Motion Planning - Trajectory calculation, PRM, RRT

1. Trajectory planning
   a) Lin and ptp are the two most common methods for trajectory planning, describe them briefly.
   b) The simplest way to calculate a trajectory (ptp) is a 3rd order polynomial. Why shouldn't this be applied?
   c) Calculate the progression of a two-axis manipulator using a 5th-order polynomial. The parameters of the joints are as follows:

$$\boldsymbol{\theta}(\tau=0)=\begin{bmatrix}50^\circ\\120^\circ\end{bmatrix},\qquad \dot{\boldsymbol{\theta}}(\tau=0)=\begin{bmatrix}0\,^\circ/\mathrm{s}\\0\,^\circ/\mathrm{s}\end{bmatrix},\ \ddot{\boldsymbol{\theta}}(\tau=0)=\begin{bmatrix}0\,^\circ/\mathrm{s}^2\\0\,^\circ/\mathrm{s}^2\end{bmatrix},$$
$$\boldsymbol{\theta}(\tau=1)=\begin{bmatrix}-30^\circ\\90^\circ\end{bmatrix},\qquad \dot{\boldsymbol{\theta}}(\tau=1)=\begin{bmatrix}20\,^\circ/\mathrm{s}\\30\,^\circ/\mathrm{s}\end{bmatrix},\ \ddot{\boldsymbol{\theta}}(\tau=1)=\begin{bmatrix}0\,^\circ/\mathrm{s}^2\\0\,^\circ/\mathrm{s}^2\end{bmatrix}$$

   Formulate the path polynomials under the normalized time τ.
   d) Discuss a method for calculating a linear trajectory in the Cartesian space.

2. Probabilistic Random Maps (PRM)
   a) Explain what the difference between single-query and multiple-query is.
   b) In Fig. 1 are random samples marked as blue crosses. Use the PRM method to create the roadmap with k =3.

3. Rapidly Exploring Random Trees (RRT)
   a) Describe the RRT algorithm. Create at first a schedule and explain the steps of the method.
   b) Explain the enhancements of the RRT*. Which new methods are introduced and to which optimization do they lead?
   c) Finally program the RRT and RRT* in the provided Matlab script. Test how the algorithm changes according to a variation of the parameters. Vary:
      - goal bias
      - step size
      - obstacle position and volume
      - search range

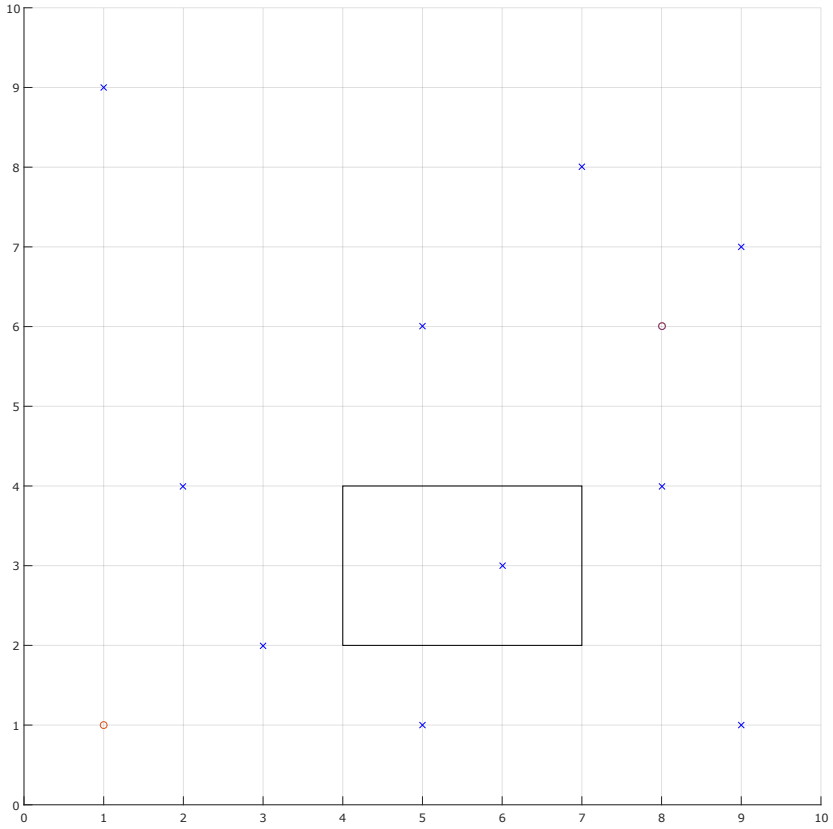

Figure 1: PRM: Start [1—1] Goal [8—6]