Motion Planning — Exercise 8

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Non-Programming

1. In RRT, an important part in practice is to post-process the output, for example by using *Path Shortening*.
   (a) Explain why path shortening does not apply in the case of kinodynamic RRT.
   (b) What alternative approaches could be used for post-processing the output?

2. For this question, we take a careful look at AO-x.

   Recall that the configuration space $\mathcal{Q}$ is changed to include an additional dimension for the cost, i.e., $\mathcal{Q}_{AO} = \mathcal{Q} \times \mathbb{R}$.

   (a) Explain how the configuration space augmentation simplifies re-using existing planners (such as RRT).
   (b) Name one challenge that arises with this augmentation with respect to the distance function.
   (c) Assume that each high-level iteration of AO-RRT reduces the previous cost by at least 5%. The initial solution has cost $c_0 = 100$, the optimal solution has cost $c^* = 10$. i) How many high-level iterations are needed to find a 1.1-bounded suboptimal solution?; ii) How can this assumption of a guaranteed cost reduction per iteration achieved in practice (i.e., what changes in the pseudo code are needed)?; and iii) Argue that this does not help to identify a "useful" convergence rate for AO-x.
   (d) Consider removing the state augmentation, i.e., $\mathcal{Q}_{AO} = \mathcal{Q}$, but keeping the iteratively reducing cost bound. Is the resulting approach still PC and AO?

3. Use SST to solve the following problem for a car-like robot. The robot starts at state $(x, y, \theta) = (0, 0, 0)$ and needs to reach the goal position $(x, y) = (10, 10)$. Use the following deterministic sampling sequence for the selection: $(5, 2, 0), (4, 5, \pi), (1, 3, 0)$, $(7, 1, \pi/2), (9, 2, 0), (6, 4, 3\pi/2)$. Use a distance metric that primarily focuses on the position, $\delta_{BN} = 2$, and a deterministic propagator that cycles through left turn, straight motion, right turn.

   Draw the resulting tree, and mark the witness set.