CSC 384
Introduction to Artificial Intelligence

Definitions of AI and
Introduction to Search

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Winter 2023

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](#)

- [Applications of Search](#)

- [Formulating a Search Problem](#)

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DEFINITIONS OF AI

Definitions of AI

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

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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)
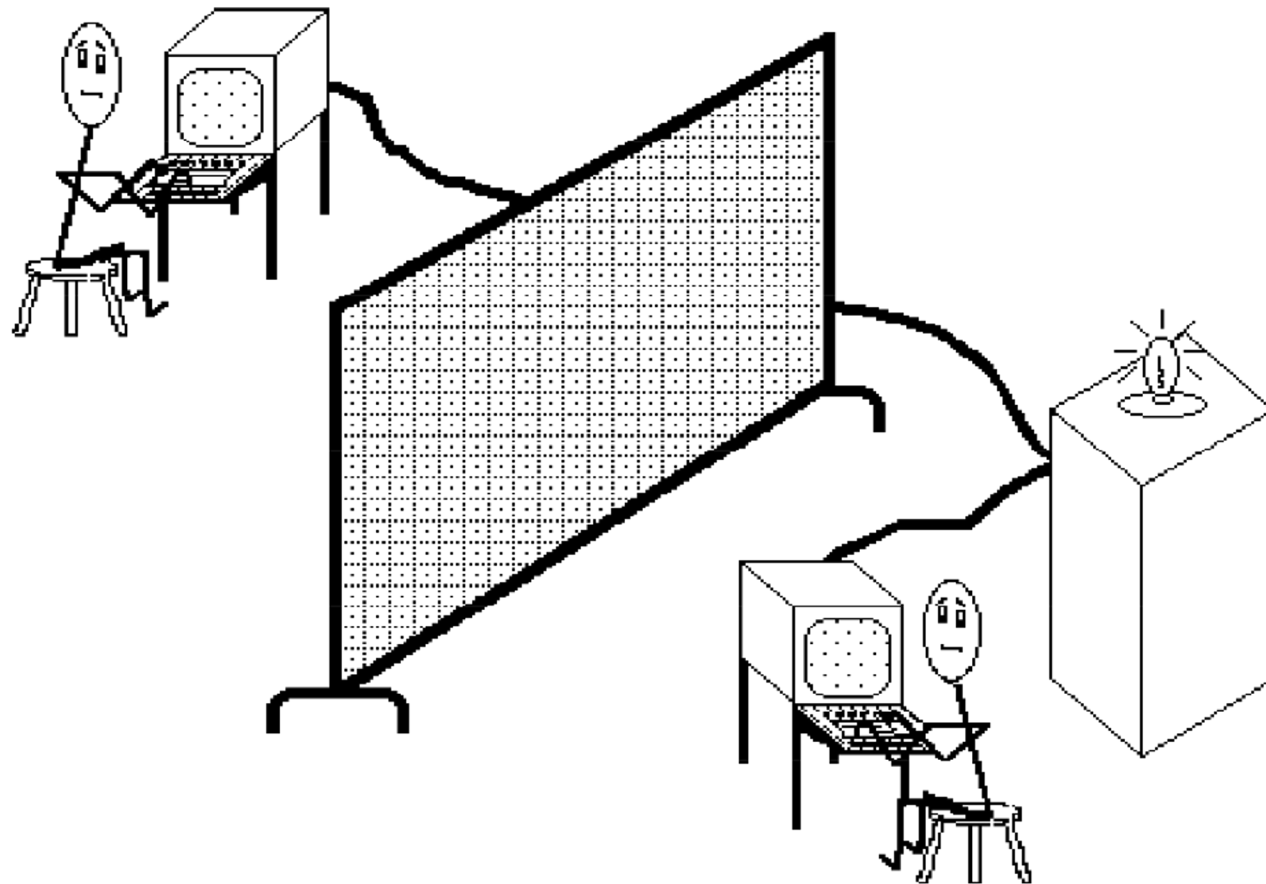
Turing Test (Acting Humanly)

- 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.

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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?

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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

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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?

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

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APPLICATIONS OF SEARCH

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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

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Hua Rong Dao Puzzle

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Alice solves Hua Rong Dao

FORMULATING A SEARCH PROBLEM

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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!

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Challenge of Problem Formulation

Real-World Problem → Search Problem

The formulation can have critical impacts
on the search process.

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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).

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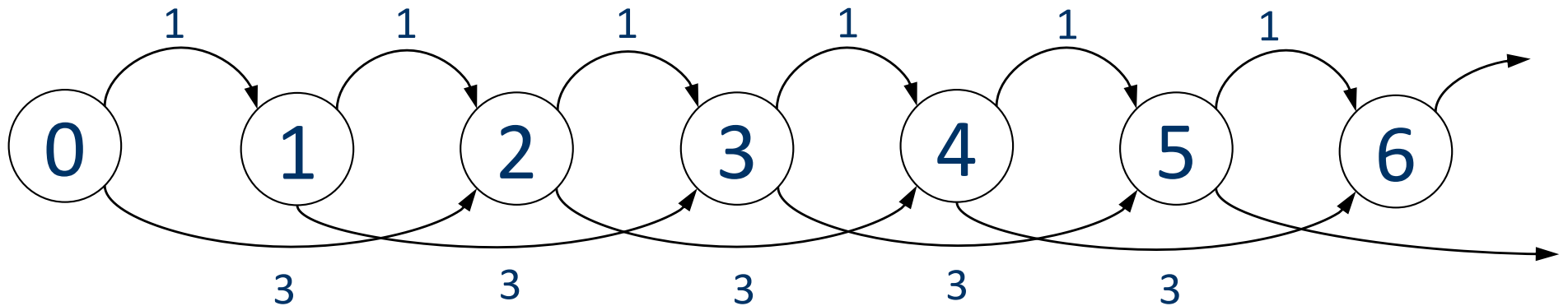
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Example: Counting Integers

- 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.

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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: $C(n, n + 1) = 1, C(n, n + 2) = 3$.

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Partial Search Graph for Counting Integers

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Example: 8-Puzzle

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

Start State

Goal State

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The 8-Puzzle as a Search Problem

State:

Initial state:

Goal states:

Successor function:

Start State   Goal State

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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.

7	2	4
5		6
8	3	1

Start State

1	2	3
4	5	6
7	8	

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

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