Theory and Practice of Humanoid Walking Control

2020 Fall semester

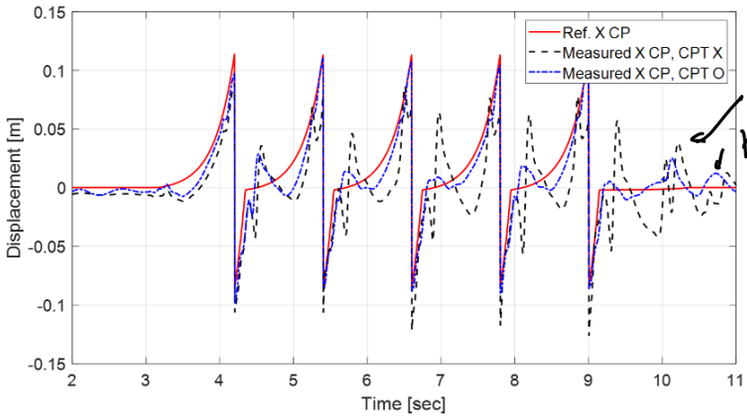
Homework # 9

Problem 9 Capture point tracking control

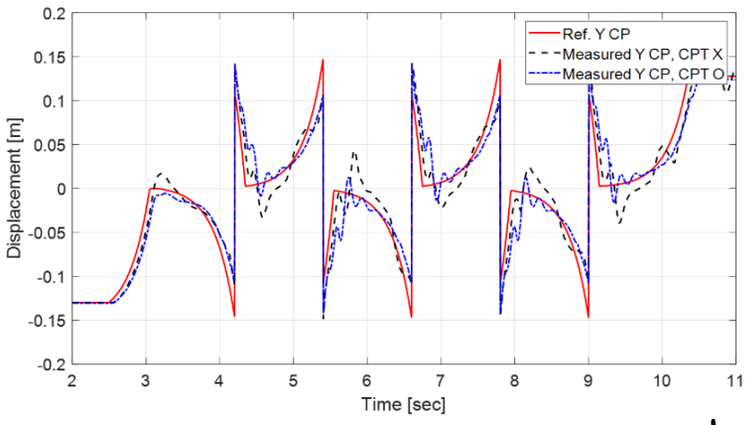
※ The first supporting foot is the left foot.

※ References:

1) Englsberger, Johannes, et al. "Bipedal walking control based on capture point dynamics." *2011 IEEE/RSJ International Conference on Intelligent Robots and Systems*. IEEE, 2011.
2) Y. Choi, D. Kim, Y. Oh, and B.-J. You, "Posture/walking control for humanoid robot based on kinematic resolution of CoM jacobian with embedded motion," *IEEE Trans. on Robotics*, vol. 23, no. 6, pp. 1285–1293, 2007.



open loop control.
tracking control.



✓ Design a capture point tracking controller.

1) Calculate ZMP for the current CP to track the desired CP.

- $p_x(k) = \frac{1}{1-e^{\omega T_d}}\xi_{x,d}(k+1) - \frac{e^{\omega T_d}}{1-e^{\omega T_d}}\xi_x(k)$

measured

- Use the desired CP trajectory designed by HW#8 / Set T_d to 50ms. (constant)

time to track from dist. C.P to desired trajectory

* our end of step.

2) Construct the ZMP controller and apply it to com closed loop control.

Tradeoff between tracking CoM & ZMP

can't follow 2 desired trajectory at once.

- $pelv_d(k) = pelv_m(k) + \mathrm{K}_1 \cdot \left(x_{c,d}(k) - x_c(k)\right) - \mathrm{K}_2 \cdot \sum_{i=0}^{k}(p_x(i) - p_{x,m}(i)) \cdot \Delta t$ } Paper
- Use the desired CoM trajectory designed by HW#8.
- In the X direction, set K1 to 1.0 and K2 to 0.15.
- In the Y direction, set K1 to 1.0 and K2 to 0.6.

✓ Run it after programming

1) rosrun dyros_jet_gui dyros_jet_gui → X: 1.0m, Step length : 0.2m → START walking button click!!
2) Plot and compare the desired and measured CP trajectories with and without CPT.
3) Record the walking simulation video.

* Hint

Simulation time → walking_tick_ (1tick : 0.005sec)

1 step time (1.2sec) → t_total_

Start time of each step → t_start_

End time of each step → t_last_

First DSP and last DSP time in one step → t_double1_ (0.15 sec), t_double2_ (0.15 sec)

The total number of steps to reach the target point. (It is automatically calculated when you click the start walking button.) → total_step_num_

Current number of steps → current_step_num_

Initial X, Y, Z CoM position w.r.t the support foot → xi_, yi_, zc_

Real pelvis position w.r.t the supporting foot frame → pelv_support_current_.translation()(n), n = 0, 1, 2 (X, Y, Z respectively.)

Initial pelvis height w.r.t the supporting foot frame → pelv_support_start_.translation()(2)

Real CoM position w.r.t the supporting foot frame → com_support_current_(n), n = 0, 1, 2 (X, Y, Z respectively.)

Foot step position w.r.t the current support foot frame

→ foot_step_support_frame_(n,0), foot_step_support_frame_(n,1)

→ The first element n of the variable means sequence, and the second elements 0 and 1 mean the positions of X and Y, respectively.

Measured joint angle → current_motor_q_leg_ (Vector12d)