

## 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 :30/11 :00) – (10 :30/12 :00)
- 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 :

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- 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**.

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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 ?

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## 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

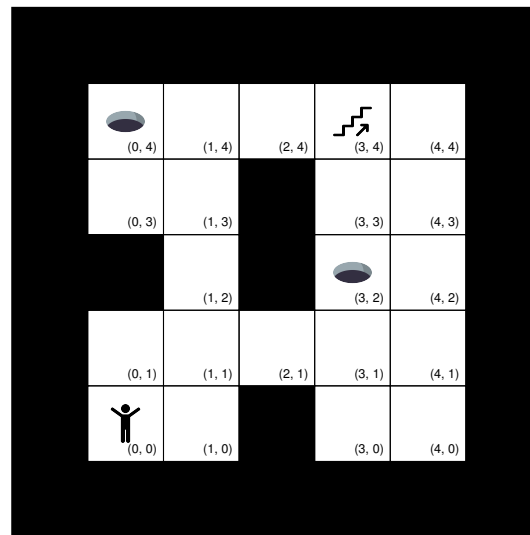


FIGURE 1 – A simple dungeon room with holes. The agent starts at position (0, 0).

**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.