CSC 384
Introduction to Artificial Intelligence

Definitions of AI and Introduction to Search

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Learning Goals

By the end of this lecture, you should be able to

- Describe each of the four definitions of AI.
- Compare and contrast the four definitions of AI.
- Give a few reasons why we chose the Rational Agent definition rather than the other three definitions.
- Formulate a real-world problem as a search problem.

Outline

DEFINITIONS OF AI

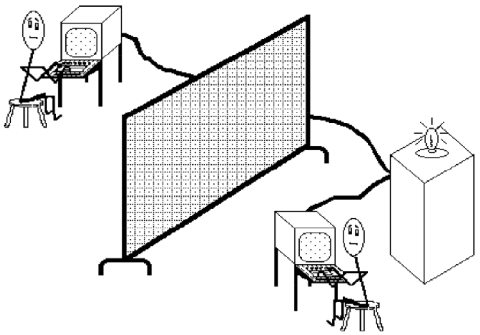
Definitions of AI

Systems that think like humans	Systems that think rationally
Systems that act like humans	Systems that act rationally

Cognitive Modeling (Thinking Humanly)

- Why humans?
- How do humans think?
  - Introspection
  - Psychological experiments
  - Brain imaging (MRI)
- Cognitive science:
  - Goal is to develop precise and testable theories of the human mind using theoretical models and experiments.

Turing Test (Acting Humanly)



Turing Test (Acting Humanly)

- An operational definition:
  - If the interrogator cannot distinguish the entity from a human, the entity passes the test and is considered intelligent.
- Is the Turing Test useful?
  - Lots of debate.
  - Allows us to recognize intelligence, but does not provide a way to realize intelligence.
  - Gave rise to core areas of AI: natural language processing, knowledge representation, machine learning, computer vision, robotics, etc.

Rationality

- Rationality: an abstract "ideal" of intelligence, rather than "whatever humans do".
- A system is rational if it does the "right thing" given what it knows.

Laws of Thought (Thinking Rationally)

- Greek philosopher Aristotle defined syllogisms:
  - formalize correct thinking.
  - gave rise to the field of logic.
- The logicist tradition:
  - goal is to express our knowledge using logic.
  - a system w/ such knowledge can solve any problem (in principle).
- Problems with using this approach in practice?

Rational Agent (Acting Rationally)

- Agent comes from Latin word "agere", meaning "to do" or "to act".
- A rational agent acts to achieve the best (expected) outcome.
- What behaviour is rational?
  - create and pursue goals,
  - operate autonomously,
  - perceive environment,
  - learn,
  - adapt to changes.

What is Artificial Intelligence?

Cognitive Modeling Systems that think like humans	**Laws of Thought** Systems that think rationally
Turing Test Systems that act like humans	**Rational Agent** Systems that act rationally

Choosing a Definition of AI

Which definition of AI would you choose and why?

Caring about Behaviour Rather than Thoughts

Why do we care about behaviour instead of thoughts?

Measure Success against Rationality Rather than against Humans

Why do we measure success against rationality instead of against humans?

APPLICATIONS OF SEARCH

What is Search?

- One of the most fundamental techniques in AI
- Solves many problems that humans are not good at.
- Achieve super-human performance on other problems (Chess, Go)
- Useful general algorithmic technique for solving problems (both in AI and in other areas)

Applications of Search



Hua Rong Dao Puzzle

Alice solves Hua Rong Dao

FORMULATING A SEARCH PROBLEM

Why Search

We have a difficult problem.

- Do not know an algorithm to solve this problem.
- Have a description that helps us recognize a solution.

We must search for a solution!

Challenge of Problem Formulation

Real-World Problem → Search Problem

The formulation can have critical impacts on the search process.

Components of a Search Problem

1. A set of states.
2. The initial state.
3. A successor function.
4. The goal states or a goal test.
5. (Optional) a cost associated with each action.
6. (Optional) a heuristic function to guide the search.

A solution to this problem is a path from the initial state to any goal state (optionally with the smallest total cost).

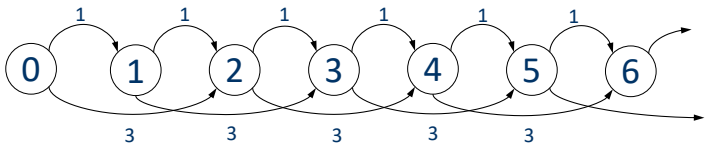
Example: Counting Integers

- Consider the non-negative integers.
- We start from 0.
- Our goal is to reach 5.
- At each step, we can add 1 or 2 to the current integer.
- The cost of adding 1 is 1. The cost of adding 2 is 3.

Counting Integers as a Search Problem

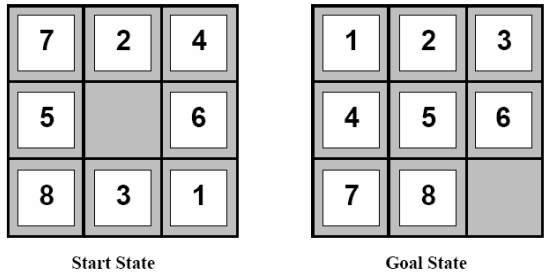
- States: the non-negative integers $\{0, 1, 2, \dots\}$.
- Initial state: 0.
- Goal state: 5.
- Successor function: $S(n) = \{n + 1, n + 2\}$.
- Cost function: $C(n, n + 1) = 1, C(n, n + 2) = 3$.

Partial Search Graph for Counting Integers



Example: 8-Puzzle

Rule: Can slide tile A into the blank square if A is adjacent to the blank square.



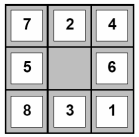
The 8-Puzzle as a Search Problem

State:

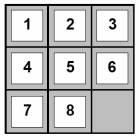
Initial state:

Goal states:

Successor function:



Start State



Goal State

The 8-Puzzle as a Search Problem

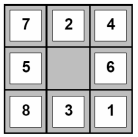
State: $x_{00}x_{01}x_{02}, x_{10}x_{11}x_{12}, x_{20}x_{21}x_{22}$ where x_{ij} is the number in row i and column j, $i, j \in \{0, 1, 2\}, x_{ij} \in \{0, \dots, 8\}$ and $x_{ij} = 0$ denotes the blank tile.

Initial state: 724,506,831

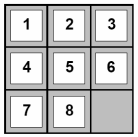
Goal states: 123,456,780

Successor function: State B is a successor of state A if and only if we can transform A to B by moving the blank up, down, left, or right.

Solution a sequence of moves of the blank that transform the initial state to a goal state.



Start State



Goal State

An alternative formulation for 8-Puzzle

State: A state consists of 8 coordinates. (x_i, y_i) denotes the (row, column) coordinates for tile i where $1 \leq i \leq 8$

Initial state: (2,2) (0,1) (2,1) (0,2) (1,0) (1,2) (0,0) (2,0)

Goal states: (0,0) (0,1) (0,2) (1,0) (1,1) (1,2) (2,0) (2,1)

Successor function: State B is a successor of state A iff we can transform A to B by moving the blank up, down, left, or right.

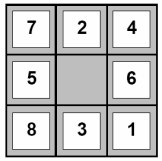
Which formulation do you prefer and why?

1

- Initial state: 724,506,831

2

- Initial state: (2,2) (0,1) (2,1) (0,2) (1,0) (1,2) (0,0) (2,0)



Start State