A1 Quadruped Mini-Project Approach

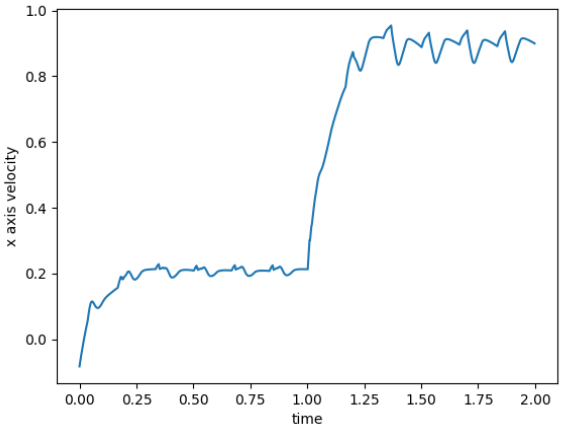
Team Name: Robusta Top Score: ___75_____

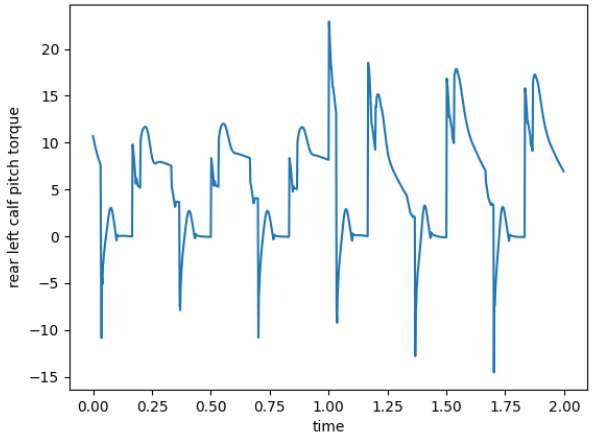
Details on your winning submission (controllers / techniques used):

- We first defined the gait pattern for walking, then we used a gait scheduler to generate the reference trajectory (include COM positon, velocity, angular velocity, euler angle). Then we used two controllers for the stance legs and the swing legs. For stance leg, a MPC controller was used to find the contact force needed to follow the desired trajectory, the built-in transformation of contact force and torque was used to convert contact force command to motor torque command, For the swing leg controller, a raibert controller was implemented to generate torque needed for following the desired trajectory.

Any cool Graphics / Equations:

- We try to input an algorithm that the x-axis velocity reference will switch to a faster one when the robot observes walking too slowly, and the controller handles the changing of the velocity from 0.5 to 2.0 pretty well!





Other Techniques you tried:

- Use Casadi to set up MPC with input of desired trajectory gait action and desired output of contact force of each foot. But the MPC we designed did not output the expected functional contact force for quadruped to stand up.
- Tried to use a QPOASES solver built in Casadi, but it was not functional, so we switched to Open-Source QPOASES in C++.

What you learned from this project:

- Implementation convex MPC in quadruped robots
- How to use gait phase and combined gait planner into legged robot trotting control
- Bezier Curve for reference trajectory combined with gait planner as reference input in MPC

References you found very useful for this project:

- J. Di Carlo, P. M. Wensing, B. Katz, G. Bledt, and S. Kim, “Dynamic locomotion in the mit cheetah 3 through convex model-predictive control,” in 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). IEEE, 2018, pp. 1–9.
- D. Kim, J. Di Carlo, B. Katz, G. Bledt, and S. Kim, “Highly dynamic quadruped locomotion via whole-body impulse control and model predictive control,” arXiv preprint arXiv:1909.06586, 2019.
- Bledt, G., Wensing, P. M., Ingersoll, S., & Kim, S. (Year). Contact Model Fusion for Event-Based Locomotion in Unstructured Terrains. IEEE Transactions on Robotics, 37(3), 736-749.

- H. Park, S. Kim, M. DiCicco and S. Kim, "High speed trot-running: Implementation of a hierarchical controller using proprioceptive impedance control on the MIT Cheetah," IEEE Robotics and Automation Letters, vol. 3, no. 3, pp. 2346-2353, 2018, doi: 10.1109/LRA.2018.2802445.
- P. M. Wensing, G. Bledt, S. Ingersoll and S. Kim, "Contact Model Fusion for Event-Based Locomotion in Unstructured Terrains," in IEEE Robotics and Automation Letters, vol. 2, no. 2, pp. 916-923, April 2017, doi: 10.1109/LRA.2016.2638036.
- https://github.com/yxyang/fast_and_efficient
- https://github.com/erwincoumans/motion_imitation/tree/master/mpc_controller

Feedback on improving the project next time:

- List some helpful functions in the project description like the first project.
- Attempting different locomotion modality controller design for quadruped robots