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Humanoid Robotics - Locomotion and whole-body control (SS 2025)

Exercise Sheet No. 1

due May 19, 2025

1.1 – The Reem-C model

Familiarize yourself with the Reem-C model provided in the devcontainer or as a file with this sheet. Look at the different parameters in the model file and understand what they mean. Also have a look at the different states used to describe the robot and their order.

Use rviz to visualize the robot standing upright with stretched legs and arms, arms hanging down...

1. ... with the parameter values as defined in the model file
2. ... making the right arm longer by 50% (all upper and lower arm segments)
3. ... making the left leg shorter by 30% (all thigh and shank segments), set right arm parameters back to normal
4. ... doubling the height the pelvis segment, set left leg parameters back to normal

For this, you will have to apply modifications to the model file. Make a copy of the original file before you start. We recommend preparing a picture of each case or have everything set up ready to load the different models on demand in case you want to show your modifications.

1.2 – Forward kinematics

We now want to put the Reem-C model into different configurations by changing its joint angles, as shown in the class for the biped robot.

1. Set all angles of the upper body (upward of pelvis segment to 0.3 rad, all other at zero.
2. Set the roll angle of the right hip to 30 degrees outward from the vertical, all other at zero.
3. Set left hip and knee pitch angles to 30 degrees flexion each.
4. Set the ankle yaw angles to 90 degrees outward (forming the first position in ballet).
5. Pick three more combinations of joint angles to explore the configuration possibilities of the robot, interesting ones preferred.

We recommend preparing a picture of each case or have everything set up ready to load the different models on demand in case you want to show your modifications. Don't forget to indicate or have at hand the joint angle values you picked for the last point.

1.3 – Inverse kinematics (by manual trial and error)
Try to put Reem-C in the following configurations:

1. Lying flat on the floor on its back, touching the floor with the pelvis segment
2. Standing straight and touching a point at $1.30m$ height the the right hand (there are infinitely many solutions, you just have to find one)
3. Standing straight and putting the left foot on a 20cm heigh stair, 20 cm in front of the robot (precisely in front of the original foot position)
4. One other inverse kinematics task of your choice, interesting ones preferred.

We recommend preparing a picture of each case or have everything set up ready to load the different models on demand in case you want to show your modifications.

1.4 – Jacobian of arm
Write a program to compute the Jacobian (as shown in the class) of the right hand of Reem-C with respect to its right shoulder assuming the shoulder is fixed in space. Test it for a couple of non-singular and singular configurations. Have your code and possible visualisations handy either in text form with pictures or as a live demonstration.

1.5 – BONUS Task: Jacobian of upper body
Extend the program of the previous task to the whole upper body: assume that the pelvis segment is fixed in space and compute the Jacobians for the left and right hands. Test it for a couple of non-singular and singular configurations. Have your code and possible visualisations handy either in text form with pictures or as a live demonstration.

1.6 – BONUS Task: Manipulability
Write a program to evaluate manipulability according to the three manipulability measures shown in the class. The program should take arbitrary 6 x n or 3 x n matrices J, compute the matrix A and then the measures. Test it for several matrices. Have your code and possible visualisations handy either in text form with pictures or as a live demonstration.