Lab 3: Motion Planning with a 6-DOF Manipulator

Due: Apr. 12th 23:59 PST

In this lab assignment, you will implement the RRT algorithm for a 6-DOF robotic manipulator. To perform the assignment, you will need to have installed the AIKIDO infrastructure. We provide for you the file **adarrt.py**, which contains several methods you will fill in. During development, you will run your code in simulation with -

```
$ python adarrt.py --sim
```

The python file contains the following classes and functions:

- `AdaRRT`: This is the main class. It initializes the start and goal node, the number of iterations, the step_size δ when extending a node in the tree, the desired goal precision ϵ and the joint limits of the robot. It also includes information about the environment, which includes a table, a soda can that we want to grasp, the robot and a set of constraints that check for collisions. This implementation will be very similar to the RRT you built in HW4, with a few modifications discussed below.
- `AdaRRT.Node`: A Node object should contain a copy of the state, a pointer to the parent node in the tree, and a list of pointers to all its child nodes in the tree. A state in the provided code is a 6D `np.array` that contains the robot's configuration.
- `main`: this function specifies the start and goal configurations, sets up the RRT planner and computes a path. It then calls the AIKIDO function `compute_joint_space_path`, which generates a trajectory for the robot to follow.

Note: If you are using ROS-Noetic/python3 for this lab, you will need to modify **adarrt.py** by finding two instances of **raw_input** (should be on lines 200 and 253), and replace both with **input**. Then find two instances of **time.clock** (should be on lines 248 and 251), and replace both with **time.process_time**.

Steps to complete the lab:

1. **Implement an RRT algorithm** by filling in the code in the provided file. For starting configuration q_S and goal configuration q_G, and parameters ϵ and δ use:

$$
\begin{aligned}
q_S &= [-1.5, 3.22, 1.23, -2.19, 1.8, 1.2] \\
q_G &= [-1.72, 4.44, 2.02, -2.04, 2.66, 1.39] \\
\delta &= 0.25 \\
\epsilon &= 1.0
\end{aligned}
$$

   Make sure you have `roscore` running before starting your RRT!

2. **Visualize the trajectory in rviz**. First, execute your `AdaRRT` implementation, but don't execute the trajectory. Then, open rviz from the command line using `rosrun rviz rviz`. In the bottom left module, click the "Add" button and navigate to the "By Topic" tab. You should see a `InteractiveMarkers` topic under `/dart_markers`. Add the topic before executing your trajectory generated by `AdaRRT`.

3. Use an off-shelf screen capture software (e.g., `https://itsfoss.com/kazam-screen-recorder/`) to **record a video** of the trajectory. Include the video in the root of your GitHub repo as a file named `question-3.mp4`.

4. The RRT trajectory is typically jerky. Typical planners use shortcutting algorithms to make the plath smoother. **Replace the function** `ada.compute_joint_space_path` with `ada.compute_smooth_joint_space_path`. Capture the new trajectory with two videos – one showing the default isometric view, and another showing the top view. Include the videos in the root of your GitHub repo as files named `question-4-default.mp4` and `question-4-top.mp4`.

5. The goal precision ϵ of 1.0 in the previous question is too large. In order to avoid collisions, we need to improve the precision. However, this dramatically increases the time to compute a solution. To improve computation, **add a method** `_get_random_sample_near_goal` that generates a sample around the goal within a distance of 0.05 along each axis of the search space. Then, change the `build` method so that it calls `_get_random_sample_near_goal` with probability 0.2 and `_get_random_sample` with probability 0.8. Reduce ϵ to 0.2.

   Write down your observations in the PDF file. Also capture the new trajectory with two videos – one showing the default isometric view, and another showing the top view. Include the videos in the root of your GitHub repo as files named `question-5-default.mp4` and `question-5-top.mp4`.

6. Explain why it is not a good idea to call `_get_random_sample_near_goal` with probability 1.0. Also present an example where this could be problematic. Write your answer in the PDF.

In-person lab: Once you are confident in your simulation results, you are ready to run it on the real robot. This can be done on the lab workstations with -

```
$ python adarrt.py --real
```

Refer to Piazza for more instructions on scheduling time in the lab.