

Assignment 4

Subject

Topics of this session :

1. Constrained Search.
2. Logical Inference, knowledge-based agents.
3. Formalise a problem as a constrained graph search problem.

This assignment is graded and must be submitted (individually) on Moodle before next week's class.

For each exercise, detail your reflexion steps :

- We are mostly interested in your actual thinking process.
- Even if you are unable to solve an exercise, write out what were you reflexion steps.
- For each attempted exercise, a written feedback will be provided.

Reference material : [Artificial Intelligence, A Modern Approach, Chapters 6, 7.](#)

For coding :

- [Noto](#) (Online Jupyter Notebook).
- Any other python coding environment you prefer using.

Exercise 1

Here is an example of how to solve a problem through logical inference :

Example :

- If it rains, then the ground is wet.
- If the ground is wet, then the grass is slippery.
- The grass is not slippery.

Question : Did it rain or not ?

Notations

- Rain : R .
- The ground is wet : W .
- The grass is slippery : S .

Knowledge base Each of the following statements are true :

1. If it rains, then the ground is wet : $R \implies W$.
2. If the ground is wet, then the grass is slippery : $W \implies S$.
3. The grass is not slippery : $\neg S$.

Deduction Using the rule of the contraposition, we have :

$$\neg S \implies \neg W. \quad (1.)$$

$$\neg W \implies \neg R. \quad (2.)$$

Thus, since $\neg S$ is true, **it did not rain.**

Following this example, answer the following questions :

1. Considering the same problem as the one given in the example, let's assume additionally that the ground is wet *only* if the grass is slippery, and that the grass is slippery.

Question : Did it rain or not ?

2. You are trying to catch a train, and you know for a fact that :

- If the train is late, you *will* catch it.
- If the train is on time and you leave on time, you *will* catch it.
- If you leave late, you *will* miss the train.
- You left late.

Question : Can you infer whether the train was late or not ?

3. We are wondering about the relationships between Alice, Bob, and Charlie. We have that :

- If Bob is friends with Charlie, then Charlie is friends with Alice.
- If Alice is friends with Bob, and Charlie is friends with Bob, then Alice is also friends with Charlie.
- If Alice is not friends with Bob, then Charlie is not friends with Alice.
- Bob and Charlie are friends.

Question : Prove whether Alice and Charlie are friends.

4. Your friend is complaining about cramps. You know that they are practicing *only* one of the four possible sports : Swimming, Running, Basketball, or Cycling. You wish to guess which sport they are actually practicing. Let's assume that :

- *Only* Swimming, Running, and Basketball *can* cause cramps.
- Basketball and Cycling *always* make you thirsty.
- Running *cannot* make you dirty *and* thirsty at the same time.

Question : Under which additional condition do you know for sure that your friend practices Basketball ?

Project – Part 2

This whole section must be done in groups of 2-3 people.

Reutilising what we did last week, we will add **constraints** to our problem using **logic**.

1 Guided Project

Dungeon Gridworld This time, we will set a more constrained observation space as well as some logic to our problem.

New Assumptions :

- The goal is to reach the stairs **as quickly as possible**.
- Falling into a hole causes the game to end immediately.
- The agent **has partial visibility**, and only senses adjacent tiles :
 - Whenever the agent is adjacent to a hole, it hears an *Echo*.
 - Whenever the agent hits a wall, it senses a *Bump*.

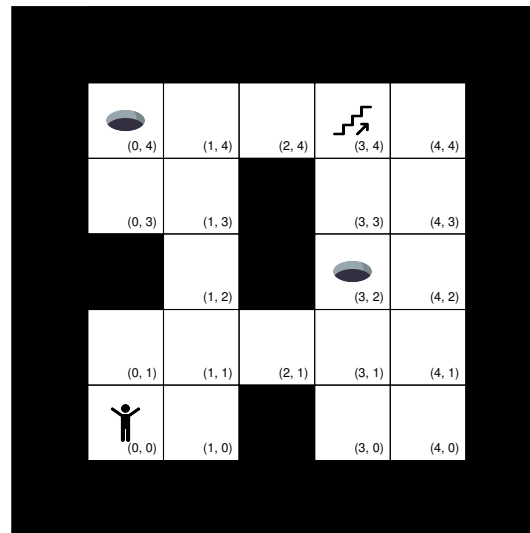


FIGURE 1 – A simple dungeon room with holes. The agent starts at position (0, 0).

- Whenever the agent is in the same row or column as the stairs, it observes *Light*.
- We can write any observation, upon picking an action as $\{e, b, l\}$, where $e = 1$ if the agent hears an *Echo* and 0 otherwise, $b = 1$ if the action resulted in no movements and 0 otherwise, etc.
- additionally, we have the following **constraints** :
 - Holes are *always* on the same row or column as the stairs.
 - The stairs are *never* adjacent to a hole.
 - If a tile is a wall, there *cannot* be any agent, hole or stairs there.

Tasks :

1. Using logic notations, and by introducing appropriate variables, formalise under which conditions the agent sense an *Echo*, a *Bump* and *Light*.
2. Let's say the agent performed the actions $[\uparrow, \uparrow, \rightarrow, \rightarrow, \rightarrow]$. What is the knowledge base of the agent at this point in time ?
3. Let's further imagine that the agent keeps going and performs next $[\rightarrow, \uparrow, \uparrow, \uparrow]$. What is the knowledge base at this point in time ? Enumerate all possible models for tile (3,4).
4. Implement a simple logical inference module (Belief State update logic) using the template code in `dungeon_with_constraints.ipynb`.
5. Implement a simple agent using that inference module (`your_agent()` function in `dungeon_with_constraints.ipynb`).

2 Personal Project

Add some constraints and/or partial observability to your problem, then, if applicable :

1. Using logic notations, and by introducing appropriate variables, formalise the new constraints and/or formalise under which conditions observations are made.
2. Implement and try solving the problem with the added sensing and constraints in Python.