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CS3105
Practical 1, Robotics

1 Free Space Travel

Completeness Both the Rapidly Exploring Random Tree (RRT) robot and the Potential Fields (PF) robot exhibit completeness. With the RRT robot, it will find a path between any starting and ending point in free space, as long as the goal is within the starting GUI width and height. The starting point of the robot it allowed to be outside of the displayable region. The PF robot can also navigate from any arbitrary point to another arbitrary point, even outside the displayable region.

Output As seen in Figure 1, the output of the RRT shows the entire developed tree as well as the final path outlined in red. To show the step-by-step development, the user can press the "Move" button. To see the development animated, press the "Animate" button. For the PF, the user can see the development of the path (planning and execution occur in the same step) by either pressing "Move" for one step or "Animate" for all of the steps. Animate is shown with a delay in order to see the PF robot movement from one point to the next.

Efficiency For RRT efficiency testing, I set the starting point at 0,0 and the goal at 500,500 and used the final recommended settings. Specifically, the robot size was 10, the step size was 10, and the goal size was 40. The number of moves and, since each move adds a node, the number of nodes is roughly 200 to 300 for an RRT free space simulation. For PF efficiency testing, the starting point and goal were again at 0,0 and 500,500, respectively. Recommended settings for PF were also used: a robot size of 10 and sonar size of 60. The number of moves for the PF in free space is the same for each run, namely 35. The length of the path is always 707.106, as expected, and the number of turns is 0.

Move Parameters To find the next move for the RRT, a random point is taken. The possible coordinate values for x and y, respectively, are from 0 to the width and 0 to the height, plus some buffer region for each. The buffer, ten percent outside of the displayable region, is needed in case the goal is at the edge of the displayable region. If this is the case, then it is much more difficult to reach as random points only reach up until the edge of the displayable region. With the buffer region, random points will reach a bit past the displayable region, making is much easier to reach goals at the edge of the displayable region. To find the next move for the PF, the robot calculates the potential for each of the sensing points (default of 7). In the absence of obstacles, the potential is calculated solely by a formula that uses the distance from the goal. The PF then picks the sensing sample with the best (lowest) potential.

Smoothing Smoothing for the RRT is relatively automatic since it uses the RRTree's nearest node method. In doing so, it

Free Space Planner Superiority The PF robot exhibits superiority in free space in a number of aspects. It is able to find a path between any two points in free space, whereas the RRT is limited by the displayable region. Unlike the RRT, the PF does not have to do any planning. Rather, it is pulled to the goal by its attractive potential. Indeed, a lot of computation is wasted in the RRT method by calculating extra unnecessary nodes in the tree. The biggest advantage of all, of course, is that the PF robot is able to move from its starting position to the goal without any turns. Additionally, in reaching the goal in this fashion, the length of the path is reduced significantly from the wavier path of the RRT. In fact, the PF robot's path is the optimal path as it is a straight line.

2 Obstacle Navigation

Output The output for the RRT and PF are the same as implemented in free space. The only difference is that the planning and execution of the paths have to avoid obstacles. For the RRT, the output only shows nodes that avoid any obstacles (also displayed on the screen). Thus, the output on the GUI shows the entire tree as well as the final path, except that this time there are obstacles which all nodes avoid, including the nonused ones. For the PF, the output shows the robot planning and executing its path around obstacles. The GUI displays the changing (shrinking and growing) of the sensor radius to help the user see where the possible moves are. Additionally, the sonar range and the rays from the sensors are shown to help visualize the robot detecting obstacles in its local area. Finally, the intersection

Efficiency The number of moves and, again, the number of nodes of the RRT with obstacles is a much larger range and depends on the specific obstacle course. However, for the random obstacle course, it generally falls in the 300 to 600 move range.

Global Map and Local Sensing In addition to the move parameters described for free space, both the RRT and PF robots use additional information about the environment to avoid the obstacle. The RRT has a global map. As such, it knows if an obstacle is in the way of its next move. If so, it discards this move. The PF uses a sensor region to detect nearby obstacles. Obstacles the PF sees apply a repulsive potential that force it away. The PF also knows where the goal is without its sensors, and the goal provides an attractive potential. The RRT did not experience any problems with any of the obstacle courses. The only situation where it could not find a solution was when the robot size was too big to get past obstacles.

Planner Superiority Overall, the RRT is a better planner when there are obstacles present

Enhancements Several enhancements were added on top of the existing programs.

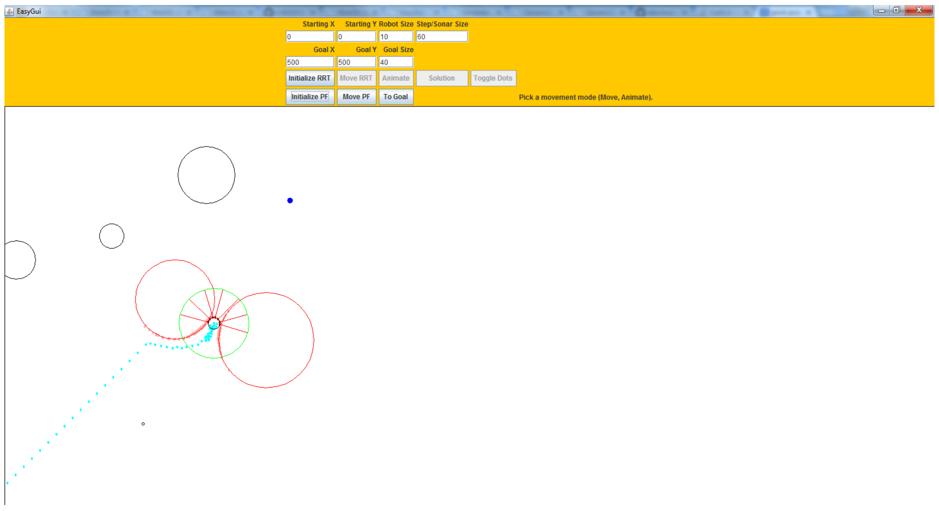
3 Overview Questions

4 Compiling and Running

Compiling The files are located in the src/skynet/ subdirectory. A Makefile and ToolBox.jar are also located in this subdirectory. The files can be compiled by running make. The program is run with the following command:

```
java -cp ../:ToolBox.jar skynet.Robot
```

Running Although the user is free to set whatever values for the simulation values such as robot size, sonar size, or goal coordinates, there are recommended settings in place. If the parameters are out of the recommended range, the program may exhibit unexpected and/or incorrect behavior.


Starting X: 0
Starting Y: 0
Robot Size: 10
Step/Sonar Size: 60
Goal X: 500
Goal Y: 500
Goal Size: 40

Pick a movement mode (Move, Animate).

Figure 1: The PF robot stuck in a local minimum point between two obstacles.