CS 440
Spring 2021

Project 3: Search and Destroy
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1 Question 1

Bayes theorem: $P(A \mid B) = \frac{P(B|A)P(A)}{P(B)}$

Let $Target\ in\ Cell_i = Target$

Let $Failure\ in\ Cell_j = Failure$

Probabilities that we know: $P(Failure\ in\ Cell_j|Target\ in\ Cell_i)$

Note: When i==j, Failure == $FNR(Cell_i)$

$P(Target\ in\ Cell_i)$

$$P(Target \mid Observation\ \wedge Failure)$$
$$= \frac{P(Observation \wedge Failure \mid Target)P(Target)}{P(Observation \wedge Failure)}$$
$$= \frac{P(Observation \mid Target)P(Failure \mid Target)P(Target)}{P(Failure)P(Observation)}$$
$$= \frac{P(Target \mid Observation)P(Failure \mid Target)}{P(Failure)}$$
$$= \frac{P(Target \mid Observation)P(Failure \mid Target)}{P(Failure \wedge Target) + P(Failure \wedge \neg Target)}$$
$$= \frac{P(Target \mid Observation)P(Failure \mid Target)}{P(Target)P(Failure|Target) + P(Failure|(1 - Target))P(1 - Target)}$$

The above essentially uses Bayes Theorem and transform them in to probabilities that are easier to evaluate and in this case values we know listed above

2 Question 2

$$P(Target\ found\ in\ Cell_i|Observations_t)?$$
$$= P(Target\ is\ inCell_i \wedge Success\ in\ Cell_i|Observation)$$
$$= P(Success\ in\ Cell_i|Target\ is\ in\ Cell_i)P(Target\ is\ in\ Cell_i|Observation)$$

3 Question 3: Performance

We ran each agent 100 times to obtain the average data for score, number of searches, and distance traveled for each agent and each terrain type. Figure 1, 2, 3, 4, and 5 shows all the data graphed.

Figure 1 and 2 shows the performance of agent 1, 2 and 3. For this section we will only focus on agents 1 and 2.

Shown in figure 1 the overall, agent 2 performs better than agent 1. From figure two we see that agent 2 performs better. Performance Score is search time + distance traveled and lower the score better means better the agent performs. Figure 2 shows the break down comparison of the search time and distance between agent 1 and 2, and as one can see, agent 2 has

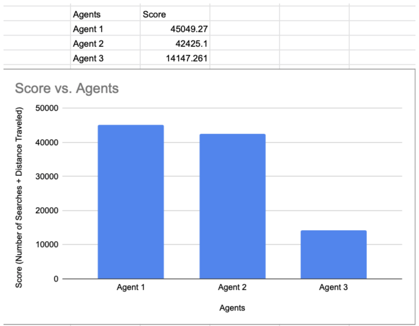

Figure 1: Agents' scores

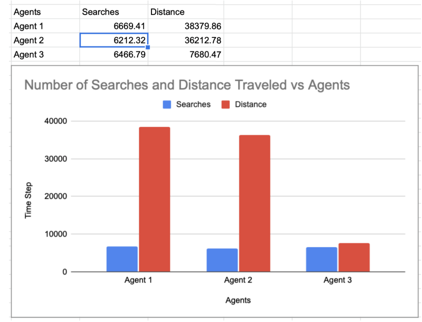

Figure 2: Agents' search and distance

a lower search time and lower travel distance compared to agent 1. Hence agent 2 has a lower score than agent 1 meaning that agent 2 has better performance than agent 1.

Outside of comparing agents, it is to note that both agents search time and distance value are relatively similar to one another.

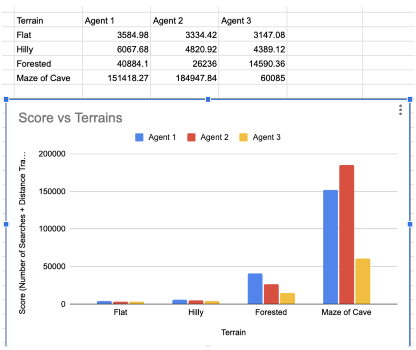

Figure 3: Agents' score per terrain

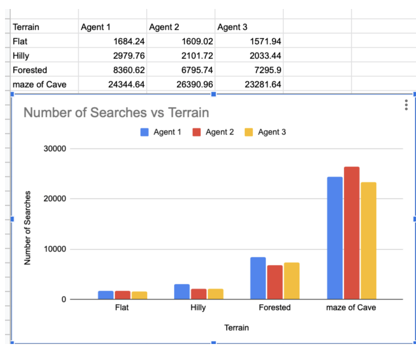

Figure 4: Agents' search per terrain

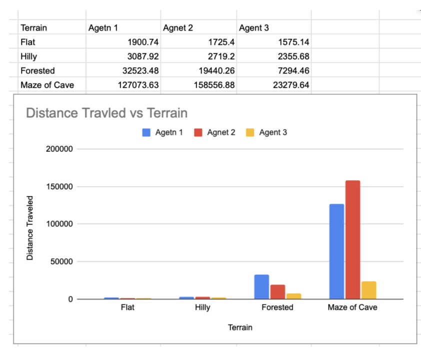

Figure 5: Agents' distance per terrain

Figures 3, figure 4, and figure 5 above shows further break down of how each agents performs in score, search time and distance by terrain type. Once again, only the results for agent 1 and 2 will be discussed in this section as agent 3 is not relavent in this question.

Figure 3 shows agents' score vs terrain, and it shows that agent 2 has better performance then agent 1 for all terrain type except the terrain type of 'maze of caves'. For the 'maze of caves' terrain agent 1 has better performance then agent 2.
Figure 4 and 5 shows number of searches vs terrain and distance traveled vs terrain respectively both of which reflects the results from figure 3 where agent 2 is better then agent 1 on all terrain except of 'maze of caves' terrain.

4 Question 4

Agent3 essentially goes for the highest probability given the amount of distance it has to travel to a given cell. It is represented as $\frac{P(Success\ in\ cell_i)}{Distance\ travel\ from\ current\ cell}$

Initially, a variable called maxValue is assigned to -1. The goal of this variable to to record the largest value that given from the formula above inside the confidence dictionary(since we know that confidence generally does better than belief). There is also a Value dictionary takes the max value as a key and as for the value of the key value pair,we insert an empty list and populate that empty list with cells with the same value.We iterate the entire confidence dictionary to find new maxValue. When we encounter a new max value, we will remove the old max value key from the value dictionary and replace it with a new list that will be populated with cells of similar value. At the end of this iteration, we will take the list contained in valueDict[maxValue] and randomly select a index to query. This way we ensure that we get the biggest bang for buck(distance) while not limited the choices found to order discovery.

This seems to work because it accounts for minimal distance for the greatest amount of probability of success.

As shown in figures 1, 2, 3, 4, and 5 above agent 3 performs better then agents 1 and 2 on all metrics measured. It is to note that the number of searches agent 3 did on average is not consistently any better than agent 1's and 2's number of searches. However, agent 3's travel distance is consistently less then agent 1 and 2 and hence the the score, which is distance+searches, for agent 3 is less then agent 1 and 2, meaning agent 3 has better performance than agent 1 and 2.

One way to improve this agent is to work on someway to probe the amount of calculations this agent requires. This agent calculates the entire grid cell by cell and compares it with each other. This causes several N*N calculations each time we query a cell. Given more time and computation, a cool away to improve on this is to simply add more agents, with more agents, we can gather information faster and the more info we get, the faster we can find the target. Another way could be to do something with the probabilities given the information that each terrain type has a 25 percent chance on the grid.

5 Bonus: Moving Target

When the target is moving we have access to the information of if the target is within a Manhattan distance of 5 from the Agent position. Given this information the agent is able to perform a more localized search on a 5x5 grid rather than a 50x50 grid. When the agent is informed that the target is within a distance of 5, the agent will only search within its immediate 5x5 region. And then normalizing the probability of a cell containing the target and the probability of finding the target in a cell for agent 1 and 2 respectively, for the cells within the 5x5 cells. Given the 5x5 region is smaller than the entire map, there would be a higher probability of the agent finding the target.

From the figure 6 above it is shown that agent 2 performs better than agetn 1.

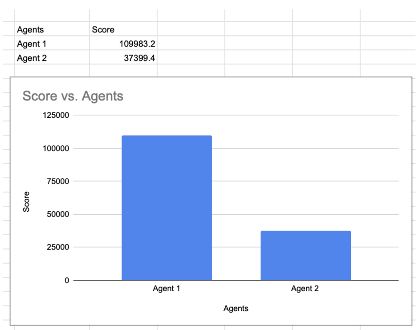

Figure 6: Agents' Score for Moving Target