The Wumpus World

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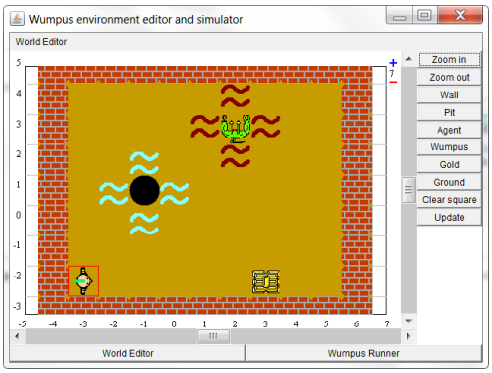
September 23, 2014

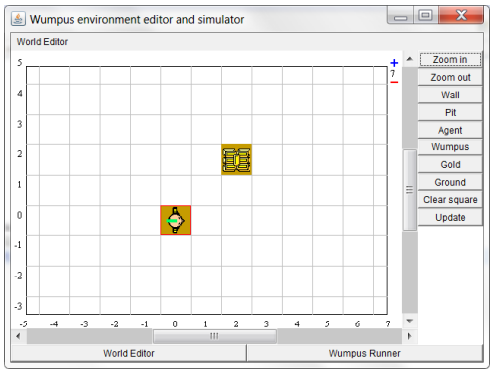
1 Introduction

The Wumpus World is a well-known two-dimensional grid that is distributed with the GOAL agent programming language and consists of cells occupied by walls, pits, and green ground areas, see Figure 1a. The Wumpus World is called so because there is one special grid cell that is occupied by the Wumpus, an ugly and dangerous beast. There is also a single agent located somewhere on the grid looking for the pile of gold that is present on one of the cells of the grid. The Wumpus World is a variation of the more classical well-known grid worlds such as the Tileworld [3].

The aim of this document is to introduce the Wumpus World, the actions that the agent can perform and the percepts that it will receive from the Wumpus World environment. For comparison and more information about the Wumpus World, you can also have a look at the discussion of this environment in [4].



(a) Wumpus World loaded at start



(b) Initial Wumpus World grid

2 Creating and Modifying Wumpus Worlds

Right after you have launched the Wumpus World, a window appears that shows a Wumpus World grid. When the Wumpus World environment is lauched a Wumpus World may be loaded immediately from file, as shown in Figure 1a. If no World is loaded initially, the World Editor starts with a more or less empty grid with only the agent and the pile of gold on it, as shown in Figure 1b.

This window is called the *World Editor*, as is also indicated by the label at the top left of the window. In the World Editor you can modify, load, and save worlds. By clicking on the *World Editor* item at the top left a two-item menu appears that allows you to load or save a world. If you want to load a world file, you need to locate `.wld` files using a file browser. Figure 1a shows the `wumpus.wld` file. Select the save option in the menu to save any grid that you created.

You can modify and create your own worlds by selecting an item you want to put on the grid with the buttons on the right hand side in the World Editor. You can select either a wall, a pit, the agent, the Wumpus, a pile of gold, or ground. After selecting an item, you can click on a grid cell to put the item on that cell. You can also drag and select an entire area on the grid in order to fill it with ground or walls.[1] By selecting the *Clear square* button, you can clear either individual cells or selected areas.

The editor ensures that at most one agent, one Wumpus, and one pile of gold are present in any world. It does not ensure however that each of these items is present. It thus is possible to create grids that do not satisfy the basic requirements of a Wumpus World. Worlds that lack either an agent, a Wumpus, or a pile of gold are said to be *invalid*.

3 Running the Agent in the Wumpus World

From the World Editor you can switch to run mode by clicking the button labeled *Wumpus Runner*, see Figure 1. The environment will not accept actions if it is in edit mode. However, when running the Wumpus World environment from GOAL this switch is automatic when a multi-agent system is started and there is no need to press the button. Of course, for getting back to the World Editor the *World Editor* button at the bottom left needs to be pressed again.

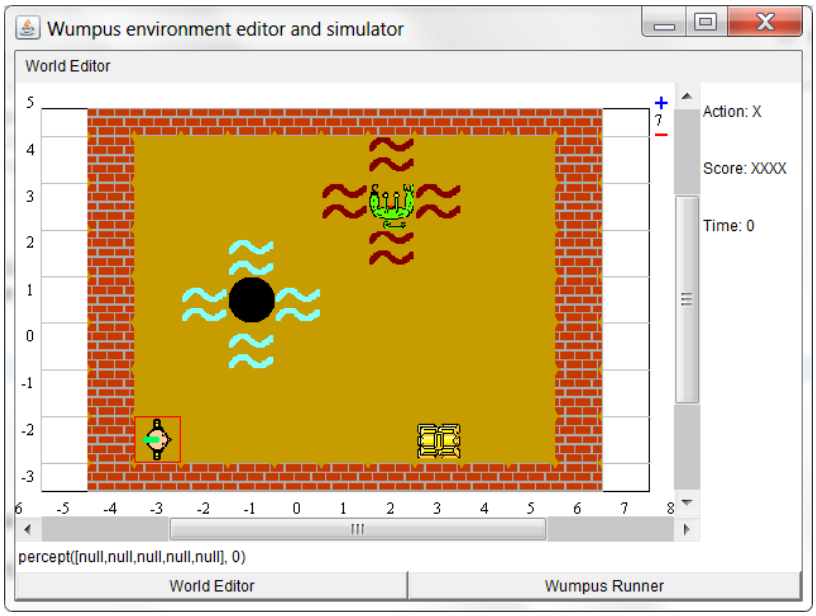


Figure 1: The Wumpus Runner window

The Wumpus Runner window differs in that it shows the action last performed, the score the agent has realized during the game so far, and the current time. Of course, it is the objective of the game to achieve a score that is as high as possible.

4 Perception in the Wumpus World

Your agent is located in a two-dimensional grid-like cave, hoping to find the pile of gold that is hidden somewhere. As there are pits and there is the Wumpus, the agent has to be careful however.

[1] Note that a breeze is shown graphically on the grid but is only visible against a green background; the breeze itself is white and does not show on an empty white cell.

Falling into a pit or hitting upon the Wumpus kills the agent immediately and terminates the game. It is known that the Wumpus is very lazy and never moves which makes exploration a little safer. The Wumpus spreads a nasty smell which the agent is able to sense just before it hits upon the Wumpus. Moreover, pits cause some hefty air circulation which the agent can sense as well before it falls into a pit. Of course, the agent also cannot move through walls and needs to detect walls to be able to explore the cave. If the agent uses its senses and makes the right inferences, it is possible to navigate safely through the cave.

When moving around on the grid, the agent receives *percepts* that inform it about the cave and its dangers. Table 1 lists all the percepts that the agent may receive from the Wumpus World environment.

Percept	**Explanation**
breeze	Breezes are perceived in each of the four grid cells adjacent to a pit
stench	A stench is perceived in each of the four grid cells adjacent to the Wumpus
bump	A bump is perceived when the agent hits a wall
scream	A scream is perceived when the Wumpus dies
glitter	A glitter is perceived when the agent is standing on the pile of gold
time(T)	T represents the time or number of rounds in natural numbers 0,1,2,...

Table 1: Overview of all Percepts in the Wumpus World

An agent hits a wall when it performs a forward action and is facing a wall. Of course, when a scream is perceived it can safely be concluded that the Wumpus is dead and the Wumpus needs to be no longer feared. The time is incremented after each action listed below that is performed. Note that the time percept is the only parameterized percept.

Finally, at the lower left bottom of the Wumpus Runner window the percept sent is displayed in a slightly different format. Initially, the following is displayed:

```
percept([null,null,null,null,null],0)
```

Here, each of the `null`s indicate that no breeze, stench, bump, scream, glitter is perceived at time 0, as is to be expected.

5 Acting in the Wumpus World

The agent can perform a number of actions to achieve its goal of finding the gold. The agent can only move forward and has to turn left or right to move into another direction. The agent needs to be explicitly instructed to grab the gold. Of course, it can only do so when it stands on the cell where the pile of gold is located and thus first has to locate the pile. Sometimes there is no other way to reach the pile of gold then by killing the Wumpus. The agent has exactly one arrow which the agent can shoot at the Wumpus. The agent thus has exactly one chance to kill the Wumpus. The Wumpus is killed if the arrow hits it and can move unobstructed in a straight line from the agent towards the Wumpus. Finally, apart from finding the gold, the agent has the goal to get out of the cave again (of course preferablly with the gold!). It can do so by the executing the action climb at the cell the agent started, i.e. the cell the agent was at time 0. Table 2 lists all actions that are available to the agent.

As discussed, moving is dangerous. If the agent hits upon the Wumpus or falls into a pit, he will be killed instantly. When the arrow is shot it moves forward in a straight line up to the first wall or the Wumpus, or it moves on forever. If the arrow never hits a wall or the Wumpus and continues forever, the environment may lock up. Finally, if an arrow is shot and the wumpus is hit, it will be killed instantly. In that case the Wumpus will make a last scream that will be heard everywhere in the cave.

Every action will increment the time counter by 1 and will decrease the score counter by 1. Shooting the arrow costs 10 points. Collecting the gold gives 1000 points. The game is over if the

Action	Result
forward	The agent moves one cell in the direction its facing
grab	The agent picks up the gold. Only works if he is standing on the pile of gold
shoot	The agent shoots an arrow (only if it still has one)
turn(left)	The agent makes a 90 degree left turn
turn(right)	The agent makes a 90 degree right turn
climb	The agent climbs out of the cave if positioned at the cell it started at

Table 2: Actions in the Wumpus World the Agent can Perform

agent has climbed out of the cave. Note that getting back to this position also costs points. The agent may climb out of the cave any time it wants to. If he does so without having found the gold, we say the agent "wuzzes".

6 Environment Interface Standard

Upon launching the Wumpus World from GOAL by starting a multi-agent system, an initialization can be performed. For the Wumpus World, an initial world can be loaded by including the following command in the environment section of a `.mas` file immediately after the reference to the environment file:

```
init [file = "worlds/wumpus.kt1.wld"].
```

The reference to the `.wld` file is relative to the directory where the wumpusenvironment jar file is located. You can use an absolute file reference but this is not recommended.

The Wumpus World has been *eisified*, meaning that it is an environment that supports the Environment Interface Standard (EIS; [2, 1]). This means that you can use in combination with any system such as GOAL that supports EIS.

References

[1] Tristan Behrens. Environment interface standard. `http://sourceforge.net/projects/apleis`, 2010.

[2] Tristan M. Behrens, Koen V. Hindriks, and Jürgen Dix. Towards an environment interface standard for agent platforms. *Annals of Mathematics and Artificial Intelligence*, 2010.

[3] Martha E. Pollack and Marc Ringuette. Introducing the tileworld: Experimentally evaluating agent architectures. In *Proceedings of the 8th National Conference on Artificial Intelligence*, pages 183–189, 1990.

[4] Stuard Russell and Peter Norvig. *Artificial Intelligence: A Modern Approach*. Prentice Hall, 2nd edition, 2003.