**Bonus – Agent 9**

Design

The general design for adapting to the moving target involves keeping two belief states: one for time t and one for time t+1. We refer to these as the current and imminent belief states respectively. For each movement into a new cell, Agent 9 examines the cell it’s currently in (no false negatives this time around per Aravind’s suggestion in the Discord server) and sense around in the adjacent 8 neighbors to see if the target is in one of the cells. There are a few scenarios that could unfold:

* The target is found in the current cell, and we terminate the program with success.
* The target is sensed in a neighboring cell and we update the current belief state accordingly.
* The target isn’t sensed in a neighboring cell, and we update the current belief state accordingly.

For the first scenario, it’s simple what happens next.

For the second, we know for certain that the target is in one of the 8 surrounding cells and that the target is not in the current cell nor any other non-neighboring cell in the grid-world. With this in mind, we can update the current and every non-neighboring cell to have a current probability of 0. What happens with the neighboring cells? The simple but misguided answer would be to assign them all a current probability of 0.125. Intuitively, it seems that it could be right, but doing this disregards the prior probabilities that the target was in each of the cells (i.e., if there was a neighboring cell that definitely didn’t contain the target based on our prior path and sensing, why would be lend it more belief?). With this in mind, we simply update the cell’s current probability = cell’s current probability / the neighbors’ collective probability. This is also derived from Bayes’ theorem, where the denominator represents the probability that the target is in one of the neighboring cells, which is simply the addition of all their probabilities together (like a giant OR statement).

For the third scenario, the inverse happens. Now, all of the neighboring cells as well as the current cell are set to a current probability of 0, and we update every other cell. Every other cell’s current probability = that cell’s current probability / (1 – the neighboring cells’ and current cell’s current probabilities). Since we’re in the reverse world, where the scenario in the denominator of Bayes’ equation represents the probability that the cell is not in one of the 9 cells that the agent can immediately see, the denominator is adjusted accordingly.

Now that we’ve updated the current belief state, for the agent to decide where to go next, we have to update the imminent belief state. For this, we recognize that the agent and target can only move in 4 directions (the cardinal directions), and the target has an equal chance of travelling in any given direction. With this in mind, we know that a cell’s imminent probability can be represented by the following:

for all N cardinal neighbors, ∑ P(target is in n currently) / n’s viable neighbors.

By n’s viable neighbors, we recognize that not every cell has 4 options to move to (i.e., a corner, an edge, or adjacent to a blocked cell), so we have to weight the distribution of the probability that the target is currently in that cell accordingly to represent the chance it travels to any of its neighbors.

There are scenarios for finding that a cell is unreachable (either a blocked cell or the agent is blocked from getting there) that’s very similar to the prior agents.

The agent decides where to go next in a very similar way to the other agents as well, but with a twist. The agent looks for the cell with the highest imminent probability of containing the target, seeing as when it moves, those imminent probabilities will now be current, so those drive the decision-making process for the agent.

Last thing for the design discussion is our decision to have Agent 9 examine at every step. Yes, examinations are costly, but what would be more costly is missing the target and having to chase it around for many more iterations. Given that there is a 0% chance the agent will miss the target if it’s in the same cell, we decided that it benefitted the agent more to examine at every step.