Introduction to Artificial Intelligence

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January 23, 2024

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Lecture 1: Intro to AI

Definition 1. **Artificial Intelligence** is the science of making machines that think like people, think rationally, act like people, and act rationally.

Definition 2. **Machine Learning** is a subfield of AI, where statistical approaches are used. It is also a subfield of Data Science, which has other fields such as visualization and statistics.

Lecture 2: Intro to AI and Agents

1 Agents and Environments

Definition 3. An **agent** is an entity that perceives and acts. It perceives the environment through **sensors** and acts on the environment through **effectors**.

Definition 4. A **rational agent** selects actions that maximize its utility.

Definition 5. Characteristics of the **percepts environment**, and **action space** dictate techniques for selecting actions.

Definition 6. An **agent function** is a mathematica description of an agent's behavior that maps sensory perceptions to effector actions:

$$F : P \to A.$$

We should keep things as simple as possible. For example, tabulation itself is very strong and powerful in the right situations. However, this table could be too big for memory, and it could resolve in an infinite loop.

To write an agent program, one must establish:

1. Actions: How the agent changes the environment
2. Sensors: What you can know about the environment
3. Prior Knowledge: Pre-loaded information
4. Objective Function: What the agnet is trying to accomplish
5. Measurement Function: How to tell if we are succeeeding or not

Definition 7. Steps 4 and 5 detail **rationality**: "Of all my actions, which ones get me closer to my objective, given what I know right now?"

Example. For the bugs in the room, you could award 1 point per bug-free room per time step, and a point for each bug killed. You could remove 1 point for each move action, to prevent the infinite loop. If we don't have a map, we can either explore or exploit. And finally, sensors and effectors could be unreliable.

Definition 8. **Reflex agents** choose actions based on the current percept (and maybe memory), and do not consider the future consequences of their actions.

Now, can a reflex agent be rational?

Example. If you put a cranberry in front of a frog, it will eat it, then spit it out immediately. Then, it will see the cranberry, and eat it again. This is an example of a reflex agent, and is also how you can "*infinite loop a frog*".

The moral of the story? Do the stupid thing first, it might just work.

Definition 9. A **model based reflex agent** can model its actions on the world first, then makes an action depending on the mmodel.

Definition 10. **Planning agents** ask "what if". They make decisions based on hypothesized consequences of actions.

Definition 11. **Utility agents** use some utility to evaluate the hypothetical consequences of actions.

Definition 12. **Learning agents** get feedback, changes, and improves it knowledge with each action, allowing them to gain knowledge over time.

"If you can't win, just confuse them." Below are some definitions for different environments.

Definition 13. **Observability** means that sensors can observe all parts and variables in the environment.

Definition 14. **Determinism** means that the world changes exactly as desired. **Stochastic** mean that there is randomness and uncertainty.

Definition 15. **Static** means the world doesn't change while agent is deliberating

Definition 16. **Discreteness** means that the world is broken up into discrete chunks.

Definition 17. **Episodic** means that the story doesn't matter.

Definition 18. There many be single or multiple **agents** in an environment.

Lecture 3: Search Techniques

2 Uninformed Search

Definition 19. **Offline** problem solving is an agent that, given a sequence, state, goal, and problem, returns an action.

Definition 20. A deterministic problem is a **single-state** problem.

Definition 21. A non-observable problem is a **conformant** problem.

Definition 22. A partially observable problem is a **contingency** problem.

Definition 23. An unknown state space is an **exploration** problem.

How do we select a state space? The world is very, very complex such that the state space must be abstracted for problem solving. These abstract solutions should be easier than the real problem.

2.1 State Space Graphs and Search Trees

Definition 24. A **state space graph** is a mathematical representation of a search problem. Arcs on this graph represent an action that causes a change from one state to another.

Note that we can rarely build this graph in memory in full. Also, a state tree for a certain graph could be infinitely large (with a cyclic state space graph).

The difference between states and nodes is that the node includes the state, but also information about its children, parents, etc.

Definition 25. **Completeness**: does it always find a solution? **Complexity**: number of nodes expanded, memory used? **Optimality**: does it always find a least-cost solution?

Time and space complexity are measured in b, d, and m, where b is the maximum branching factor, d is the depth of the least-cost solution, and m is the maximum depth of the state space.

Example. What is the completeness, complexity, and optimality of DFS?

Explanation. DFS fails in infinite depth spaces and spaces with loops, so it is not complete. It has b^m time complexity and bm space complexity.

Example. What about BFS?

Explanation. Yes, time complexity of b^{d+1}, in b^{d+1} space, etc.

Sometimes, the shortest path is not the fastest path, so a uniform cost search could be used.

Lecture 4: Uninformed Search

2.2 Adversarial Search and Games

Note that in a tree search, you may repeatedly process already visited states. In some cases you should use a state graph instead.

In a graph search, you should **never** expand a state twice. Instead, you use a data structure to see which nodes have already been visited. It is important to store the closed set as a set, and not a list. Also note that a graph search will not wreck completeness.