Robotics
Exercise 7

Marc Toussaint
Machine Learning & Robotics lab, U Stuttgart
Universitätsstraße 38, 70569 Stuttgart, Germany

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1 RRTs for path finding

In the code in `teaching/RoboticsCourse/04-rrt` you find an example problem (rename `main.problem.cpp` to `main.cpp`).

a) The code demonstrates an RRT exploration and displays the explored endeffector positions. What is the endeffector's exploration distribution in the limit $n \to \infty$? Specify such a distribution analytically for a planar 2 link arm.

b) First grow an RRT *backward* from the target configuration $q^* = (0.945499, 0.431195, -1.97155, 0.623969, 2.22355, -0.665206, -1.48356)$. Stop when there exists a node close (<`stepSize`) to the $q = 0$ configuration. Read out the collision free path from the tree and display it. Why would it be more difficult to grow the tree *forward* from $q = 0$ to q^*?

c) Find a collision free path using bi-directional RRTs (that is, 2 RRTs growing together). Use q^* to root the backward tree and $q = 0$ to root the forward tree. Stop when a newly added node is close to the other tree. Read out the collision free path from the tree and display it.

d) (Bonus) Propose a simple method to make the found path smoother (while keeping it collision free). You're free to try anything.

2 A distance measure in phase space

Consider the 1D point mass with mass $m = 1$ state $x = (q, \dot{q})$. The 2D space of $(q, \dot{q})$ combining position and velocity is also called phase space. In RRT's (in line 4 on slide 04:39) we need to find the nearest configuration q_{near} to a q_{target}. But what does "near" mean in phase space? This exercise explores this question.

Consider a current state $x_0 = (0, 1)$ (at position 0 with velocity 1). Pick *any* random phase state $x_{\text{target}} \in \mathbb{R}^2$. How would you connect x_0 with x_{target} in a way that fulfils the differential constraints of the point mass dynamics? Given this trajectory connecting x_0 with x_{target}, how would you quantify/meassure the distance? (If you defined the connecting trajectory appropriately, you should be able to give an analytic expression for this distance.) Given a set (tree) of states $x_{1:n}$ and you pick the closest to x_{target}, how would you "grow" the tree from this closest point towards x_{target}?