Robot Dynamics & Control

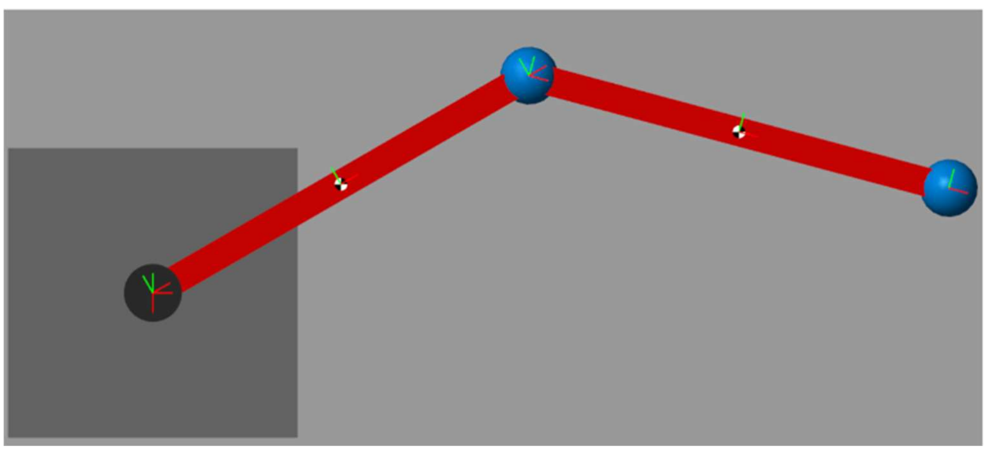
September session - 07/09/2023

Duration - 2:30 h

Important notes:

- It is advised to define the link widths and joint sizes reasonably.
- It is strongly advised to define the manipulator frames according to Denavit-Hartenberg convention. Incorrectly defined frames can lead to grade reduction.
- 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 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 = [-15°, -65°]. Implement gravity compensation using the manipulator statics.
2) Implement gravity compensation in the same configuration using the manipulator statics

considering a spherical end-effector of mass Me = 3 Kg.

3) Implement gravity compensation in the same configuration using the manipulator statics considering a spherical end-effector of mass Me = 1 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 ½ of its total length.

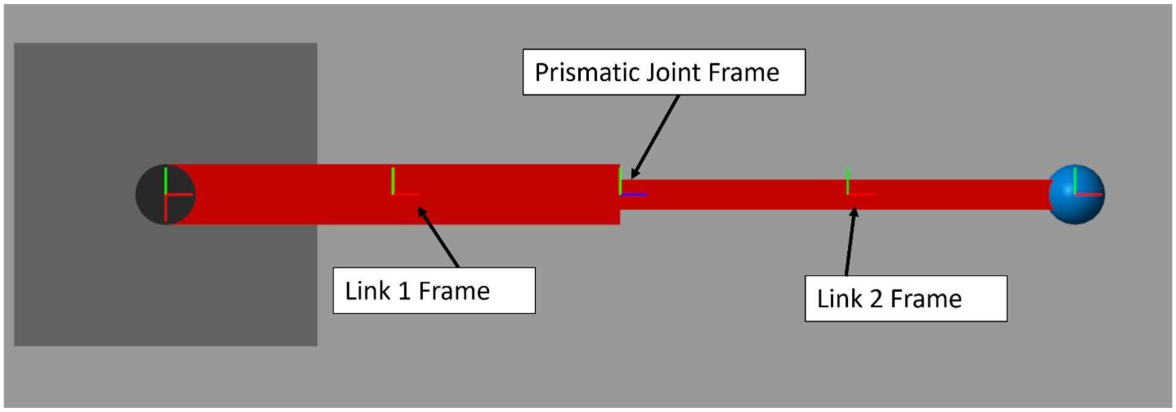
Task 2: Newton-Euler Algorithm

1) Implement the Newton-Euler algorithm for recursive inverse dynamics. Generate a cubic polynomial trajectory with the following initial and final configurations: $q_{\mathrm{i}} = [0°, 70°]$, $q_{\mathrm{f}} = [-20°; 90°]$. Consider gravity effect. Do not consider damping in the joints.

Task 3: Control

1) 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 $q_{\mathrm{f}} = [55°; -30°]$.
2) Implement the Computed Torque control law using the Robotics System Toolbox blocks. Generate a quintic polynomial trajectory with the following initial and final configurations: $q_{\mathrm{i}} = [10°, 35°]$, $q_{\mathrm{f}} = [95°; 110°]$. Also, the trajectory should pass by an intermediate joint configuration $q = [60°, 85°]$. Also consider gravity action.

RP Robot



Consider a planar RP robot like the one shown in figure (**second joint is a prismatic joint with motion axis along the x-axis of the link**) with the following set of parameters:

Mass of link 1: 2 Kg

Length of link 1: 40 cm

Mass of link 2: 2.5 Kg

Length of link 2: 30 cm

Task 1: Statics

1) Joint position q = [30°, 15 cm] . Implement gravity compensation using the manipulator statics.
2) Implement gravity compensation in the same configuration using the manipulator statics considering a spherical end-effector of mass Me = 2 Kg.
3) Implement gravity compensation in the same configuration using the manipulator statics considering a spherical end-effector of mass Me = 1 Kg and an additional mass of 5 Kg (modeled as a spherical object) placed on link 2 at 2/3 of its total length.

Task 2: Newton-Euler Algorithm

1) Implement the Newton-Euler algorithm for recursive inverse dynamics. Generate a cubic polynomial trajectory with the following initial and final configurations: $q_{\mathrm{i}} = [15°, 0\ cm]$, $q_{\mathrm{f}} = [65°; 25\ cm]$. Consider gravity effects. Do not consider damping in the joints.

Task 3: Control

1) Implement the PD controller with gravity compensation term. Given the following initial joint configuration $q_{\mathrm{i}} = [30°,\ 0\ cm]$, control the robot to reach the final configuration $q_{\mathrm{f}} = [0°; 20cm]$.

2) Implement the Computed Torque control law using the Robotics System Toolbox blocks. Generate a quintic polynomial trajectory with the following initial and final configurations: $q_{\mathrm{i}} = [30°, 0\ cm]$, $q_{\mathrm{f}} = [-20°; 20cm]$. Also, the trajectory should pass by an intermediate joint configuration $q = [0°, 10cm]$. Also consider gravity action.