

# Wumpus World!

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## INTRODUCTION

I used both Java and prolog to create Wumpus Worlds and solve them. Most everything is written in Java. The Java application consults prolog before making informed decisions. While the entire map is generated and stored by the Java application, prolog only ever knows what the agent knows, so there's no cheating!

I tried to make the prolog file itself, `wumpus_writs.pl`, only contain rules to infer where obstacles are and are not. The knowledge base is built up by Java during execution. Information such as starting space is added during map generation; even though we always start at (1, 1) for this exercise, I wanted it to remain flexible. I also opted to *not* infer where walls were without bumping into them for that same reason. I want my program to work with maps of irregular sizes and maps with walls added as obstacles in the middle!

## ACTIONS

Using only the basic actions `forward()`, `turnRight()`, `turnLeft()`, and `shoot()`, I made a few compound actions the agent can perform. These also could be used to make the controls more intuitive for a human player, e.g. using the arrow keys to control movement with `moveAdj`.

- `turnToFace`- Points the agent in the desired direction using as few turns as possible.
- `moveAdj`- Turns the agent to face an adjacent square (if needed), then walks forward.
- `goTo`- Uses an A\* search algorithm to find a path of rooms from the agent to the destination that prolog deems safe to traverse. The destination room itself does not need to be safe. The method then calls `moveAdj` along the path.
- `goToClosestRoom`- Calls `goTo` on whichever coordinate pair in the list is the least cost away. Only counts movement towards cost, as turning does not subtract points.
- `shoot`- If `shoot` is called with a coordinate pair, the agent will `goToClosestRoom` along one of the target room's axis, turn to face the target room, and `shoot()`.

## PROLOG RULES

- A room has no Wumpus and no pit if we have explored it, as we lived to tell the tale.
- There is no Wumpus/pit in any room that has an adjacent room that isn't stinky/drafty.
- There is a pit in a room if three of the adjacent rooms are drafty.
- If two diagonal stinky rooms are both adjacent to a non-stinky room, the other room that they are both adjacent to must contain the Wumpus.

- If a room is sandwiched between two stinky rooms that share exactly one coordinate, that room must contain the Wumpus.
- Any room with no pit and no Wumpus is safe.
- Any room with no pit is safe, so long as we have heard a scream.
- Any room with a pit is dangerous.
- Any room with a Wumpus is dangerous if we have not heard a scream.

There may be some additional ways to pinpoint where danger is and isn't, but if so, I am not clever enough to devise them. Some of these rules seem redundant, but it's important to distinguish between a guaranteed safe room, a room of certain death, and the unknown (which evaluates to false for both safe and dangerous).

## DECISION MAKING

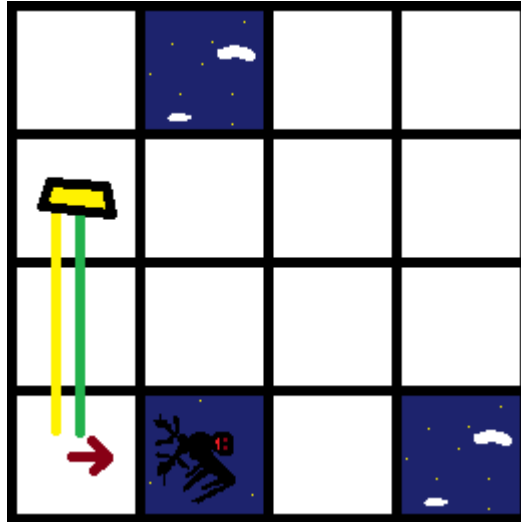
Java loops through `makeAction` until the game is over. This is where the agent decides what the best course of action to take is. The thought process is as follows.

- If there's glitter here, take the gold and go to the starting space!
- If there's no glitter, try to move to the closest room that is unexplored and guaranteed to be safe.
- If no room meets that criteria...
  - Gather information/create a safe path by shooting into a stinky room with unknown Wumpus status.
  - If we are out of arrows, know where the Wumpus is, or don't know of any stinky rooms, try to move to the closest potentially dangerous room that does not contain certain death.
  - If every remaining room contains certain death...
    - Try to shoot the Wumpus if we know where he is! Maybe he's on top of the gold or blocking our path?
    - If we can't do that, (or already have and get here again on the next pass), the game is unwinnable. Commit suicide as soon as possible to minimize point loss. ☹️

## RESULTS

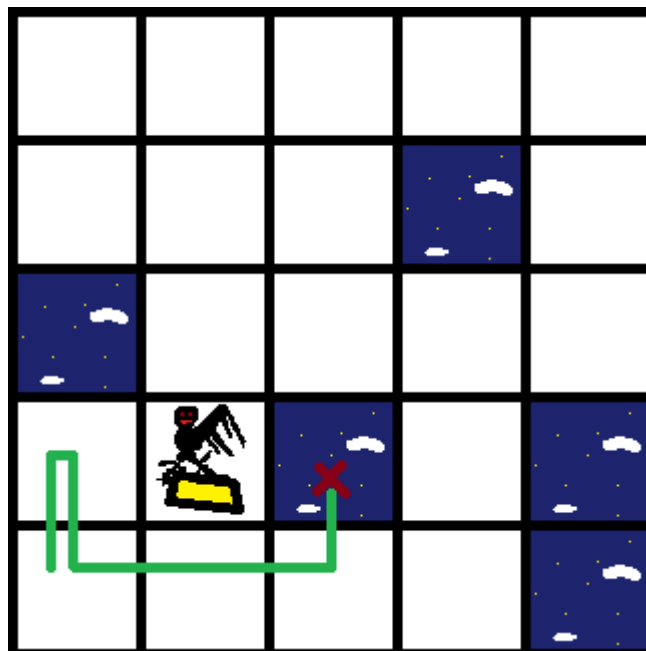
Each map size was run 20 times. I had a benchmark made to run them all 100 times and give statistics, but I couldn't reset the prolog engine without stopping the Java application, so I had to do this by hand and can't give as many statistics as I'd like.

**4x4-** 55% success rate    986 points, 12 actions made, 3 rooms visited



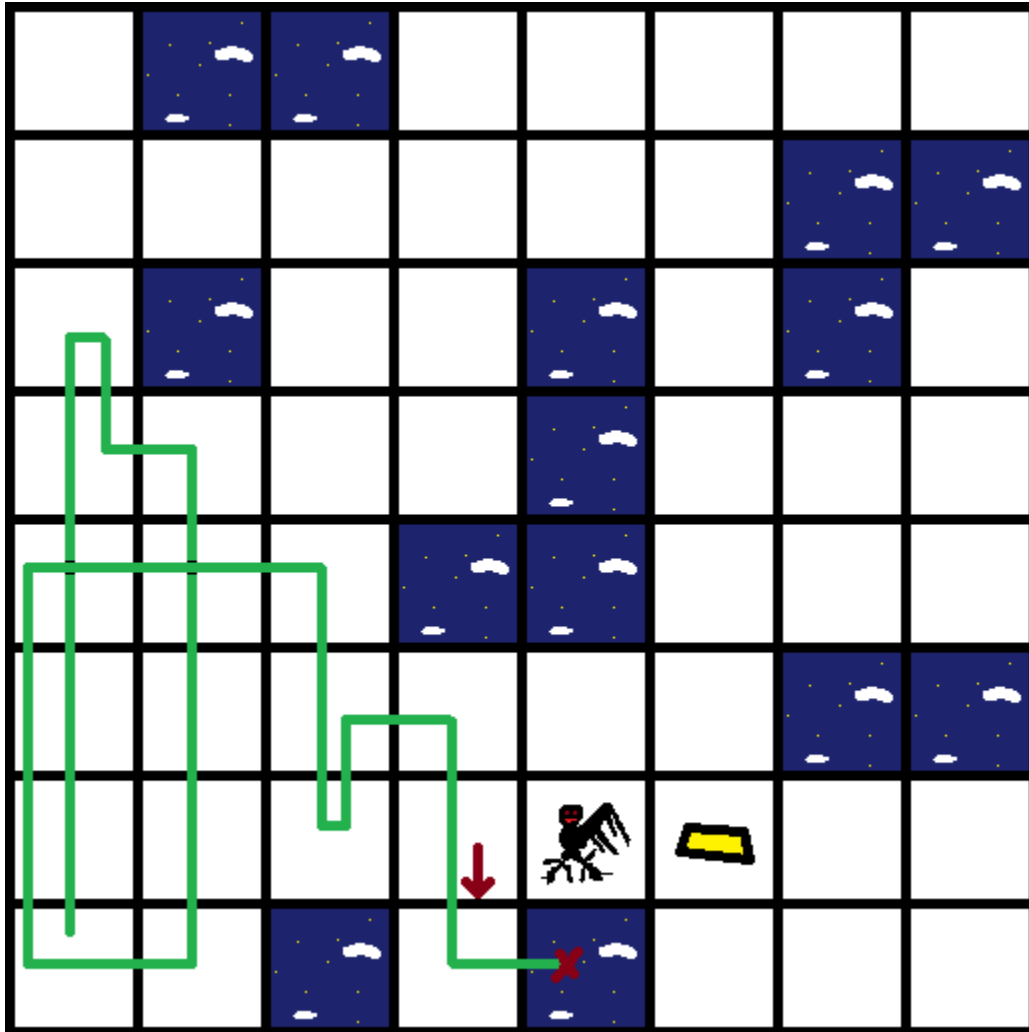
We fired an arrow here when we didn't really need to because the Wumpus was in the same room as the pit, and by chance we ended up avoiding the room entirely. Next time we can check to see if that's a possibility before shooting?

**5x5-** 60% success rate    -1005 points, 22 actions made, 5 rooms visited



Here, my decision to hold back from shooting a space that certainly contains the Wumpus ended up costing the agent the game: they instead decided to venture into risky territory and fell into it a pit, all because I figured it wouldn't ever be necessary to spend an extra 10 points.

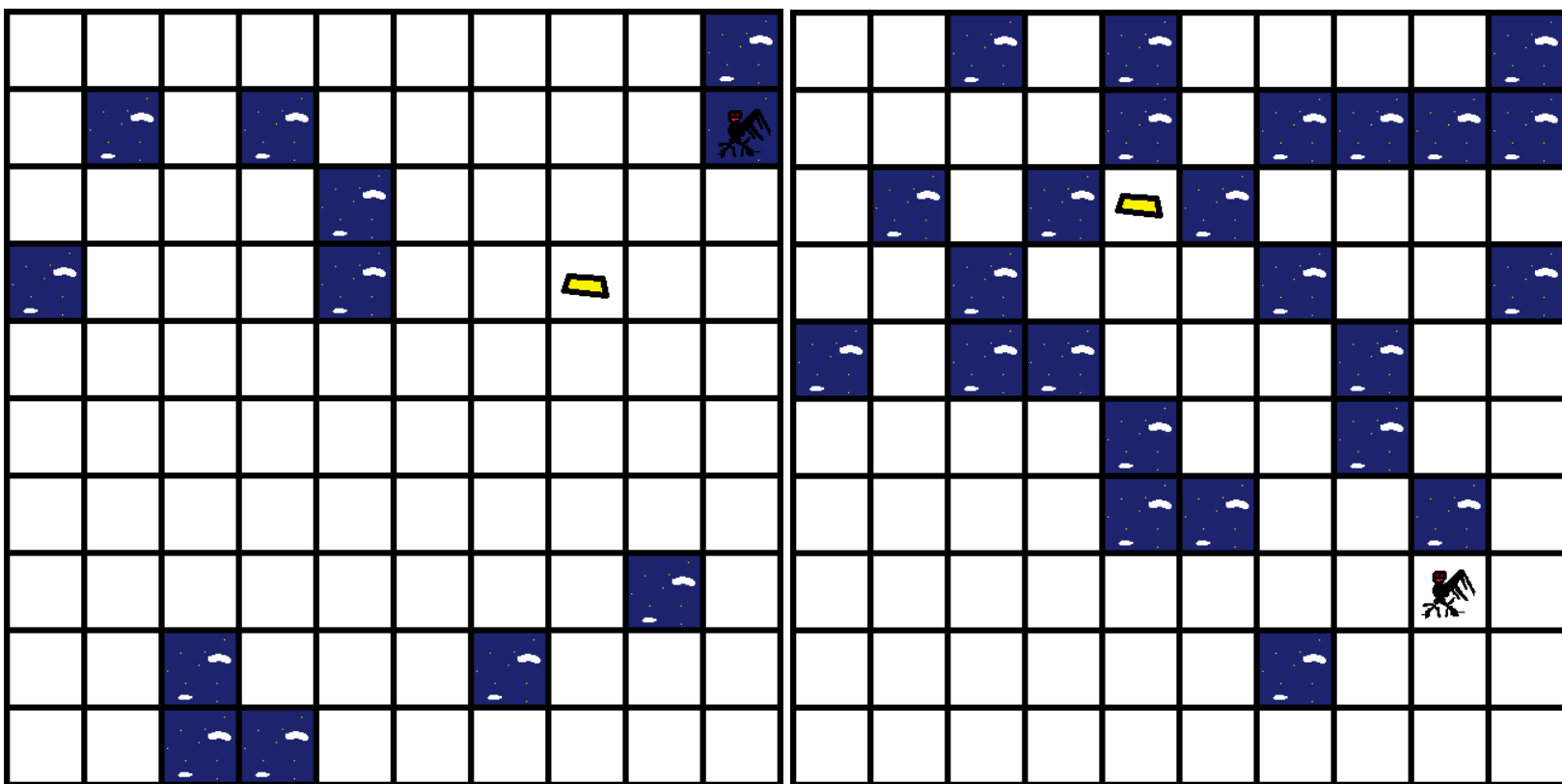
**8x8**- 35% success rate    -1034 points, 56 actions made, 18 rooms visited



Here's another failure I found interesting. When the agent first encounters the stench of the Wumpus, there are no safe rooms to explore, so it decides to fire off an arrow and ensure the safety of the space in front of it. Unfortunately, all this does is ensure the safety of one useless edge room surrounded by pits.

**10x10**- 10% success rate

924 points, 144 actions made, 51 rooms visited -1041 points, 86 actions made, 26 rooms visited



Here we have a win on the left and a loss on the right. Like most maps this big, the Wumpus is never encountered or even smelled in either! On the left, there was plenty of open space for the agent to traverse comfortably. On the right, the gold is protected by a kind of gauntlet, almost like it was designed as a challenge. The agent, of course, had no way to gather enough information and fell into a pit while crossing towards the Wumpus.

## RESULTS (RAW CONSOLE OUTPUT)

### 4x4

The gold is in 1, 3  
The Wumpus is in 2, 1  
A pit is in 2, 1  
A pit is in 2, 4  
A pit is in 4, 1  
You head to 1, 1.  
You smell the unmistakable stench of the wumpus.  
You feel a draft and hear the gentle howl of the empty sky below you.  
There are no safe spaces left!!  
You draw back your bow and fire off an arrow into the darkness.  
You hear a terrible scream. Your arrow must have hit its mark!  
There are no safe spaces left!!  
You head to 1, 0.  
...but fall backwards after walking straight into a wall. D:  
There are no safe spaces left!!  
You head to 1, 2.  
You head to 1, 3.  
The walls reflect with the glitter of gold! The treasure must be in here, somewhere...  
You find the treasure and load up on as many gold bars as you can carry!  
You head to 1, 2.  
You head to 1, 1.  
You smell the unmistakable stench of the wumpus.  
You feel a draft and hear the gentle howl of the empty sky below you.  
After making 12 actions, you made it out alive with half your weight in solid gold!

FINAL SCORE: 986

### 5x5

The gold is in 2, 2  
The Wumpus is in 2, 2  
A pit is in 1, 3  
A pit is in 3, 2  
A pit is in 4, 4  
A pit is in 5, 1  
A pit is in 5, 2  
You head to 1, 1.  
You head to 1, 0.  
...but fall backwards after walking straight into a wall. D:

You head to 1, 2.  
You smell the unmistakable stench of the wumpus.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 1, 1.  
You head to 0, 1.  
...but fall backwards after walking straight into a wall. D:  
You head to 2, 1.  
You smell the unmistakable stench of the wumpus.  
There are no safe spaces left!!  
You head to 2, 0.  
...but fall backwards after walking straight into a wall. D:  
There are no safe spaces left!!  
You head to 3, 1.  
You feel a draft and hear the gentle howl of the empty sky below you.  
There are no safe spaces left!!  
You head to 3, 0.  
...but fall backwards after walking straight into a wall. D:  
There are no safe spaces left!!  
You head to 3, 2.  
You smell the unmistakable stench of the wumpus.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You suddenly find yourself falling through the open sky! You have plenty of time to  
contemplate your career choices before you hit the ground.  
After making 22 actions, you fell out of the wumpus' lair to your death.

FINAL SCORE: -1005

### **8x8**

The gold is in 6, 2  
The Wumpus is in 5, 2  
A pit is in 2, 6  
A pit is in 2, 8  
A pit is in 3, 1  
A pit is in 3, 8  
A pit is in 4, 4  
A pit is in 5, 1  
A pit is in 5, 4  
A pit is in 5, 5  
A pit is in 5, 6  
A pit is in 7, 3  
A pit is in 7, 6



A pit is in 7, 7  
A pit is in 8, 3  
A pit is in 8, 7  
You head to 1, 1.  
You head to 1, 0.  
...but fall backwards after walking straight into a wall. D:  
You head to 1, 2.  
You head to 1, 3.  
You head to 1, 4.  
You head to 1, 5.  
You head to 1, 6.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 1, 5.  
You head to 0, 5.  
...but fall backwards after walking straight into a wall. D:  
You head to 2, 5.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 2, 4.  
You head to 2, 3.  
You head to 2, 2.  
You head to 2, 1.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 1, 1.  
You head to 0, 1.  
...but fall backwards after walking straight into a wall. D:  
You head to 1, 2.  
You head to 0, 2.  
...but fall backwards after walking straight into a wall. D:  
You head to 1, 3.  
You head to 0, 3.  
...but fall backwards after walking straight into a wall. D:  
You head to 1, 4.  
You head to 0, 4.  
...but fall backwards after walking straight into a wall. D:  
You head to 2, 4.  
You head to 3, 4.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 3, 3.  
You head to 3, 2.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 3, 3.

You head to 4, 3.  
You feel a draft and hear the gentle howl of the empty sky below you.  
There are no safe spaces left!!  
You head to 4, 2.  
You smell the unmistakable stench of the wumpus.  
There are no safe spaces left!!  
You draw back your bow and fire off an arrow into the darkness.  
You head to 4, 1.  
You feel a draft and hear the gentle howl of the empty sky below you.  
There are no safe spaces left!!  
You head to 4, 0.  
...but fall backwards after walking straight into a wall. D:  
There are no safe spaces left!!  
You head to 5, 1.  
You smell the unmistakable stench of the wumpus.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You suddenly find yourself falling through the open sky! You have plenty of time to  
contemplate your career choices before you hit the ground.  
After making 56 actions, you fell out of the wumpus' lair to your death.

FINAL SCORE: -1034

### **10x10**

The gold is in 8, 7  
The Wumpus is in 10, 9  
A pit is in 1, 7  
A pit is in 2, 9  
A pit is in 3, 1  
A pit is in 3, 2  
A pit is in 4, 1  
A pit is in 4, 9  
A pit is in 5, 7  
A pit is in 5, 8  
A pit is in 7, 2  
A pit is in 9, 3  
A pit is in 10, 9  
A pit is in 10, 10  
You head to 1, 1.  
You head to 1, 0.  
...but fall backwards after walking straight into a wall. D:  
You head to 1, 2.

You head to 1, 3.  
You head to 1, 4.  
You head to 1, 5.  
You head to 1, 6.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 1, 5.  
You head to 0, 5.  
...but fall backwards after walking straight into a wall. D:  
You head to 2, 5.  
You head to 2, 4.  
You head to 2, 3.  
You head to 2, 2.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 2, 1.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 1, 1.  
You head to 0, 1.  
...but fall backwards after walking straight into a wall. D:  
You head to 1, 2.  
You head to 0, 2.  
...but fall backwards after walking straight into a wall. D:  
You head to 1, 3.  
You head to 0, 3.  
...but fall backwards after walking straight into a wall. D:  
You head to 1, 4.  
You head to 0, 4.  
...but fall backwards after walking straight into a wall. D:  
You head to 2, 4.  
You head to 3, 4.  
You head to 3, 3.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 3, 4.  
You head to 3, 5.  
You head to 3, 6.  
You head to 2, 6.  
You head to 2, 7.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 3, 7.  
You head to 3, 8.  
You head to 3, 9.  
You feel a draft and hear the gentle howl of the empty sky below you.

You head to 3, 8.  
You head to 2, 8.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 3, 8.  
You head to 4, 8.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 4, 7.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 4, 6.  
You head to 4, 5.  
You head to 4, 4.  
You head to 4, 3.  
You head to 4, 2.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 4, 3.  
You head to 5, 3.  
You head to 5, 2.  
You head to 5, 1.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 5, 2.  
You head to 6, 2.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 6, 3.  
You head to 6, 4.  
You head to 5, 4.  
You head to 5, 5.  
You head to 6, 5.  
You head to 6, 6.  
You head to 5, 6.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 6, 6.  
You head to 6, 7.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 6, 6.  
You head to 7, 6.  
You head to 7, 5.  
You head to 7, 4.  
You head to 7, 3.  
You feel a draft and hear the gentle howl of the empty sky below you.  
You head to 7, 4.  
You head to 8, 4.

You head to 8, 3.

You feel a draft and hear the gentle howl of the empty sky below you.

You head to 8, 4.

You head to 8, 5.

You head to 8, 6.

You head to 8, 7.

The walls reflect with the glitter of gold! The treasure must be in here, somewhere...

You find the treasure and load up on as many gold bars as you can carry!

You head to 7, 7.

You head to 6, 7.

You feel a draft and hear the gentle howl of the empty sky below you.

You head to 6, 6.

You head to 5, 6.

You feel a draft and hear the gentle howl of the empty sky below you.

You head to 4, 6.

You head to 3, 6.

You head to 2, 6.

You head to 1, 6.

You feel a draft and hear the gentle howl of the empty sky below you.

You head to 1, 5.

You head to 1, 4.

You head to 1, 3.

You head to 1, 2.

You head to 1, 1.

After making 144 actions, you made it out alive with half your weight in solid gold!

FINAL SCORE: 924