Visual-Locomotion: Learning to Walk on Complex Terrains with Vision

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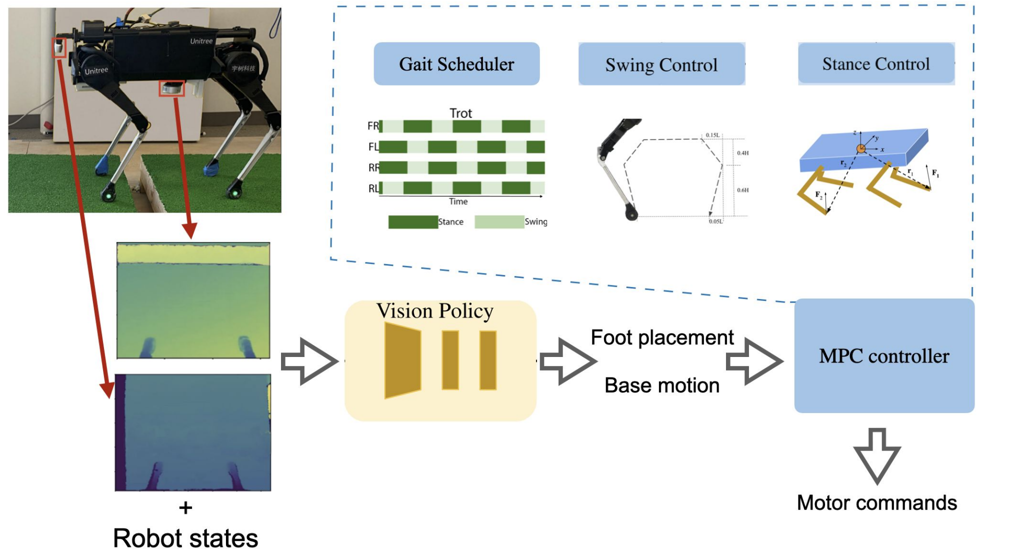
Introduction

- Enabling legged robot to acquire agile, animal-like visual-locomotion skills is a key milestone towards applying them to real-world tasks.
- We propose a learning-based algorithm to train real quadruped robots to traverse challenging uneven environments.

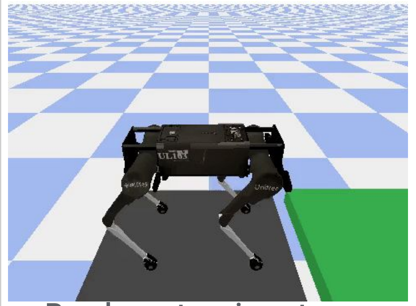
Method

- We use hierarchical structure for our visual-locomotion controller.
- High-level vision policy (RL):
  - input: vision and proprioception data
  - output: target foot placement, desired CoM pose and velocity
- Low-level motion policy (Optimal Control):
  - input: desired foot placement, CoM pose and velocity, robot states
  - output: target joint position for swing legs, joint torques for stance legs

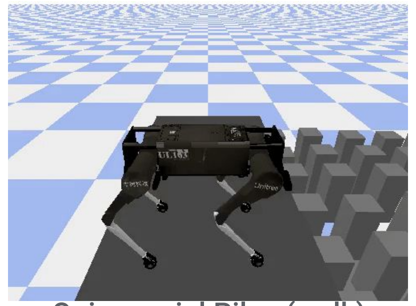


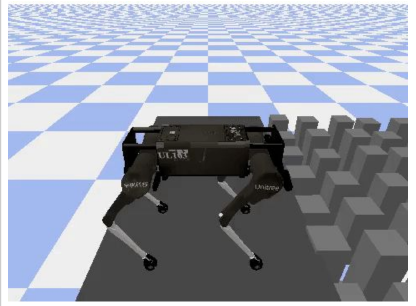
Experiments

- We train our policy to traverse a variety of challenging terrains with different gaits.


Random stepping stones


Stairs


Quincuncial Piles (walk)

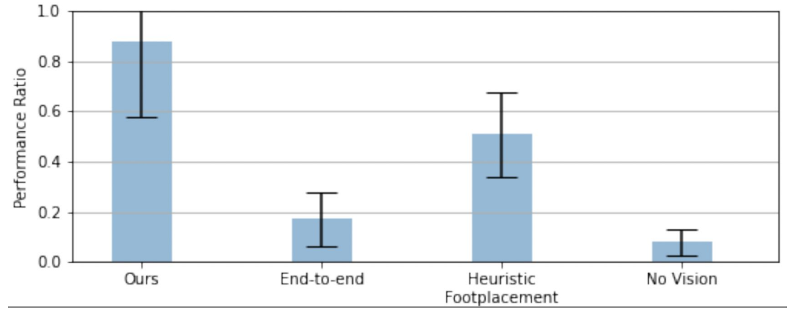

Quincuncial Piles (trot)

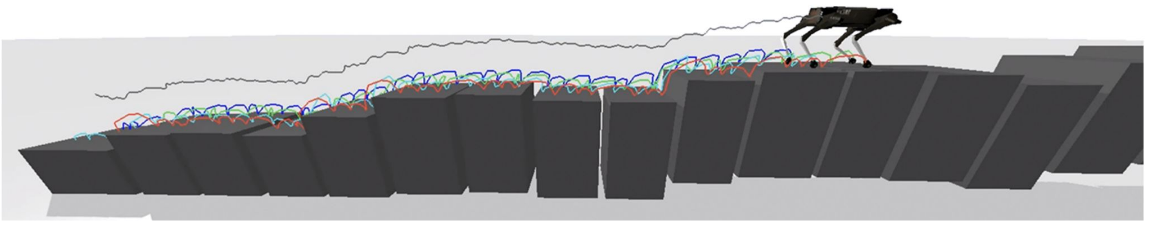

Uneven Terrain


Moving platforms

Baselines

- We compare our method to baseline on the uneven terrain (see below).
- Our method is able to walk 60% farther than alternative methods.

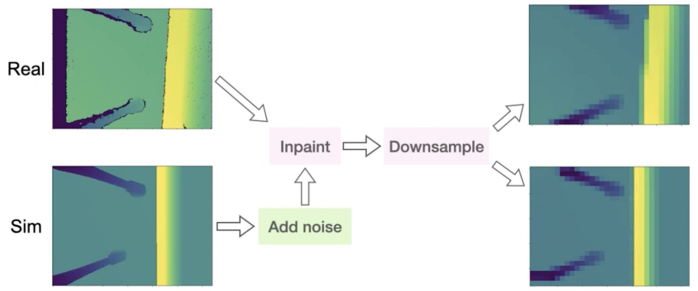




Real-World Results

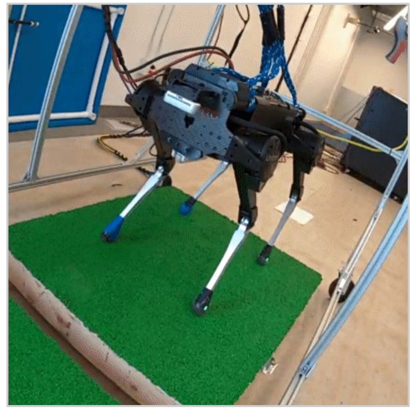
Sim-to-real Transfer

- We develop a post-processing procedure to bridge the gap in simulated and real-world camera images.



- We apply Dynamics Randomization to bridge the gap in dynamics.

Parameter	Minimal value	Maximum value
Mass	90%	110%
Inertial	90%	110%
Ground Friction	0.45	0.55
Motor Position Gain	200	220
Motor Velocity Gain	3.6	4.8



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- https://sites.google.com/corp/google.com/visual-locomotion/home