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CS 4300 - 001

1 September 2016

Assignment A1: Random Actions in Wumpus World

1. INTRODUCTION

A Wumpus World is a simulated environment where an agent must reach a goal without being caught by a Wumpus. In the environment, a Wumpus World consists of a 4x4 board with an agent, a variable number of pits, a Wumpus, and a goal which is represented by gold. This system allows to test the rigour of an agent that performs random actions. The purpose of this paper is to provide a mathematical and experimental analysis of the probabilities for a random agent to reach the goal on a solvable board.

The algorithm used for this agent is based on random actions from the set of:

$$A = \{FORWARD, RIGHT, LEFT\}$$

Where *FORWARD* is moving forward, *RIGHT* is turning right, and *LEFT* is turning left. Actions are determined randomly by MATLAB's rand function. The robustness of this agent can be tested with multiple simulations to determine how effective it is as rudimentary artificial intelligence

2. METHOD

To verify the data obtained, The method for this experiment was to create a program that can run a large number of data samples. The program was created to check the frequency of boards solved while varying the number of pits, thereby creating a new board every time. For each selected number of pits, a large number of boards was checked to observe close to all possible boards.

To test the an agent that picked an action at random to move around in the world, the board was kept to a constant configuration. This agent was then run against a large number of trials to observe the number of steps taken and whether or not it reached the gold.

3. VERIFICATION OF PROGRAM

To verify the program, three special cases are considered to confirm that the program is correct. The case where the board has 0 pits, the case where the board has 1 pit, and the case where the board has 14 pits.

For 0 pits, the only unsolvable boards are where the Wumpus placed on the agent. However, the gold can still spawn on the remaining 15 spaces, making the total number of unsolvable boards 15. The total number of boards that can be generated with 0 pits is given by:

$$P(n,\ r)\ = P(16,\ 2)\ =\ 240\ \textit{boards}$$

Denoting 16 board spaces and a generation of ordered subset of 2 elements. Thus the percentage of solvable boards is given by:

240-15 = 225/240 = **93.75%**

For 1 pit, there are three cases where the board is unsolvable. The first case is when the agent is placed at the same position as a Wumpus. However, the positions of the pit and gold can still vary. Therefore, while varying the pit and gold, the number of unsolvable boards is given by:

$$P(n,\ r)\ = P(15,\ 2) = 15*14 = 210\ \textit{unsolvable boards}$$

Further, to calculate the number of boards while the agent is placed at the same position as the Pit, the same number of possibilities exist. Therefore:

$$210*2 = 420 \textit{ Total unsolvable boards}$$

The second case is when the agent, at start position, is surrounded (above and to the right) by a wupus and pit. For all unsolvable boards the Wumpus and pit will always be at (2,1) and (1,2) blocking any movement from start position. Therefore, there are 13 other positions for gold. Taking into consideration both positions for the Wumpus and pit number of unsolvable boards for this case is given by:

$$(13*2) = 26 \textit{ boards}$$

The third case is when the Wumpus and pit block all possible paths to the gold. This case occurs like the previous case, but the pit and Wumpus block the gold instead of the agent in the other three corners of the board.

For the 3 possible corners of the board the 2 permutations of the Wumpus and pit is given by:

$$(2*3) = 6 \textit{ boards}$$

In conclusion, the total unsolvable boards is given by: 420+26+6 = 452

All possibilities of board permutations with 1 pit is given by:

$$P(n,\ r)\ = P(16,\ 3)\ (16*15*14) = 3360$$

By considering the variations of the positions of Gold, Wumpus, and 1 pit total solvable boards is given by subtracting unsolvable boards from total boards: 3360 - 452 = 2908 *boards*

Therefore, The percentage of solvable boards is:

2908/3360 = **86.5476%**

For 14 pits, the only solvable boards are when the gold is positioned at the start position. However, the Wumpus can still spawn on the remaining 15 spaces, making the total number of solvable boards 15. The total number of boards that can be generated with 14 pits is given by:

$$P(n,\ r)\ = P(16,\ 2)\ =\ 240 \textit{ boards}$$

Denoting 16 board spaces and generation of an ordered subset of two elements. Thus, the percentage of solvable boards is given by:

$$15/240 = 1/16 = \mathbf{6.25\%}$$

4. DATA AND ANALYSIS

4.1 Solvable Board Data

The table below shows the mean, variance and 95% confidence interval of solvable boards for each 0≤p≤14. The data was collected for 1000 boards for each value of p.

Data for 1000 Generated Boards				
Pit Count	Mean	Variance	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
0	0.938	0.0582	0.9254	0.9506
1	0.882	0.1042	0.8652	0.8988
2	0.769	0.1778	0.7471	0.7909
3	0.656	0.2259	0.6313	0.6807
4	0.54	0.2486	0.5141	0.5659
5	0.384	0.2368	0.3587	0.4093
6	0.288	0.2053	0.2644	0.3116
7	0.214	0.1684	0.1927	0.2353
8	0.194	0.1565	0.1734	0.2146
9	0.136	0.1176	0.1182	0.1538
10	0.111	0.0988	0.0947	0.1273
11	0.103	0.0925	0.0872	0.1188
12	0.072	0.0669	0.0585	0.0855
13	0.065	0.0608	0.0522	0.0778
14	0.062	0.0582	0.0494	0.0746

Figure 1: Data for 1000 Generated Boards

Seen above in Fig 1., the mean value for number of pits of 0,1 and 14 are very close to the manual calculation provided in section 3. Further, for the 95% confidence intervals, it is observed hat for the 1000 boards generated for 0 pits, between 92.5% and 95% of the boards were solved. Similarly, the data for 1 and 14 pits can be seen above. It is also observed that the mean number of solved Boards decreases when pits increase, as expected.

4.2 Random Agent Data

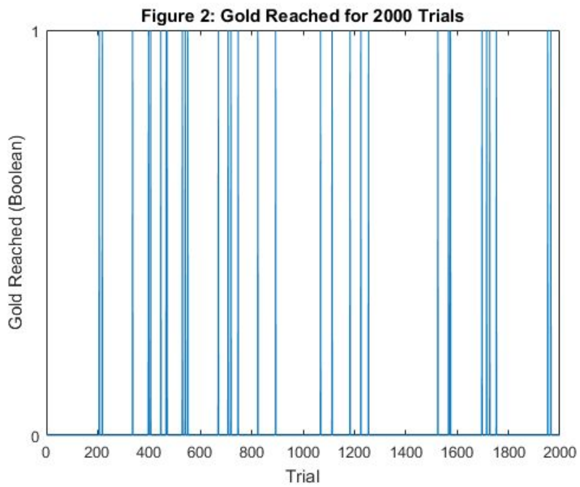

Figure 2: Reaching the gold

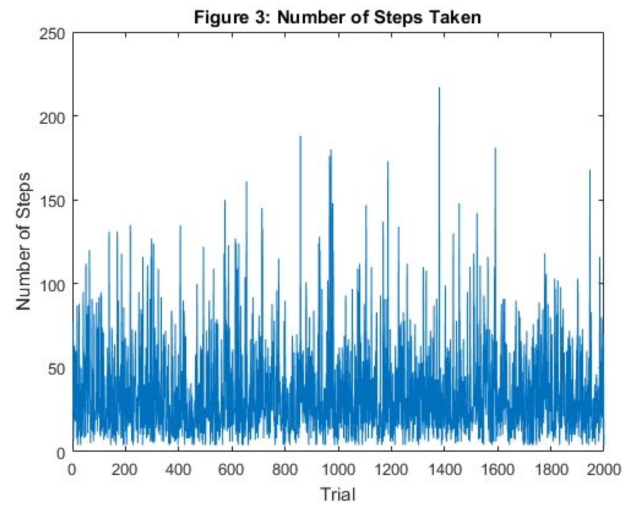

Figure 3: Number of steps

The data in the above graphs [Figure 2 & 3] represent the behavior of the random agent. The agent was tested for 2000 trials against the given board [Figure 4]. The graph for the number of steps shows the random nature of the agent due to the highly varying number of steps for the trials.

Statistics for Random Agent using 2000 Trials		
Values	Gold Reached	Steps Taken
Mean	0.0150	34.4570
Variance	0.0148	700.0362
95% Confidence Interval Lower Bound	0.0105	33.4838
95% Confidence Interval Upper Bound	0.0195	35.4302

Figure 4: Random Agent Statistics

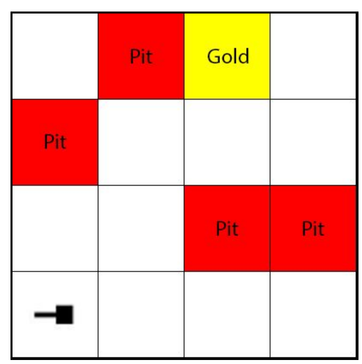

Figure 5: Board Layout

5. INTERPRETATION

In table for Random Agent Statistics [Figure 4], it is observed that the random agent reaches the goal about 1.5% of the time with an average of 34.457 steps. However, the variance on the number of steps is 700.0362, which is why the graph for Number of Steps Taken [Figure

3] has so many spikes in values. The variance for number of steps also lies outside of the lower and upper bounds for our 95% confidence interval, which implies the random agent is not an effective program to find the goal in the given board [Figure 5]. A 1.5% chance of success can also be seen in the graph for Gold Reached [Figure 2], where there are large gaps between successful trials.

6. CRITIQUE

While writing the simulation code, it was very important to take into consideration the simulation concept of trials. Calculating the statistical data became more accurate when averaged over number of trials to produce all possibilities of the experiment.

As for the Agent, with the limited requirements of randomized movement and limited capabilities, the agent was not necessarily reactive to its surrounding in any way. The problem is that the agent currently ignores the raw data and percept provided. This becomes the cause for a very wide range of random data. The suggestion to this would be to develop an agent that reacts to percept. This data would then help narrow down to an Agent that will in turn use the most effective way(which in this case, was number of steps) to get to the gold.

7. LOG

Conan: I spent 3 hours on Part 1 and 2.5 hours on Part 2.

Rajul: I spent 3 hours on Part 1 and 2.5 hours on Part 2.