Fault-tolerant Dynamic Gait for Quadruped Robot with Reinforcement Learning

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Context

Legged robots have advantages over regular wheeled robot when travelling through difficult terrains. However, the kinematics for legged robot are much more complicated thus the gait of the robot needs to be carefully designed. Due to mechanical failures or manufacturing deficiencies, the physics model for the robot in the real world can be different from the physics model used in simulation, therefore simulated gait might not perform well on real world robots. Many of the current designs use engineering approaches to tackle the problem, for example, design a special gait pattern to handle the mechanical failures[1]. We propose to use reinforcement learning method to let the robot to adapt its simulated gait to different physical configurations in the real world. Using [2] as the starting point, we aim to show the possibility of using reinforcement learning to overcome the mechanical failure of the robot. We first define a standard gait for then robot and simulate the robot in a testing environment. We change the physics model of the robot during action (for example, change the length of its legs or its mass center) to simulate the mechanical failure of the robot. We then use a reinforcement learning algorithm for the robot to calibrate the standard gait for the new physics model, using readings from the Inertial Measurement Unit and the Ultrasonic distance sensor as the return from the environment. After calibration, the robot will use the new gait to compensate for the changes in its real world physics model. Our research aims to show the following advantages over the traditional engineering-based approach: 1) This method can adapt to different mechanical failures, 2) This method can handle the mechanical failures during operation.

Objectives

The project consists of two phases: simulation and real world test. During the simulation, we would verify if the designed approach works for a quadruped robot. We would first implement and test the standard gait in the simulation environment, and then modify the physics model of the robot in the simulation environment. We then use a reinforcement learning algorithm to calibrate the standard gait so that the modified robot can perform the same actions. After verifying the approach, we will apply the method to a robot in real world and see if the method works for real world models.

The general workflow for the project is as follows:

1. Configure the simulation environment. Set up the physics model of the robot and the simulation environment.
2. Design and implement the reinforcement learning architecture for the project.
3. Iterate the procedure of modifying the reinforcement learning architecture, running tests in the simulation environment and comparing its performance with other methods until the result is desirable.
4. Deploy the method to an actual robot and test its performance on real robot.

Supervision

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References

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[2] M. Rahme, I. Abraham, M. Elwin, and T. Murphey, "Spotminimini: Pybullet gym environment for gait modulation with bezier curves," 2020. [Online]. Available: https://github.com/moribots/spot_mini_mini