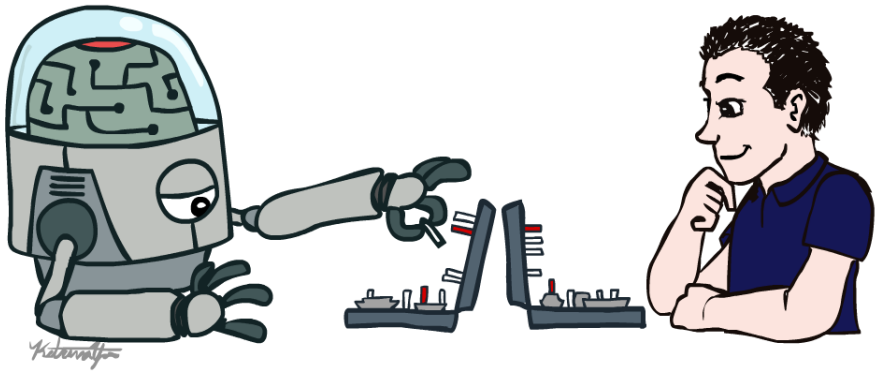
CSE 3521:
Introduction to Artificial Intelligence



[These slides are partially adapted from the UC Berkeley. CS188 Intro to AI at UC Berkeley]

THE OHIO STATE UNIVERSITY

Course Information

- **Instructor:**
  - Jeniya Tabassum (bintejafar.1@osu.edu)

- **Grader:**
  - Prashant Serai (serai.1@osu.edu)

- **Course website:**
  - https://sites.google.com/view/osu-cse-3521-5521/

Course Information

- **Carmen Zoom:**
  - For online lectures and office hours and/or exams
- **Carmen:**
  - For homework submission
- **Proctorio/Carmen quizzes:**
  - For exams and quizzes

Grading and Homework

Grading Policy

- Homework & Labs – 40%
- Quizzes & participation – 10%
- Midterm – 25%
- Final – 25%

Guidelines

- Expect 5 homework/programming assignments over the course.
  - Homework submissions are individual, but feel free to discuss.

Pre-requisites & What to Expect?

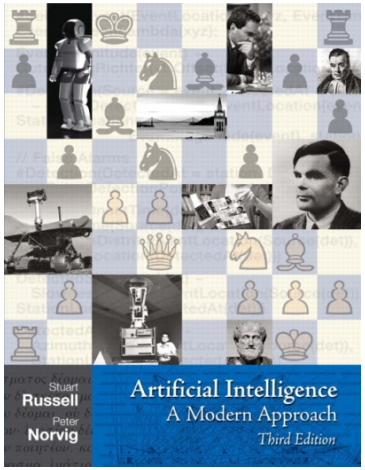
- **Pre-requisites**
  - Required: CSE 2331 (Foundations 2)
  - Suggested: MATH 3345 (Foundations of Higher Math), Stat 3460 or 3470 (Intro to Probability and Stats), MATH 2568 (Linear Alg)

- Extensive math and programming related Homework
  - Multivariate calculus, linear algebra, and probability
  - Python

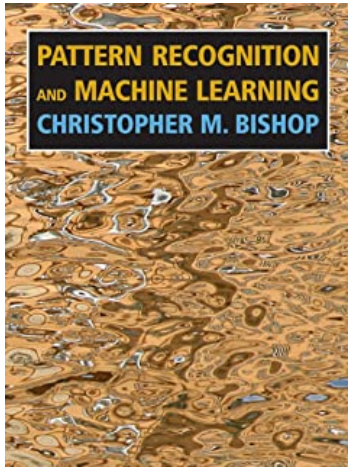
- AI algorithms often difficult to debug
  - We **strongly** recommend that you start early.

Textbook

- Not required, but for students who want to read more we recommend



Russell & Norvig,
AI: A Modern Approach, 3rd Ed.

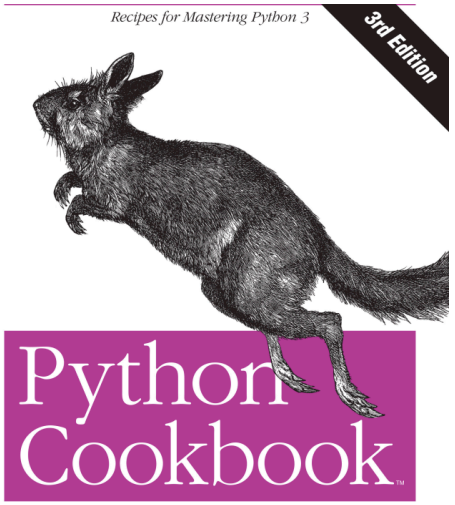


Bishop,
Pattern Recognition and Machine Learning

- Warning: Not course textbooks, so our presentation does not necessarily follow the presentation in the book.

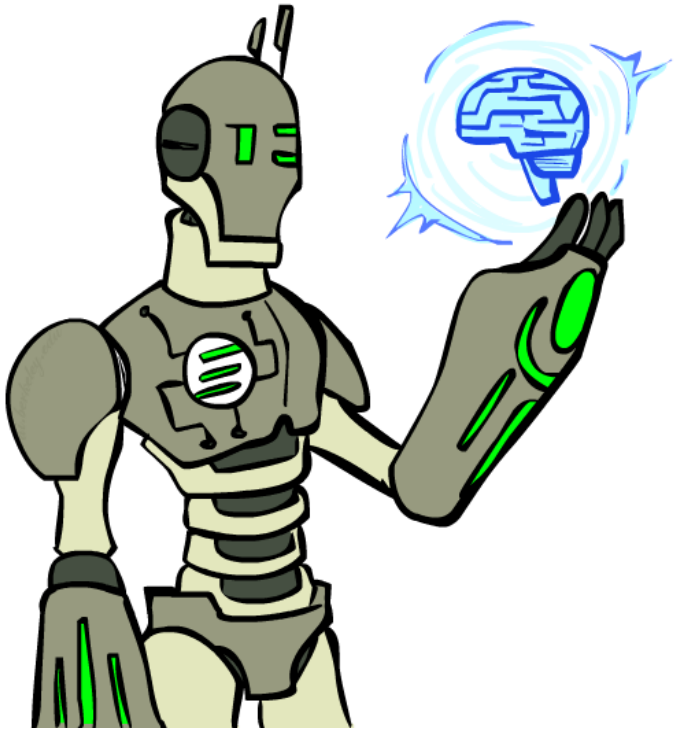
Important* This Week

- **Register**
  - If you are wait-listed, you might or might not get in depending on how many students drop ☹
- **Math review/self-diagnostic**:
  - Check suggested/require materials
  - important to check your preparedness for second half
- **Python:**
  - Check suggested tutorials on the website



Today

- What is artificial intelligence?
- What is this course?
- What can AI do?
- What is an AI agent?
- How to evalute an AI agent?



Some Definitions of AI

- "The scientific understanding of the mechanisms underlying thought and intelligent behavior and their embodiment in machines"

  – American Association of Artificial Intelligence (AAAI)

- "Artificial Intelligence is the branch of computer science that is concerned with the automation of intelligent behavior"

  – Luger and Stubblefield

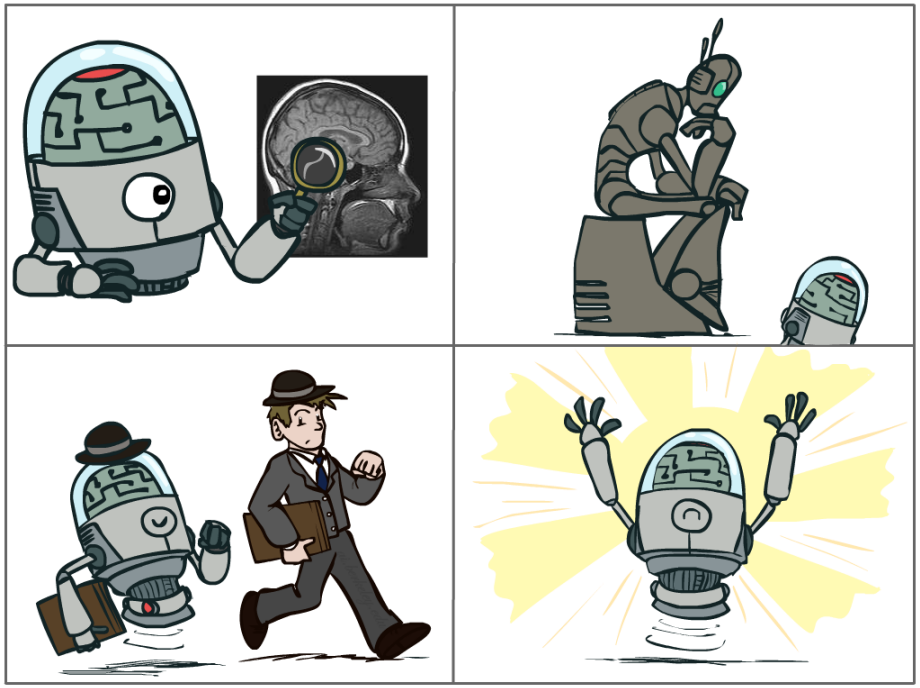
- "AI strives to understand and build intelligent entities (also helps us to learn more about ourselves)"

  – Russell and Norvig

What is AI?

The science of making machines that:

Think like people



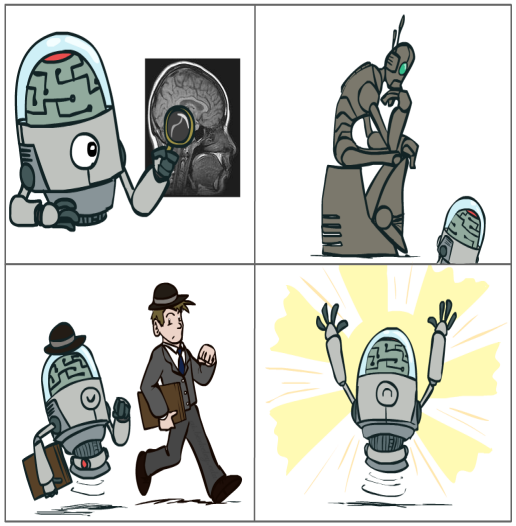
Think rationally

Act like people

Act rationally

What is AI?

How can we test it?



The Turing Test

- Ingredients:
  - Human Judge, unknown Entity
  - 2 computer terminals in different room

- Recipe:
  - Have human Judge sit at one computer
  - Judge converses with Entity via chat window for 5 minutes
  - Judge decides if Entity is human or computer

Which is Which?

Left hand side

- Judge: Hi what's your name?
- Entity: I don't know
- Judge: My name's Jane. I live in London. Where do you live?
- Entity: I live in London as well
- Judge: Do you like living in London?
- Entity: Yes I like it because there are a lot of things to do and it is the capital city of England
- Judge: What's my name?
- Entity: sorry?
- Judge: What's my name?
- Entity: Jane
- Judge: And what's your name?
- Entity: I don't know

Right hand side

- Judge: What color is the carpet in your room
- Entity: I like pink; what do you like?
- Judge: I like pink. My name is John. What's your name?
- Entity: Red. Hello John. Its nice to meet such a fine person as yourself.
- Judge: Red is my favorite color. What's yours?
- Entity: My favorite color is red.
- Judge: You use American spelling. Are you in the USA?
- Entity: But you are not even American. Just remember atheism is only a belief system. And it too can be forced on people who don't agree.
- Judge: How do you like your eggs – ever easy or sunny side up?
- Entity: How I wonder if I like my eggs-over easy or sunny side up? This is so explainable. That list makes me feel unsure John.

Example taken from "Turing's Imitation Game," by Warwick and Shah (2016)

How to do well in the Turing Test?

- Chatting “like a human” involves:
  - Generating coherent language
  - Responding appropriately to unexpected inputs
  - …

What is not shown?

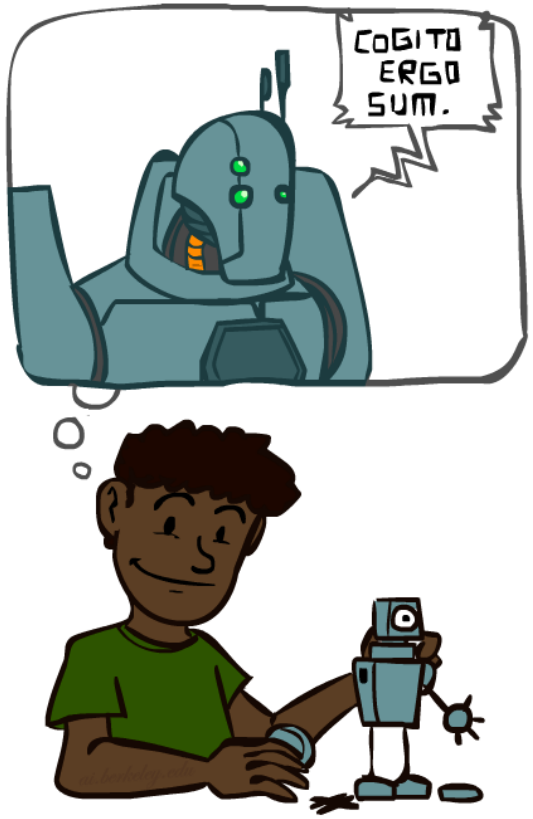
- The Turing Test does not show
  - Understanding or thinking
  - Ability to learn
  - Interaction with an unconstrained world
  - Processing sensory input
  - Having knowledge
  - Much of anything useful, really

Act Rationally; Rational Decisions

- We'll use the term **rational** in a very specific, technical way:
  - Rational: maximally achieving pre-defined **goals**
  - Rationality only concerns what decisions are made (not the thought process behind them)
  - Goals are expressed in terms of the **utility** of outcomes
  - Being rational means **maximizing your expected utility**
  - Rational behavior = doing the right thing, does not necessarily involve thinking

A (** Short **) History of AI

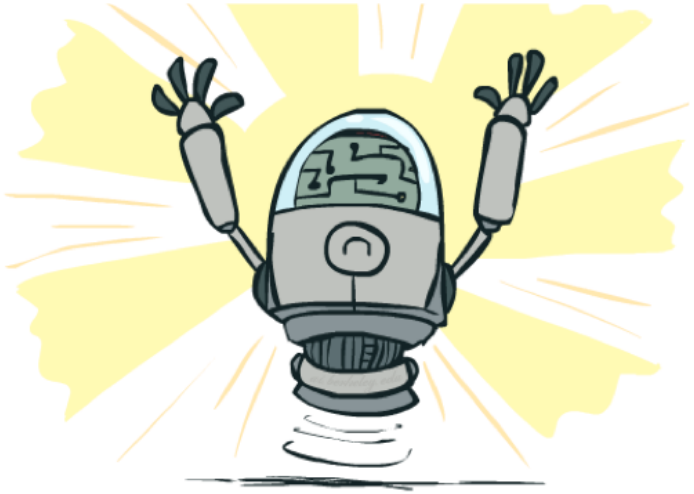
- 1940-1950: Early days
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
  - 1950: Turing's “Computing Machinery and Intelligence”
- 1950—70: Excitement: Look, Ma, no hands!
  - 1950s: Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
  - 1956: Dartmouth meeting: the term **“Artificial Intelligence”** adopted
  - 1965: Robinson's complete algorithm for logical reasoning
- 1970—90: Knowledge-based approaches
  - 1969—79: Early development of knowledge-based systems
  - 1980—88: Expert systems industry booms
  - 1988—93: Expert systems industry busts: “AI Winter”
- 1990—: Statistical approaches
  - Resurgence of probability, focus on uncertainty
  - General increase in technical depth
  - Agents and learning systems… “AI Spring”?
- 2000—: Where are we now? (Machine learning, neural networks, deep learning, …)



What AI Can Do

Quiz: Which of the following can be done at present?

- Play a decent game of table tennis?
- Play a decent game of Jeopardy/Go/Atari/Star raft?
- Drive safely along a curving mountain road (w/o other traffic agents
- Drive safely along High Street?
- Buy a week's worth of groceries on the web?
- Buy a week's worth of groceries at Worthington Farmers Market?
- Discover and prove a new mathematical theorem?
- Converse successfully with another person for an hour?
- Perform a surgical operation?
- Put away the dishes and fold the laundry?
- Translate spoken Chinese into spoken English in real time?
- Write an intentionally funny story?



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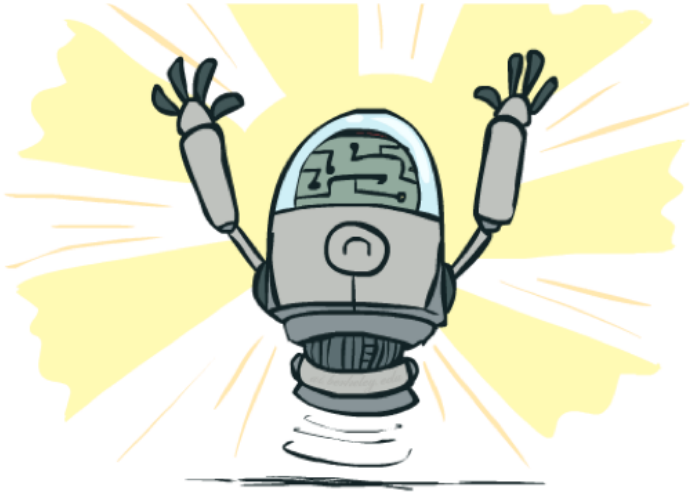
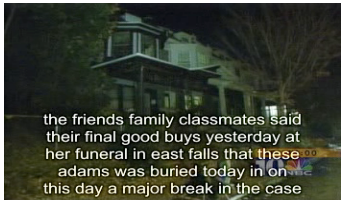


Important research areas related to AI

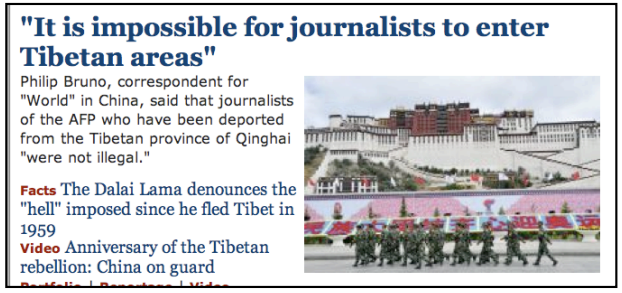
- Speech processing
- Natural language processing
- Computer vision
- Robotics
- Logic
- Game playing
- Decision making
- Autonomous driving
- ……

Speech Processing & Natural Language Processing

- Speech technologies (e.g. Siri, Alexa)
  - Automatic speech recognition (ASR)
  - Text-to-speech synthesis (TTS)
  - Dialog systems



- Language processing technologies
  - Question answering
  - Machine translation

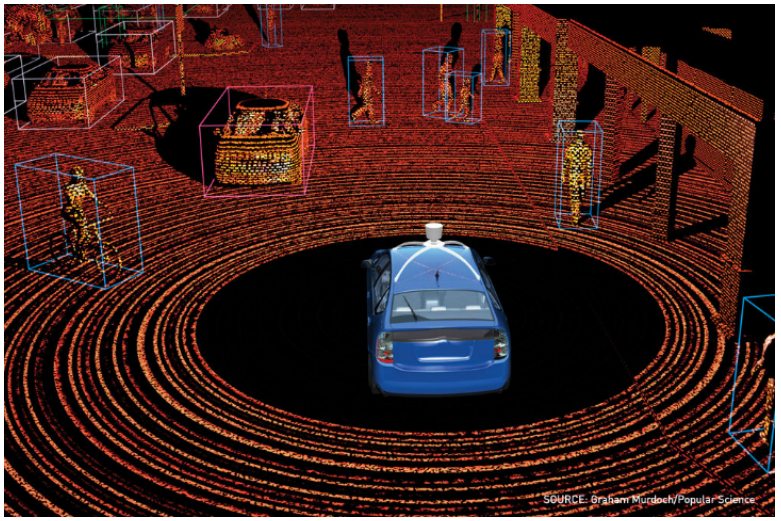


  - Web search
  - Text classification, spam filtering, etc…

Computer Vision

- Object and face recognition
- Scene segmentation
- Image classification

[Source: Detectron2]

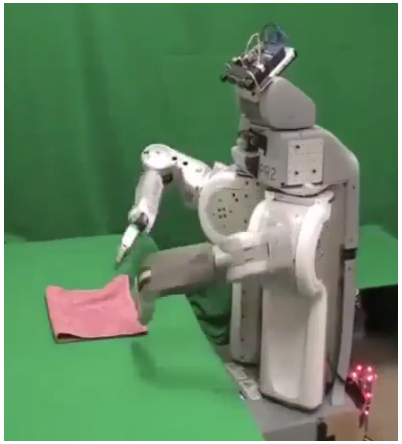


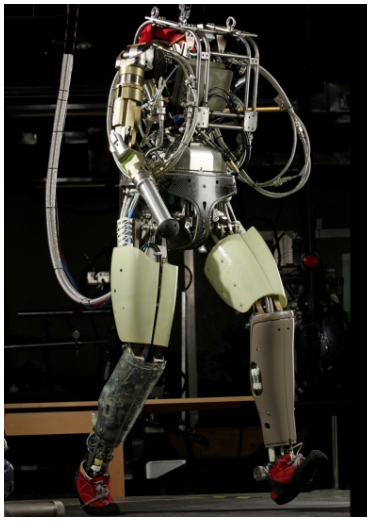
[Source: Graham Murdoch/Popular Science]

Robotics

- Robotics
  - Part mech. eng.
  - Part AI
  - Reality much harder than simulations!

- Technologies
  - Vehicles
  - Rescue
  - Soccer!
  - Lots of automation…

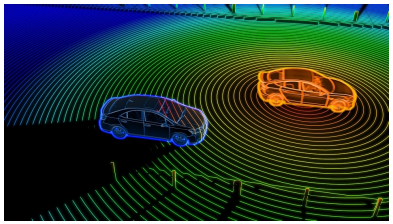




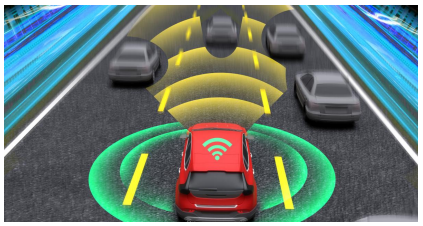
[Images from UC Berkeley, Boston Dynamics, RoboCup, Google]

Autonomous Driving

LiDAR



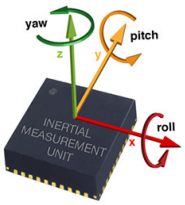
Radar



Sonar

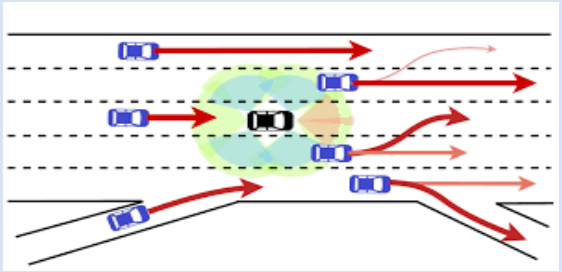
Camera

Others

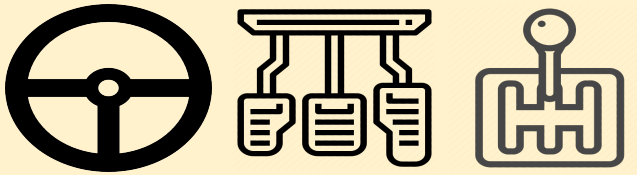


Perception

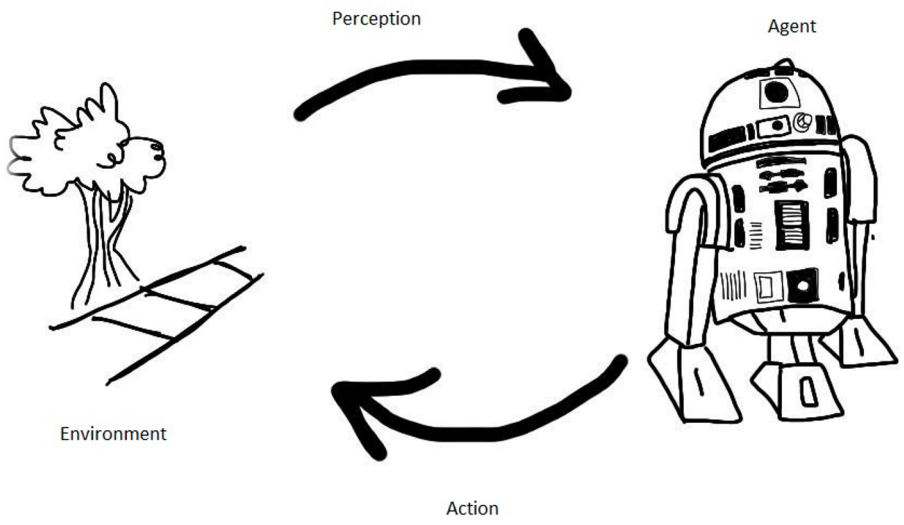
Prediction & Planning



Action & decision



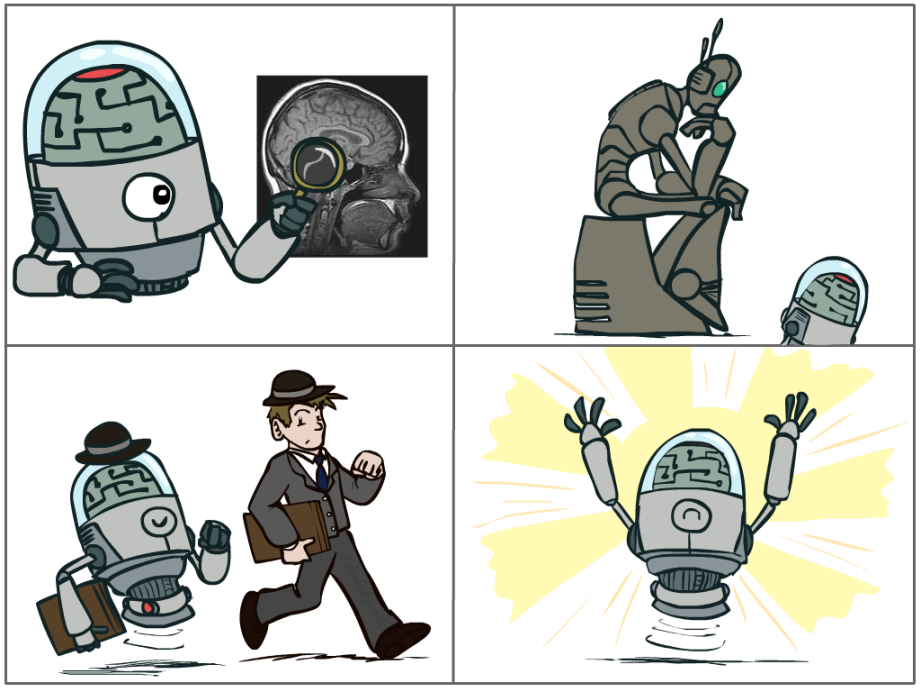
How can we evaluate such agent?



What is AI?

The science of making machines that:

Think like people



Think rationally

Act like people

Act rationally

The Fundamental question for this course topics
(and really this whole AI field !):

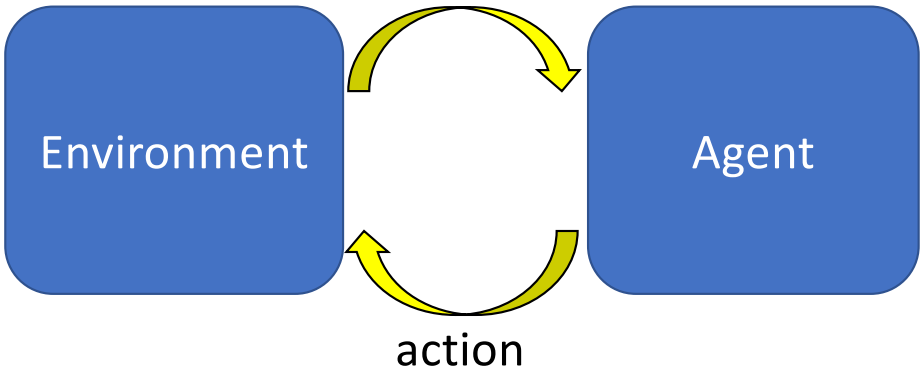
How do you turn a real-world problem into an AI solution?

AI – Agents and Environments

- Much (though not all!) of AI is concerned with **agents** operating in **environments.**
- **Environment –** the problem setting
- **Agent –** an entity that *perceives* its environment through *sensors* and *acts* upon that environment through *effectors (actuators)*

AI – Agents and Environments

Cross walks



Humans

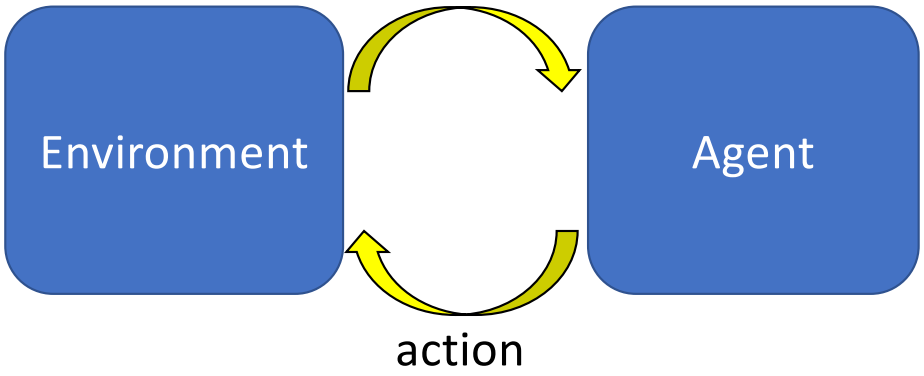
Sensors: eyes, ears, etc.
Effectors: hands, legs, mouth, etc.

Sensors: cameras, 3D sensors, etc.
Effectors: various motors, robot arms, etc.

Robots

AI – Agents and Environments

Cross walks



- **Percept:** Agent's perceptual inputs at any given instant
- **Percept sequence:** Complete history of everything agent has perceived
- Agent's choice of **action** (e.g., walk forward for a step, push the bottom) can depend on entire percept sequence

Humans

Sensors: eyes, ears, etc.
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Robots

Fleshing it out

- **P**erformance – measuring the agent's success
- **E**nvironment – what populates the problem's world?
- **A**ctuators – what can the agent act with?
- **S**ensors – how can the agent perceive the world?

Peas in Automated-Taxi

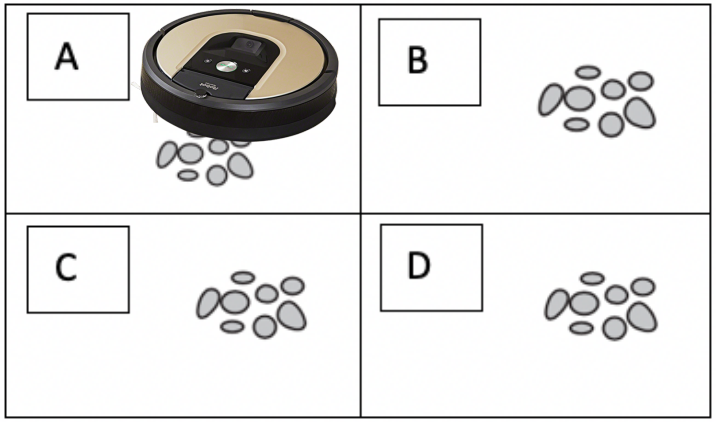
- **P**erformance – Safe, fast, legal, comfortable trip, maximize profits
- **E**nvironment – Roads, other traffic agents (e.g., pedestrians), customers
- **A**ctuators – Steering, accelerator, brake, signals, horn, display
- **S**ensors – Cameras, sonar, LiDAR, radar, speedometer, GPS, odometer, accelerometer, engine sensors, microphone/keyboard

Peas: Other Examples

Agent Type	**Perf. Measure**	**Environment**	**Actuators**	**Sensors**
Medical diagnosis system	Healthy patient, minimize costs/lawsuits	Patient, hospital, staff	Display questions, tests, diagnoses, treatments, referrals	Keyboard entry of symptoms, findings, patient's answers
Satellite image analysis system	Correct image classification	Downlink from orbiting satellite	Display classification of scene	Color pixel arrays (cameras)
Part-picking robot	Percentage of parts in correct bins	Conveyor belt with parts, bins	Jointed arm and hand	Camera, joint angle sensors
Refinery controller	Maximize purity, yield, safety	Refinery, operators	Valves, pumps, heaters, displays	Temperature, pressure, chemical sensors
Interactive English tutor	Maximize student's score on test	Set of students, testing agency	Display exercises, suggestions, corrections	Keyboard entry

In Class Exercise

- Give a ‘PEAS’ description of the task environment for the following vacuum-cleaner world with four locations.



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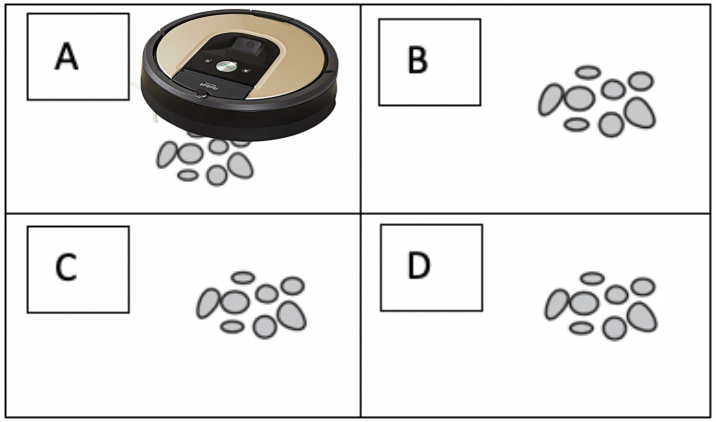
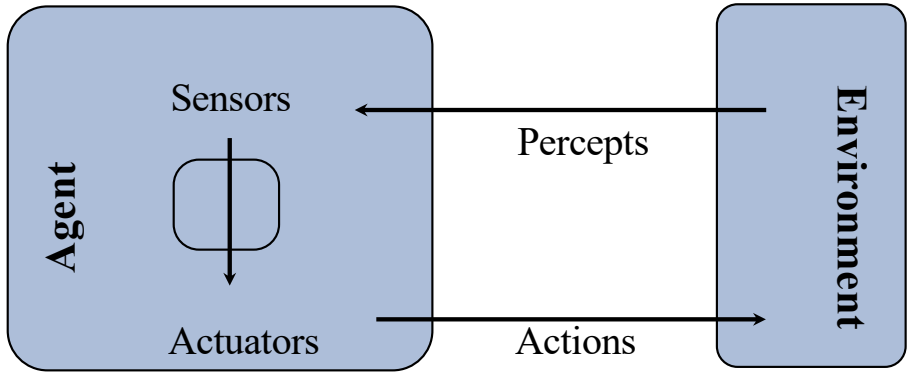


- **P**erformance – cleanness, efficiency, distance traveled
- **E**nvironment – room with 4 squares
- **A**ctuators – wheels, brushes, vacuum extractor
- **S**ensors – dirt detection

What makes an AI agent

- **Agent** – an entity that perceives its environment through sensors, and acts on it with effectors (actuators).

- Percepts are constrained by Sensors + Environment
- Actions are constrained by Actuators + Environment



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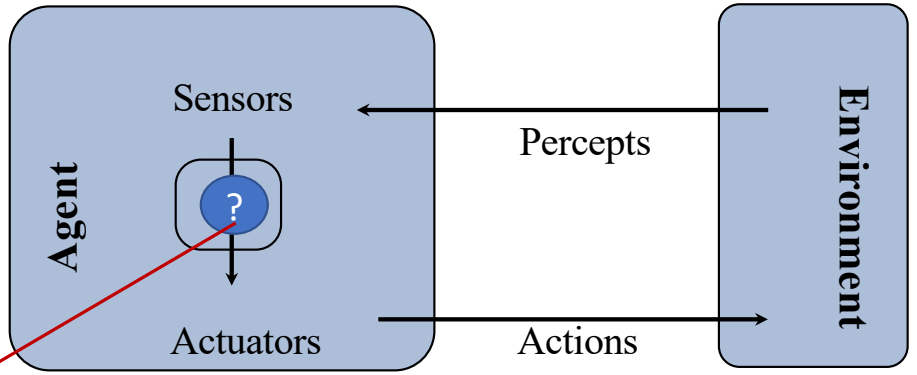
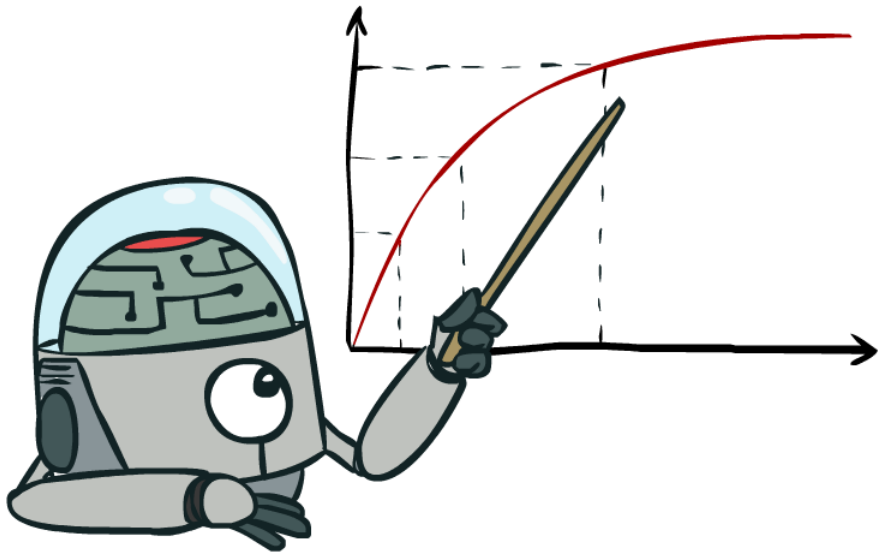


Agent Function (policy) – how does it choose the action?

What is a rational AI agent?

- A **rational agent** always acts to **maximize its expected performance measure**, given current **percept/state**

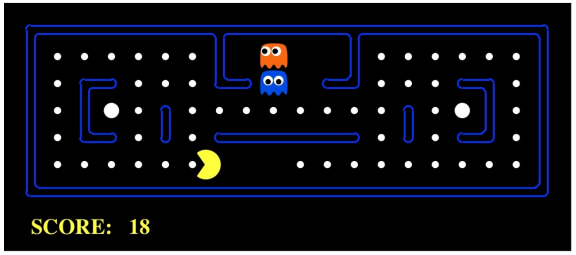
- Rationality ≠ omniscience
  - There is “uncertainty” in the environment.
  - That is why we emphasize “expected”.



Our Sample Agent

Pacman

- Percepts – squares around Pacman
- Actions – move U/D/L/R
- Environment – map with walls, dots, and ghosts



Spam Detector

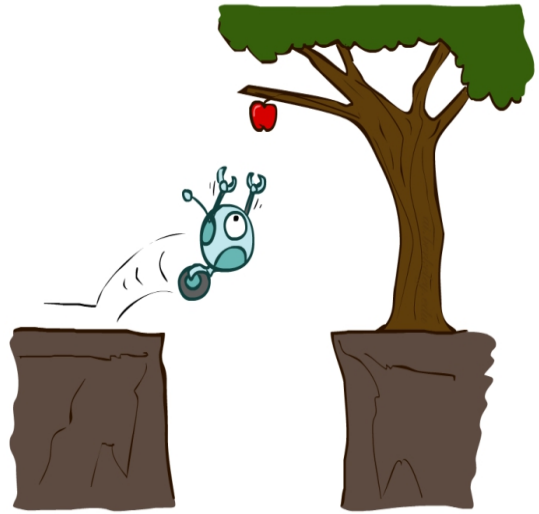
- Percepts – sender, subject line, body of current email
- Actions – mark Spam/Not Spam
- Environment – your email inbox

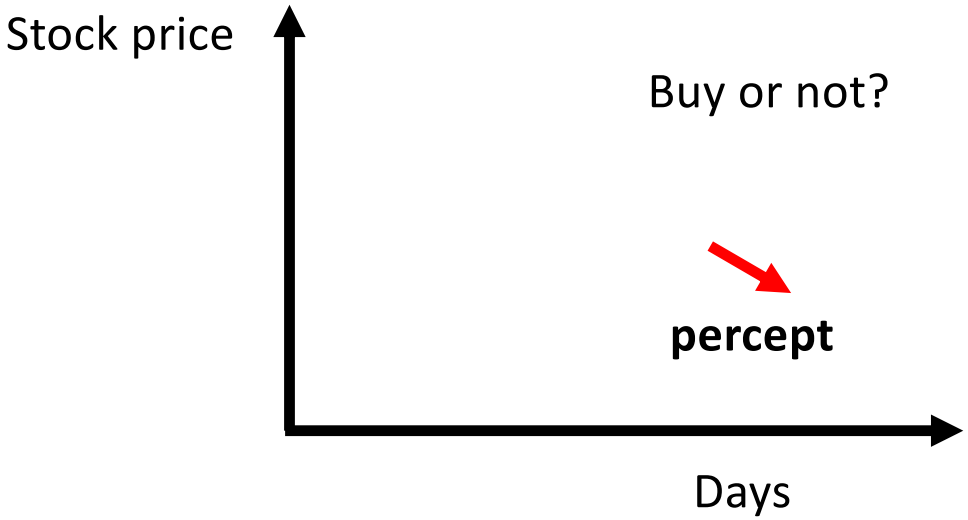
Types of Agent

- Reflex Agent
- Planning Agent
- Goal Based Agent
- Learning agents, Utility-based agents, …

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
- Consider how the world **IS**





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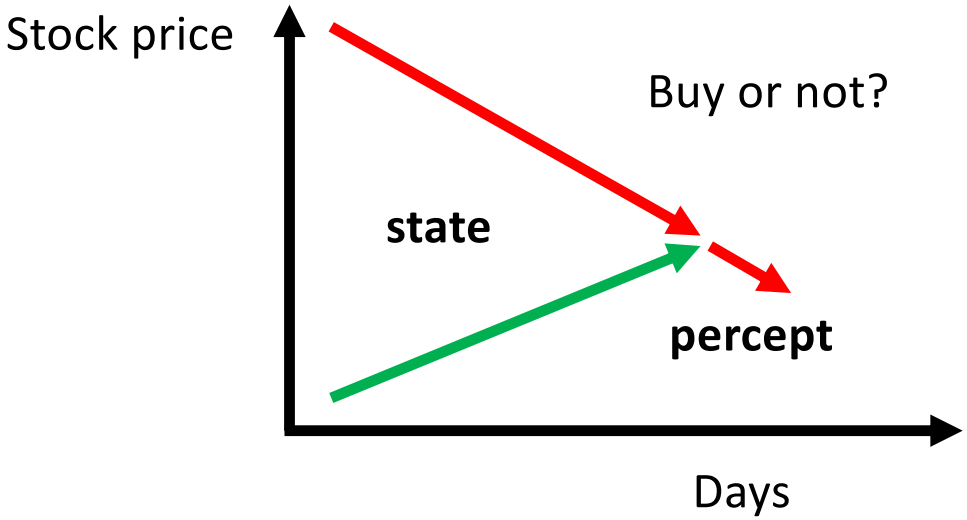
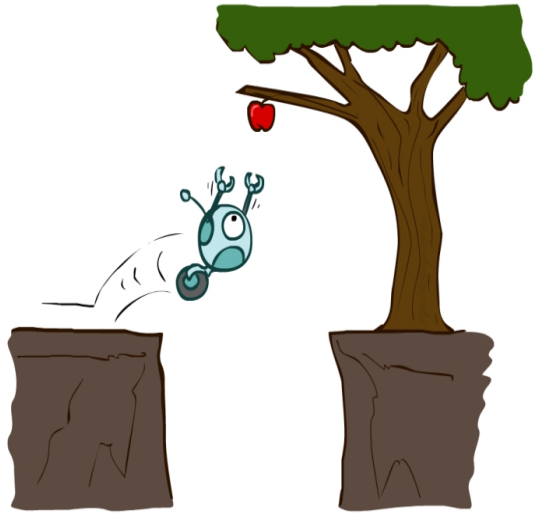
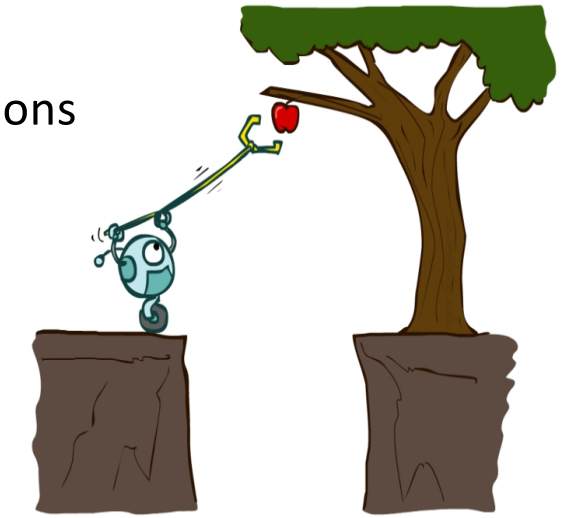




Planning Agent

- 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
- Consider how the world **WOULD BE**



Goal Based Agent

- Chooses action (sequence) to get from current state to some goal

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Pacman

- Percepts – squares around Pacman
- Actions – move U/D/L/R
- Environment – map with walls, dots, and ghosts
- Goal:

Spam Detector

- Percepts – sender, subject line, body of current email
- Actions – mark Spam/Not Spam
- Environment – your email inbox
- Goal:

Goal Based Agent

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…in as short a path as possible

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…in as short a path as possible

Can also have a **Learning Agent**
we'll learn it later in the course!

Spam Detector

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  ail
  Spam
- Environment – your email inbox
- Goal:

AI – Agents and Environments

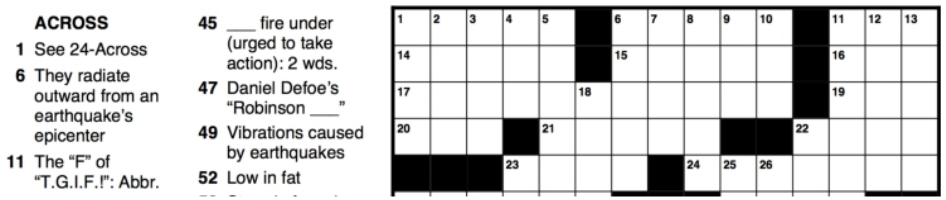
- Much (though not all!) of AI is concerned with **agents** operating in **environments.**
- **Environment –** the problem setting
- **Agent –** an entity that *perceives* its environment through *sensors* and *acts* upon that environment through *effectors (actuators)*

Kinds of Environments

- **Six** common properties to distinguish environments (not exhaustive)
  - Fully observable vs Partially observable
  - Single agent vs Multiagent
  - Deterministic vs Stochastic
  - Episodic vs Sequential
  - Static vs Dynamic
  - Discrete vs Continuous

Fully Observable vs Partially Observable

- Fully observable
  - Agent is able to sense everything in the environment



ACROSS

1 See 24-Across

6 They radiate outward from an earthquake's epicenter

11 The "F" of "T.G.I.F.": Abbr.

45 ___ fire under (urged to take action): 2 wds.

47 Daniel Defoe's "Robinson ___"

49 Vibrations caused by earthquakes

52 Low in fat

- Partially observable
  - noisy, inaccurate, or incomplete sensors

Single Agent vs Multiagent

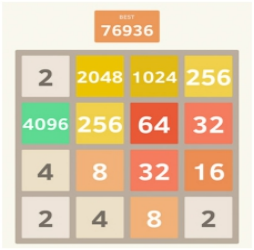
- Single Agent
  - Self-explanatory

- Multiagent
  - Task involves more than one agent
  - Each with its own performance measure
  - May be competitive (measures are opposed) or cooperative (measures are aligned)

Deterministic vs Stochastic

- Deterministic
  - Next state of the world is fully determined by current state + agent action

- Stochastic
  - it's not deterministic

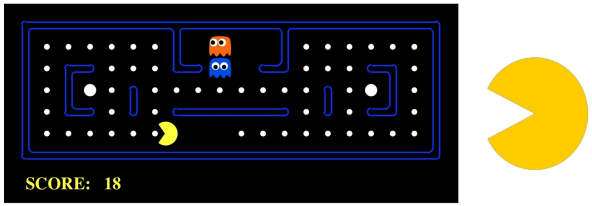


https://2048game.com/

Episodic vs Sequential

- Episodic
  - Each step's state/decision is independent of the previous ones

- Sequential
  - Each step's state/decision affects later ones



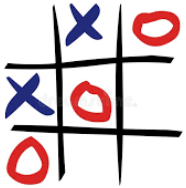
Static vs Dynamic

- Static
  - world doesn't change while agent is choosing an action

- Dynamic
  - decision time matters!

Discreet vs Continuous

- Discrete
  - Possible states/actions are distinct; world changes discretely



- Continuous
  - states/actions take on continuous values

These help to find how to approach a problem

- **Static:** focus on getting really high accuracy/utility
- **Dynamic:** trade some utility for higher efficiency (speed!)
- **Episodic:** reflex agent with a great model
- **Sequential:** need a goal oriented agent
- **Stochastic:** need robustness to uncertainty/failure (robots!)
- **Deterministic:** can focus on efficiency and exactness (Internet crawler)

Examples

	Crossword puzzle	Taxi Driving
Observability	Fully	Partially
Deterministic vs Stochastic	Deterministic	Stochastic
Episodic vs Sequential	Sequential	Sequential
Static vs Dynamic	Static	Dynamic
Discrete vs Continuous	Discrete	Continuous
Single vs Multi Agent	Single	Multi

Summary

- Description of AI (and intelligent agent)
- Evaluation of an AI agent
  - PEAS description
- Different types of AI agent
- Different types Types of agent environment