Theory and Practice of Humanoid Walking Control

2020 Fall semester

Homework # 8

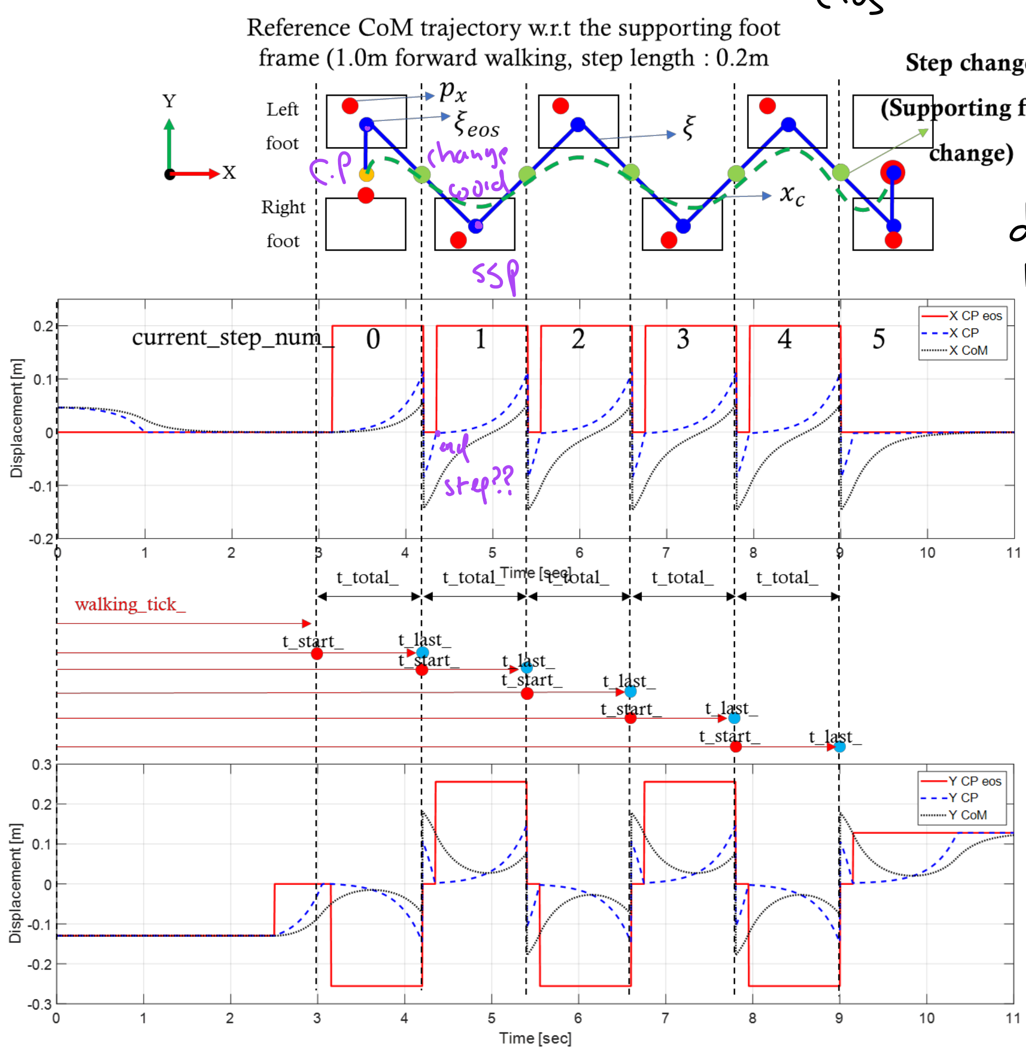
Problem 8 Walking pattern generation using capture point end of step control

※ 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.

ξ_{eos} = center foothold



diff to ppt bc local coordinate.

✓ Using the planned foot step, design the capture point end of step (CP eos) w.r.t the supporting foot frame.

1) In the single support phase, place the CP eos at the next foot step position. ✓

2) Place the first y direction CP eos on the first supporting foot 0.5 seconds before the start of walking (because there is no previous SSP). ✓

Start DSP.

- ✓ Design Capture point trajectory using CP eos.
  1) Calculate ZMP to shift current CP to CP eos.
     - ✓ $p_x(k) = \frac{1}{1-e^{\omega T_d}}\xi_{x,eos} - \frac{e^{\omega T_d}}{1-e^{\omega T_d}}\xi_x(k)$ within supporting foot check in practice IRL
  2) Update the CP using the calculated ZMP and CP – ZMP dynamics.
     - ✓ $\xi_x(k+1) = p_x(k) + e^{\omega \Delta t}(\xi_x(k) - p_x(k))$
  3) Update the CoM using the CP of the next time and the CoM of the current time.
     - ✓ $x(k+1) = \frac{\omega \Delta t}{1+\omega \Delta t}\xi_x(k+1) + \frac{1}{1+\omega \Delta t}x(k)$
  4) T_d decreases with a slope of $\frac{d(T_d)}{dt} = -1$ (Limit T_d to 50ms. Low T_d may cause P_x divergence.) then IK.
- ✓ 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 the CP eos, CP, ZMP and CoM in X and Y directions.
  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)