Assignment 3 – Collision Avoidance or Traffic Control

Scenario

Multiple holonomic circular robots of radius 1 m with 360-degree field of view sensors of unlimited range approach a four-way intersection. The width of the road is 7 m and the speed limit is 20 m/s. At each time step dt = 0.2 s, the probability of a robot entering a region of radius 200 m from the intersection in one of the four directions is p = 0.04. The goal of the robots is to travel straight across the intersection as quickly as possible without leaving the road and without colliding with each other.

Hint

Consider implementing either the collision avoidance approach from class on October 17th and 19th, as described in "Reciprocal n-body collision avoidance," Robotics Research, Springer Tracts in Advanced Robotics 70, 3:19, Springer, Berlin, 2011 as implemented by RVO2 Library, or the traffic control approach using one lane in each direction and traffic signals from class on Thursday, October 26th, as described in "Multiagent Traffic Management: A Reservation-Based Intersection Control Mechanism," Proceedings of the Third International Joint Conference on Autonomous Agents and Multiagent Systems, 530:537, 2004.

Experimentation

Observe the changes of behavior as you vary the probability p of the robot entering region around the intersection from p = 0.04 to p = 0.2. If implementing the collision avoidance approach, plot the probability p of a robot entering the region around the intersection vs. the average number of collisions per robot. If implementing the traffic control approach, plot the probability p of a robot entering the region around the intersection vs. the average delay of each robot.

Extra Credit

Instead of each robot always continuing straight across the intersection, instead allow robots to also turn left or right at the intersection. Each robot has a probability 0.25 of turning right at the intersection, a probability 0.25 of turning left at the intersection, and a probability 0.5 of continuing straight across the intersection. Repeat the experiments above and observe any changes in behavior.

What to Submit

Upload to Sakai your documented source code, graphs, and multiple plots, multiple screenshots, or a video showing the locations of the robots as your code runs for the original scenario with p= 0.04. For the extra credit, upload your documented source code, graphs, and multiple plots, multiple screenshots, or a video showing the locations of the robots as your code runs with p = 0.04. Include detailed instructions for building and running your code, as appropriate.

Deadline

Before class (4:40 pm) on Tuesday, November 21st. For one of the assignments, you may choose to take a seven-day extension without penalty, otherwise you will be deducted one point for each day that the assignment is late. Additional extensions will only be given for unforeseen circumstances, which do not include computer hardware or virtual machine failures or submissions lost due to lack of backup. No late assignments will be accepted after the last day of class, Thursday, November 30th.

Note on Collaboration

You may discuss solutions with other members of the class and share code related to the simulator or visualization, but implementation of the algorithm and all other work should be your own. When submitting the assignment acknowledge others with whom you discussed your solution and any code that you shared.

Homework 3

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1 Instructions

Instructions for installing and running the simulation can be found in the `README.md` file.

2 Experimental Methods

Collision avoidance was the chosen approach for this problem and implemented using the RVO2 library.

3 Results

In addition to the plots below, sample videos of the following scenarios can also be found in `data/sim.mp4` and `data/sim_ec.mp4`.

3.1 Straight Travel

The simulation was run with the specified range of probabilities, from $p = 0.04$ to $p = 0.20$ in increments of 0.1, on a 2-way highway. For each probability, results were averaged across $N = 25$ simulations, each lasting $T = 60$ seconds. The probability is plotted against the average number of collisions per robot in Figure 1. The data show that the number of collisions is roughly directly related to the probability of a robot entering the simulation. Of course, this is expected as more robots create more opportunities for collisions.

Note that because collisions are infrequent, the average number of collisions is highly susceptible to being skewed. For a smoother trend line, the simulation would need to averaged across a much higher duration.

3.2 Perpendicular Travel (Extra Credit)

The simulation was run again, this time with each robot have a chance to turn left (25%), right (25%), or continue straight (50%) at the intersection. The same data are plotted in Figure 2. As shown, the results roughly follow the same trend, just with a greater number of collisions. Again, this is expected since turning at the intersection creates more opportunities for collisions.

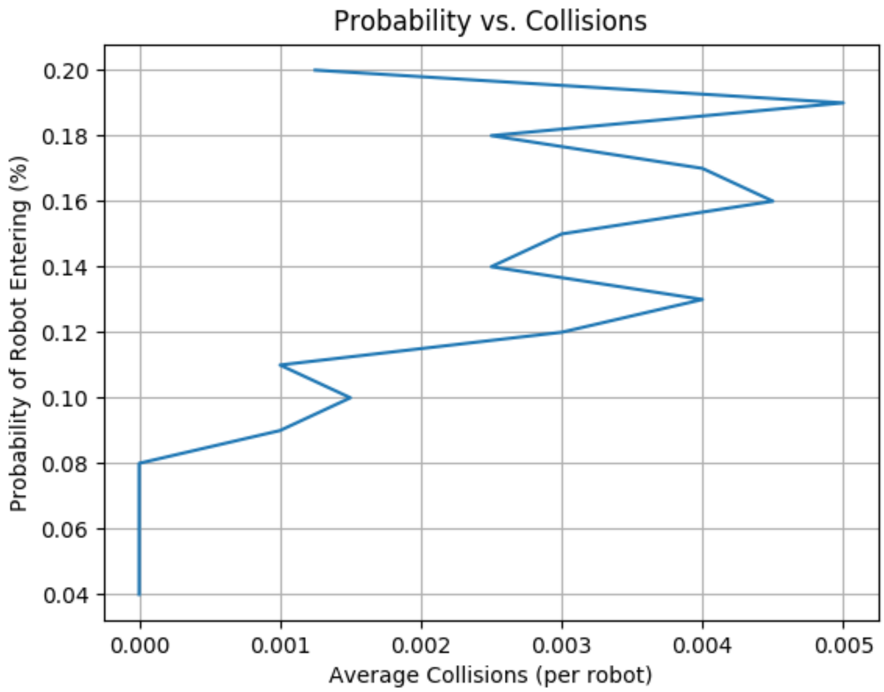

Figure 1: Average collisions per robot (without turning)

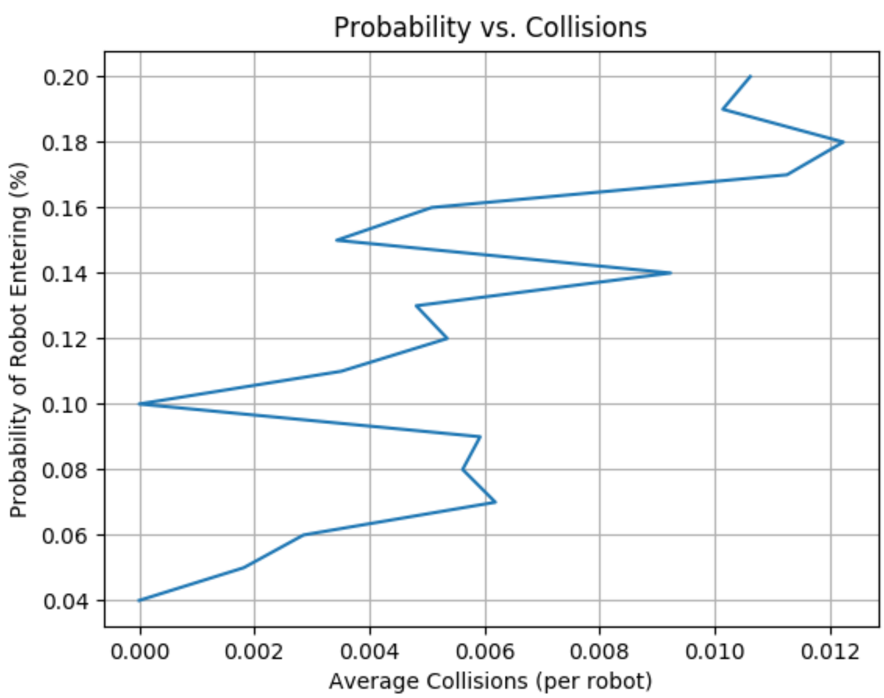

Figure 2: Average collisions per robot (with turning)