



# Simulation, fabrication and programming of a low-cost quadruped robot

Papadopoulou Nikoleta Panagiota 2023-2024

Supervisor: Koustoumpardis Panagiotis

Department of Mechanical Engineering & Aeronautics - Division of Design & Manufacturing

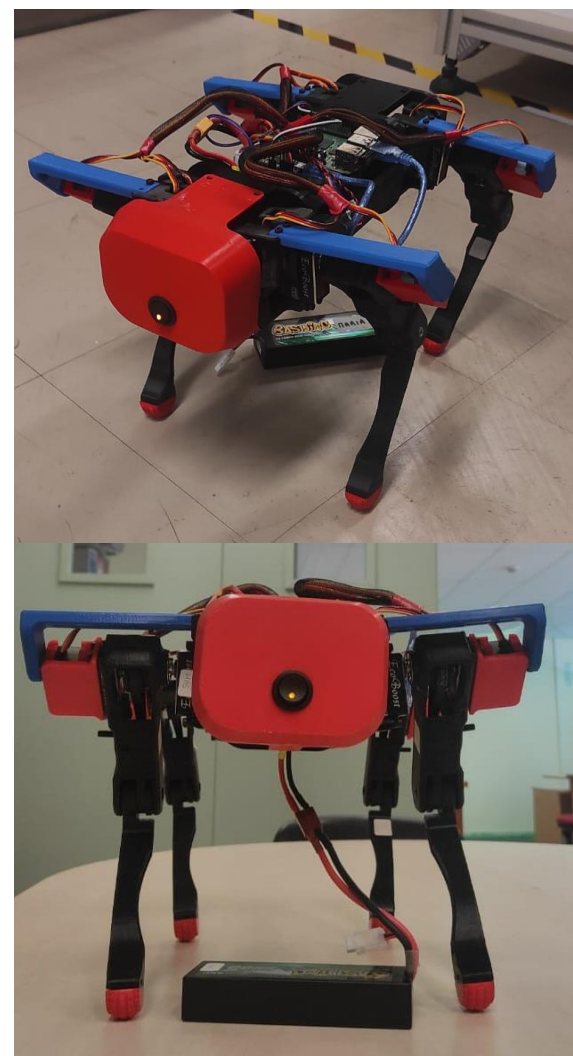
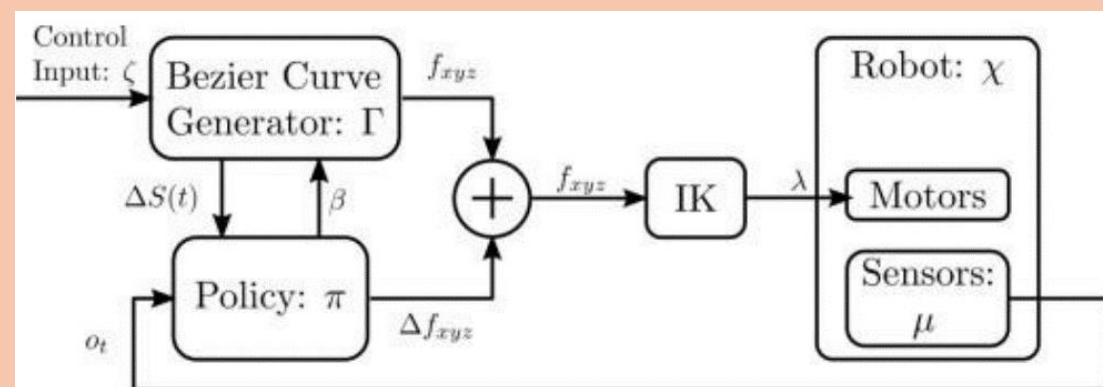


## Abstract

Inspired by the work of Maurice Rahme on Github, this thesis presents a low-cost Open-Source quadruped robot development, the *OpenQuadruped/SpotMiniMini*. SpotMiniMini features a fully 3D printed frame, 12 brushless servo motors that drive four 3-DOF legs. The robot's onboard computer is a Raspeberry Pi 4B that runs as its operating system an Ubuntu 20.04 LTS headless server. The quadruped's software is built inside a ROS Noetic environment. This framework establishes a communication infrastructure that integrates the RPi with a Teensy 4.0 microcontroller for the low-level control of the robot's servos. Moreover, the robot has an IMU sensor that provides data for orientation sensing and can receive joystick commands from a wireless gamepad connected via Bluetooth to the RPi. A lithium battery powers a PCB that distributes it to all the hardware components of the robot. Finally, the Quadruped uses a D2-Randomized Gait Modulation method with Bezier Curves for foot trajectories generation.

## Robot Control

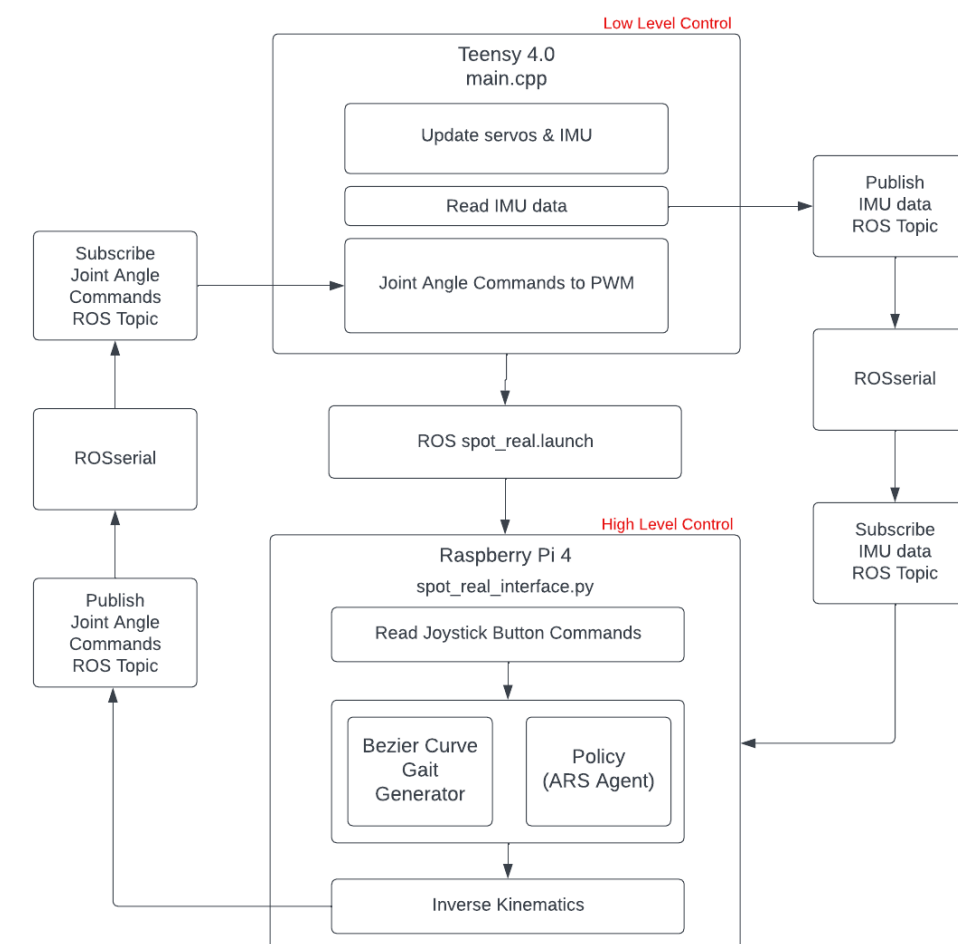
Spot Mini Mini uses a hybrid approach to legged locomotion that combines reinforcement learning (RL) and open-loop gaits. The method used, is named Dynamics and Domain Randomized Gait Modulation with Bezier Curves and is using 12-point Bezier curves in order to be able traverse unobserved and unmodeled rough terrain. The quadruped's gait modulation uses a learned policy in conjunction with an open-loop dynamics model for control. The model provides a baseline behavior while the policy uses sensor feedback to adapt the model and to improve control. The policy is trained in simulation. To enhance the sim-to-real efficacy of the gait modulation policies, both Dynamics Randomization and Domain Randomization are employed via Augmented Random Search.



## Results

SpotMiniMini's original build was based on an older operating system version, Ubuntu 18.04 and ROS Melodic. The first, has reached its EOL status meaning that it no longer receives updates. The updated and revisited code of the robot, as well as the bug fixes on the source code can be found on GitHub forked under the original repository and constitute the further contribution of this thesis in the SpotMiniMini project.

## Software Configuration Block Diagram



## Hardware Configuration Block Diagram

