Robot Dynamics & Control

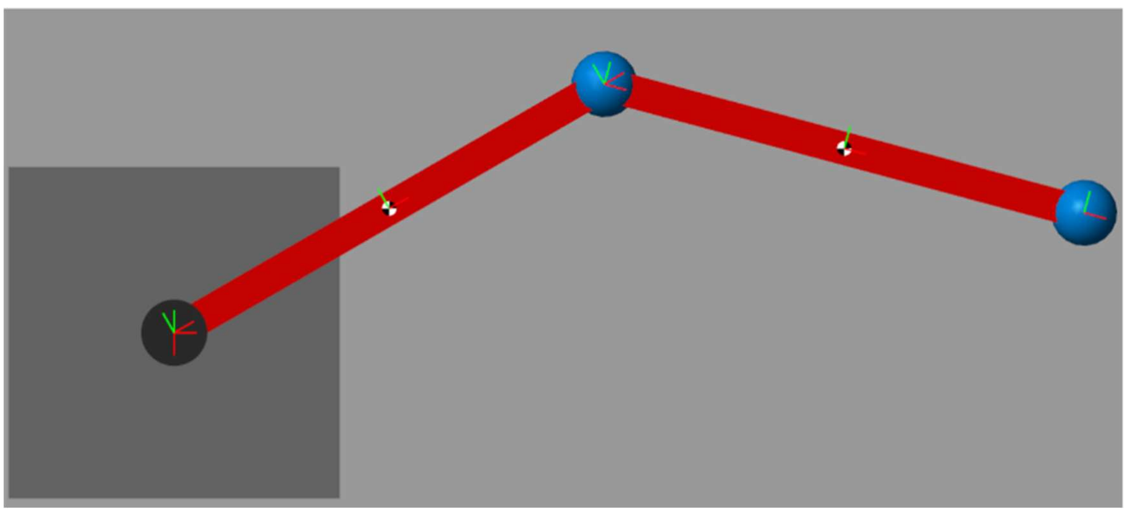
June, 5th, 2024

Duration - 3:00 h

Important notes:

- If the model parameters / joint positions / trajectories do not correspond to those defined in the task, the corresponding task will not be graded.
- If the model uses workspace variables, a *.mat* file or an *.m* script defining them must be included, otherwise the corresponding tasks will not be graded.
- In the tasks using *RigidBodyTree*, a *.mat* file or an *.m* script defining it must be included, otherwise the corresponding tasks will not be graded.

2R Planar Robot



Consider a planar 2R robot with the following set of parameters:

Mass of link 1: 4 Kg
Length of link 1: 35 cm
Mass of link 2: 0.7 Kg
Length of link 2: 17.5 cm

Task 1: Statics

1) Set joint positions at q = [-35°, 55°]. Implement gravity compensation using the manipulator statics.
2) Implement gravity compensation in the same configuration of ex. 1) considering a spherical end-effector of mass M_{ee} = 4.5 Kg and two additional masses (modeled as a spherical objects): one of 1 Kg placed on link 1 at 1/3 of its total length, the other one of 0.5 Kg placed on link 2 at 2/3 of its total length.

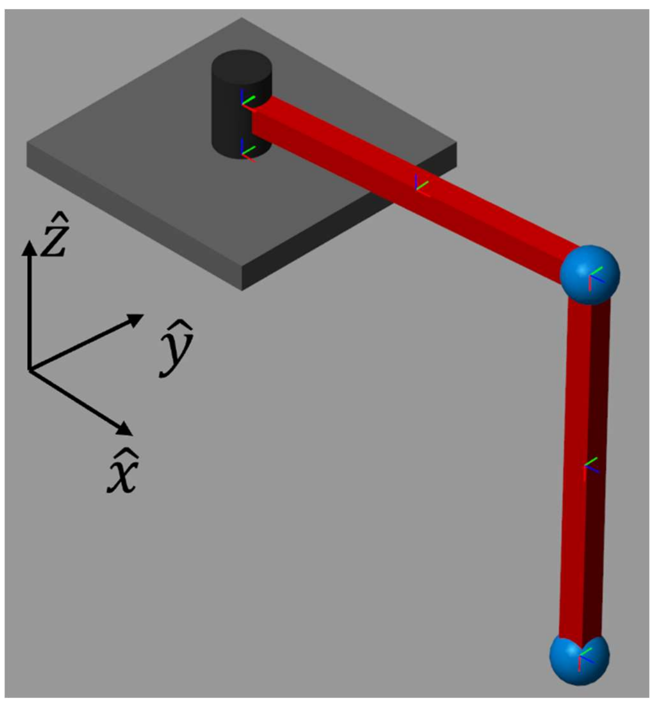
Task 2: Newton-Euler Algorithm

Implement the Newton-Euler algorithm for recursive inverse dynamics. Generate a cubic polynomial trajectory with the following initial and final configurations: $q_{\mathrm{i}} = [20°, 60°]$, $q_{\mathrm{f}} = [-20°; 90°]$. Consider gravity effect. Do not consider damping in the joints.

Task 3: Control

Implement the PD controller with gravity compensation term. Given the following initial joint configuration $q_{\mathrm{i}} = [30°, 65°]$ control the robot to reach the final configuration $q_{\mathrm{f}} = [55°; -30°]$.

2R Spatial Robot



- Consider a 3-dimensional 2R robot like shown in figure (**second joint axis should be orthogonal to first joint axis**) with the following set of parameters:
- **Mass of link 1:** 2 Kg
- **Length of link 1:** 40 cm
- **Mass of link 2:** 6.5 Kg
- **Length of link 2:** 30 cm

- **Gravity** should act on the **z-axis of the world frame**

Task 1: Statics

1) Consider the joint configuration q = [60°, -25°] . Implement gravity compensation using the manipulator statics.

2) Implement gravity compensation in the same configuration of ex. 1) using the manipulator statics considering a spherical end-effector of mass Me = 4.8 Kg and an additional mass of 2.2 Kg (modeled as a spherical object) placed on link 2 at 2/3 of its total length.

Task 2: Newton-Euler Algorithm

Implement the Newton-Euler algorithm for recursive inverse dynamics. Generate a cubic polynomial trajectory with the following initial and final configurations: $q_i = [-45°, 25°]$, $q_f = [-45°; 10°]$. Consider gravity effects. Do not consider damping in the joints.

Task 3: Control

Implement the PD controller with gravity compensation term. Given the following initial joint configuration $q_i = [-25°, 45°]$ control the robot to reach the final configuration $q_f = [100°; 80°]$.