DoNRS_HW4

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Task 1: Jacobian computation

In this task the Jacobian was computed by numerical derivatives approach. The Jacobian obtained is following:

$$J = \begin{bmatrix} -cos(q1)*(cos(q2+q3)+cos(q2)) & sin(q1)*(sin(q2+q3)+sin(q2)) & sin(q2+q3)*sin(q1) \\ -sin(q1)*(cos(q2+q3)+cos(q2)) & -cos(q1)*(sin(q2+q3)+sin(q2)) & -sin(q2+q3)*cos(q1) \\ 0 & cos(q2+q3)+cos(q2) & cos(q2+q3) \\ 0 & cos(q1) & cos(q1) \\ 0 & sin(q1) & sin(q1) \\ 1 & 0 & 0 \end{bmatrix}$$

Task 2: Joint trajectory (polynomial)

Given: $q(0) = (0,0,0), q(2) = (2,3,4), v(0) = v(2) = 0, a(0) = a(2) = 0$
The task is to find the joint trajectory using polynomial of 5th order (we have 6 constraints).
The functions of $q(t), v(t), a(t)$ are following:

$$q(t) = a_0 + a_1 t + a_2 t^2 + a_3 t^3 + a_4 t^4 + a_5 t^5$$

$$v(t) = \dot{q}(t) = a_1 + 2a_2 t + 3a_3 t^2 + 4a_4 t^3 + 5a_5 t^4$$

$$a(t) = \dot{v}(t) = 2a_2 + 6a_3 t + 12a_4 t^2 + 20a_5 t^3$$

Then we obtain matrix of coefficients by multiplying the inverse matrix which contains time and the matrix of initial and final positions. As we have three joints, so we have to calculate the trajectory for each of them. The position, velocity and acceleration vs time graphs are represented in the fig.1-3.
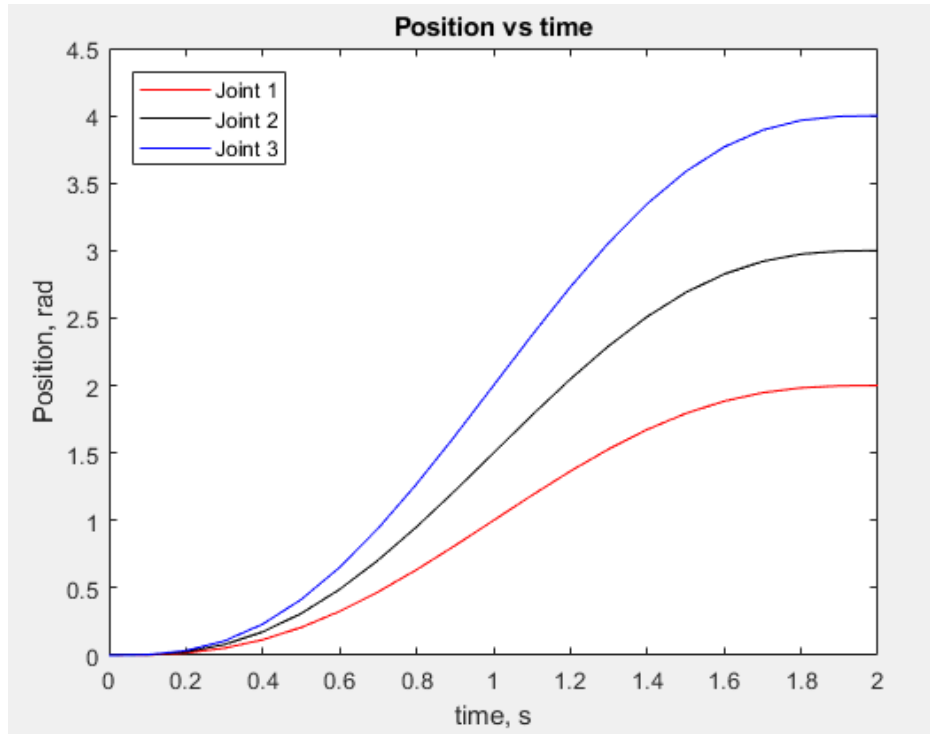
Figure 1: Position

Task 3: Joint trajectory (trapezoidal)

Given: $q(0) = (0, 0, 0), q(2) = (2, 3, 4), v_{max} = 1rad/s, a_{max} = 10rad/s^2$, frequency=100Hz.

The task is to derive the joint trajectory knowing that the velocity has a trapezoidal profile. This means that the function $q(t)$ has different dependencies on time from 0 to ta, from ta to tf-ta, from tf-ta to tf.

And remembering the existence og the second and third joints also we compute coefficients a and then the trajectory.

The results of computation are shown in the fig.7-10.
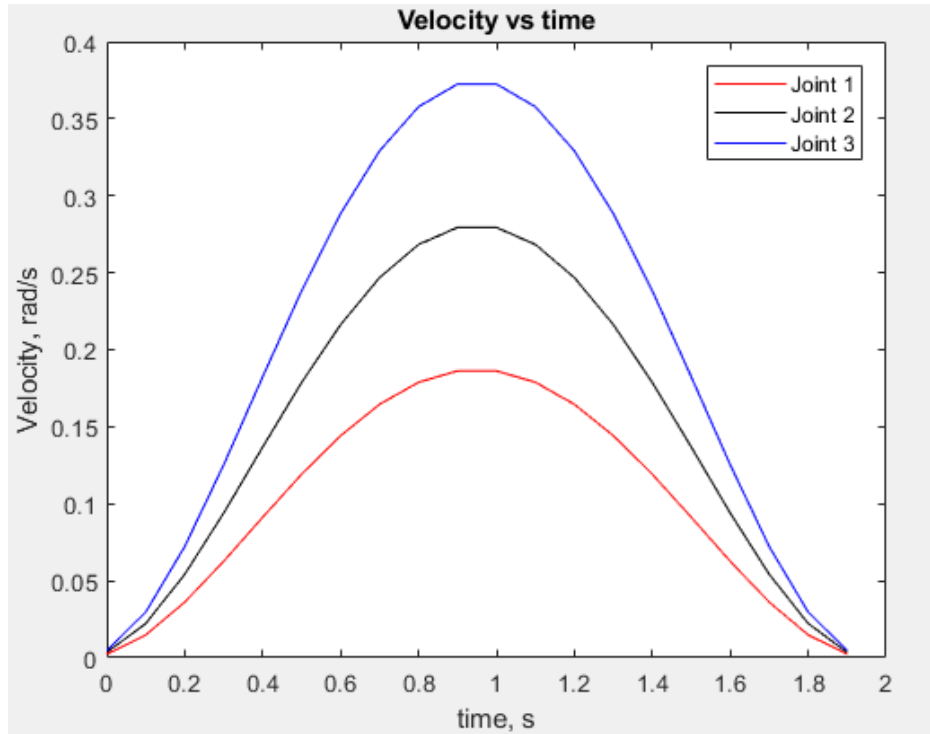
Figure 2: Velocity

Task 4: Joint trajectory (trapezoidal) with given initial and final positions of end-effector

Given: $p1(0) = (1, 0, 1), q(2) = (sqrt2/2, sqrt2/2, 1.2), v_{max} = 1m/s, a_{max} = 10m/s^2$, frequency=100Hz.

The task is to find the joint trajectory with known initial and final positions of end effector.

In this task the robot moves in a straight line from beginning to the end and for each point we calculate IK, also Jacobians (for joint velocities). Then we compute the joint trajectory.
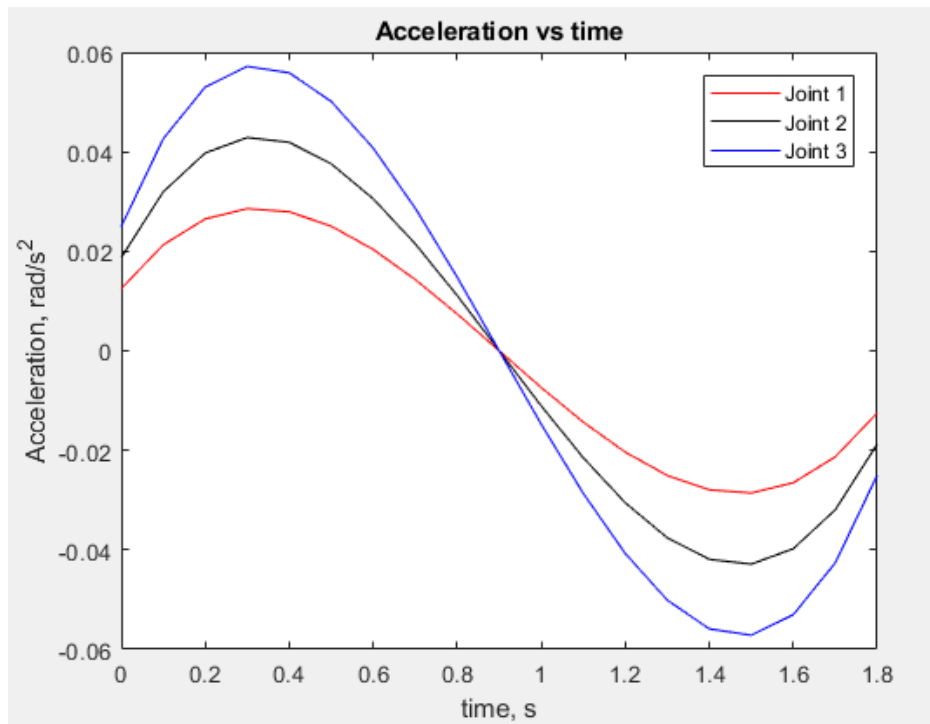
Figure 3: Acceleration

Task 5: Visualization

The visualization is represented in the figure 11.

Link on the Github: https://github.com/fam-ca/D0NRS_HW4.git
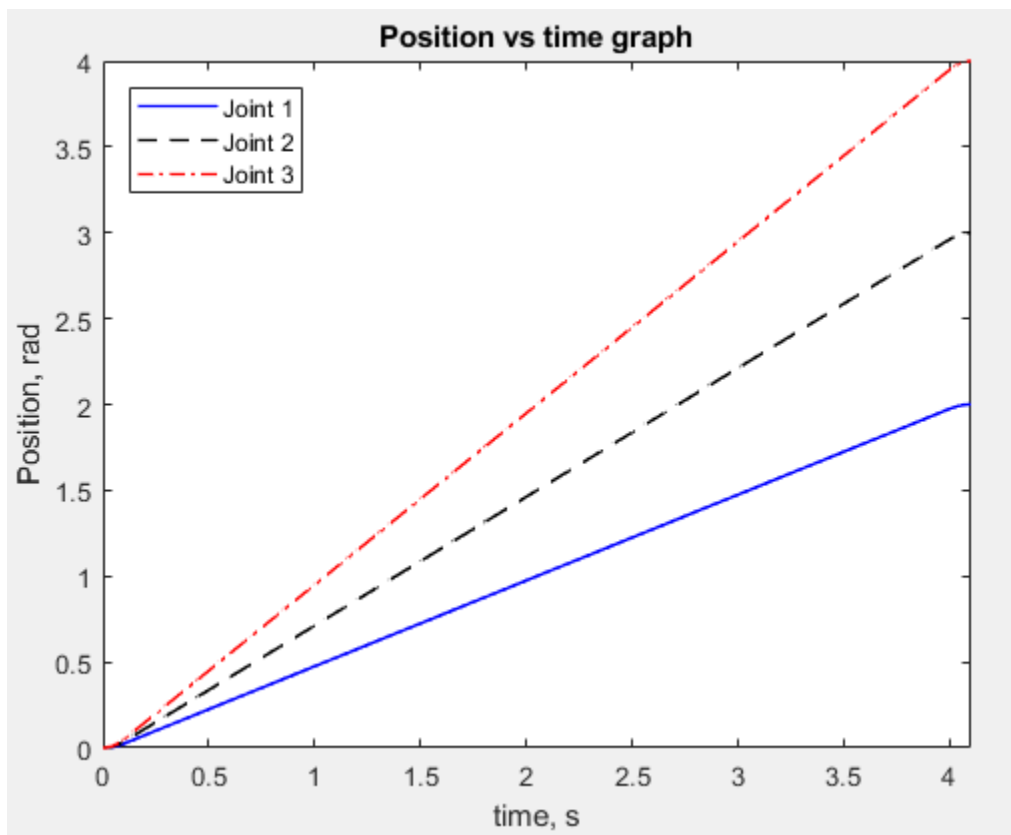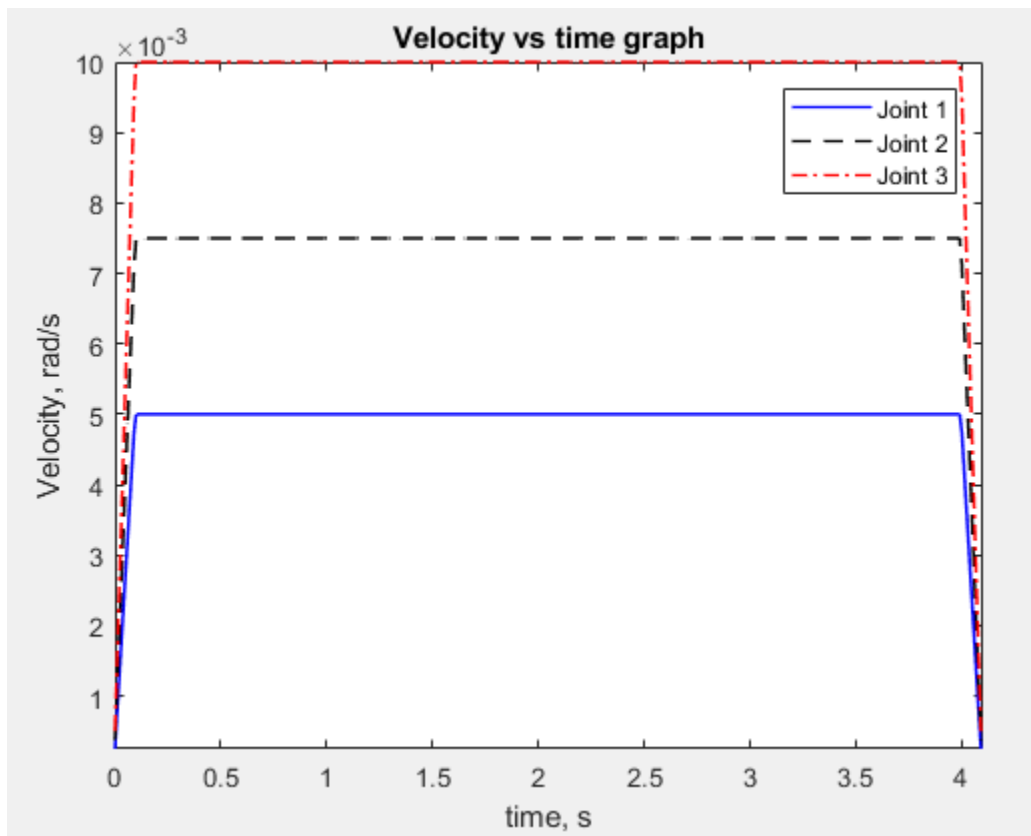
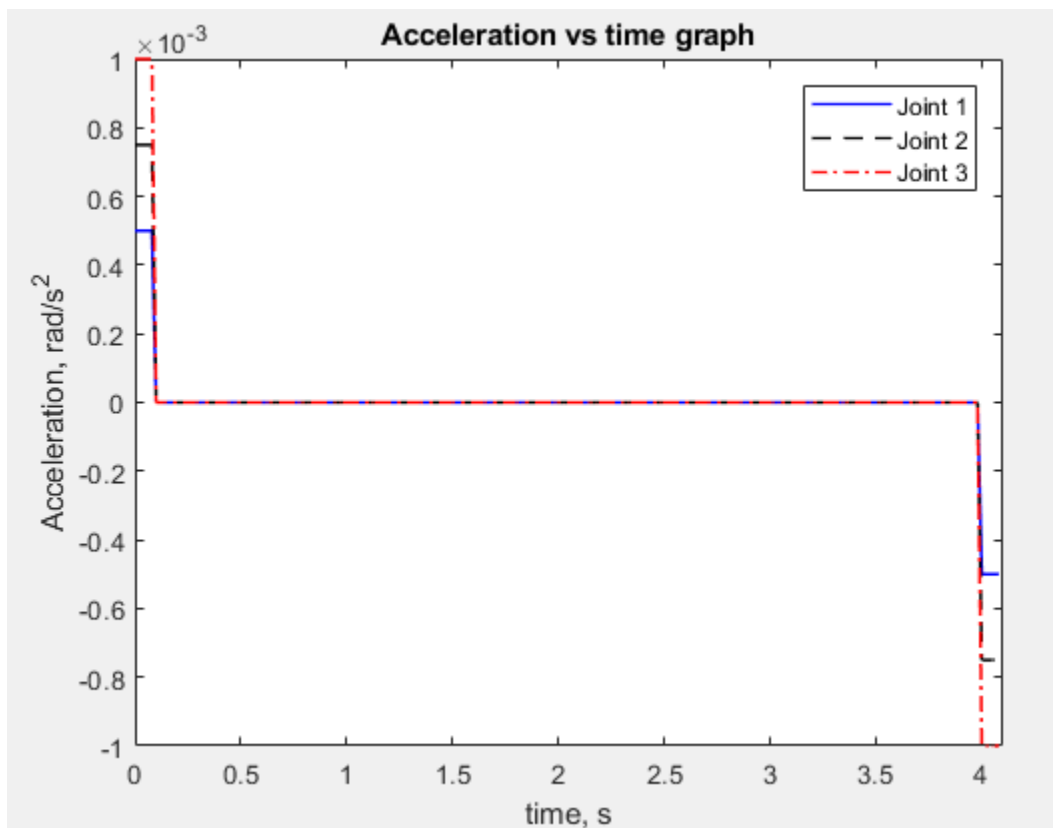Figure 4: Position
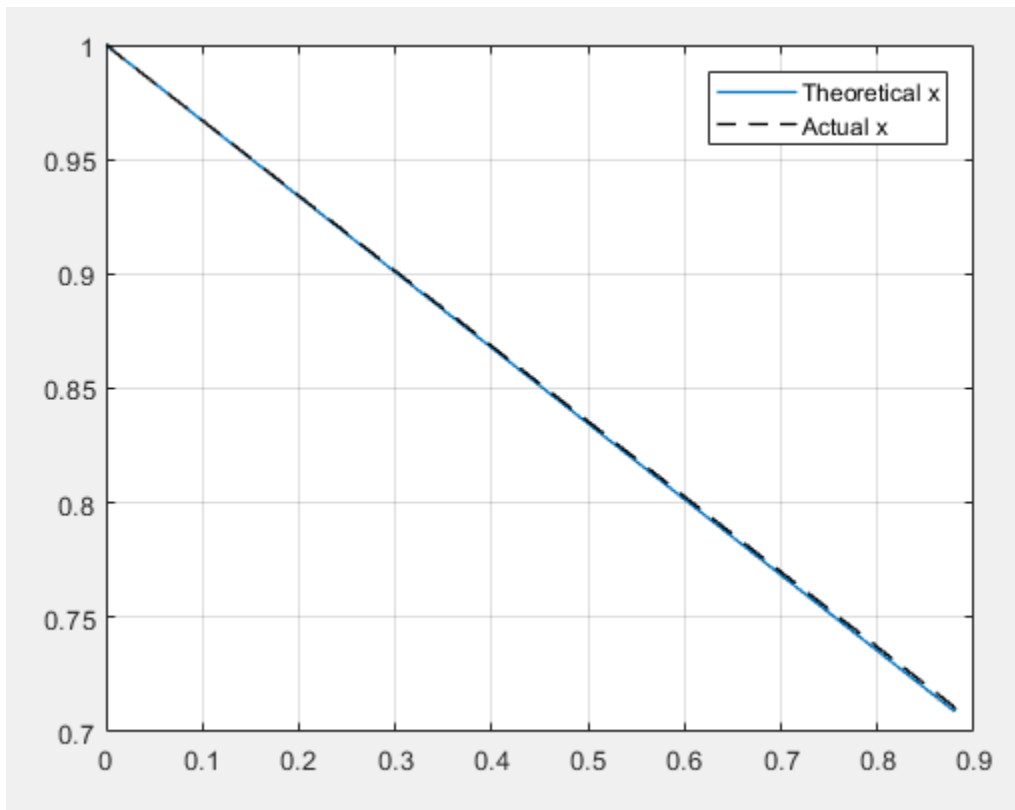
Figure 5: Velocity

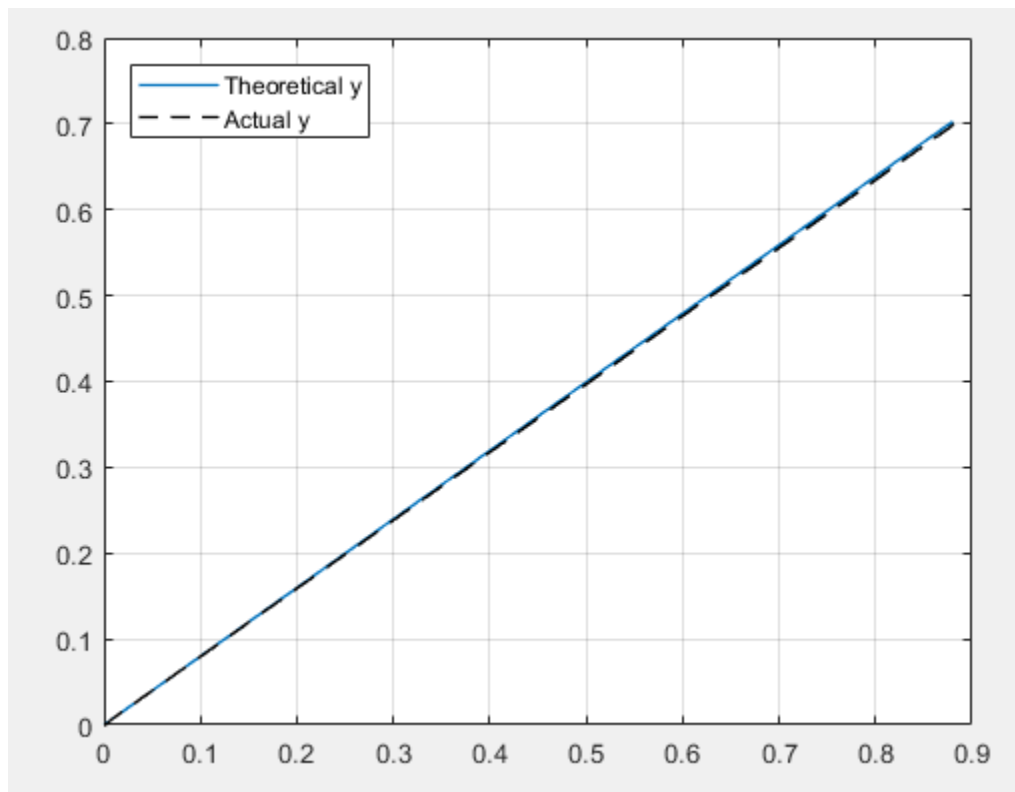Figure 6: Acceleration

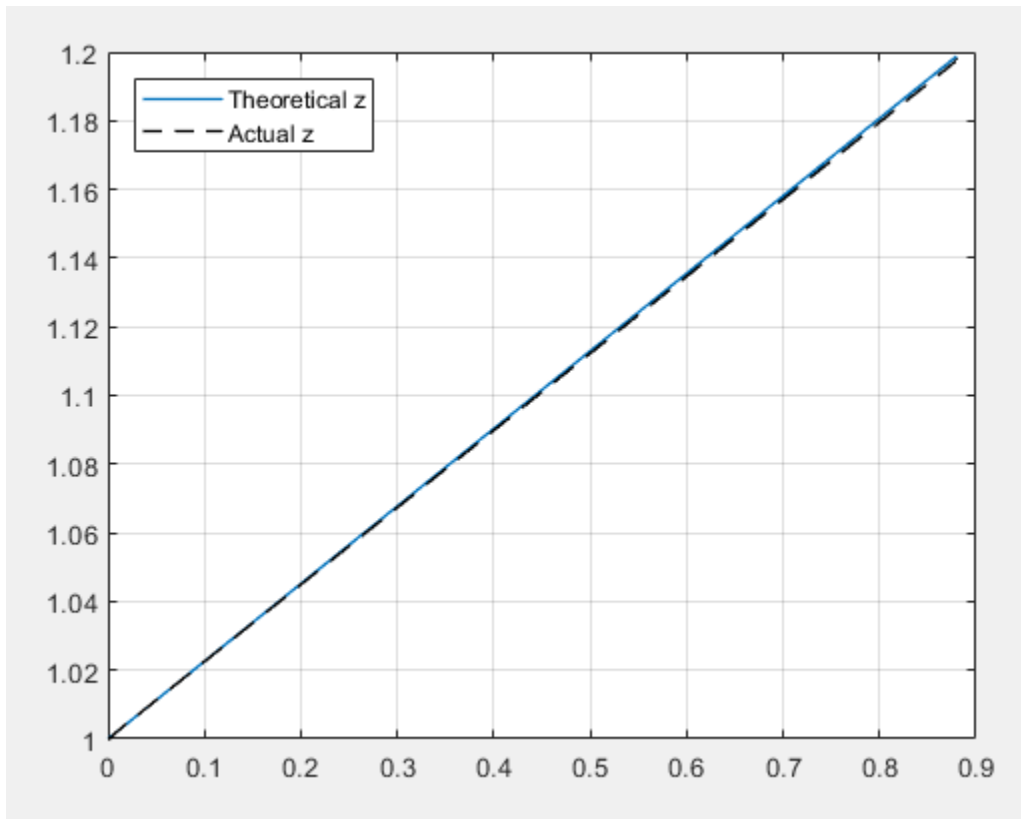Figure 7: X position graph

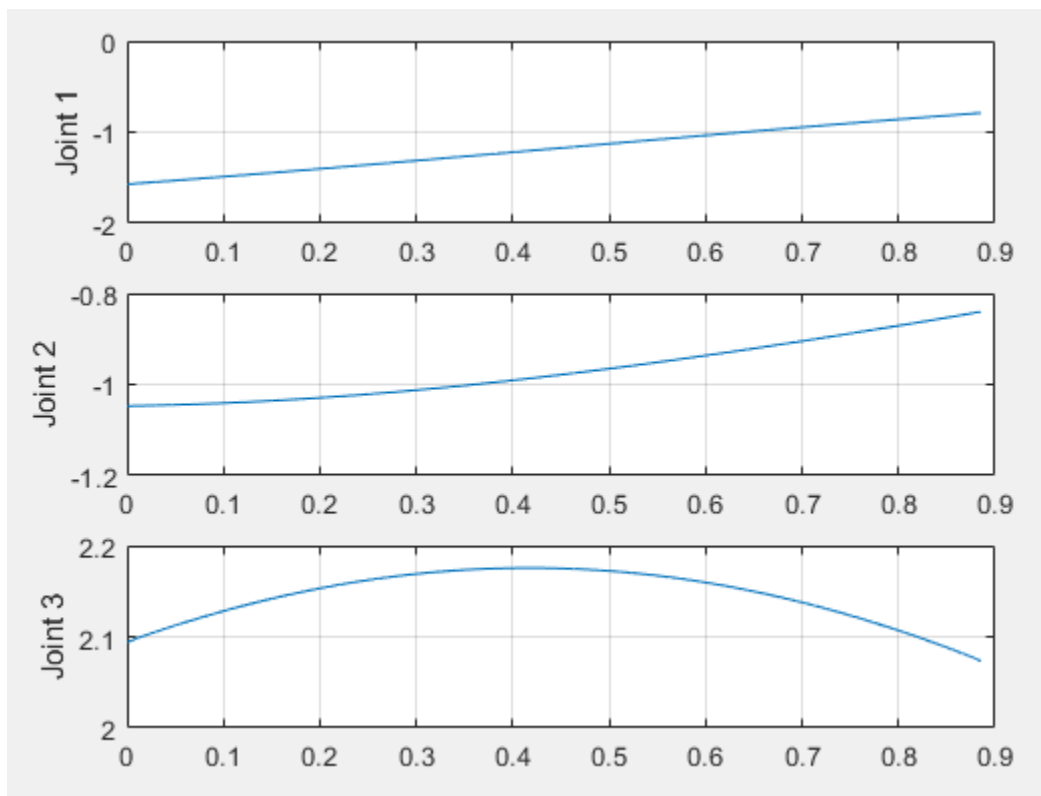Figure 8: Y position graph
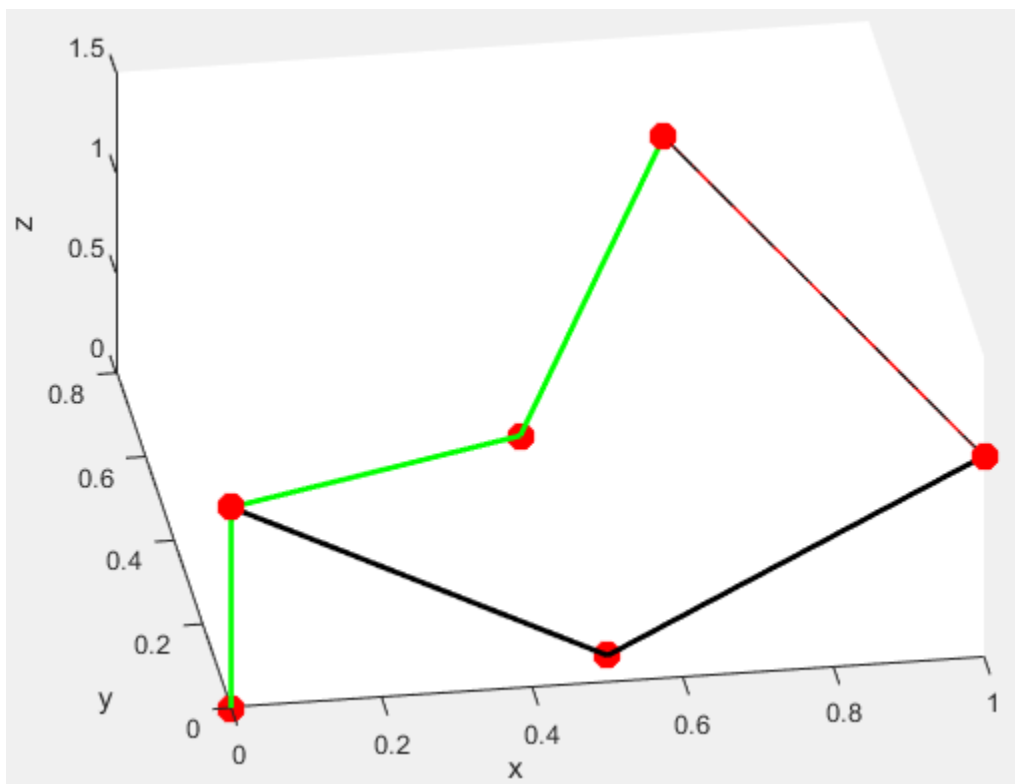
Figure 9: Z position graph

Figure 10: Joints' trajectory graph

Figure 11: Robot's move visualization