The Robot Doctor

Episode 107: Robot Sensing

Common Core Standards:

- Probability:
    - Describe events as subsets of a sample space (the set of outcomes) using characteristics (or categories) of the outcomes, or as unions, intersections, or complements of other events ("or," "and," "not").
    - Conditional Probability:
        - Recognize and explain the concepts of conditional probability and independence in everyday language and everyday situations. For example, compare the chance of having lung cancer if you are a smoker with the chance of being a smoker if you have lung cancer.
        - Understand the conditional probability of A given B as P(A and B)/P(B)
        - Find the conditional probability of *A* given *B* as the fraction of *B*'s outcomes that also belong to *A*, and interpret the answer in terms of the model.
        - Apply the general Multiplication Rule in a uniform probability model, P(A and B) = P(A)P(B|A) = P(B)P(A|B), and interpret the answer in terms of the model.
        - Bayes' Theorem (without getting into where it comes from)
    - Construct and interpret two-way frequency tables of data when two categories are associated with each object being classified.
    - Total Probability

Review:

Robots keep track of position of obstacles on a map

Each cell on the map is either free, an obstacle, or unknown. Some cells we haven't seen yet, others we have a reflection from, and yet others had the sensor beam travel through them without detecting anything.

Since the sensors have some error, we track the probability that each cell is occupied instead of just the binary option of free or occupied.

We use conditional probability to keep track of this. We want the probability of their being an obstacle given that there was or was not a return from that cell.

$$p(obstacle|return)$$

However, what we typically have from our sensor specifications is the probability of getting a return if the cell has an obstacle (true positive rate) and the probability of getting a return when the cell is clear (false positive rate).

$$p(return|obstacle) \text{ or } p(return|clear)$$

Since we either get a return or we don't, we know that the probability of not getting a return is one minus the probability of getting a return for each case.

$$p(return|obstacle) = 1 - p(no\ return|obstacle)$$

We can also calculate the probability of getting a return from both cases by taking the probability of each event multiplied by the probability of that event happening.

$$p(return) = p(obstacle) \cdot p(return|obstacle) + p(clear) \cdot p(return|clear)$$

This leads us to Bayes' Theorem

$$p(cell_{new}) = \frac{p(obstacle) \cdot p(cell_{old})}{p(return)}$$

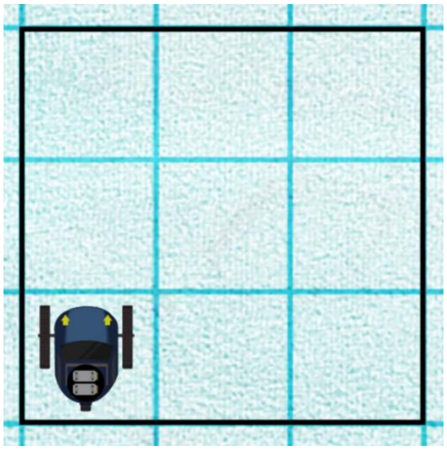
Challenge Questions

Start with a 3m by 3m grid with 1m cells as shown. The robot is in the center of the bottom left cell.
Initially the map has a value of 50% for all cells. Use:

$$p(return|obstacle) = 80\%$$

And

$$p(return|clear) = 10\%$$



1. The robot gets a lidar return from the bottom right cell – Which cells will have a change in value?
2. What are the updated values for each cell?
3. If the robot gets a second return from the bottom right cell, what are the updated values now?