Artificial Intelligence

Lec 1 - Introduction

Pratik Mazumder

Content taken from various sources including
CS188 Intro to AI at UC Berkeley

Timings

Classroom: LHB 105

Lectures:
Tue: 10am-11am
Wed: 9am-10am
Fri: 9am-10am

Office Timings:
CSE 223, Thursday 11am-12pm

Syllabus

Introduction: Uninformed search strategies, Greedy best-first search, And-Or search, Uniform cost search, A* search, Memory-bounded heuristic search, Local and evolutionary searches (9 Lectures)
Constraint Satisfaction Problems: Backtracking search for CSPs, Local search for CSPs (3 Lectures)
Adversarial Search: Optimal Decision in Games, The minimax algorithm, Alpha-Beta pruning, Expectimax search (4 Lectures)
Knowledge and Reasoning: Propositional Logic, Reasoning Patterns in propositional logic; First order logic: syntax, semantics, Inference in First order logic, unification and lifting, backward chaining, resolution (9 Lectures)
Planning: Situation Calculus, Deductive planning, STRIPES, sub-goal, Partial order planner (3 Lectures)
Bayesian Network, Causality, and Uncertain Reasoning: Probabilistic models, directed and undirected models, inferencing, causality, Introduction to Probabilistic reasoning (6 lectures)
Reinforcement Learning: MDP, Policy, Q-value, Passive RL, Active RL, Policy Search (8 Lectures)

Textbook: Russel,S., and Norvig,P., (2015), Artificial Intelligence: A Modern Approach, 3rd Edition, Prentice Hall

Course Logistics

Assignments: 2 [30%]
Quizzes: 2 [10%]
Minor: 20%
Major: 40%
Optional: Project on Reinforcement Learning - Certificates for Top 3 Teams

Textbook: Russel,S., and Norvig,P., (2015), Artificial Intelligence: A Modern Approach, 3rd Edition, Prentice Hall

Google Classroom for Assignment Submission, Announcements: Invite Sent to Registered Students

Lecture Site: https://sites.google.com/iitj.ac.in/ai2024

Doubts?

Intelligence

- It is a complex and multifaceted concept that generally refers to the ability to learn, understand, reason, solve problems, and adapt to new situations.
- Human intelligence is the intellectual capability of humans.
- Howard Gardner's Multiple Intelligences
    - In order to capture the full range of abilities and talents that people possess, Gardner theorizes that people do not have just an intellectual capacity,
    - but have many kinds of intelligence, including musical, interpersonal, spatial-visual, and linguistic intelligences
- In this course, we deal with intelligence required to solve problems

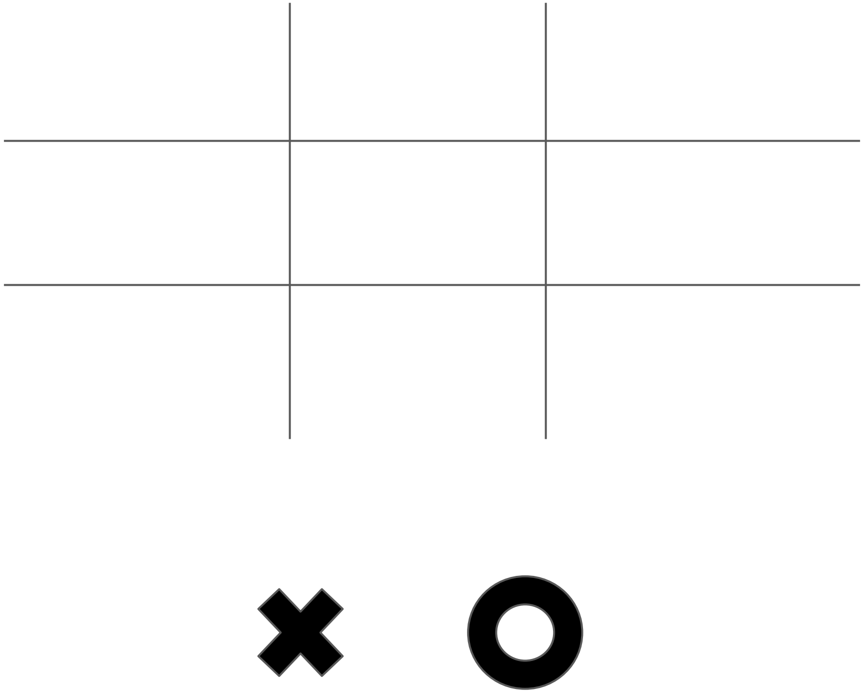
Artificial Intelligence

- Human beings have tried to **understand** how we think, perceive, understand, predict, and manipulate the complicated world around us.

- The field of Artificial Intelligence (AI) deals with **building intelligent entities/agents** which can perceive, understand, predict, and manipulate the world like us and may be even better than us.

- Performing a Task vs Intelligently Performing a Task

Let’s Play a Turn-based Game



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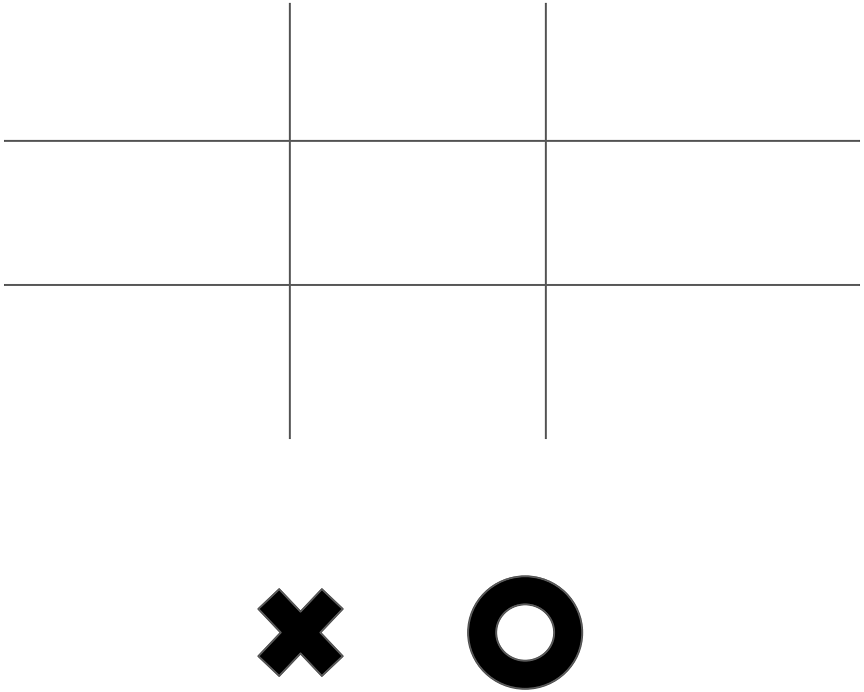
Task: Player should get 3 of his/her marks in marks in a row/column/diagonal



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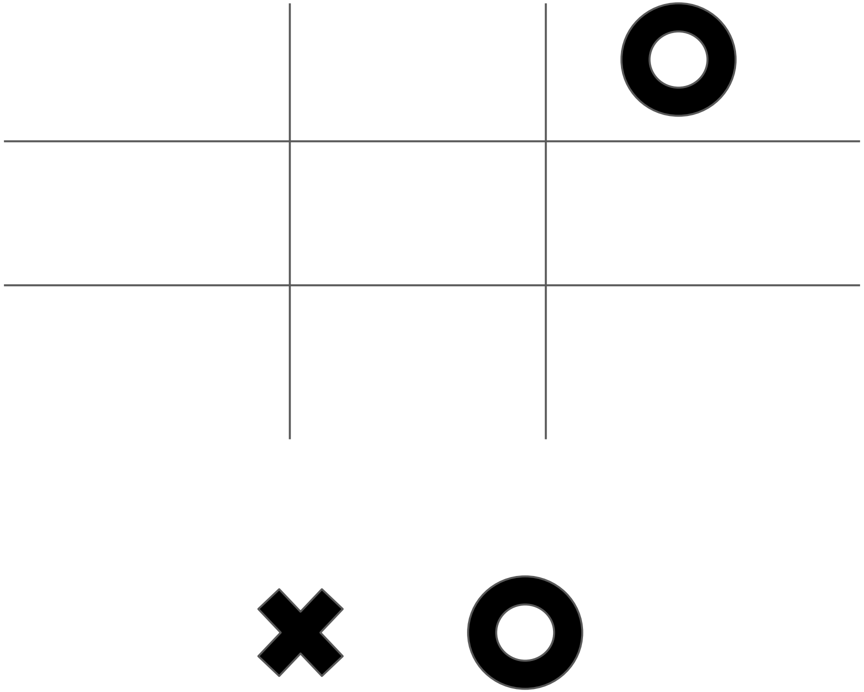

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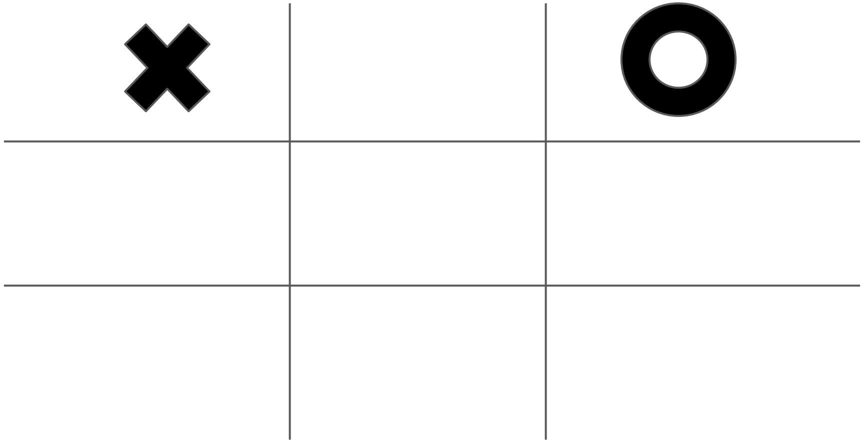

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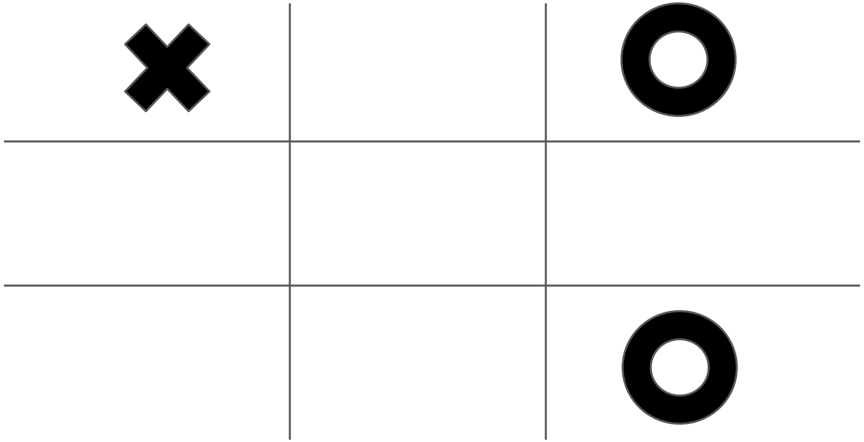

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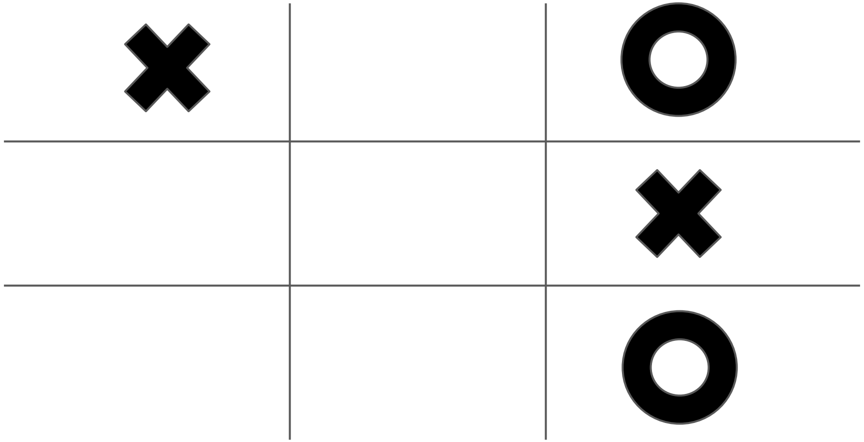

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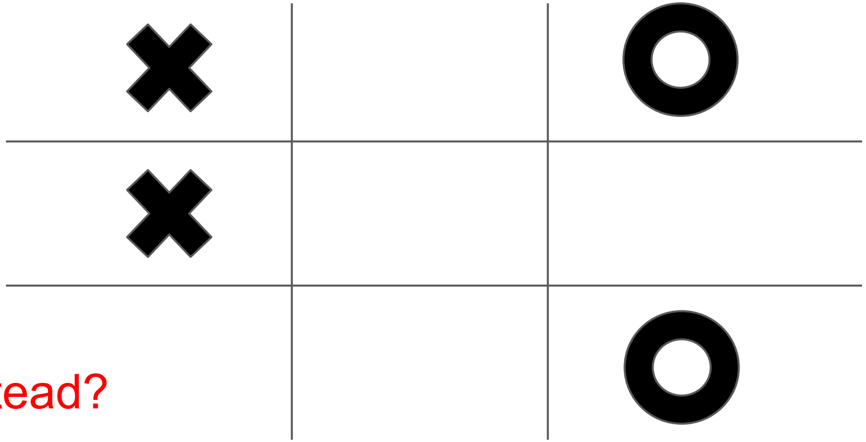

Why not this step instead?

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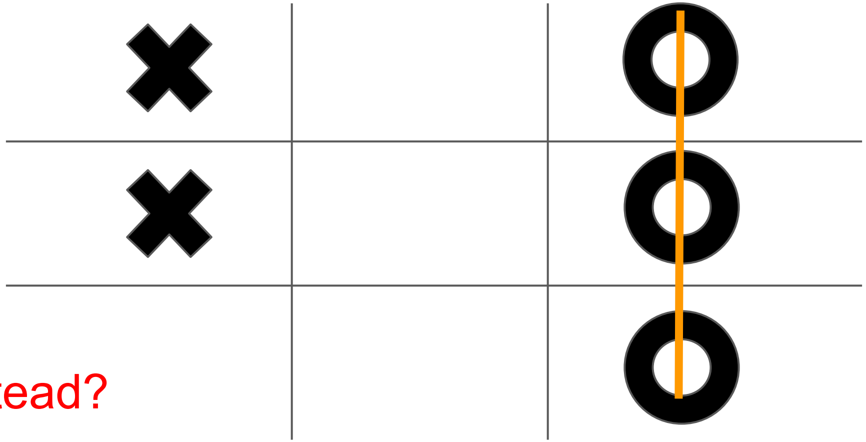

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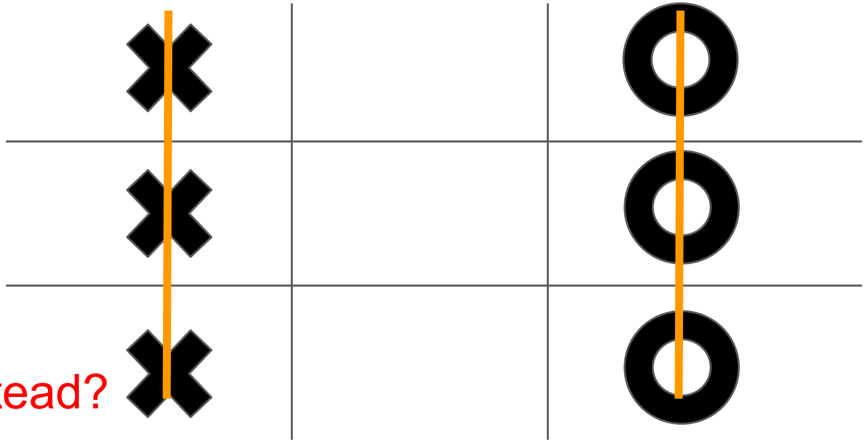
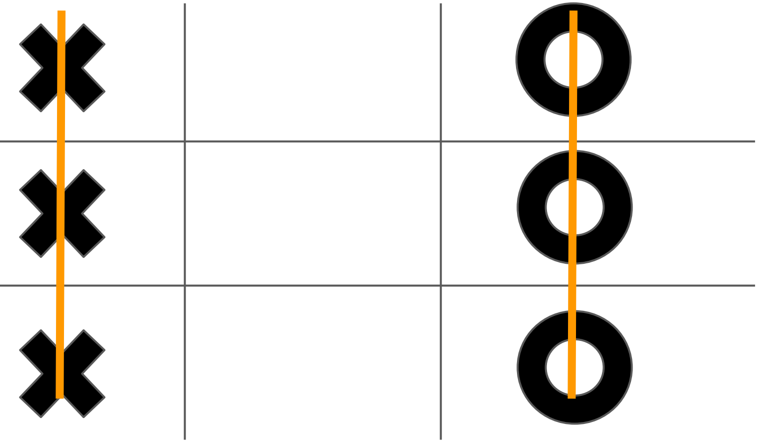


Why not this step instead?

Let’s Play a Turn-based Game

Goal: To be the **First** Player to get 3 of his/her marks in marks in a row/column/diagonal



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Simply completing a task is not enough.
Intelligently solving a task involves considering the rewards/penalties

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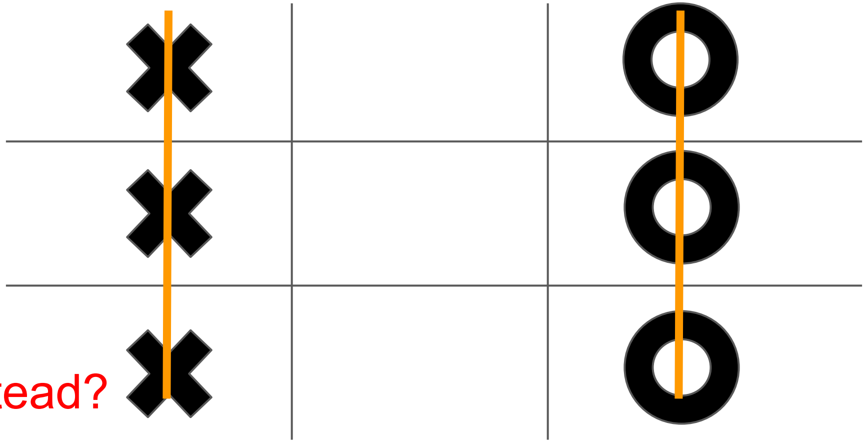

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Isn’t that how we learn too? – Parents, Teachers

Artificial Intelligence

- How do you consider anything intelligent: **Turing Test (originally called the imitation game)**
    - was designed to provide a satisfactory operational definition of intelligence
    - A computer passes the test if a human interrogator, after posing some written questions, cannot tell whether the written responses come from a person or from a computer.

Artificial Intelligence

- In order to pass the Turing Test, the entity should posses the following capabilities:
    - **natural language processing** to enable it to communicate successfully
    - **knowledge representation** to store what it knows or hears
    - **automated reasoning** to use the stored information to answer questions and to draw new conclusion
    - **machine learning** to adapt to new circumstances and to detect and extrapolate patterns.
- Not a fool-proof measure

Artificial Intelligence

- Turing’s test deliberately avoided direct physical interaction between the interrogator and the entity or computer.

- The Total Turing Test includes a video signal so that the interrogator can test the subject’s perceptual abilities, as well as the opportunity for the interrogator to pass physical objects “through the hatch”.

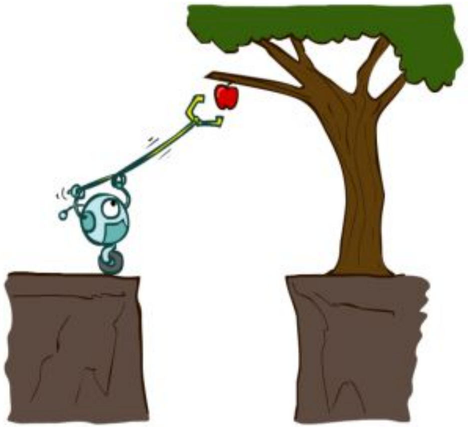
- To pass the total Turing Test, the computer will need

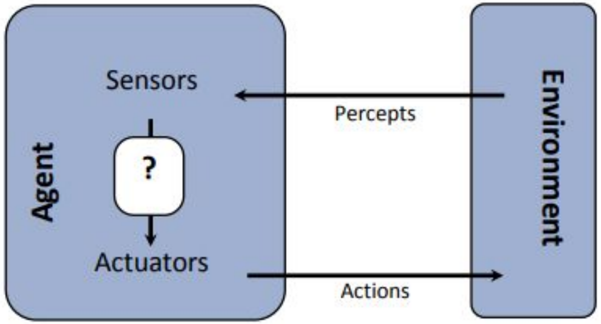
    - **computer vision** to perceive objects

    - **robotics** to manipulate objects and move about.

Artificial Intelligence: Agent

- An agent is an entity that perceives and acts.
- Operate **autonomously**, perceive their environment, persist over a prolonged time period, adapt to change, and create and pursue goals.
- Building AI for a task = Agent





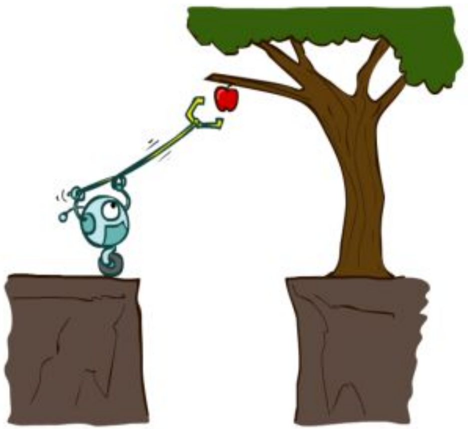
Designing Rational Agent

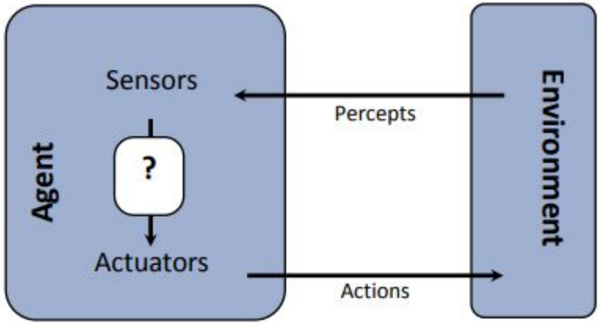
- A **rational** agent is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome against an ideal performance measure

- System is rational if it does the “right thing”, given what it knows, e.g., decisions taken by an autonomous car

- A rational agent selects actions that maximize its (expected) utility.

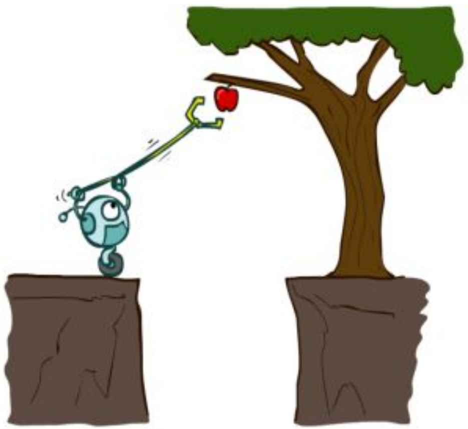
- Characteristics of the **percepts**, **environment**, and **action space** dictate techniques for selecting rational actions

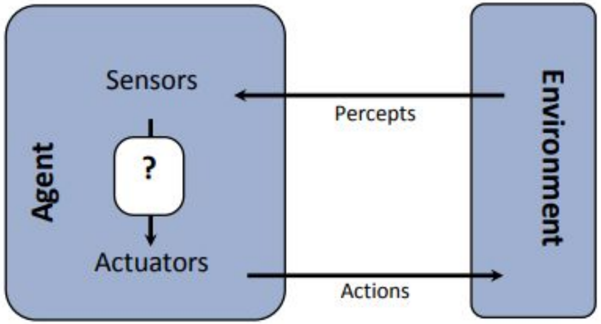




Rational Decisions

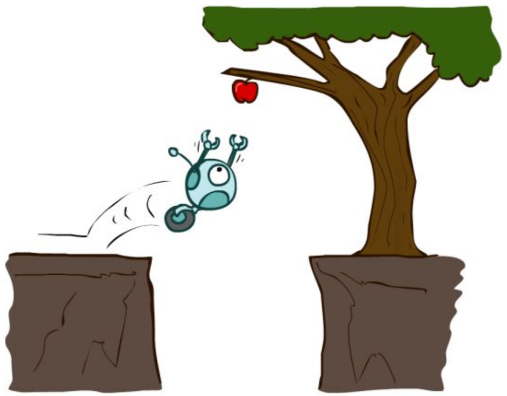
- Rational: Achieve goals while Maximizing pre-defined rewards/utilities
- Rationality only concerns what decisions are made (not the thought process behind them)
- Being rational means maximizing your expected utility

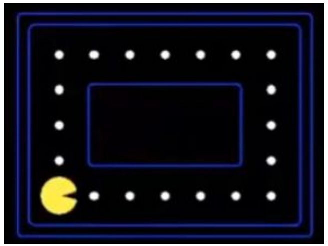


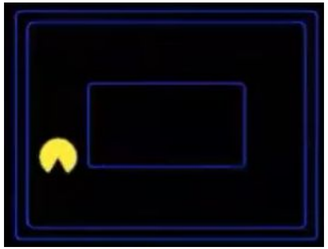


Reflex Agent

- Choose action based on current percept (and maybe memory)
- May have memory or a model of the world's current state
- Do not consider the future consequences of their actions
- Not planning ahead







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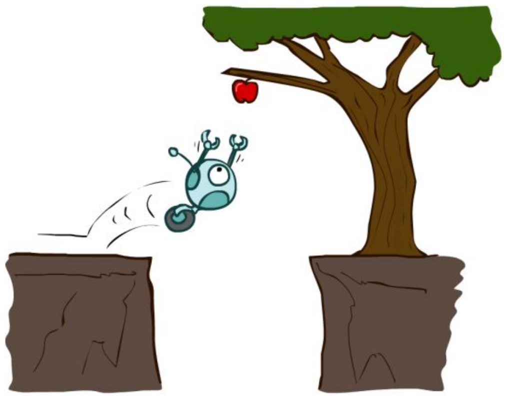
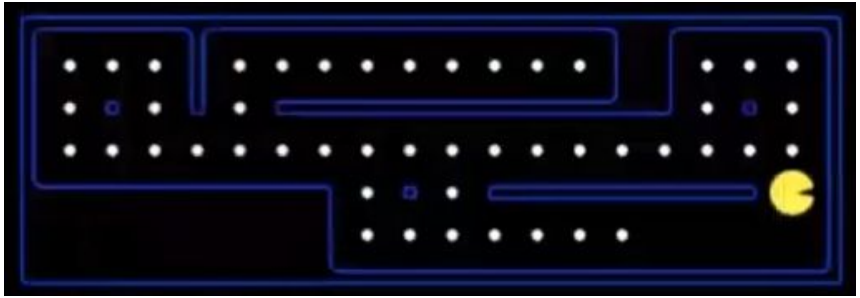
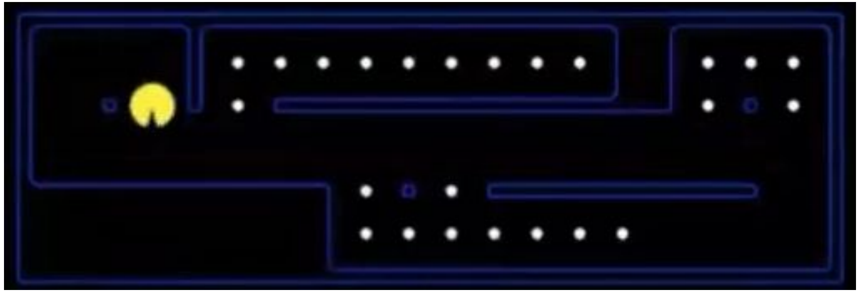




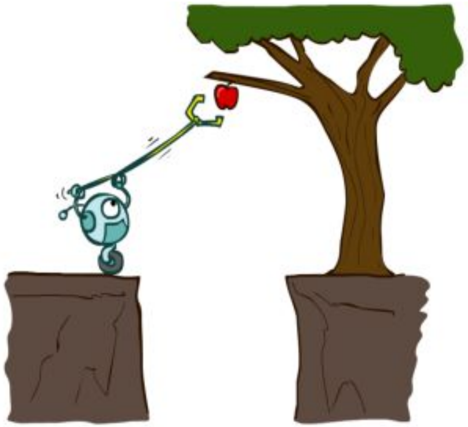


Stuck

Planning Agent

- Planning agents:
    - Ask “what if”
    - Decisions based on (hypothesized) consequences of actions
    - Must have a model of how the world evolves in response to actions
    - Must formulate a goal (test)

- Optimal vs. complete planning:
    - Optimal: Find best solution
    - Complete: If there is a solution then find it, even if it is not the best



Search Problems

- Framework for solving problems

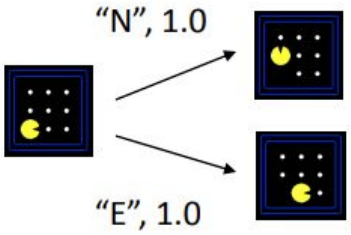
- A search problem consists of:
    - A state space: List of all possible states, i.e., all possible configurations of elements/conditions in the world or environment, e.g., passing one pen across the class, situations in a pac man game.

    - A successor function (with actions, costs): Action may also change the state.

    - A start state

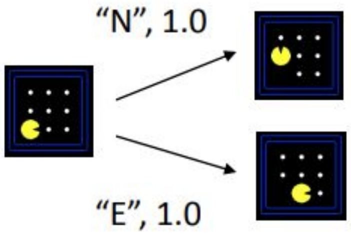
    - A goal test: There can be multiple goal states

- A solution is a sequence of actions (a plan) which transforms the start state to a goal state



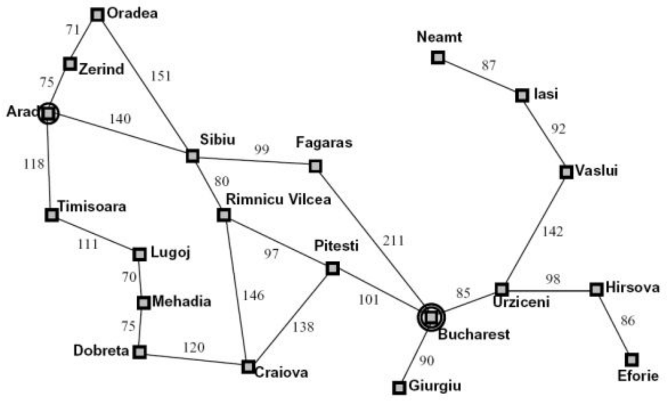
Search Problems

- **There are algorithms to solve search problems**
- **Learn to map real-world problems to search problems**
  - **Then the above algorithms can give you a way to solve the problem**



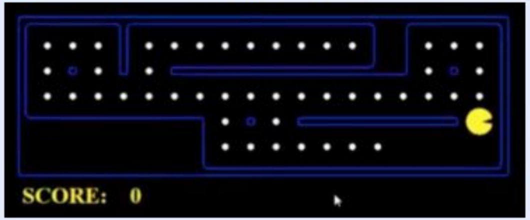
Search Problems: Example

- State space:
  - Cities
- Successor function:
  - Roads: Go to adjacent city with cost = distance
- Start state:
  - Arad
- Goal test:
  - Is state == Bucharest?
- Solution?



State Space

The world state includes every last detail of the environment



A search state keeps only the details needed for planning (abstraction)

- Problem: Pathing
  - States: (x,y) location
  - Actions: NSEW
  - Successor: update location only
  - Goal test: is (x,y)=END
- Problem: Eat-All-Dots
  - States: {(x,y), dot booleans}
  - Actions: NSEW
  - Successor: update location and possibly a dot boolean
  - Goal test: dots all false

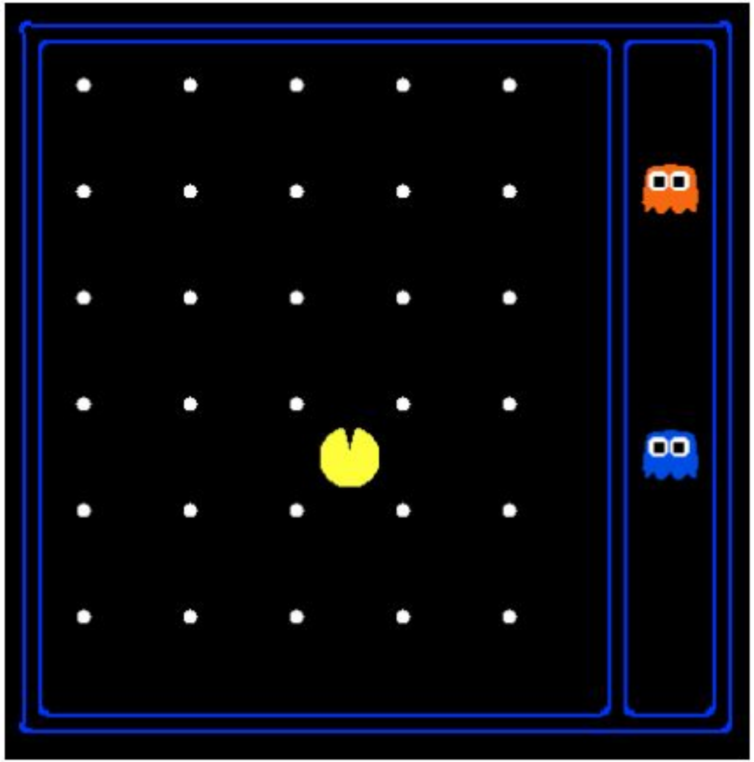
State Space

- World state:
  - Agent positions: 120
  - Food count: 30
  - Ghost positions: 12
  - Agent facing: NSEW

- How many
  - World states?
  - $120 \times (2^{30}) \times (12^{2}) \times 4$

- States for pathing?
  - 120

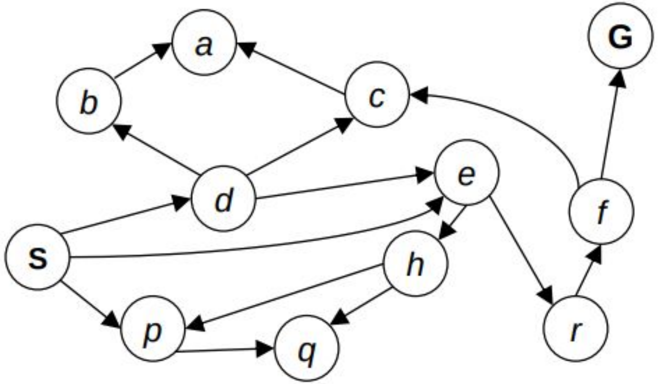
- States for eat-all-dots?
  - $120 \times (2^{30})$

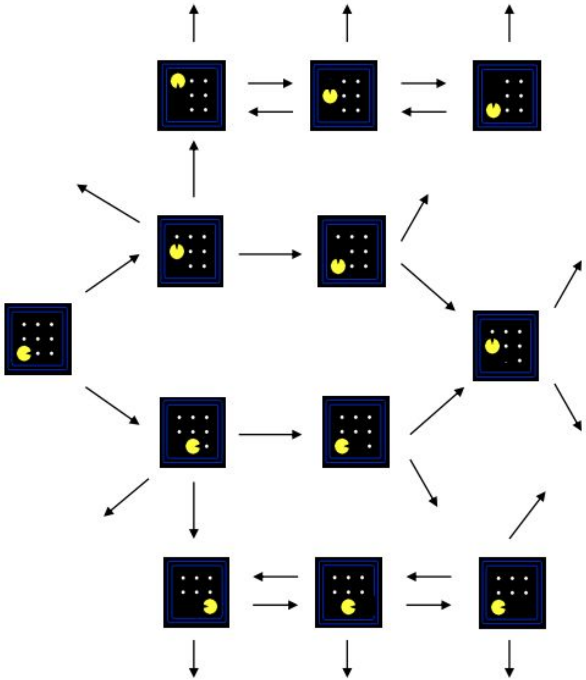


State Space Graphs

- A mathematical representation of a search problem
  - **Nodes** are (abstracted) world configurations/states
  - **Arcs** represent successors (action results)
  - The **goal test** is a set of goal nodes (maybe only one)

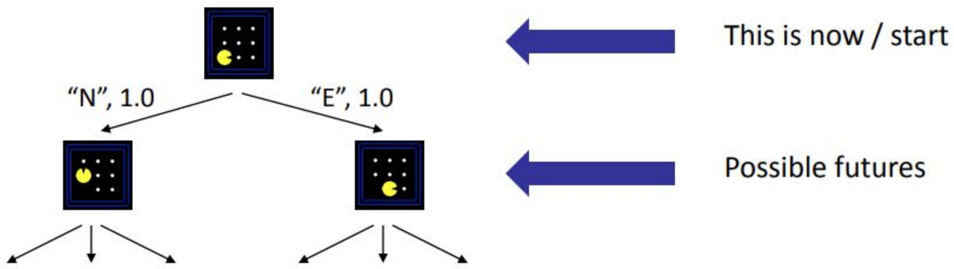
- In a state space graph, each state occurs only once!



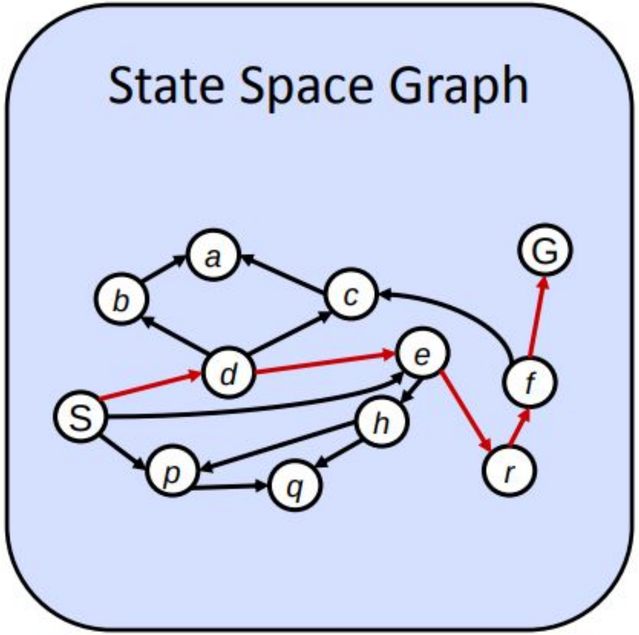


Search Trees

- A search tree:
  - A “what if” tree of plans and their outcomes
  - The start state is the root node
  - Children correspond to successors
  - Nodes show states, but correspond to plans that achieve those states

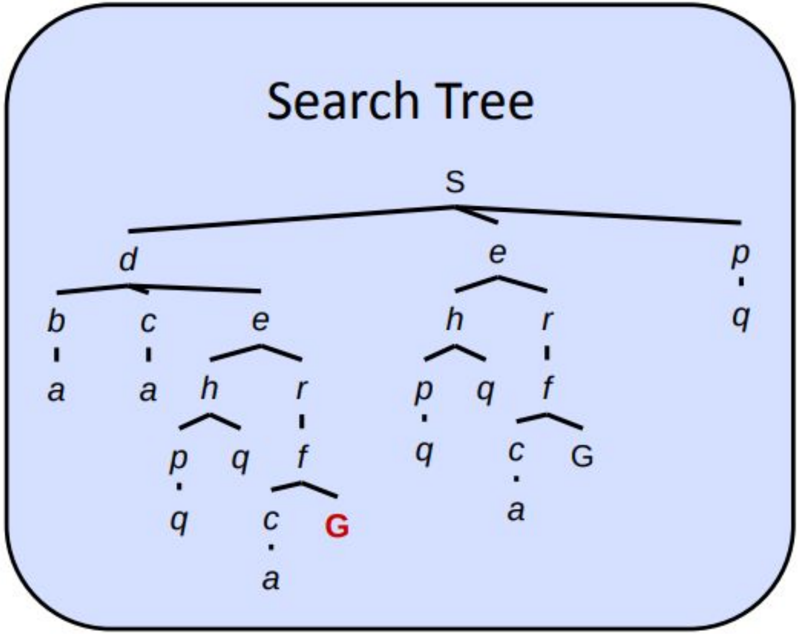


State Space Graphs vs. Search Trees



Each NODE in the search tree is an entire PATH in the state space graph.

We construct both on demand – and we construct as little as possible.



Try: Represent Problems/Tasks as Search Problems

- Cook a Meal with some Ingredients
- Build a Team Project
- Build an agent to play Call of Duty