Monish Gupta (Evens) and Eric Waugh (Odds)
U1008121 U0947296
CS4300
November 4 2017

Assignment 5 : Lab Report

1. *Introduction*

The Wumpus World Monte Carlo agent assigns probabilities of danger in respect to wumpuses and pits to each cell on its board and will select actions based on cells with the least likeness of danger. The agent uses persistent knowledge about the board that it gains via the agent's percepts to make better guesses about the likeliness of danger at a particular spot (probability of a wumpus or pit). With this comes some questions.

**Question 1:** How does an increase in Monte Carlo samples affect the average score an agent has on boards?

**Hypothesis 1:** As the number of Monte Carlo samples increases the agent will obtain a better and more accurate depiction of the board and so its score should go up on each attempt.

**Question 2:** How does the accuracy (wumpuses killed / arrows shot) of the agent change as the number of trials to the monte carlo method increase?

**Hypothesis 2:** With a greater number of samples onto the monte carlo method, it follows that the agent will have a better picture of the dangers of the board. From this, we can guess that as the amount of monte carlo trials goes up the accuracy of the agent will be higher.

2. *Method*

**CS4300_WP_Estimates** : This function takes in as parameters a stench board and a breeze board, boards that contains stench and breeze information on our agent's perception of a the board as well the number of trials to the monte carlo agent. The function starts out by generating a random board with a certain probability that a cell will contain a pit at that location, this is initially set to 20%. Along with the percentage we can guarantee that there will be a wumpus and a gold on each of these boards. Next, we see if the breeze and stench knowledge is satisfied by the generated board meaning that if a pit on the generated board exists then the existing breeze knowledge should be consistent with that pit location, this process also checks wumpuses with stench knowledge. If a generated board checks out with the agent's knowledge we increment a success count. From here, each spot that was a pit or wumpus on the generated board gets incremented on the resulting wumpus and pit estimates board. At the end of our amount of trials, or if we hit the success threshold via the number of trials we pass in we divide each board, the resulting boards, by our success count (in matlab this operation divides each cell by the count).

**CS4300_MC_Agent :**

The Monte Carlo agent follows a set of procedures with priority. It first uses percept knowledge to update the agent's persistent knowledge of the board that it is traversing. After, it consults CS4300_WP_Estimates to get probabilities of danger on each of the

spots. If there exists a safe spot from these probabilities (a spot in which both wumpus probabilities and pit probabilities is zero) the agent will plan a route to visit each of these safe spots and store this plan within a persistent variable to be popped off if this queue isn't empty. If there are no more safe spots to visit, upon the next call to CS4300_WP_Estimates a board is formed by taking the maximum of each cell from the two boards and converging the result into a single board. From here we take the cell with the smallest percentage on the frontier, the neighbors of the outermost visited cells, and visit that cell. If we come across a CS4300_WP_Estimates that yields a 100% probability on a cell on the wumpus estimates board we plan a route to shoot the wumpus from a safe spot. If at any point the agent finds that its litter percept is 1 (the agent is on the gold), it will discard its old plan and plan a route to the gold. The agent should continue roaming the board until it finds a gold. If the gold is unreachable the agent will succumb to choosing a cell that is highly dangerous (even guaranteed) and will likely

3. *Verification*

To verify our WP_Estimates function we will compare these given probabilities from breezes and stenches to what our functions generates.

```
1c.     breezes                pit probabilities

-1    -1    -1    -1           0.2 0.2 0.2 0.2
-1    -1    -1    -1           0.2 0.2 0.2 0.2
-1    -1    -1    -1           0.0 0.2 0.2 0.2
 0    -1    -1    -1           0.0 0.0 0.2 0.2

      stenches                 Wumpus probabilities

-1    -1    -1    -1           0.0 0.0 0.0 0.0
-1    -1    -1    -1           0.0 0.0 0.0 0.0
-1    -1    -1    -1           0.5 0.0 0.0 0.0
 1    -1    -1    -1           0.0 0.5 0.0 0.0
```

First example Values

```
pits =

    0.2160    0.1820    0.2260    0.2260
    0.2100    0.1940    0.2000    0.2140
         0    0.2440    0.2120    0.2360
         0         0    0.2060    0.1920

Wumpus =

         0         0         0         0
         0         0         0         0
    0.5060         0         0         0
         0    0.4940         0         0
```

Our Results with breezes and

```
1d.     breezes                pit probabilities

-1    -1    -1    -1           0.2 0.2 0.2 0.2
-1    -1    -1    -1           0.2 0.2 0.2 0.2
-1    -1    -1    -1           0.5 0.2 0.2 0.2
 1    -1    -1    -1           0.0 0.5 0.2 0.2

      stenches                 Wumpus probabilities

-1    -1    -1    -1           0.0 0.0 0.0 0.0
-1    -1    -1    -1           0.0 0.0 0.0 0.0
-1    -1    -1    -1           0.5 0.0 0.0 0.0
 1    -1    -1    -1           0.0 0.5 0.0 0.0
```

```
pits =

    0.1671    0.1923    0.2054    0.1970
    0.3427    0.1858    0.1933    0.2092
         0    0.8301    0.1914    0.1839
         0         0    0.3445    0.1746

Wumpus =

    0.0906    0.1008    0.0924    0.1139
         0    0.1092    0.0971    0.1139
         0         0    0.0878    0.0962
         0         0         0    0.0980
```

stenches

| 1e. breezes | | | | pit probabilities |
|---|---|---|---|---|
| -1 | -1 | -1 | -1 | 0.2 0.2 0.2 0.2 |
| -1 | -1 | -1 | -1 | 0.3 0.2 0.2 0.2 |
| 1 | -1 | -1 | -1 | 0.0 0.8 0.2 0.2 |
| 0 | 1 | -1 | -1 | 0.0 0.0 0.3 0.2 |

| stenches | | | | Wumpus probabilities |
|---|---|---|---|---|
| -1 | -1 | -1 | -1 | 0.1 0.1 0.1 0.1 |
| -1 | -1 | -1 | -1 | 0.0 0.1 0.1 0.1 |
| 0 | -1 | -1 | -1 | 0.0 0.0 0.1 0.1 |
| 0 | 0 | -1 | -1 | 0.0 0.0 0.0 0.1 |

Second example Values

pits =

| | | | |
|---|---|---|---|
| 0.2273 | 0.1923 | 0.2098 | 0.2273 |
| 0.2063 | 0.2552 | 0.2133 | 0.1958 |
| 0.4930 | 0.2133 | 0.2063 | 0.1993 |
| 0 | 0.5070 | 0.2063 | 0.2203 |

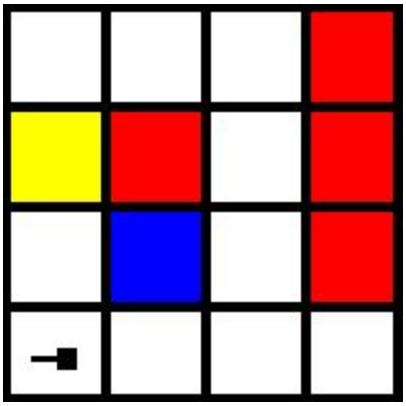
Wumpus =

| | | | |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 |
| 0.5070 | 0 | 0 | 0 |
| 0 | 0.4930 | 0 | 0 |

Our Results with breezes and stenches

Third example Values

Our Results with breezes and stenches



Board to Verify

Since the starting location of the agent is always marked as safe, the agent will check its precepts. Since there is no stench and breeze on our current spot we can assume (1,2) and (2,1) are safe. The agent decides to visit (1,2) first. Here, the agent picks up a stench and decides not to proceed up again because it is unsure that it is safe, so it proceeds to its other safe spot (2,1). At this location we also pick up a stench! Wumpus Estimates deems (2,2) as guaranteed to have a wumpus. Now, the agent can shoot the wumpus from either (2,1) or (1,2). Shooting the wumpus at (2,1) yields a shorter route. After the wumpus is successfully shot the spot is deemed clear and can proceed to (2,2) or (3,2). Proceeding to (3,2) lies a gold! We now plan a route that grabs the gold and heads down to (1,1) to climb out of the board.

Real Actions Taken by Agent : [3,1,3,3,1,3,1,3,3,1,2,1,2,5,3,1,4,3,3,1,1,6]

4. *Data and Analysis*

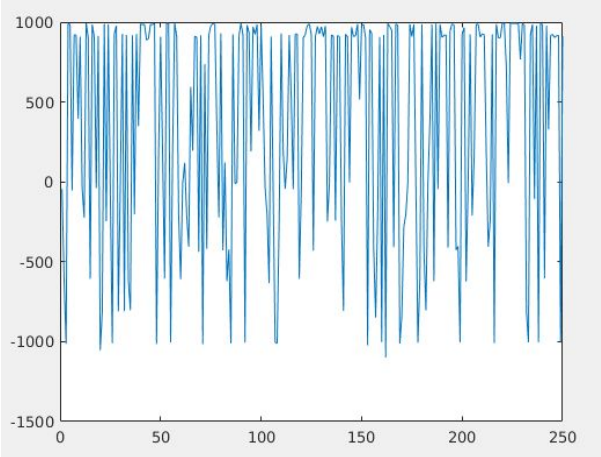
We are going be running the 250 boards provided and taking data on them with extra data to answer our wumpus killed related question.

All boards ran once

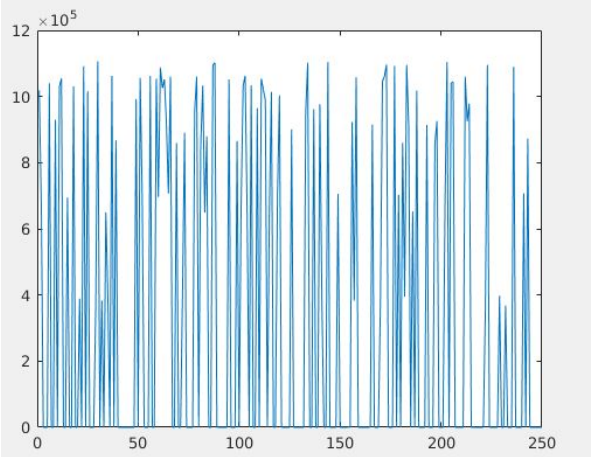
| | Mean Score | Number of Success | Number of Failures | Variance of Score | 95% Confidence interval of Score | % of successful arrows and arrows shot |
|---|---|---|---|---|---|---|
| No MC (Astar_AC) | -215.59 | 91 | 159 | 8.8553e+5 | -1.7636e+3 to 1.332e+3 | N/A |
| 50 Samples | 378.62 | 177 | 73 | 8.2422e+5 | 2.85037e+2 to 1.530e+3 | 100% |
| 100 Samples | 391.904 | 179 | 71 | 8.7842e+5 | 2.92558e+2 to 1.581e+3 | 100% |
| 200 Samples | 359.26 | 175 | 75 | 7.8247e+5 | 2.93590e+2 to 1.475e+3 | 100% |

*N/A does not shoot in this agent

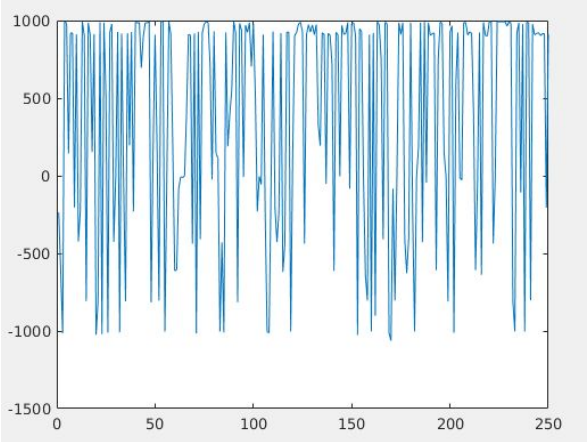
Running all the boards 10 times and taking avg score and variance for each one.



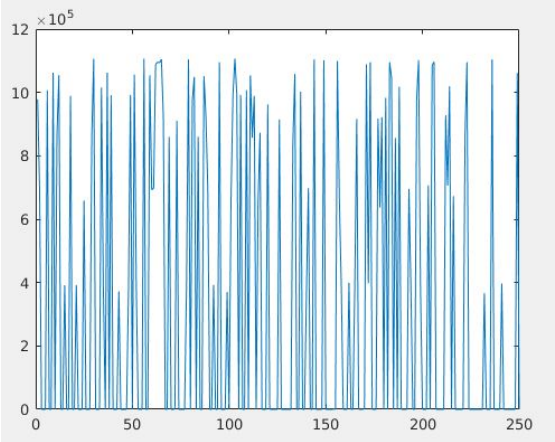

Avg Score 50 trials



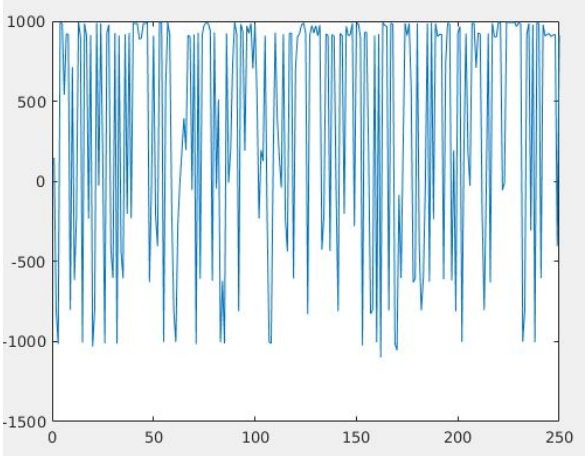

Variance of score 50 trials



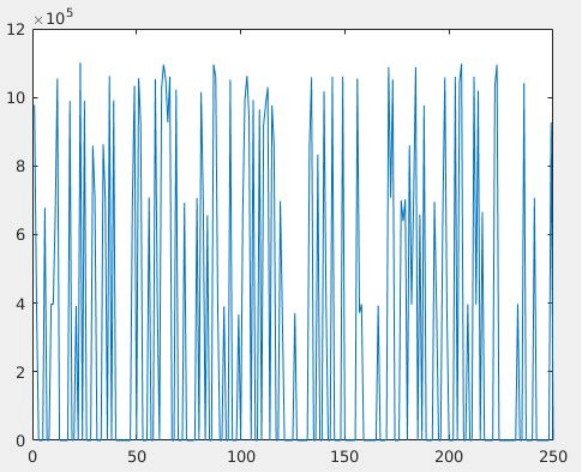

Avg Score 100 trials




Variance of score 100 trials




Avg Score 200 trials




Variance of score 200 trials

5. *Interpretation*

We can interpret that changing the pit percentage did not change anything significantly to our data besides that we occasionally missed. Besides for that looking at the data with the number of samples we can see that our agent was smart and it did not change the percentage of times he killed the wumpus since he would only shoot at it when he was confident it was a wumpus. In terms of being successful it was not conclusively better to have more samples even though in theory it would be but this just mattered on our agent taking a risk when he didn't know much and how lucky he was with this.

When looking at our average scores and variance for different number of trials we can see that it supports our theory that as the number of trials increases we will more likely being able to complete boards proven by our larger average scores. If we look at our variance we also have more cases of it being really low or zero showing that our agent is really consistent with it estimations and guessing correctly. Overall the increase in num trials will help our agent have more accurate data due to more proper estimates.

6. *Critique*

   Surprisingly, not much changed with respect to data as the pit percentage change in CS4300_WP_Estimates. It seemed as though now the agent is missing with its arrows some of the time, but even that seldom happens. Throughout this experiment, it seemed that improvements could be made to CS4300_WP_estimates. Improvements such as tweaking the maximum threshold on generating boards or even sampling with a higher number of trials passed in. Overall, the Monte Carlo method proved very effective. On one board, with pits all around the wumpus, the agent still managed to explore all spaces on the board and infer that a wumpus was on spot that was unreachable. If this experiment was tried again at a later time, it would be necessary to look back on the MC agent itself as there may have still been some optimization to be made allowing for a bigger range of testing and data collection.

7. *Log*

   Monish:

   Assignment: 15 hours
   Lab: 3 hours

   Eric:

   Assignment: 17 hours
   Lab: 3 hours