CSE 5521: Introduction to Artificial Intelligence

Instructor: Jeniya Tabassum

Administrative Details

- Course Webpage:
  https://sites.google.com/site/cse5521sp2020/

- Instructor
  - Jeniya Tabassum
  - Office Hour: Friday 4:00-5:00 pm
  - Office: DL 190

- TA
  - Rayan Hamza

Administrative Details

- Piazza (For discussion and resources)
  http://piazza.com/osu/spring2020/5521
- Carmen (Homework Submission)
  https://osu.instructure.com/courses/72347

Evaluation

Grading

Grading will be based on:

Participation and in-class Exercises (10%)

You will receive credit for asking and answering questions related to the homework on Piazza, engaging in class discussion and participating in the in-class exercises.

Homeworks (30%)

The homeworks will include both written and programming assignments. Homework should be submitted to Carmen by 11:59 pm on the day it is due (unless otherwise instructed). No late homework or lab is accepted without substantial documentation of the reason.

Midterm (20%)

There will be an in-class midterm.

Final (20%)

There will be an in-class final.

What to Expect

- Lots of math and programming related Homework
- AI algorithms often difficult to debug
  - We ***strongly*** recommend you start early.

Definitions of AI

- Based on theoretical and applied principles of CS
  - Data structures for knowledge representation
  - Algorithms needed to apply that knowledge
  - Languages and programming techniques used for implementation

Why is AI difficult?

- (or is it easy?)

How Can it be?

- How can a slow and tiny brain (biological, technological)
  - Perceive
  - Understand
  - Predict
  - Manipulate

Consider even a tiny spider!

- How can we build something with these properties?

Sub-Fields of AI

- Many sub-fields
  - Knowledge
  - Reasoning
  - Machine learning
  - Language
  - Robotics
  - Vision
  - …

Four Categories of AI

Thinking humanly (Systems that think like humans)	Thinking rationally* (Systems that think rationally)
Acting humanly (Systems that act like humans)	Acting rationally* (Systems that act rationally)

*** Rational system "does the right thing"**

(People make mistakes)

Q: What is Artificial Intelligence?

- It is the science and engineering of making intelligent machines, especially intelligent computer programs.
- It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.

Q: Yes, but what is intelligence?

- Intelligence is the computational part of the ability to achieve goals in the world.
- Varying kinds and degrees of intelligence occur in people, many animals, and some machines.

AI in OSU CSE Dept.

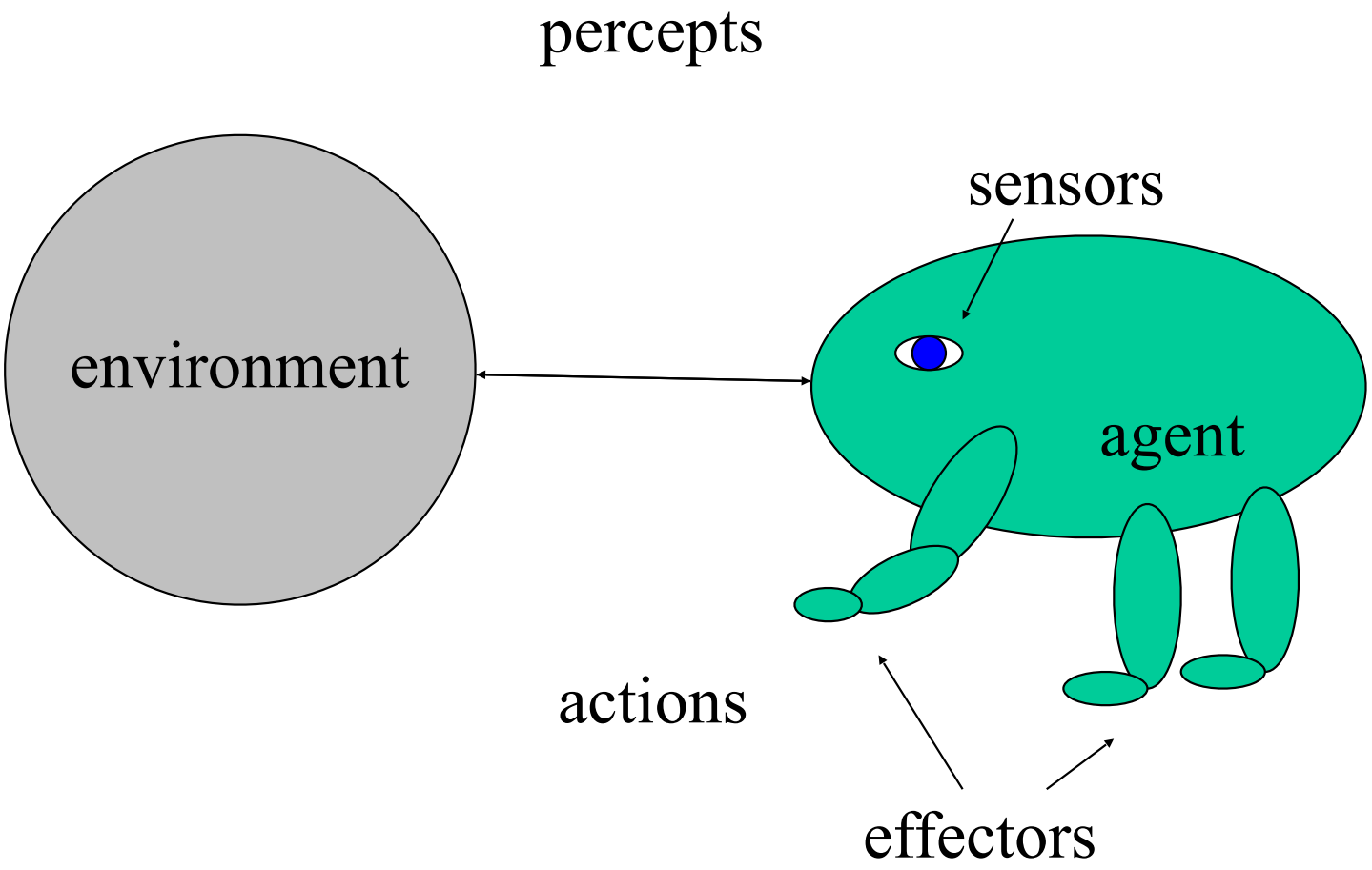
- Laboratory for Artificial Intelligence Research
  - **https://u.osu.edu/lair/**

- AI Club
  - **https://www.osuaiclub.com/**

Agent

- **Agent** is anything that **perceives** its environment through **sensors** and **acts** upon that environment through **effectors**.
- Humans
  - Sensors: eyes, ears, etc.
  - Effectors: hands, legs, mouth, etc.
- Robots
  - Sensors: cameras, infrared range finders
  - Effectors: various motors

Generic Agent



Agent Percepts

- Percept
  - Agent's perceptual inputs at any given instant
- Percept "sequence"
  - Complete history of everything agent has perceived
- Agent's choice of action can depend on entire percept sequence

Agent Function and Program

- Agent function
  - Specifying which action to take in response to any given percept sequence
    - Maps any given percept sequence to an action
  - Abstract mathematical description
- Agent program
  - Implements the agent function for an agent
    - Runs on the agent architecture

Mapping of Percepts to Actions

- Table of actions in response to each possible percept sequence
  - Simple table representation can be huge
    - For chess, the table would have 35^{100} entries!
  - Takes too long to build the table
- Define a specification of the mapping
  - Example: sqrt() using Newton's method rather than enumeration of all possible mappings

Good Behavior: The Rational Agent

- A **rational agent** is one that does the right thing (to be most successful)
  - e.g., every entry in the function table is filled out correctly
- What is the rational action for a particular circumstance?
  - Whichever action that will cause the agent to be most successful
    - Given what you have seen/know
  - Need a way to measure success: performance measure
  - "Whichever action maximizes the expected value of the performance measure given the percept sequence to date"

Performance Measure

- Performance measure
  - A way to evaluate the agent's success
    - Embodies the criterion for success of an agent's behavior
  - Specifies numerical value for any environment history toward the goals
- Performance measures for vacuum cleaner
  - Amount of dirt cleaned up in shift
    - BUG: Could maximize by cleaning-up, dumping, cleaning-up, etc!
  - Amount of electricity consumed
  - Amount of noise generated
- When to evaluate is also important
  - Timespan (shift, day, month, etc.)

Rationality Depends on…

- The **performance measure** that defines degree of success
- Everything the agent has perceived so far
  - The **percept sequence**
- What the agent **knows about the environment**
- The **actions** that the agent can perform

This leads to…

Ideal Rational Agent

- For each possible percept sequence, do whatever action is expected to maximize its performance measure, using evidence provided by the percept sequence and any built-in knowledge
  - Do actions in correct order

Rationality

- Rationality ≠ omniscience
  - Omniscient agent knows actual outcome of its actions and can act accordingly
  - Impossible in reality (though available in simulation)
- Rationality is concerned with *expected* success *given what has been perceived*
  - Considered safe crossing street, but then hit from above…
  - Can "explore" to gather more information

Autonomy

- Autonomous behavior
  - Behavior is determined by its own experience
- Non-autonomous behavior
  - If no use of percepts (use only built-in knowledge), then system has no autonomy
    - A clock
    - But consider a clock that detects and sets to atomic clock, or adjusts to different time zones
  - All of its assumptions must hold
  - Certain animal behaviors
- A rational agent should be autonomous

Nature of Environments

- Must specify the setting for intelligent agent design
- Task environments
  - The "problems" to which rational agents are the "solutions"
- Multiple flavors of task environments
  - Directly affects the design of the agent
- PEAS description
  - (P)erformance Measure
  - (E)nvironment
  - (A)cutators
  - (S)ensors

PEAS Description

- Consider an "automated taxi driver" (Total Recall)
  - **P**erformance Measure?
    - Safe, fast, obey laws, reach destination, comfortable trip, maximize profits
  - **E**nvironment?
    - Roads, other traffic, pedestrians, weather, customers
  - **A**ctuators?
    - Steering, accelerator, brake, signal, horn, speak, display
  - **S**ensors?
    - Cameras, microphone, sonar, speedometer, GPS, odometer, accelerometer, engine sensors, keyboard

Other PEAS 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

Properties of Environments

- Fully observable vs. partially observable
  - If sensors give access to complete state of environment
- Deterministic vs. stochastic
  - If next state of environment is completely determined by current state and the action executed by the agent (Can't predict environment in stochastic)
- Episodic vs. sequential
  - Experience divided into atomic episodes (perceiving and acting)
  - Next episode does not depend on previous episodes
- Static vs. dynamic
  - Environment not change while agent is "thinking"
- Discrete vs. continuous
  - Distinct, clearly defined percepts and actions (chess)
- Single Agent vs. multi-agent
  - Solving a puzzle is single agent
  - Chess is competitive multi-agent environment

Environment 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

Structure of Intelligent Agents

- Agent = Architecture + Program
  - Architecture is the computing device
    - Makes sensor percepts available to the program
    - Runs the program
    - Feeds action choices to effectors
  - Program
    - Implements agent function mapping of percepts to actions
- The job of AI is to design **Agent Programs**
  - Though much current emphasis on embodiment

Basic Types of Agent Programs

- Simple reflex agents
  - Condition-action rules on current percept
    - Environment must be fully observable
- Model-based reflex agents
  - Maintain internal state about how world evolves and how actions effect world
- Goal-based agents
  - Use goals and planning to help make decision
- Utility-based agents
  - What makes the agent “happiest”
- Learning agents
  - Makes improvements