Collaborative Autonomy Interview Questions

Thank you for taking time to interview with the Collaborative Autonomy Branch in RASD. Please see below for information pertinent to completing this portion of the interview:

- Please answer as many of the following questions as possible *to the best of your ability*.
- Additional guidance notes are provided with each question.
- The purpose of these questions is for us to gauge your prior knowledge and your ability to learn.
- If there is some aspect of any question you are unsure of, please make a note of it and bring it to the attention of the review committee when you meet with them again.

Question 1

Suppose you have a point robot with the following dynamics in the global reference frame:

$$dx/dt=cos(u)$$

$$dy/dt=sin(u).$$

That is, your robot moves at unit speed and allows you to instantaneously set the robot heading u.

Given an environment with circular obstacles with radius=5, implement a planning solution in your preferred programming language (e.g. C++ or Python) to plan a **collision-free path** from the starting position at (xi,yi) = (0,0) to the end position at (xf,yf) = (100,100). Assume that the obstacles are static and their positions are given by the coordinates in the attached csv file. Your solution should be able to handle other csv file inputs.

Additional guidance on Question 1:

- Your resulting code should be prepared in an easy-to-read/easy-to-share format (e.g. within an IDE like Eclipse, VS Code, Sublime, etc.) so that you can share your screen via the WebEx session and the review committee can clearly follow along as you explain your solution.

Question 2

1) Explain and provide pseudocode for the RRT algorithm.

2) Explain and provide pseudocode for the PRM algorithm.

Additional guidance on Question 2:

- Your approach to providing pseudo code means that you present a solution concept, graphically, outlined, and/or in code (or cleanly written/typed), to present the algorithms start to finish. Be sure to include what is input to and output from the algorithm.
- Your response should be prepared in an easy-to-read/easy-to-share format (e.g. markdown or Microsoft Word) so that you can share your response via the WebEx session and the review committee can clearly follow along.

Question 3

1) Explain and provide pseudocode for the Kalman Filter algorithm.

2) Explain and provide pseudocode for the Particle Filter algorithm.

Additional guidance on Question 3:

- Your approach to providing pseudo code means that you present a solution concept, graphically, outlined, and/or in code (or cleanly written/typed), to present the algorithms start to finish. Be sure to include what is input to and output from the algorithm.
- Your response should be prepared in an easy-to-read/easy-to-share format (e.g. markdown or Microsoft Word) so that you can share your response via the WebEx session and the review committee can clearly follow along.

Question 4

1) Below is the model of an inverted pendulum attached to a cart. The states x is the angle of the pendulum where 0 is upright. Parameter r is the length of the pendulum and g is the acceleration due to gravity. Input a is the cart acceleration.

$$\ddot{x} = \frac{g}{r}\sin(x) - \frac{a}{r}\cos(x)$$

Linearize the system about an appropriate equilibrium point.

2) Express the system in state space and transfer function forms.

3) Evaluate the stability of the system

4) Design a controller to stabilize the system

5) What factors should a designer consider when choosing gains for the closed loop system.

6) Under what conditions might the controller not perform as expected in practice? How might one address these in the controller.