[30.12.2020]

[Highly Dynamic Quadruped Locomotion via Whole-Body Impulse Control and Model Predictive Control]

Summary

This paper combines MPC and WBC together and bridge the frequency gap as Ruben's paper did. Two major advantages: 1. WBC provides alternative in dealing with high frequency updates. 2. MPC has a prediction horizon and compensate for the limitation of WBC that it couldn't consider more than a single time step ahead.

Some key points of this paper:

- MPC generates contact forces, and those contact forces are guidance to WBC (integrate into QP formulation), Existing WBC tends to focus on how to track body trajectory by manipulating contact forces.
- On mini-cheetah, can be very fast...

Major Analysis and Comparison

1) Graph:
   - Model predictive control:
     - state: x(k): body position (3), orientation (3), body velocity (3), body angle velocity(3)
     - control inputs u(k): contact forces (12)
     - reference computation:
   - WBC
     - Input from MPC:
       - contact forces→ together with desired acceleration(related to torque alwasy) would used for QP control to generate torques
     - Input from body estimation:
       - x(t) and \dot x(t)

$$\ddot{\mathbf{x}}_i^{\text{cmd}} = \ddot{\mathbf{x}}^{\text{des}} + \boldsymbol{K}_p \left(\mathbf{x}_i^{\text{des}} - \mathbf{x}_i\right) + \boldsymbol{K}_d \left(\dot{\mathbf{x}}^{\text{des}} - \dot{\mathbf{x}}\right),$$

- desired acceleration and desired velocity as shown in yellow are normally user-defined ans would be set to zero. Desired joint acceleration can be computed then for QP.

- Foot position command is also a task that will be stacked in the WBC where foot kd and kp are found.

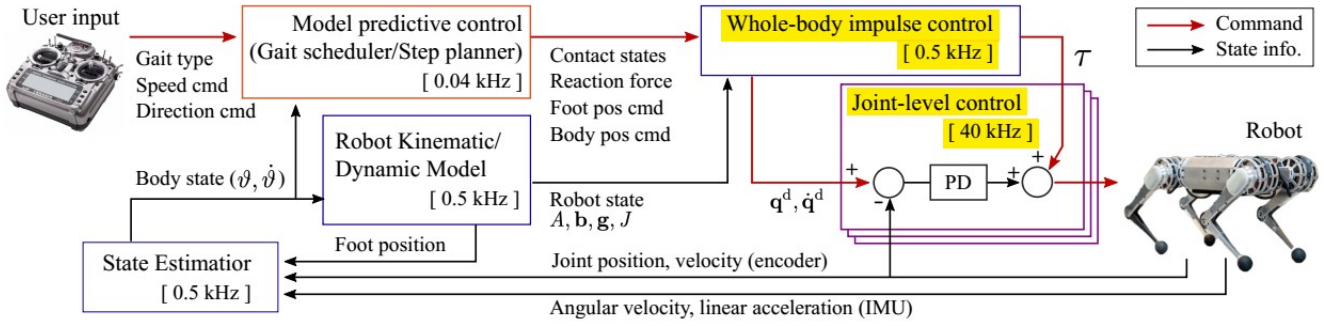

Fig. 2. **Overall Control Framework.** Using the user commanded gait type, speed, and direction from the RC-controller, the MPC computes desired reaction forces and foot/body position commands. From these, WBC computes joint torque, position, and velocity commands that are delivered to the each joint-level controller. Each component's update frequency is represented by the color of its box.

2)

Thoughts

1) compare to Ruben's MPC
2)