

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

Let's consider a train scheduling problem. We must ensure that connections are all feasible. We assume that a connection between train A and B at station S is feasible if train A arrives at S exactly when B leaves S.

Here are the required connections (this is simplified) :

- The Neuchâtel-Lausanne train must connect to the Lausanne-Geneva and Lausanne-Bern.
- The Lausanne-Geneva train must connect to the Geneva-Versoix train.
- The Bern-Lausanne train must connect to the Lausanne-Geneva.

Here are the possible times for departure/arrival for each trains :

- Neuchâtel-Lausanne : (08 :30/09 :30) – (09 :30/10 :30) – (10 :30/11 :30)
- Lausanne-Geneva : (07 :30/08 :30) – (08 :30/09 :30) – (09 :30/10 :30) – (10 :30/11 :30)
- Lausanne-Bern : (09 :00/09 :30) – (10 :00/11 :30)
- Geneva-Versoix : (09 :30/09 :50) – (10 :00/10 :20) – (10 :30/10 :50)
- Bern-Lausanne : (07 :00/08 :30) – (08 :00/09 :30) – (09 :00/10 :30)

Task :

- Define appropriate variables to formalise the problem.
- Find a valid solution to the problem by drawing a graph.

Exercise 2

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 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. 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** and **logical rules** to our problem.

1 Guided Project

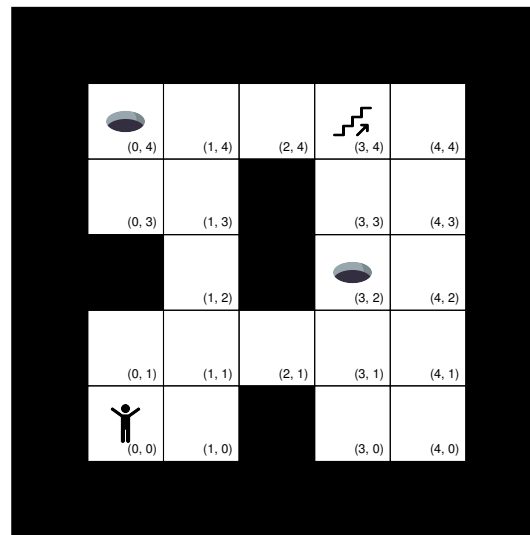


FIGURE 1 – A simple dungeon room with holes. The agent starts at position (0, 0).

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*.
 - Whenever the agent is in the same row or column as the stairs, it observes *Light*.
- Each time the agent picks an action, it observes $\{e, b, l\}$, 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 **rules** :
 - 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 possibilities for tile (3,4) : does it have stairs, a wall, a hole ?

4. Think about one constraint you could have in this problem.

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.