Multi-Modal Locomotion Robot

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Motivation and Objective

Many animals can switch between quadrupedalism and bipedalism to better complete certain tasks. However, very few robotic platforms can mimic this ability. A multi-modal robotic platform like this would provide additional adaptability in unstructured environments, broadening its potential applications. For this purpose, in our project, we extended an existing quadrupedal platform with the capability to transition into a bipedal stance.

Robot Modifications

Due to time constraints, we chose to build the **Solo8**, an 8DOF open-source quadruped. To achieve bipedal capabilities, we **modified** the Solo8 in three ways:

Point Foot

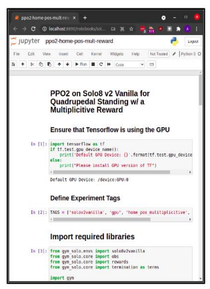
Flat Foot

1. Servo-actuated **flat foot** that converts to a **point foot** for quadrupedal walking
2. Replaced custom boards with **off-the-shelf electronics** for better community support
3. Created a new software stack and simulation environment **pipeline**

Software Stack

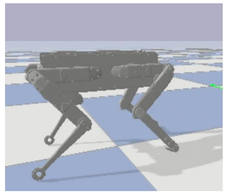
We created a **custom software stack** that supports the modified robot and provides a seamless **simulation-to-robot pipeline** for developing and testing robotic control algorithms.

- **ROS** for higher level operations
- **Teensy** and **ODrive** for lower-level control
- Modular **simulation wrappe**r that can easily be extended
- Complies with **Open AI Gym API** for Reinforcement Learning

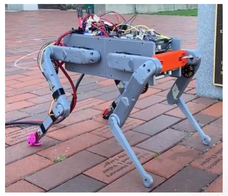


Code

Simulation



Robot



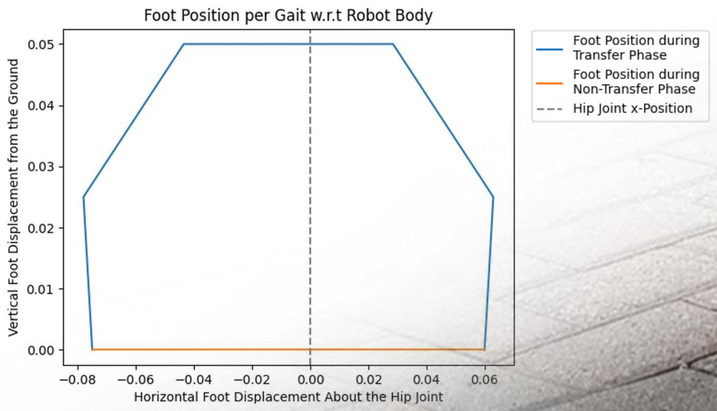
Reinforcement Learning

Our reinforcement learning pipeline was **developed in conjunction** with our software stack to train the robot to accomplish different tasks in simulation.

- The automatic training pipeline **runs, visualizes, debugs and optimizes** our models
- Implemented a **reward function** that penalizes joint jitter, horizontal tilt, and translational movement and reinforces a fixed vertical height
- The robot learned to **stand quadrupedally**

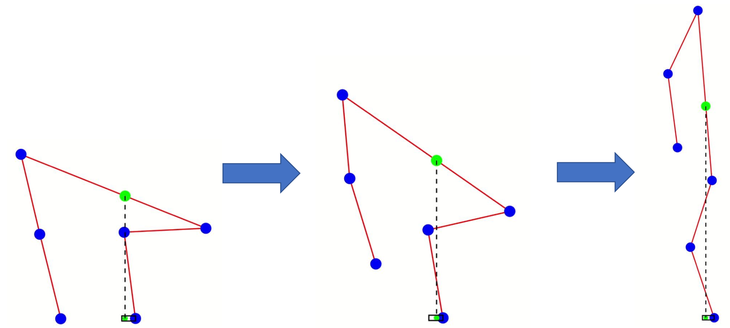
Quadrupedal Gait

A quadrupedal **symmetric wave gait** was analytically developed and tested in both simulation and the real robot. We achieved a stable walking behavior in both environments.



Stance Transition

We generated a **statically stable standing trajectory** by keeping the robot's center of mass (green circle) within its support polygon (foot). Using this trajectory, stable bipedal standing was achieved in simulation.



Future Outlook

We believe that we have created a **novel multi-modal platform** and we are excited about the possibilities that our platform affords to future roboticists. Potential future work includes:

- Implementing stance transition on real robot
- Developing a bipedal walking gait
- Increasing robot's degrees of freedom
- Adding dynamic control