Tiny Steps Towards Applying Reinforcement Learning to Achieve Walking Gaits on a Constrained Quadruped Robot

Harvard Edge Computing Lab

Tiny Robots Group

- Dr. Sabrina Neuman
- Brian Plancher
- Mark Mazumder
- Colby Banbury
- Shvetank Prakash
- Christopher Zhu
- Jason Jabbour

VLSI-Arch Undergraduate Research Presentations

Overview

Problem Description

Applying Reinforcement Learning to Achieve Walking Gaits

Achieving Natural-Looking Walking Gaits through Imitation Learning

Problem Description

Goal

Compensate for cheap hardware with intelligence to achieve robust locomotion

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Compensate for cheap hardware with intelligence to achieve robust locomotion

Intermediate Goal

Train a sensor, actuator, and power impoverished robot to walk

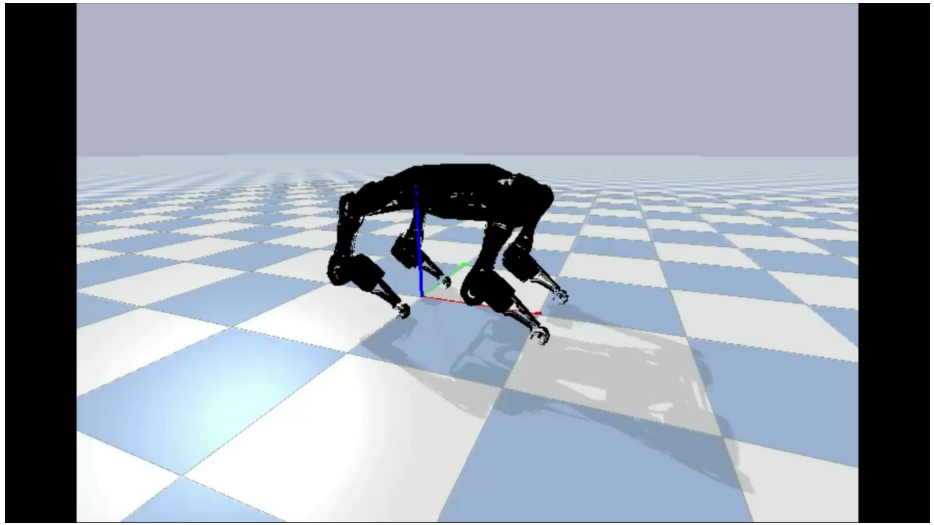
Choosing a Robot Platform

Petoi's Bittle

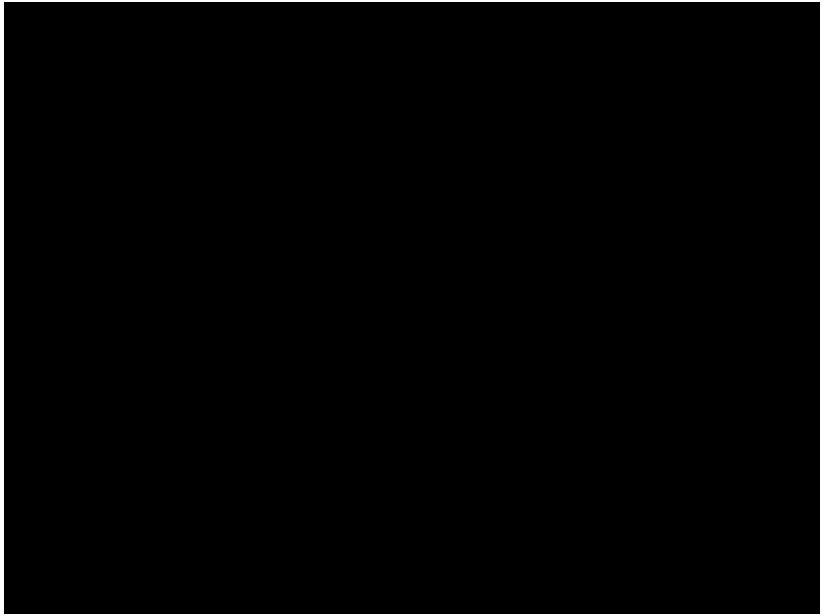
~$300

2 DoF

Problem Description

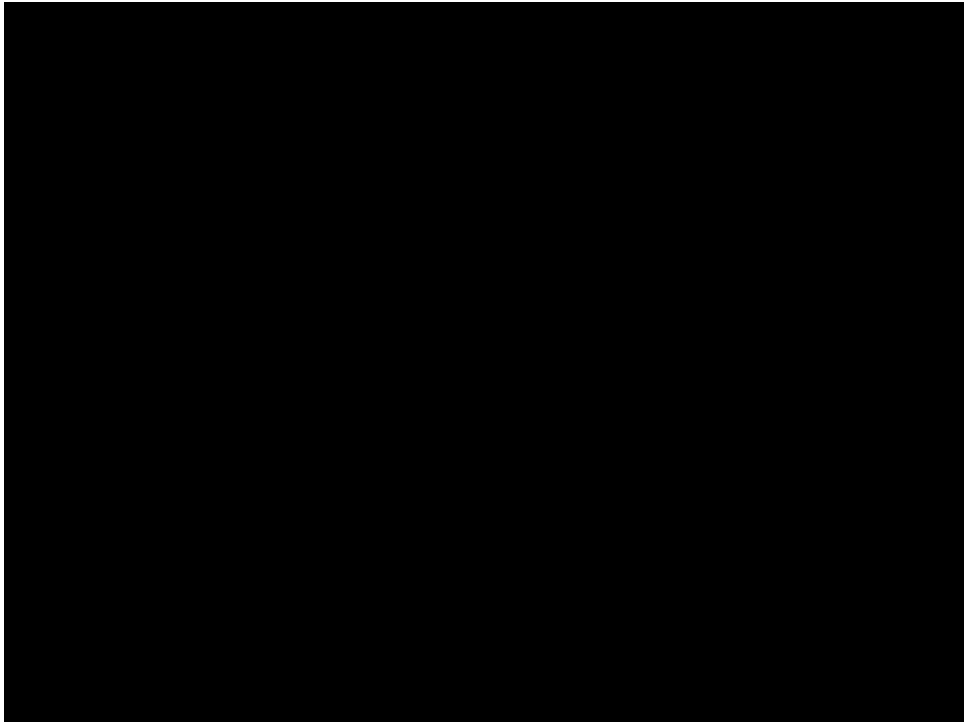


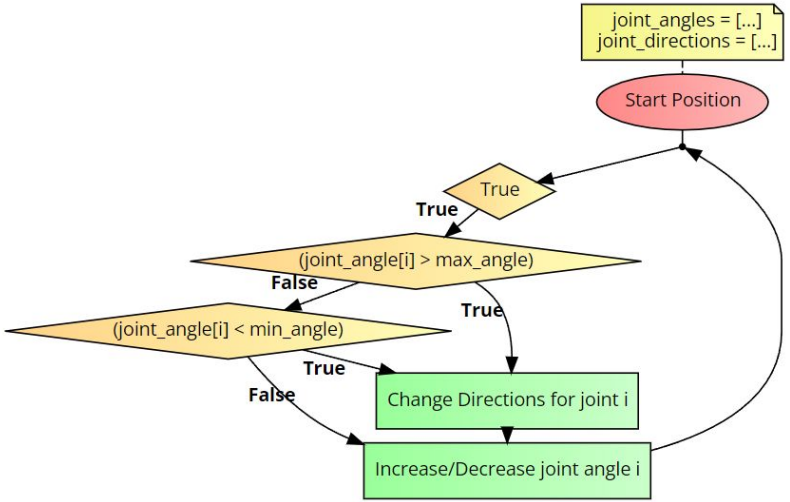
8 DoF



18 DoF

Manual Control





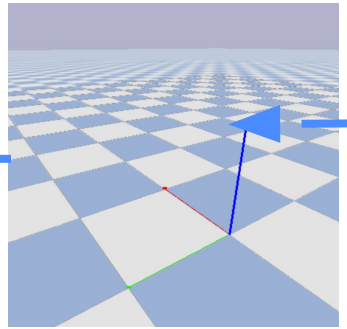
RL Overview

Agent

State
(S_t)

Reward
(R_t)

Action
(A_t)



Environment

Tools:

- Pybullet
- OpenAI Gym
- Stable Baselines
- URDF File

Initial Policies

Action Space = 8 Joint Angles
Observation Space = Position, Orientation, Linear Velocity, Angular Velocity

Tuning

$$\text{Reward Function} = W_1(\text{X Position}) + W_2(\text{X Velocity}) - W_3(|\text{Z Position} - \text{Bittle Height}|) - W_4(|\text{Z Velocity}|) - W_5(|\text{Roll}|) - W_6(|\text{Pitch}|)$$

Tuning

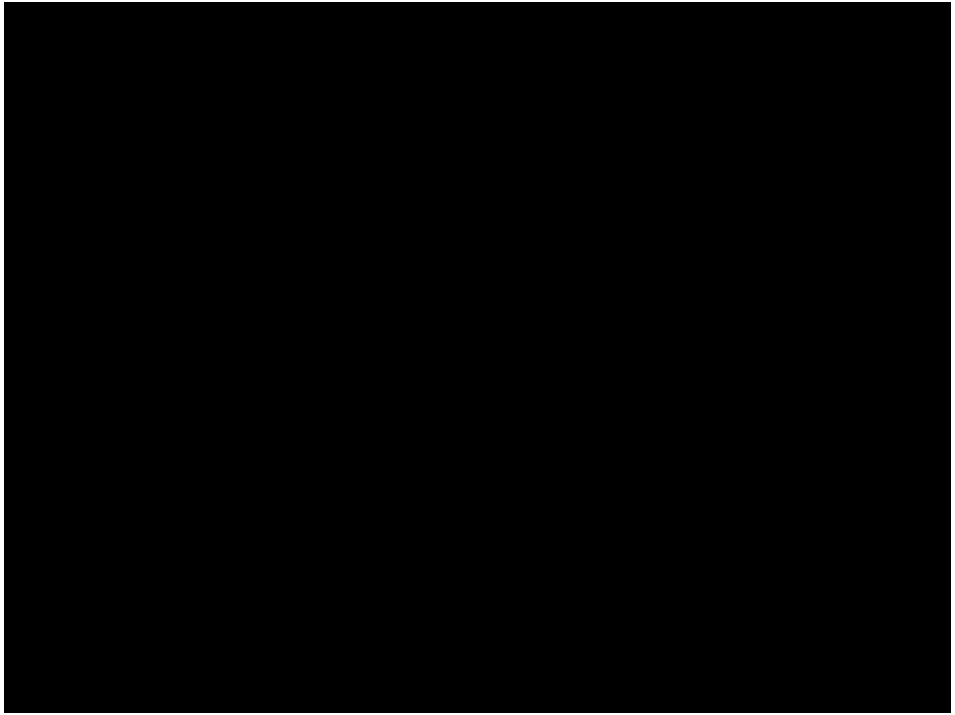
Reward Function = ~~W_1(X Position)~~ + W_2 (X Velocity) - ~~W_3(|Z Position - Bittle Height|) - W_4(|Z Velocity|) - W_5(|Roll|)~~ - W_6(|Pitch|)

Action Space = [-.1, .1] for all 8 Joint Angles

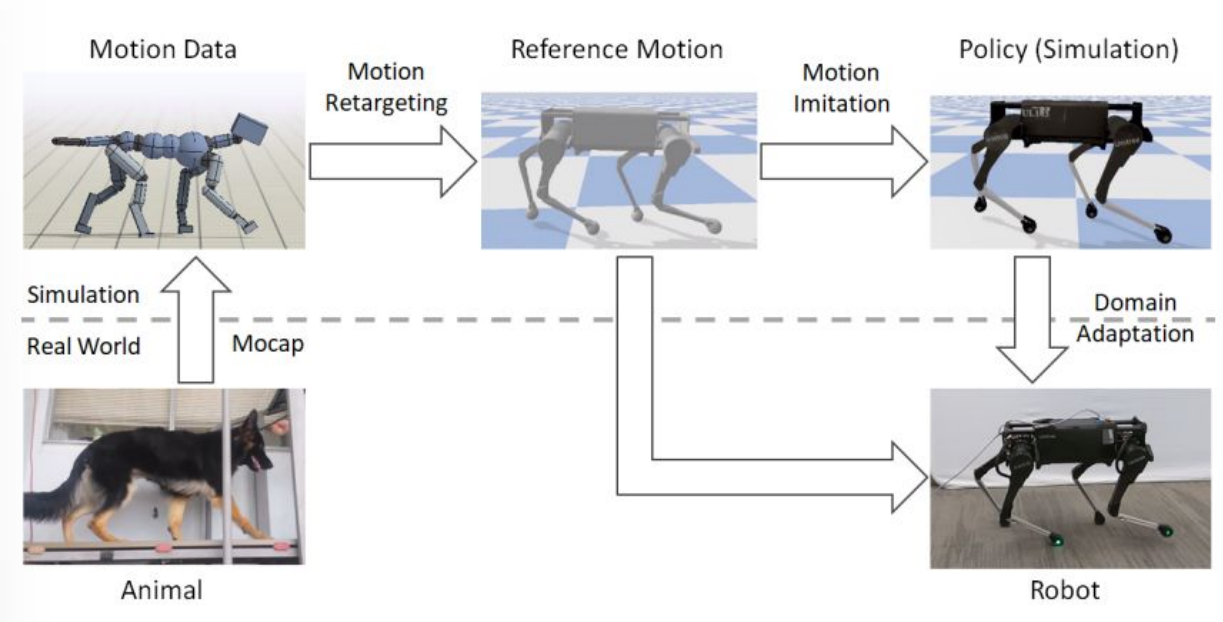
Tuning: Final Policy

```
if (X_Velocity > velocity) and self.is_upright() \
 and (Z_Position > (Torso_Position - Perturbation)):
    reward = .1
    if (X_Velcoity > velocity*2):
        reward = .2
else:
    reward = 0

if self.is_fallen():
    reward = -.1
```



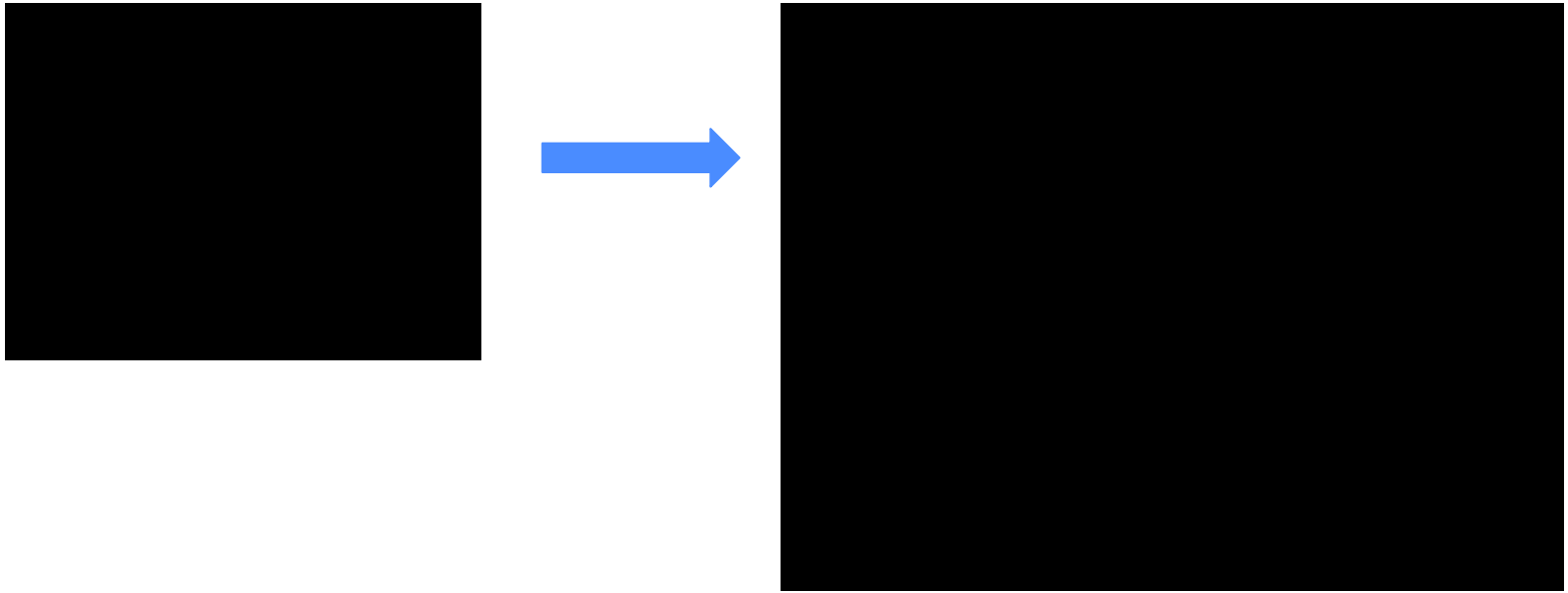
Imitation Learning



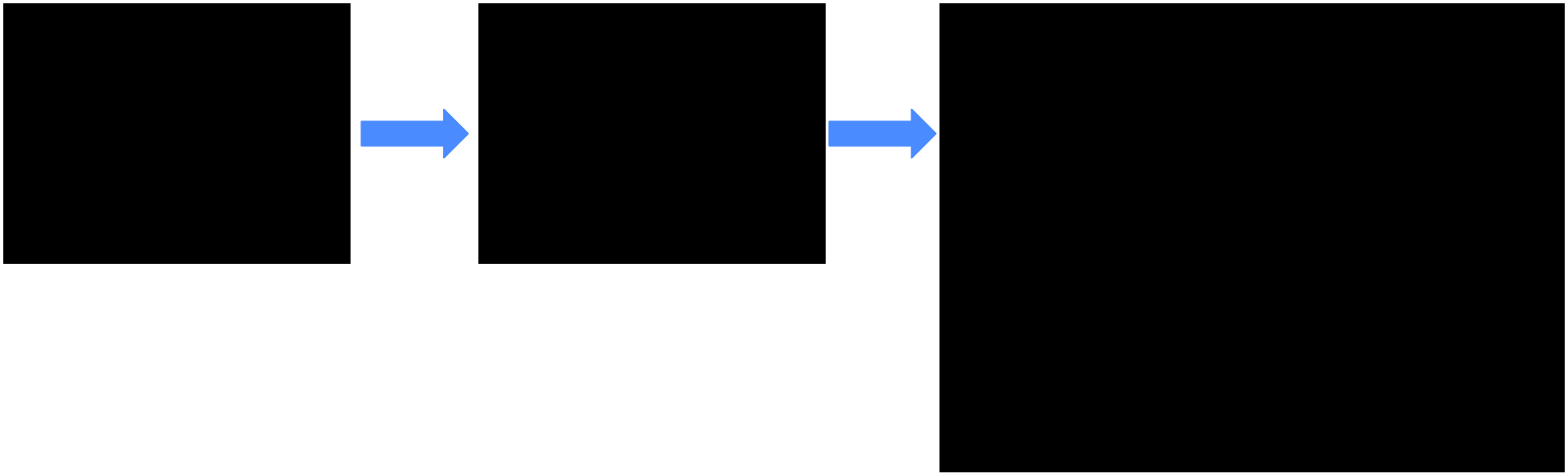
(Peng et al., 2020)

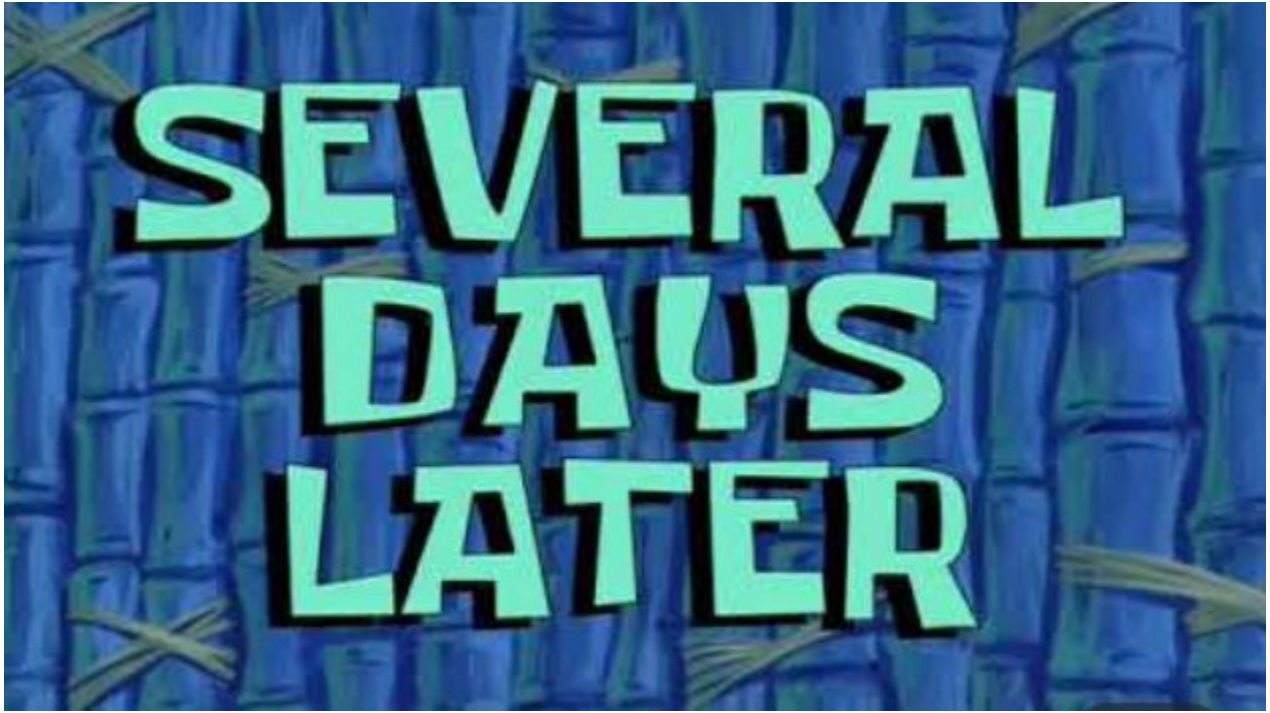
Imitation Learning: **Motion Capture**

Imitation Learning: **Motion Retargeting**



Imitation Learning: Using Reference Motion to Train Policy




SEVERAL
DAYS
LATER

Imitation Learning: **Final Imitation Learning Policy**

Future Work

Domain Adaptation

TinyML Shrink our Policy

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