Project 2: Intruder Alert

01:198:440

It is another day on the deep space vessel *Archaeopteryx*, and you are a lonely bot. You're responsible for the safety and security of the ship while the crew is in deep hibernation. As an example, in the case that the ship picks up a deep space mouse, it is your responsibility to catch it and release it back into the wild (they can survive in the vacuum of space for up to 10,000 years).

1 The Ship

The ship layout is as in Project 1. For the purpose of this project, set the dimension to 40×40.

2 The Bots

The bot occupies an open cell somewhere in the ship (more on this in a moment). The bot can move to one adjacent cell every timestep (up/down/left/right). The bot has access to sensor data, that measures how close the deep space mouse is. The bot needs to utilize this sensor information to locate and reach the mouse as quickly as possible (before it chews on life support cables, for instance). The bot will start at a randomly selected open cell in the ship. The bot knows/can sense when it enters the cell the mouse is located in.

> At each timestep - the bot must choose whether to **move** or to **sense**.

The mouse sensor works as follows - the bot has a sensor that, when activated, gives a beep if it detects a mouse. The nearer the bot is to the mouse, the more likely it is to give a beep. Note that if the bot stays in place, it may receive a beep at some timesteps, and not at others (because of the probabilistic nature). If the bot is d-distance from the mouse (manhattan distance), the probability of receiving a beep is $e^{-\alpha*(d-1)}$, for some $\alpha > 0$. Note that if the bot is immediately next to the mouse, the probability of receiving a beep is 1.

> Note that α sets the sensitivity of the detector. If α is very small, then the probability of a beep is high regardless of distance (the sensor is so sensitive it beeps regardless of where the mouse is in the ship); if α is large, then the probability of a beep is small unless the mouse is very very close to the sensor.

3 The Mice

There are two kinds of mice: stationary mice (they do not move); and stochastic mice (every timestep, they randomly move to an adjacent cell or stay in place).

4 The Bot Strategies

- **Bot 1:** Move to the location with highest probability, sense.
- **Bot 2:** Move toward the location with highest probability, alternate moving and sensing.

- **Bot 3:** Bot of your own design.

> Note, Bot 3 needs to be more interesting/intelligent than a variant of Bot 2 that just senses every two or three moves, or senses twice before moving.

5 Data and Analysis

The purpose of this project is to implement and compare the performance of the three bots. In particular, I am interested in comparing *the total number of actions (move + sense) in order to catch the mice*. Your Bot 3 should aim to be more efficient (on average) than the first two bots. The second goal of this project is to correctly analyze and utilize the sense information with the correct probability calculations. As ever, your writeup needs to effectively communicate your ideas, design choices, calculations, and results.

1) Meet with the TA to discuss your ideas.
2) Suppose the ship had four rooms, A, B, C, D, and the probability the mouse was in each of them was $0.4, 0.3, 0.2, 0.1$. If you looked in room B, and the mouse was not there, what is the probability it is in room A?
3) Given a probabilistic knowledge base of where the mouse is, how should you update your probabilistic knowledge base if the bot sensor gets a beep? Be precise and mathematical.
4) Given a probabilistic knowledge base of where the mouse is, how should you update your probabilistic knowledge base if the bot sensor fails to beep? Be precise and mathematical.
5) Given a probabilistic knowledge base of where the mouse is, how should you update your probabilistic knowledge base if you know the mouse might have moved? Be precise and mathematical.
6) How did you design your Bot 3? Be precise and thorough as to your choices.
7) Evaluate and compare Bots 1, 2, 3 in the case of a stationary mouse: plot their average moves to catch the mouse as a function of α. (How can you find a good range of α values?)
8) Evaluate and compare Bots 1, 2, 3 in the case of a moving mouse: plot their average moves to catch the mouse as a function of α. (How can you find a good range of α values? Does it change?)
9) How does the math change if there are two stationary mice? Two moving mice?
10) Evaluate and compare Bots 1, 2, 3 in the case of two moving mice: plot their average moves to catch the mice as a function of α. (You may assume that after the first mouse is caught, it is removed from the board - reducing the situation to the previous situation.)