Robotics I

July 10, 2015

Exercise 1

Consider the timing law $s = s(t)$ defined by means of the bang-bang type profile shown in Fig. 1 for the fourth time derivative $s^{(4)} = d^4s/dt^4$ (called *snap*) of the path parameter s. The boundary conditions at time $t = 0$ and $t = T$ for all lower order time derivatives are zero. Moreover, $s(0) = 0$.

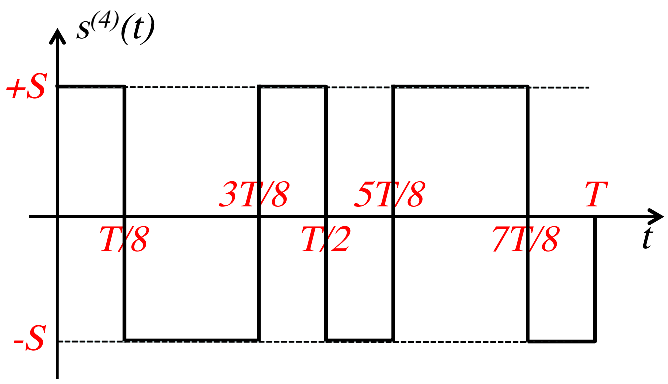

Figure 1: The time profile of the fourth time derivative $s^{(4)}(t)$

- Determine the expressions of the total displacement $\Delta = s(T)$, as well as of the maximum speed $\dot{s}_{\max}$ and maximum (absolute value of) acceleration $\ddot{s}_{\max}$ reached during motion, in terms of motion time T and maximum absolute value S of the snap.
- Sketch the time profiles of $s(t)$, $\dot{s}(t)$, $\ddot{s}(t)$, and $\dddot{s}(t)$, for $t \in [0, T]$.

Exercise 2

Consider a 2R planar robot having link lengths $\ell_1 = 0.8$ and $\ell_2 = 0.4$ [m]. The robot should execute a motion along the straight path from the initial point $A = \begin{pmatrix} 1.42 & 0.6 \end{pmatrix}^T$ [m] to the final point $B = \begin{pmatrix} 1.42 & -1.6 \end{pmatrix}^T$ [m], both expressed in the world reference frame $\mathcal{F}_w$.

- Define a position $\boldsymbol{P}_0 = \begin{pmatrix} x_0 & y_0 \end{pmatrix}^T$ in the plane, expressed in frame $\mathcal{F}_w$, where to place the robot base so that its end-effector is capable of moving along the entire given path.
- Are there any kinematic singularities encountered along this path?
- Find a robot configuration $\boldsymbol{q}^*$ such that the end-effector is at the midpoint of the given path.
- At $\boldsymbol{q} = \boldsymbol{q}^*$, compute an instantaneous joint velocity $\dot{\boldsymbol{q}} \in \mathbb{R}^2$ that realizes the desired Cartesian motion with a speed $V = 1.5$ [m/s].

[150 minutes; open books]