

# Assignment 5: Escape the Wumpus Cave

AI-1 Systems Project (Summer Semester 2024)

Jan Frederik Schaefer

Friedrich-Alexander-Universität Erlangen-Nürnberg, Department Informatik

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Author: Jan Frederik Schaefer

## 1 Task summary

Your agent is trapped in the Wumpus world. Find a way for your agent to leave it using a PDDL planner. The assignment repository [[AR](#)] contains maps for you to solve. It also contains a script for checking your solutions.

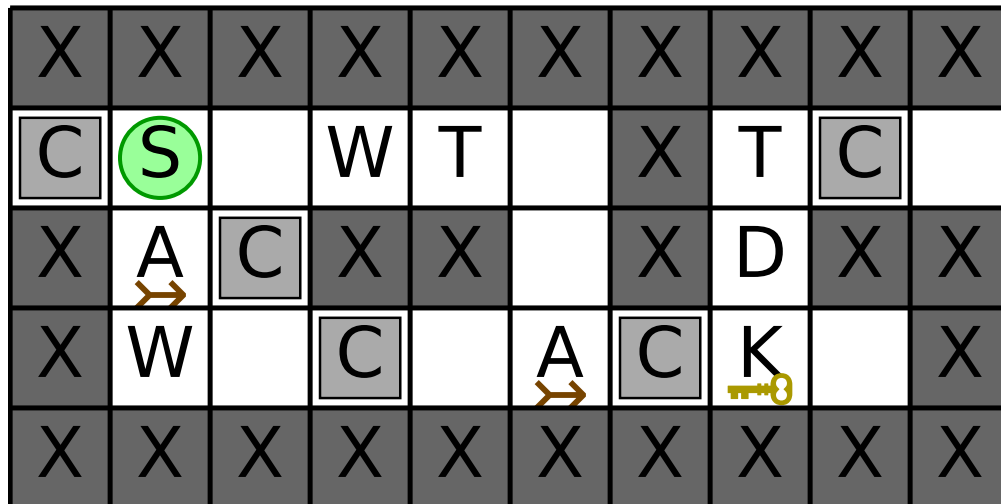


Figure 1: Example map of the Wumpus world.

### Didactic objectives

1. Get to know the PDDL format,
2. learn how to encode a problem as a planning problem.

## Prerequisites and useful methods

1. Planning and the PDDL format.

## 2 The Wumpus world

Maps of the Wumpus world are encoded as a text file, where each line corresponds to a row of cells and each character describes the properties of an individual cell. Here is an example map:

```
XXXXXXXXXX
CS_WT_XTC
XACXX_XDXX
XW_C_ACK_X
XXXXXXXXXX
```

Your starting position is marked with an **S**. Leaving the wumpus world is not easy because cells can be blocked by e.g. walls (**X**) or a wumpus (**W**). Section 2.2 describes the different cells in more detail. Figure 1 shows a visualization of the example map.

### 2.1 Plans

Your plan is a sequence of actions. After performing those actions, your agent should be “off the map”. You can use the following actions:

- **walk** [**north|east|south|west**]: The agent walks to the neighboring cell in the indicated direction. If there is no cell in that direction, the agent has left the map (which is the goal). Whether you are allowed to walk to a cell depends of course on the map – for example, you cannot walk into a wall. Section 2.2 has more details. Note that you cannot walk off a trampoline – you have to jump off instead.
- **push** [**north|east|south|west**]: The agent pushes an object to the neighboring cell in the indicated direction. The agent will also walk one step in the indicated direction. Section 2.2 describes what things can be pushed under what circumstances.
- **shoot** [**north|east|south|west**]: Shoot a Wumpus. This requires a Wumpus to be in the neighboring cell in the indicated direction. You also must have at least one arrow. Afterwards, you have one arrow less and the Wumpus is gone.
- **unlock** [**north|east|south|west**]: Unlock a door. This requires that there is a locked door in the neighboring cell in the indicated direction. You also must have at

least one key. Afterwards, you have one key less and the door is unlocked.

- **jump** [**north|east|south|west**]: If you are on a trampoline, you can jump over a neighbouring cell into the cell behind it. The neighbouring cell may have all kinds of obstacles except for walls. The cell you land on, must “free”, i.e. it must not have any of the obstacles that would normally prevent you from walking onto it.

The agent can jump out of the cave from a trampoline (including if the trampoline is on the edge of the map).

Note that these actions do not have to correspond to the actions that you use for the planning itself. Instead, you can convert the planner actions to the ones above in a post-processing step (however, it should be a fairly simple transformation, i.e. the planner has to do the hard work).

## 2.2 Cell properties

As mentioned earlier, the properties of each cell are summarized by a single character:

- **S**: The starting position of the agent. Otherwise the cell is empty. Note that we also use **S** to mark the current position of the agent in visualizations.
- **␣** (a single whitespace): An empty cell.
- **X**: A wall. Your agent cannot walk into a cell with a wall.
- **W**: A wumpus. Your agent cannot walk into a cell with a Wumpus. However, the Wumpus can be shot with an arrow. Afterwards, the cell is free.
- **A**: An arrow. If you walk into a cell with an arrow, you automatically pick it up (and have one more arrow). Afterwards, the cell is empty.
- **K**: A key. If you walk into a cell with a key, you pick it up automatically (and have one more key). Afterwards, the cell is empty.
- **D**: A (locked) door. You cannot walk into a cell with a locked door. If you have a key, you can **unlock** (see Section 2.1) the door. After unlocking the door, you can treat the cell like an empty cell. Note that you cannot re-use the key for a different door.
- **C**: A crate. Your agent cannot walk into a cell with a crate. However, your agent can **push** (see Section 2.1) the crate to an adjacent cell if the adjacent cell fullfills one of the following conditions:
  - It is empty.
  - It contains only an item that can be picked up. The adjacent cell will then contain both the item and the crate.
- **T**: A trampoline. Your agent can walk to a cell with a trampoline. However, once

on a trampoline, it can only **jump** (see Section 2.1). Your agent can also **push** (see Section 2.1) the trampoline to an adjacent cell if the adjacent cell fulfills one of the following conditions:

- It is empty.
- It contains only an item that can be picked up. The adjacent cell will then contain both the item and the trampoline.

### 3 Planners

You should use a PDDL planner for this problem. PDDL planners require two files: a domain file and a problem file. The domain file should describe the rules of the Wumpus world in general and the problem file specifies the details of a particular map. A planner can then find a plan that solves the problem. The plan may use different actions than the expected solution format, so you can convert the planner output to the expected format in a post-processing step.

The assignment repository [AR] describes different planners that you can use and how to run them.

### 4 What to submit

You should submit

- All your code for solving this assignment.
- A `README.md` file explaining
  - i. dependencies (programming language, version, external libraries and how to get them),
  - ii. what planner you used (there are differences in what PDDL subset they support),
  - iii. how to run your code on different environments,
  - iv. the repository structure,
  - v. anything else we should know.
- A solution summary (see [SoS] for more details – it should describe the main ideas, not document the code).
- Your domain file(s).
- Solutions to all the example maps in the assignment repository [AR]. Concretely, you should submit for every map `mapXYZ.txt` the problem file `mapXYZ.pddl`, the solution of

Maps	Used cell types
map000.txt – map009.txt	S □ X
map010.txt – map019.txt	S □ D K X
map020.txt – map029.txt	S □ A D K W X
map030.txt – map039.txt	S □ C X
map040.txt – map049.txt	S □ A C D K W X
map050.txt – map059.txt	S □ T X
map060.txt – map069.txt	S □ C T X
map070.txt – map079.txt	S □ A C D K T W X

Figure 2: Overview of cell types used in maps.

the PDDL problem `mapXYZ.pddl.soln`, and the actual plan as specified in Section 2.1 listed line by line in a file `mapXYZ-solution.txt`.

## 5 Points

The total number of points for this assignment is 100. You can get up to 20 points for the quality of the submission (README, evaluation, ...). Furthermore, you will get 1 point for every correctly solved map, which means that you can get up to 80 points for the solutions.

## References

- [AR] *Repository for Assignment 5: Escape the Wumpus Cave*. URL: <https://gitlab.rrze.fau.de/wrv/AISysProj/ss24/a1.5-escape-wumpus-cave/assignment>.
- [SoS] *Solution Summary*. URL: <https://gitlab.rrze.fau.de/wrv/AISysProj/admin/general/-/blob/main/solution-summary.md>.

# A Solution to the Example Problem

A solution to the example problem from Section 2 would be:

```
walk south
walk north
walk east
shoot east
walk east
push east
walk east
jump south
push east
push east
unlock north
walk north
walk north
jump east
walk east
```

which could be visualized as

0) Initial state:

X	X	X	X	X	X	X	X	X	X
C	S		W	T		X	T	C	
X	A	C	X	X		X	D	X	X
X	W		C		A	C	K		X
X	X	X	X	X	X	X	X	X	X

→: 0 ←: 0

1) After walk south:

X	X	X	X	X	X	X	X	X	X
C			W	T		X	T	C	
X	S	C	X	X		X	D	X	X
X	W		C		A	C	K		X
X	X	X	X	X	X	X	X	X	X

→: 1 ←: 0

2) After walk north:

X	X	X	X	X	X	X	X	X	X
C	S		W	T		X	T	C	
X		C	X	X		X	D	X	X
X	W		C		A	C	K		X
X	X	X	X	X	X	X	X	X	X

→: 1 ←: 0

3) After walk east:

X	X	X	X	X	X	X	X	X	X
C		S	W	T		X	T	C	
X		C	X	X		X	D	X	X
X	W		C		A	C	K		X
X	X	X	X	X	X	X	X	X	X

→: 1 ←: 0

4) After shoot east:

X	X	X	X	X	X	X	X	X	X
C		S		T		X	T	C	
X		C	X	X		X	D	X	X
X	W		C		A	C	K		X
X	X	X	X	X	X	X	X	X	X

→: 0 ←: 0

5) After walk east:

X	X	X	X	X	X	X	X	X	X
C			S	T		X	T	C	
X		C	X	X		X	D	X	X
X	W		C		A	C	K		X
X	X	X	X	X	X	X	X	X	X

→: 0 ←: 0

6) After push east:

X	X	X	X	X	X	X	X	X	X
C				S	T	X	T	C	
X		C	X	X		X	D	X	X
X	W		C		A	C	K		X
X	X	X	X	X	X	X	X	X	X

>>: 0   ←0: 0

7) After walk east:

X	X	X	X	X	X	X	X	X	X
C				S	X	T	C		
X		C	X	X		X	D	X	X
X	W		C		A	C	K		X
X	X	X	X	X	X	X	X	X	X

>>: 0   ←0: 0

8) After jump south:

X	X	X	X	X	X	X	X	X	X
C					T	X	T	C	
X		C	X	X		X	D	X	X
X	W		C		S	C	K		X
X	X	X	X	X	X	X	X	X	X

>>: 1   ←0: 0

9) After push east:

X	X	X	X	X	X	X	X	X	X
C					T	X	T	C	
X		C	X	X		X	D	X	X
X	W		C			S	C		X
X	X	X	X	X	X	X	X	X	X

>>: 1   ←0: 0

10) After push east:

X	X	X	X	X	X	X	X	X	X
C					T	X	T	C	
X		C	X	X		X	D	X	X
X	W		C			S	C	X	
X	X	X	X	X	X	X	X	X	X

>>: 1   ←0: 1

11) After unlock north:

X	X	X	X	X	X	X	X	X	X
C					T	X	T	C	
X		C	X	X		X		X	X
X	W		C			S	C	X	
X	X	X	X	X	X	X	X	X	X

>>: 1   ←0: 0

12) After walk north:

X	X	X	X	X	X	X	X	X	X
C					T	X	T	C	
X		C	X	X		X	S	X	X
X	W		C					C	X
X	X	X	X	X	X	X	X	X	X

>>: 1   ←0: 0

13) After walk north:

X	X	X	X	X	X	X	X	X	X
C					T	X	S	C	
X		C	X	X		X		X	X
X	W		C					C	X
X	X	X	X	X	X	X	X	X	X

>>: 1   ←0: 0

14) After jump east:

X	X	X	X	X	X	X	X	X	X
C					T	X	T	C	S
X		C	X	X		X		X	X
X	W		C					C	X
X	X	X	X	X	X	X	X	X	X

>>: 1   ←0: 0

15) After walk east:

X	X	X	X	X	X	X	X	X	X
C					T	X	T	C	
X		C	X	X		X		X	X
X	W		C					C	X
X	X	X	X	X	X	X	X	X	X

>>: 1   ←0: 0