CSCI–4190 Introduction to Robotic Algorithms, Spring 2004
Assignment 3: out March 18, due April 5

SONAR mapping

For this assignment, you will implement the Dempster-Shafer theory approach to SONAR mapping. The support code will provide representation and display for grid-based maps and a simulator to produce SONAR data.

Another aspect of this assignment is to evaluate the resulting maps. You will need to devise a method to compare the SONAR map with the world.

Program interface

Here is a rough idea of the interface your program should provide. See the support code for the exact specification.

- The user should, at any time, be able to switch to any of 4 different views:
  - the empty map
  - the full map
  - the combined map
  - the "working" map (see below for details)
- The SONAR data will consist of a number of scans (readings for each sensor in the SONAR ring) from different configurations. The user should be able to "step" through the SONAR data, incorporating a single reading from a scan. There will also be a command for incorporating an entire scan, 10 scans, and the remaining scans.
- The user can "break down" the process of incorporating a single reading from a scan and see the results in the "working" map. For example, the user should be able to see the SONAR cone drawn over the grid, which cells are determined to be in the interior of the cone, which are on the arc, etc. This should be useful for your debugging and testing as well as for us to see that your program is working properly.
- The user will be able to save the sonar map as an image. You should write a separate program to compare the generated SONAR map with the actual world.

The support code will have a "skeleton" for this functionality.

Written part

Turn in answers to the following questions:

1. Describe the details of your implementation: anything that was not straightforward. One thing in particular is how you determined which cells are in the interior or on the arc of the SONAR cone.
2. Describe your results: qualitatively, how good are the maps? Describe the method you used to compare the maps with the actual world? How good are the maps according to this measure?
3. How would you use these maps for motion planning? (Describe details of your proposed approach.) Are the maps good enough to plan an obstacle free path under your approach?

Dempster-Shafer based mapping

The model of the SONAR is:

- For cells on the arc of the sonar cone:
  - The probability of being full is based on the assumtions that a single occupied cell is responsible for the reading and that we consider each cell equally likely to be full.

    $$P_F(i,j) = \frac{1}{n}$$

    where n is the number of cells on the arc.
  - There is no evidence that these cells are empty, so

    $$P_E(i,j) = 0$$

- For cells within the cone:
  - The probability of being empty is assumed to be equal over all the cells.

    $$P_E(i,j) = \rho$$

    [Although it is not quite clear from Pagac et al. [**?**], it appears that they take $\rho = \frac{1}{n}$ where n is the number of cells on the arc.]
  - There is no evidence that these cells are full, so

    $$P_F(i,j) = 0$$

SONAR readings are incorporated into the current map by the following equations:

- for the new empty probability of a cell:

$$m_m \oplus m_s(E) = \frac{m_m(E)m_s(E) + m_m(E)m_s(\{E,F\}) + m_m(\{E,F\})m_s(E)}{1 - m_m(E)m_s(F) - m_m(F)m_s(E)}$$

- for the new full probability of a cell:

$$m_m \oplus m_s(F) = \frac{m_m(F)m_s(F) + m_m(F)m_s(\{E,F\}) + m_m(\{E,F\})m_s(F)}{1 - m_m(E)m_s(F) - m_m(F)m_s(E)}$$