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 assignement 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)

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

Question : Define appropriate variables

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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 :
$\neg S \implies \neg W$. (1.)
$\neg W \implies \neg R$. (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.
   Quesiton : 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

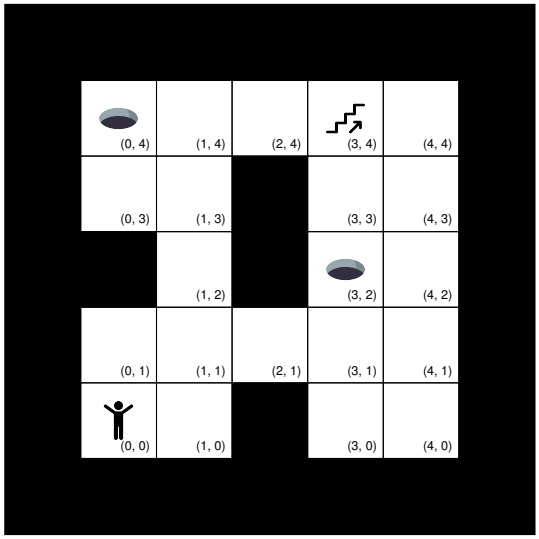

FIGURE 1 – A simple dungeon room with holes. The agent starts at position (0, 0).

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 adjecent 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 [↑,↑,→,→,→]. 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 [→, ↑, ↑,↑]. 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.