Development of Four-Legged Walking Robot Integrating Simulation and Reinforcement Learning

An Interdisciplinary Effort: Combining Software, Electrical, and Mechanical Engineering, Robotics and AI

Graduate

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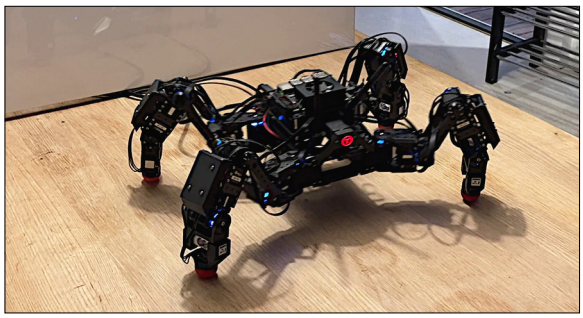
Introduction: Inspired by the academic and industrial in advancements legged robotics, this project's aim was to develop a walking robot for the Interdisciplinary Center for Artificial Intelligence (ICAI) at OST. This endeavor, a joint effort led by Michael Schneeberger and Joel Meier, merged the expertise of software, electrical, and mechanical engineering and data science. The overarching ambition was not just to construct a functional robot but to establish a versatile platform for future student projects. As the project progressed, a detailed simulation of the robot was crafted using Onshape and Nvidia's IsaacGym, focusing on reinforcement learning to teach the robot locomotion.

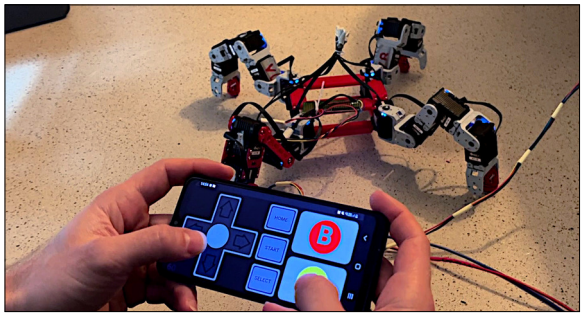
Approach / Technology: The robot's creation involved a series of prototypes, facilitated by the use of a 3D printer. It is equipped with a Jetson Xavier NX processor, an inertial measurement unit (IMU) featuring an accelerometer and gyroscope, and specialized sensors in each foot for measuring distance and weight. The design incorporates smart servo motors for precise movement control and feedback. For the software part, a software package was developed in C++, incorporating a web server with WebSocket support and a user-friendly interface. This interface, built with React, allows users to interact with the robot, monitor its status, and control it through a virtual gamepad, all via WiFi. Further achievements of the project include the development of custom inverse kinematics and walking algorithms, enabling the robot to maneuver on flat surfaces and perform intricate movements like dancing.

Result: The reinforcement learning aspect of the project showed promising results, especially in software. A pipeline was developed for transferring models from simulation to the actual robot, and a basic model was tested successfully. This progress opens doors for future projects to potentially complete the sim2real gap, allowing the robot to navigate based on advanced reinforcement learning methods. Future goals include enhancing the software and integrating sensors more deeply into the robot's movements, enabling it to adapt to challenging environments like uneven terrain.

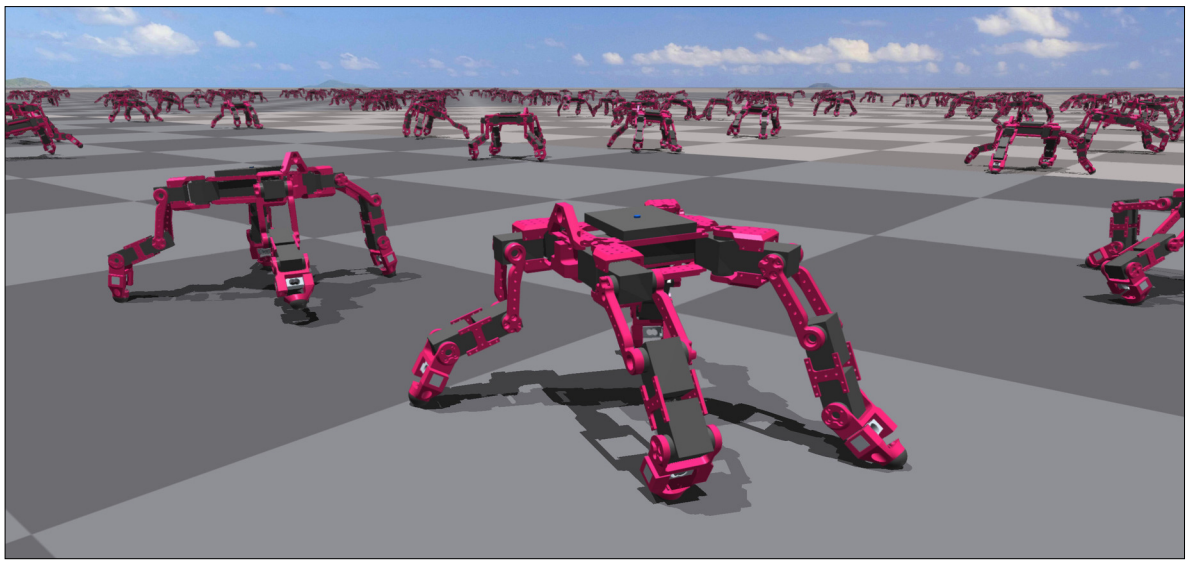
The four-legged robot constructed for this project, standing on a wooden table.
Own presentment



An early prototype of the robot, remotely controlled using a virtual gamepad on a smartphone.
Own presentment



The physically accurate virtual replica of the robot, used in Nvidia IsaacGym for reinforcement learning.
Own presentment



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Subject Area
Mechanical Engineering, Electrical Engineering, Software and Systems, Computer Science

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