Theory and Practice of Humanoid Walking Control

2022 Fall semester

Homework # 1

Problem 1 Inverse kinematics

- ✓ In the circling_motion() function, program the pelvis w.r.t the base frame to be zero position, zero orientation, and the position of both feet to be circular motion and the orientation to be zero orientation. (Perform motion in the air.)
    1) The reference position of pelvis w.r.t the base frame is set to $(0,0,0)^T$, and the reference rotation is set to Identity.
    2) The reference rotation of both feet w.r.t the base frame is set to identity.
    3) The reference Y position of both feet w.r.t the base frame remains in place, and the reference positions of X and Z generate a trajectory using cosine and sine.
    4) The radius of the circle is set to 0.05m and the period of circular motion T = 4 sec.

- ✓ Convert the reference trajectory of pelvis and both feet into the joint angle of the lower body using the Inverse kinematics Analytic method.
    1) Calculate the inverse kinematics by receiving the reference trajectory of Pelvis and both feet created by the circling_motion() function as an input variable.
    2) Implement the motion by substituting the calculated angle into the desired_q_ variable in the compute() function.
- ✓ Run it after programming
    1) rosrun dyros_jet_gui dyros_jet_gui → START walking button click!!
    2) Plot the X,Z trajectory of both feet, and record the simulation video

※ Hint

- Matrix and Vector can be implemented using Eigen library.

If the Pelvis frame w.r.t the base frame is defined as follows,

Eigen::Isometry3d pelv_trajectory_float_

Rotation matrix and Position can be implemented as follows.

pelv_trajectory_float_ →Homogeneous transformation matrix (4 x 4 matrix)

pelv_trajectory_float_.linear() → Orientation (R_3^0) (3 x 3 matrix)

pelv_trajectory_float_.translation() → Position (p_3) (3 x 1 vector)

If the Foot frame w.r.t the base frame is defined as follows,

Eigen::Isometry3d rfoot_trajectory_float_

Rotation matrix and Position can be implemented as follows.

rfoot_trajectory_float_→ Homogeneous transformation matrix (4 x 4 matrix)

rfoot_trajectory_float_.linear() → Orientation (3 x 3 matrix)

rfoot_trajectory_float_.translation() →Position (3 x 1 vector)

- Rotation matrix for each axis rotation can use the following function

DyrosMath::rotateWithX(q), DyrosMath::rotateWithY(q), DyrosMath::rotateWithZ(q)

- pelv_trajectory_float_.translation().setZero() → Set position to zero.
- pelv_trajectory_float_.linear().setIdentity() → Set the Rotation matrix to Identity.

- The initial position of Pelvis and both feet.

$p_3 = (0, 0, 0)^T, \mathrm{p}_9 = (0, 0.12782, -0.76548)^T, \mathrm{p}_{15} = (0, -0.12782, -0.76548)^T$

- Simulation time → walking_tick_ (1tick : 0.005sec)