Assignment 2: Catch the Wumpus

AI-2 Systems Project (Winter Semester 2024/2025)

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1 Task summary

Your goal is to capture the Wumpus. As the Wumpus has good hearing and hides from people, you decided to use the help of a friend who can remotely create a portal that teleports the Wumpus into your cage. You have different ways of tracking the Wumpus, but unfortunately they are not very precise and you will have to combine the tracking data with your knowledge of how the Wumpus behaves to make an educated guess. You can test and evaluate your implementation on the server[1].

Didactic objectives

1. Gain experience modelling a problem with a non-trivial state space as a hidden Markov model,
2. implement basic algorithms for hidden Markov models,
3. solve various challenges involving probabilistic reasoning.

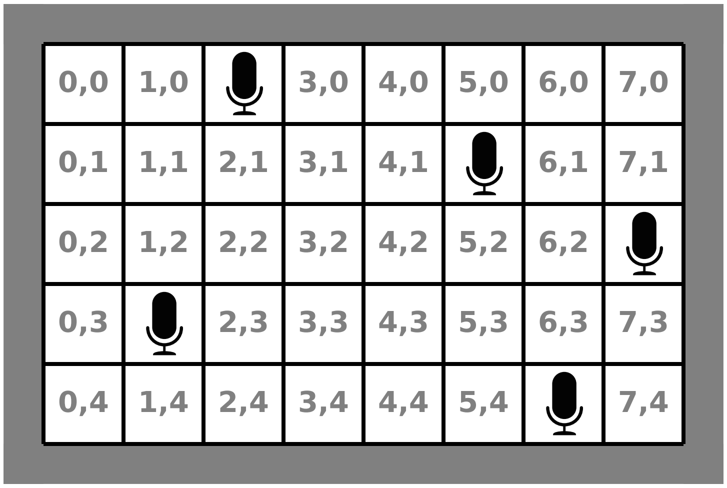
Prerequisites and useful methods

1. Basics of working with probabilities,
2. (hidden) Markov models and their basic algorithms (as covered in the lecture notes).

2 Detailed problem description

The Wumpus (👹) lives in a 8×5 cave (Figure 1). Depending on the environment, you have different ways of tracking the Wumpus: via a precise location tracker, via a GPS tracker or

[1] https://aisysproj.kwarc.info



0,0	1,0	🎤	3,0	4,0	5,0	6,0	7,0
0,1	1,1	2,1	3,1	4,1	🎤	6,1	7,1
0,2	1,2	2,2	3,2	4,2	5,2	6,2	🎤
0,3	🎤	2,3	3,3	4,3	5,3	6,3	7,3
0,4	1,4	2,4	3,4	4,4	5,4	🎤	7,4

Figure 1: The Wumpus cave.

via microphones placed in the cave. After tracking the Wumpus for 10 time steps, you can attempt to catch it with the help of a portal-maker. The portal-maker is only available for 5 time steps. You will have to create the portal within that time and have only one attempt. Creating a portal takes 1 time step, i.e. you have to create the portal in the square where you expect the Wumpus next.

In the following subsections, we will see how the Wumpus moves and how the sensors work.

2.1 Wumpology – how does the Wumpus move?

Every time step, the Wumpus either moves to one of the adjacent squares (north, east, south, west) or stays in its current square. The probability of the Wumpus taking a particular action depends on its previous action:

1. If the Wumpus stayed in its square, there is a $\frac{1}{2}$ probability that it will stay there for another time step. Otherwise, it will move to any of the adjacent free squares with equal probability. Note that the Wumpus cannot leave the 8×5 cave, so if it is e.g. in square $\langle 0, 1 \rangle$, it only has 3 options.
2. If the Wumpus moved in one direction, there is a $\frac{3}{5}$ probability that it will move in the same direction again (if that's possible) and a $\frac{1}{10}$ probability that it will move to the left or right respectively (if possible). Otherwise, it will stay in its square.

Figure 2 illustrates action probabilities with an example. We assume that the Wumpus has previously moved one square north. Then it is most likely ($\frac{3}{5}$) to next move north again,

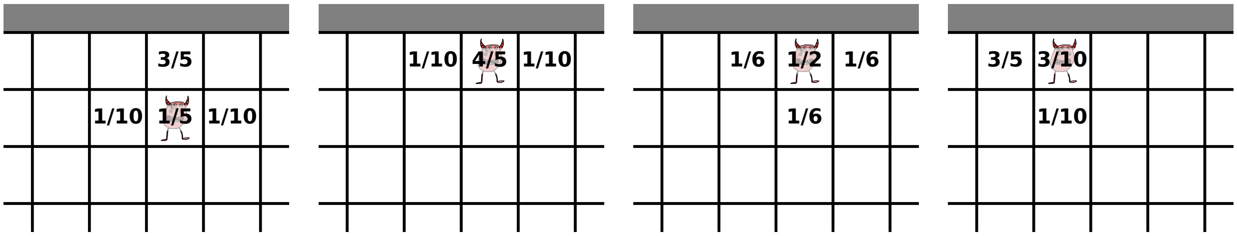


Figure 2: Probabilities of the Wumpus moving in a particular direction.

but there is also a $\frac{1}{10}$ chance that it turns left or right respectively. With the remaining probability ($\frac{1}{5}$), it will stay in its square. If the Wumpus ends up moving north, it reaches a wall, so it has to either stop (probability of $\frac{4}{5}$) or move left or right.

2.2 Sensors

Depending on the environment, you have different sensors to track the Wumpus.

2.2.1 Precise location tracker

The precise location tracker tells the exact location of the Wumpus at any time. It is intended to help you get started.

2.2.2 GPS tracker

The GPS tracker tells you the estimated coordinates of the Wumpus, but it is not very precise. Concretely, it reports the correct coordinates with a probability of $\frac{1}{9}$. It also reports each of the 8 surrounding squares with a $\frac{1}{9}$ probability. It is possible that the GPS tracker reports a square that is outside the cave.

2.2.3 Microphones

During every time step, the Wumpus makes a certain amount of noise, which can be picked up by microphones that were placed in the cave (Figure 1). If the Wumpus moves to a new square, the amount of noise it makes is uniformly randomly distributed over the interval $[1, 10]$. Otherwise, it is much quieter and the noise is uniformly randomly distributed over $[\frac{1}{2}, 2]$. For simplicity, we assume that the Wumpus only makes noise on its new square, i.e. if it moves from $\langle x_1, y_1 \rangle$ to $\langle x_2, y_2 \rangle$, we assume that the noise is produced in $\langle x_2, y_2 \rangle$.

	$P(\text{silent})$	$P(\text{quiet})$	$P(\text{loud})$
$\frac{N}{d^2} \geq 1$	0	0	1
$\frac{N}{d^2} \in [\frac{1}{4}, 1)$	0	$\frac{9}{10}$	$\frac{1}{10}$
$\frac{N}{d^2} < \frac{1}{4}$	$\frac{8}{10}$	$\frac{1}{10}$	$\frac{1}{10}$

Table 1: Reported noise level depends on the amount of Wumpus noise N and the distance d to the microphone.

There are three noise levels that the microphones can report: 0 (silent), 1 (quiet) and 2 (loud). If the Wumpus lands on a square with a microphone, it will report a loud noise. Otherwise, the amount of Wumpus noise that a microphone picks up is $\frac{N}{d^2}$, where N is the amount of noise made by the Wumpus and d is the (Euclidean) distance between the microphone and the Wumpus. The microphone reports quiet or loud noise if it picked up noises above a certain threshold. Sometimes there are random noises in the cave not caused by the Wumpus. Table 1 shows the probabilities for the reported volume depending on $\frac{N}{d^2}$.

In some environments, the precise amount of Wumpus noise is also reported, which can be helpful for debugging.

3 Catching the Wumpus on the server

You should test and evaluate your agent by competing on the server. The rating of your agent is the ratio of successful captures in 1000 consecutive runs. Your agent can communicate with the server via HTTP requests. A Python implementation of the protocol is provided in the assignment repository [AR]. The details of the protocol are described in [CSP], but you will only need them if you want to create your own implementation (e.g. in a different programming language).

3.1 Action requests

The server will send you action requests, which contain an identifier for the request and a JSON object describing the current state of your Wumpus capturing attempt. Here is an example state description:

```
{
  "sensors": [
    {
      "microphones": {
        "2,0": 2, "5,1": 1, "7,2": 1, "6,4": 1, "1,3": 2, "wumpus": 7.873971570789526
      },
      "gps": "3,2"
    },
    {
      "microphones": {
        "2,0": 1, "5,1": 1, "7,2": 0, "6,4": 0, "1,3": 0, "wumpus": 1.844736280968114
      },
      "gps": "3,0"
    },
    ...
  ],
  "remaining-attempts": 5
}
```

sensors lists the sensor history until now. remaining-attempts indicates how many attempts you have left to make a portal.

3.2 Sending Actions

Your agent should respond to an action request by sending an action as a string:

1. send "WAIT" to indicate that you do not want to make a portal yet,
2. send "PORTAL X,Y" to make a portal at the position $\langle$[X], [Y]$\rangle$.

4 What to submit

Your solution should be submitted to your team's repository. It should contain:

1. all your code for solving this assignment,
2. a README.md file explaining
   1. dependencies (programming language, version, external libraries and how to get them),
   2. how to run your code for a server environment,
   3. the repository structure,

iv. anything else we should know,

3. a solution summary (see [SoS] for more details – it should describe the main ideas, not document the code).

5 Points

You can get up to 80 points for the strength of your agent according to the server (assuming it is reproducible). Note that the debug environments are ignored for grading. Assuming you have at least a partial solution, you can additionally get up to 20 points for the quality of the submission (README, solution summary, ...). The maximum number of points is therefore 100. If the grading scheme doesn't seem to work well, we might adjust it later on (likely in your favor).

Figure 3 summarizes how many points you can get for each environment according to the rating on the server. When grading, we will only consider the environment in which you would get the most points.

References

[AR] *Repository for Assignment 2: Catch the Wumpus*. URL: https://gitlab.rrze.fau.de/wrv/AISysProj/ws2425/a2.2-catch-wumpus/assignment.

[CSP] Jan Frederik Schaefer. *AISysProj server – Clients and server protocol*. URL: https://aisysprojserver.readthedocs.io/en/latest/clients.html.

[SoS] *Solution Summary*. URL: https://gitlab.rrze.fau.de/wrv/AISysProj/admin/general/-/blob/main/solution-summary.md.

Config	**Sensors**	**Points**
ws2425-2.2.1.json	tracker	$\begin{cases} 0 & \text{if rating } < 0.5 \\ 20 & \text{if rating } \geq 0.5 \\ 30 & \text{if rating } \geq 0.65 \end{cases}$
ws2425-2.2.2.json	gps	$\begin{cases} 0 & \text{if rating } < 0.2 \\ 30 & \text{if rating } \geq 0.2 \\ 40 & \text{if rating } \geq 0.3 \\ 55 & \text{if rating } \geq 0.4 \end{cases}$
ws2425-2.2.3.json	microphones, wumpus-noise	$\begin{cases} 0 & \text{if rating } < 0.1 \\ 30 & \text{if rating } \geq 0.1 \\ 40 & \text{if rating } \geq 0.25 \\ 50 & \text{if rating } \geq 0.4 \\ 65 & \text{if rating } \geq 0.45 \end{cases}$
ws2425-2.2.4.json	microphones	$\begin{cases} 0 & \text{if rating } < 0.15 \\ 35 & \text{if rating } \geq 0.15 \\ 60 & \text{if rating } \geq 0.3 \\ 75 & \text{if rating } \geq 0.45 \end{cases}$
ws2425-2.2.5.json	microphones, gps	$\begin{cases} 0 & \text{if rating } < 0.3 \\ 40 & \text{if rating } \geq 0.3 \\ 55 & \text{if rating } \geq 0.4 \\ 70 & \text{if rating } \geq 0.45 \\ 77 & \text{if rating } \geq 0.5 \\ 80 & \text{if rating } \geq 0.55 \end{cases}$

Figure 3: Number of points that you can get. Points are awarded for the "real" environments, not the debug environments.