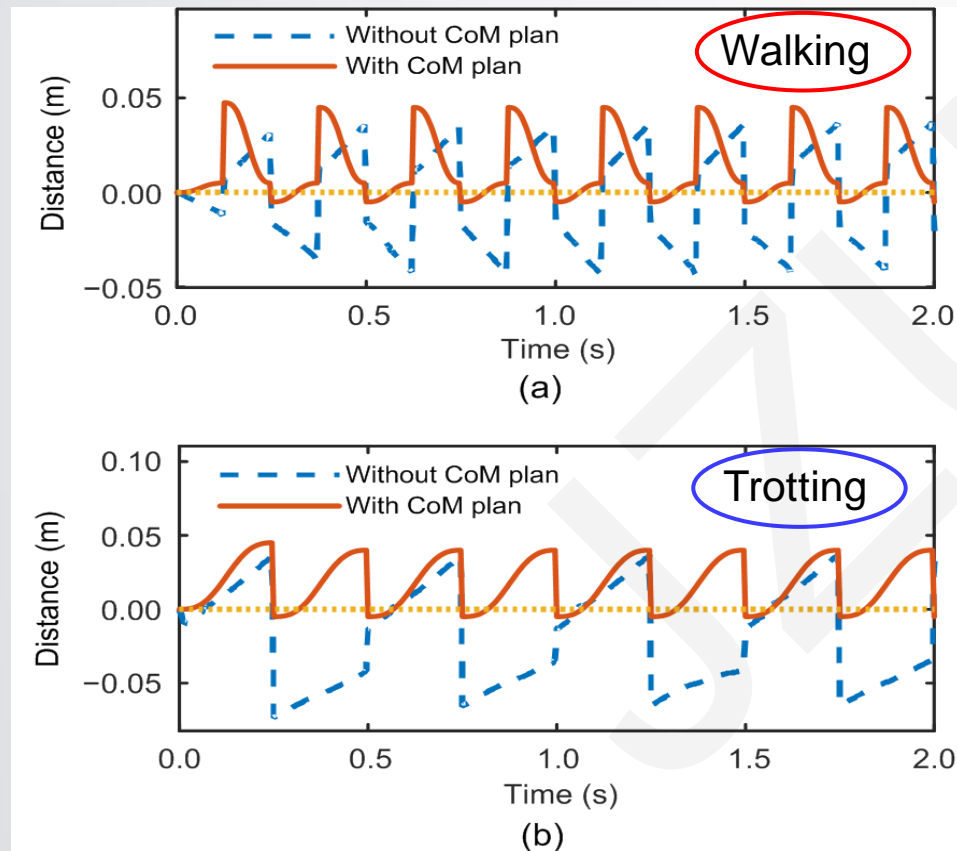
Comparison of two cooperative schemes

Innovation



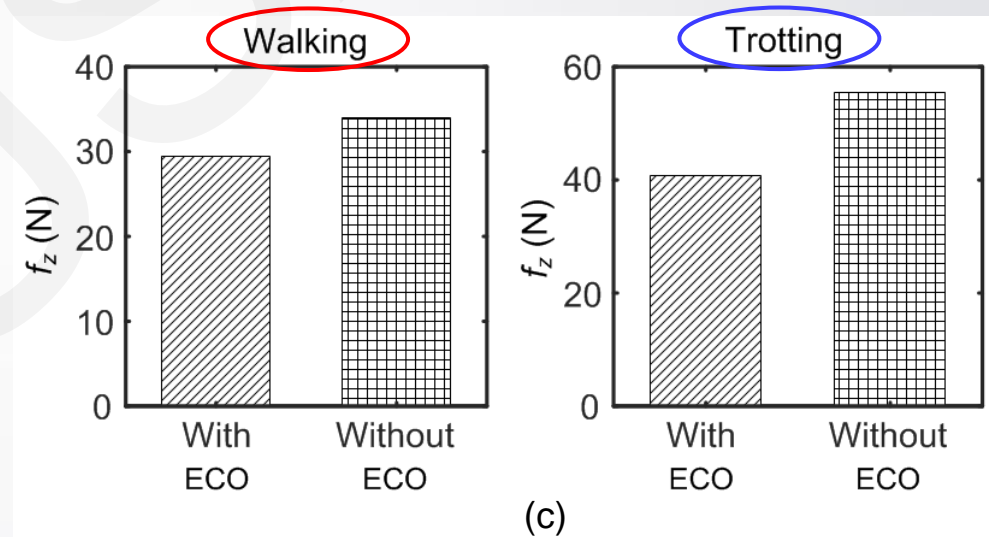
03

Locomotion stability and **energy consumption** are simultaneously considered with a constant desired velocity.



Comparison of stability margins

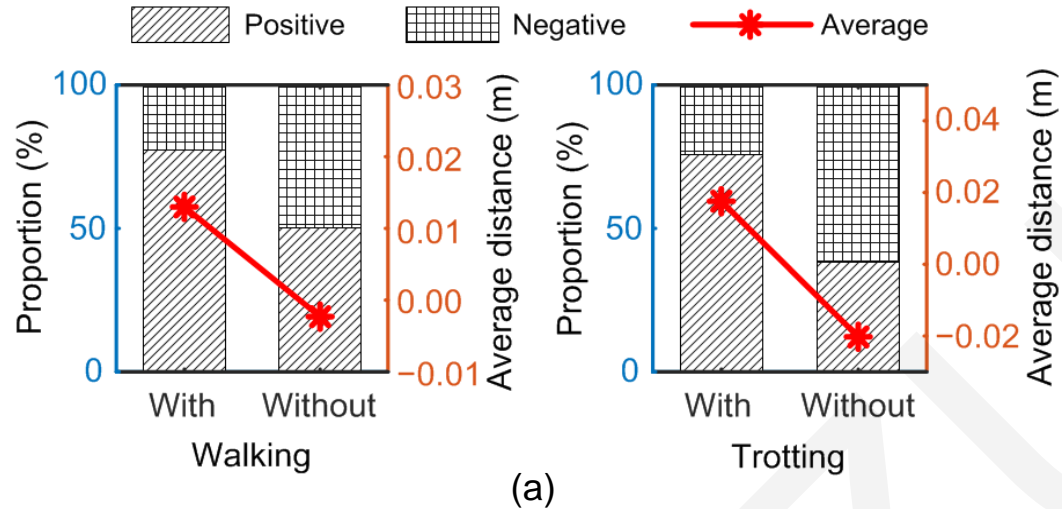
Comparison of mean GRFs



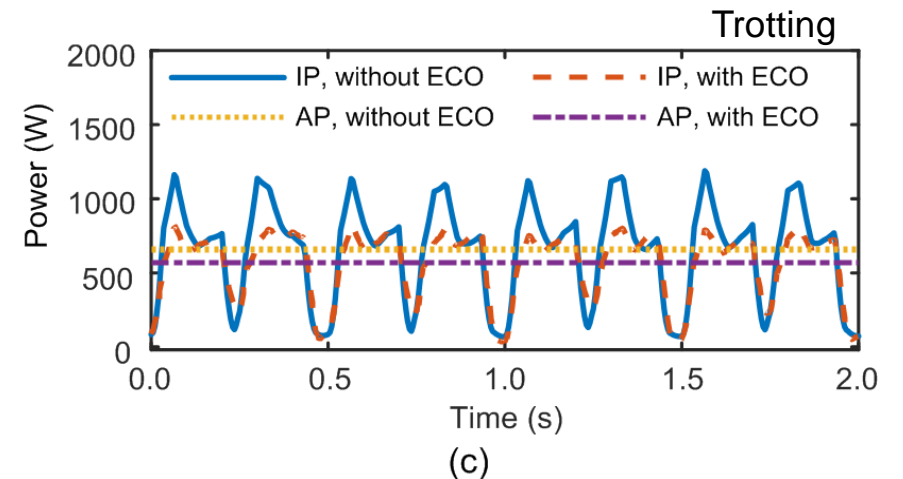
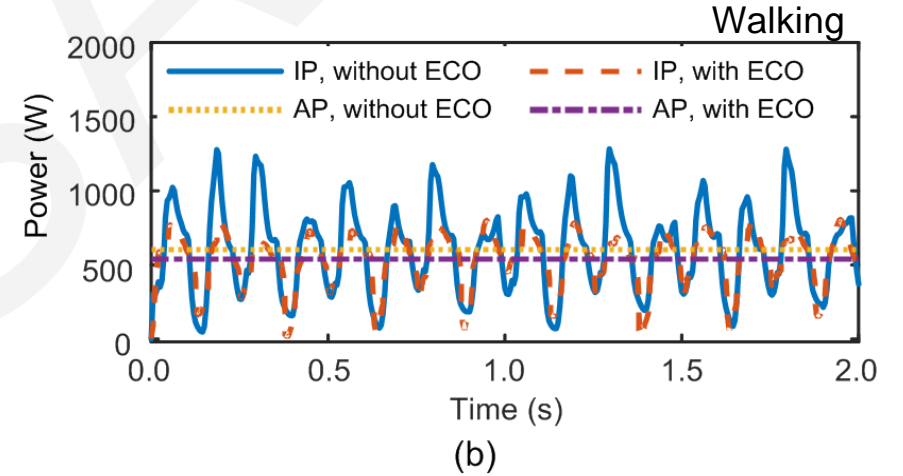
The strategy applies to both **static walk gait** and **dynamic trot gait**.

Conclusions

Proportions and averages of stability margins



Comparison of energy consumption



At a given locomotion speed, the **stability margins** for the robot during walking and trotting were **27.25%** and **37.25% higher**, respectively, than in the scheme without CoM planning. The control strategy with **energy consumption optimization (ECO)** **reduced** the energy consumption of the robot in walk and trot gaits by **11.25%** and **13.83%**, respectively, from those of the control scheme without ECO.

IP: instantaneous power; AP: average power