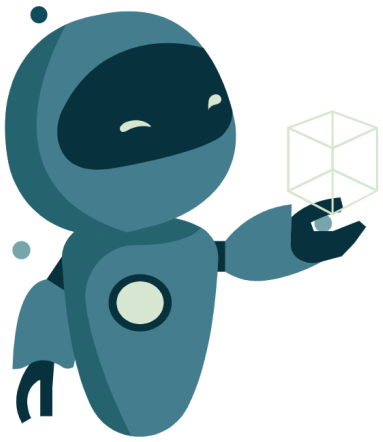


Agents and Multi-Agents Systems

Practice 1: Solving the Wumpus World using **BDI Agents**

Objectives

- Familiarize yourself with the concept of BDI (Belief-Desire-Intention) agents and their application in problem-solving.
- Implement a BDI agent in the GAMA platform or any other alternative to solve the Wumpus world.
- Understand how the BDI agent makes decisions based on beliefs, desires, and goals.
- Evaluate the performance and effectiveness of the BDI agent in solving the Wumpus world.

Tools

- In case you decide to use GAMA:
  - GAMA Platform
  - GAML programming language
  - Template (can be found in Moodle)

Description

The practice involves implementing a BDI agent to solve the Wumpus world challenge. The Wumpus world is an environment where the agent must collect treasures while avoiding traps and confronting the Wumpus. The BDI approach allows the agent to make rational decisions based on its beliefs, desires, and goals.

The practice is divided into the following stages:

1. **Theoretical Introduction**: Presentation of the concept of BDI agents and their application in problem-solving, explanation of the Wumpus world and its rules and discussion about how the BDI approach can be useful for this challenge.
2. **Initial Setup**: Creation of an environment representing the Wumpus world (size, location of treasures, traps, and agent's initial position). Implementation of the agent's perception.
3. **Development of the BDI Agent**: Definition of the agent's beliefs, identification of its desires, and development of the logic for its decision-making.
4. **Evaluation, Analysis, and Extras**: Execution of multiple simulations to evaluate the performance and effectiveness of the solution. Analysis of the results and possible improvements.

Theoretical Introduction

In this introductory section, two key aspects will be addressed: the concept of BDI agents and their application in problem-solving, as well as an explanation of the Wumpus world and its rules. Additionally, a discussion will be held on how the BDI approach can be useful in tackling the Wumpus world challenge.

BDI Agents and Their Application in Problem-Solving

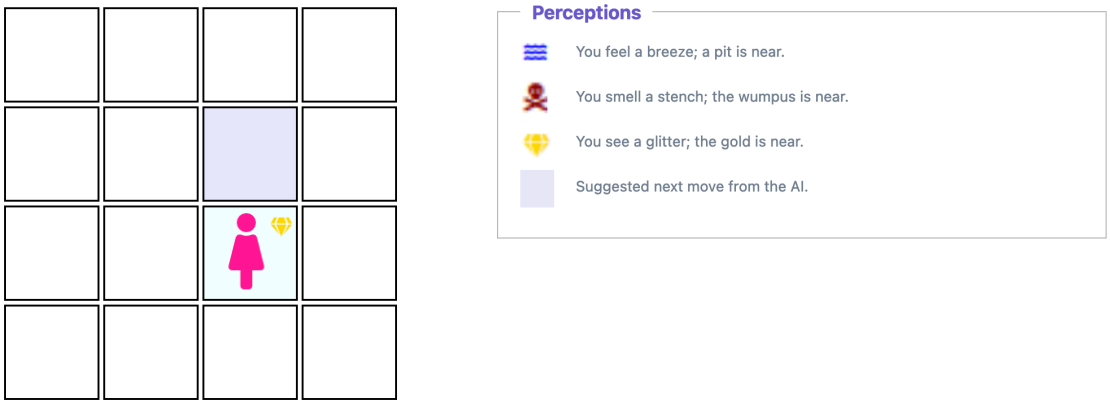
BDI (Belief-Desire-Intention) agents are a modeling and design approach for intelligent agents that is based on three fundamental components: beliefs, desires, and intentions.

- **Beliefs**: Represent the agent's knowledge about the state of the world and its environment. These beliefs can be sensory information or information acquired through interaction with the environment. Beliefs provide an internal representation of the world as perceived by the agent.
- **Desires**: Represent the goals or objectives that the agent wishes to achieve. Desires can arise internally (e.g., needs or preferences) or can be influenced by the environment or interactions with other agents.
- **Intentions**: Represent the action plans the agent has selected to achieve its goals. Intentions are rational decisions made by the agent based on its beliefs and desires.

The application of BDI agents in problem-solving provides a solid conceptual framework for modeling and representing intelligent behavior. By considering beliefs, desires, and intentions, BDI agents are able to reason about available information, set priorities, make goal-based decisions, and adapt to changes in the environment.

The Wumpus World and Its Rules

The Wumpus world is a classic environment in artificial intelligence that presents a challenge for intelligent agents. It consists of a grid-like cave where an agent must collect treasures while avoiding falling into traps and facing the Wumpus, a dangerous creature. You can try a demo here: http://primaryobjects.github.io/wumpus/



The rules of the Wumpus world are as follows:

1. The agent can move up, down, left, or right in the cave, but cannot move through walls.

2. The agent perceives its surroundings using sensors. Specifically, it can feel a breeze when there is a nearby trap, smell a stench when the Wumpus is near, and see a glow when there is a treasure in an adjacent square. It only perceives one adjacent square at a time.
3. If the agent falls into a trap or faces the Wumpus, the game ends and the agent loses.
4. The agent must collect all the treasures without getting caught or falling into traps to win the game.

How the BDI Approach Can Be Useful for the Wumpus World Challenge?

The BDI approach is well-suited for addressing the Wumpus world challenge due to its ability to model reasoning based on beliefs, desires, and intentions.

- **Beliefs**: The BDI agent can maintain an internal model of the Wumpus world, updating its beliefs based on received perceptions. For example, if the agent perceives a breeze in an adjacent square, it can infer that there is a nearby trap and update its beliefs accordingly.
- **Desires**: The desires of the BDI agent in the Wumpus world may relate to collecting treasures and avoiding dangers. The agent can set goals to collect all treasures while steering clear of traps and the Wumpus.
- **Intentions**: Based on its beliefs and desires, the BDI agent can form intentions to make rational decisions. For example, if the agent knows that there is a treasure in an adjacent square and no nearby dangers, it may form the intention to move towards that square.

In summary, the BDI approach provides a structured framework for the agent to reason about its environment, set goals, and make decisions based on its knowledge and desires. This enables the agent to tackle the Wumpus world challenge by intelligently avoiding dangers and collecting treasures.

Initial Setup (only when using GAMA Platform)

In this stage, we will focus on the initial setup of the practice, which includes using the GAMA platform, creating the environment that represents the Wumpus world, and implementing the agent's perception.

Familiarization with the GAMA Interface and Its Console:

1. Familiarize yourself with the GAMA interface, which includes a model editor and a visualizer for the simulated environment.
2. Choose a simple model. Try writing to the output console using the `write` command.
3. Use the GAMA console. Can you check the value of any variable in the model? How?

Creating an Environment in GAMA That Represents the Wumpus World

1. Open the GAMA model editor and load the initial template.
2. Understand the characteristics of the Wumpus world environment. The `grid` entity of GAMA has been used. Look for documentation about it: https://gama-platform.org/wiki/GridSpecies
3. How is the location of treasures and traps defined in the cave? Can you think of another way to do it?
4. How are objects visualized? Could the Wumpus be changed to an image instead of using a background color?
5. Add the pits and their smell. Test to ensure they are displayed correctly.

Implementation of an Agent

1. Add a `player` species, represented by a circle.
2. This agent should move randomly through the environment. Therefore, it should use the skill `moving` . Look for information about skills and this one in particular.
3. The agent should be placed in the `grid` world. To do this, we must update its `location` when we create it. Update its `init` method so that the agent is placed in a cell of our grid world.

Development of the BDI Agent

In this section, we will focus on the design and development of the BDI agent to address the challenge of the Wumpus world. We will explore the key components of a BDI agent, define the agent's beliefs, identify its desires, and develop the logic for decision-making based on beliefs, desires, and goals.

Key Components of a BDI Agent

- **Beliefs**: Beliefs represent the agent's knowledge about the state of the environment and the available actions. These beliefs are updated based on received perceptions and actions taken. In the context of the Wumpus world, beliefs may include information about the presence of traps, treasures, and the agent's status.
- **Desires**: Desires are the goals or objectives that the agent must achieve. In the context of the Wumpus world, desires may include collecting all treasures and avoiding traps and the Wumpus. Desires are based on the evaluation of the current situation and may change over time.
- **Intentions**: Intentions represent the plans of action that the agent has selected to achieve its goals. Intentions are formulated through the evaluation of beliefs and desires. In the Wumpus world, intentions may include moving to an adjacent cell perceived as safe or collecting a treasure when located in a spot with a glow.

Definition of the Agent's Beliefs (only when using GAMA Platform)

1. The agent should have beliefs about the locations of traps in the cave. We will assume a simple agent with limited memory that cannot store the entire map matrix as it navigates.

2. The agent should have beliefs about the locations of treasures but can only remember a few perceptions.

3. Define three predicates in GAMA using `predicate` to indicate that the agent desires to patrol, collect gold, or avoid the Wumpus.

4. Using `perceive`, add the agent's perceptions in the world. Create predicates when necessary to indicate the current perceptions in the agent's state. The predicates do not have to be boolean.

Identification of the Agent's Desires (only when using GAMA Platform)

The main desire of the agent in the Wumpus world is to move through the environment to collect all the treasures present in the cave. This implies setting our patrolling state as a goal. Use `add_desire` in the `init` of the player to add that desire.

Now create a `plan` that allows the agent to patrol if that desire is active.

Development of the Agent's Decision-Making Logic (only when using GAMA Platform)

1. Evaluate the agent's current beliefs and desires to determine possible actions. For example, if the agent perceives a breeze in an adjacent cell, this indicates the presence of a trap, and the agent should avoid moving in that direction.
2. Establish the agent's intentions based on beliefs and desires. For instance, if the agent perceives a glow in an adjacent cell and there are no nearby dangers, it can form the intention to move toward that cell to collect the treasure.
3. Execute the actions corresponding to the selected intention. This may involve moving to an adjacent cell, collecting a treasure, or avoiding a trap.
4. The agent should have the desire to avoid traps and the Wumpus. This involves setting the goal of avoiding falling into traps and staying away from the Wumpus at all times.
5. Define a rule with `rule` so that when a glow is detected, the agent changes its intention to approach the treasure.
6. Now define another `plan` for the agent to move randomly near the glow, thereby maximizing the probability of finding the treasure.

7. When a pit is perceived, the agent should attempt to move away from that position. We can try a reactive approach: each time the breeze from a pit is perceived, the last movement will be undone. Add the necessary predicates and rules to achieve this.
8. Do the same as in 6 for the Wumpus. Can you reuse the previous plan?

Evaluation, Analysis, and Extras

In this section, we will focus on evaluating the performance and effectiveness of the BDI agent in solving the Wumpus world. We will conduct multiple simulations to collect data and analyze the results obtained. Additionally, we will discuss possible improvements in the agent's design and explore other implementations that could optimize its performance.

Evaluation of Multiple Simulations to Assess the Performance

1. Define a set of test cases representing different configurations of the Wumpus world. This can include variations in cave size, treasure and trap locations, and the agent's starting position.
2. Run multiple simulations using different test cases and record relevant data, such as the number of treasures collected, the number of traps avoided, and the total execution time.
3. Analyze the collected data to evaluate the performance of the BDI agent. You can calculate metrics such as the success rate (percentage of simulations where all treasures were collected without falling into traps), average execution time, and efficiency in collecting treasures.

Analysis of Results

Examine the metrics obtained during the performance evaluation of the BDI agent. Identify the agent's strengths and weaknesses in solving the Wumpus world.

Discussion of Potential Improvements in the Agent's Design and Other Implementations

1. Consider improvements in the agent at the information level. You can use any data structure to store details of the cave as long as you use a BDI strategy.
2. (Only when using GAMA Platform)Explore other implementations of intelligent agents in GAMA, such as rule-based agents or probabilistic model-based agents, and compare their performance with the BDI agent in solving the Wumpus world.

Submission

All developed code and a practice report in PDF must be included in a single compressed file, which **must be uploaded via Moodle before November, 26th 23:59**.

Bibliography

1. Russell, S., & Norvig, P. (2016). Artificial Intelligence: A Modern Approach (3rd ed.). Pearson.
2. GAMA Platform. https://gama-platform.github.io