Introduction to AI

Chao Lan
Outline

Course Introduction

Basic AI Setting and Concepts

What is an intelligent agent?

What is task environment and how to categorize it?

How to categorize agent program?
Welcome
Course Information

Time:  MWF 1:10pm - 2pm

Location:  College of Business, Room 111

Instructor:  Chao Lan

Office:  4084A

Office Hour:  MWF 2pm-3pm, or by appointment

Email:  clan@uwyo.edu

Course Webpage:  http://www.cs.uwyo.edu/~clan/teach/ml2018
Prerequisites

COSC 3020 or approval of the instructor.

Python programming.

Working knowledge in probability & linear algebra.

Latex.
Grading

COSC 4550
- assignment 60%
- midterm 15%
- final 25%
- project 10% (bonus)

COSC 5550
- assignment 60%
- midterm 10%
- final 20%
- project 10%
Assignments

Writing (Latex)
- explain principle
- do math
- document experimental results
- paper review

Programming Assignment (Python)
- implement basic algorithm
- sensitivity analysis
- visualize results
Project

Required for graduate student. Bonus for undergraduate student.

Free to choose any topic related to AI.

One needs to lead a project; can participate in others.

Task & Schedule

- Proposal, Oct 26
- Presentation, Dec 3 - 10
- Final report, Dec 21
Project Grading

Leading Project (100%)
- Proposal (20%)
- Presentation (20%)
- Report and result (40%)
- Consistency between proposal and report (20%)

Participant Project (10% bonus)
Course Topics

Search

Reasoning

Application
Topic 1: Search
Topic 2: Reasoning

agent

from state $s$, take action $a$

environment

get reward $R$, new state $s'$
Topic 3: Application
Outline

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**Basic AI Setting and Concepts**

What is an intelligent agent?

What is task environment and how to categorize it?

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### What is AI?

<table>
<thead>
<tr>
<th>Thinking Humanly</th>
<th>Thinking Rationally</th>
</tr>
</thead>
<tbody>
<tr>
<td>“The exciting new effort to make computers think ... machines with minds, in the full and literal sense.” (Haugeland, 1985)</td>
<td></td>
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<tr>
<td>“[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning ...” (Bellman, 1978)</td>
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<tr>
<td>“The study of mental faculties through the use of computational models.” (Charniak and McDermott, 1985)</td>
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<tr>
<td>“The study of the computations that make it possible to perceive, reason, and act.” (Winston, 1992)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Acting Humanly</th>
<th>Acting Rationally</th>
</tr>
</thead>
<tbody>
<tr>
<td>“The art of creating machines that perform functions that require intelligence when performed by people.” (Kurzweil, 1990)</td>
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<tr>
<td>“The study of how to make computers do things at which, at the moment, people are better.” (Rich and Knight, 1991)</td>
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<tr>
<td>“Computational Intelligence is the study of the design of intelligent agents.” (Poole et al., 1998)</td>
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<tr>
<td>“AI ... is concerned with intelligent behavior in artifacts.” (Nilsson, 1998)</td>
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</table>
Act Humanly = Pass Turing Test

A machine passes Turing Test if a human interrogator, after posing questions, cannot tell whether the responses come from a person or from a computer.
Capabilities to Pass Turing Test

A computer needs several capabilities to pass the test, including natural language processing, knowledge representation, automated reasoning, machine learning, computer vision, robotics, etc.
Basic Setting of AI
Concepts

Agent

Agent Function
- map percept sequence to action
- implemented by agent program

Agent state

Environment state
Example: Vacuum-Cleaner

environment state?

agent?

percept?

action?

agent function?
**Example: Vacuum-Cleaner**

<table>
<thead>
<tr>
<th>Percept sequence</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>[A, Clean]</td>
<td>Right</td>
</tr>
<tr>
<td>[A, Dirty]</td>
<td>Suck</td>
</tr>
<tr>
<td>[B, Clean]</td>
<td>Left</td>
</tr>
<tr>
<td>[B, Dirty]</td>
<td>Suck</td>
</tr>
<tr>
<td>[A, Clean], [A, Clean]</td>
<td>Right</td>
</tr>
<tr>
<td>[A, Clean], [A, Dirty]</td>
<td>Suck</td>
</tr>
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<td>:</td>
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<td>[A, Clean], [A, Clean], [A, Clean]</td>
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<tr>
<td>:</td>
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</table>

- **environment state?**
- **agent?**
- **percept?**
- **action?**
- **agent function?**
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What is an intelligent agent?

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How to categorize agent program?
Basic Setting of AI
What is an intelligent agent?

An intelligent agent is a rational agent.

For any percept sequence, a rational agent should take action that is expected to maximize some performance measure over environment states.

There are many ways to design performance measure.

Read [AIMA] Section 2.2.1. for a formal definition of rational agent.
What is an intelligent agent?

An intelligent agent is a rational agent.

For any percept sequence, a rational agent should take action that is expected to maximize some performance measure over environment states.

Q: can we measure performance over agent state?

There are many ways to design performance measure.
What is an intelligent agent?

An intelligent agent is a rational agent.

For any percept sequence, a rational agent should take action that is expected to maximize some performance measure over environment states.

Q: can we measure performance over agent state?

Q: why is the agent ‘expected’ to maximize performance? (omniscient)

There are many ways to design performance measure.
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Basic Setting of AI
What is a task environment?

A task environment specifies AI problem in four dimension (PEAS).

- Performance Measure
- Environment
- Actuator
- Sensor
An Example of Task Environment

<table>
<thead>
<tr>
<th>Agent Type</th>
<th>Performance Measure</th>
<th>Environment</th>
<th>Actuators</th>
<th>Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxi driver</td>
<td>Safe, fast, legal, comfortable trip, maximize profits</td>
<td>Roads, other traffic, pedestrians, customers</td>
<td>Steering, accelerator, brake, signal, horn, display</td>
<td>Cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors, keyboard</td>
</tr>
</tbody>
</table>

Read [AIMA] Section 2.3.1. for more examples.
How to categorize task environment?

Fully Observed vs Partially Observed
- whether all aspects relevant to action choice are detected
How to categorize task environment?

Fully Observed vs Partially Observed
- whether all aspects relevant to action choice are detected

Q: a cleaner with local dirt detector is…?
How to categorize task environment?

Fully Observed vs Partially Observed
- whether all aspects relevant to action choice are detected

Q: a cleaner with local dirt detector is…?

Q: a cleaner with global dirt detector is…?
How to categorize task environment?

Fully Observed vs Partially Observed
- whether all aspects relevant to action choice are detected

Q: a cleaner with local dirt detector is…?
Q: a cleaner with global dirt detector is…?

What is the difference?
How to categorize task environment?

Fully Observed vs Partially Observed

Single-Agent vs Multi-Agent
  - whether there is one or more cooperative/competitive agents
How to categorize task environment?

Fully Observed vs Partially Observed

Single-Agent vs Multi-Agent
- whether there is one or more cooperative/competitive agents

Q: taxi-driving scheduling is…?
How to categorize task environment?

Fully Observed vs Partially Observed

Single-Agent vs Multi-Agent
  - whether there is one or more cooperative/competitive agents

Q: taxi-driving scheduling is…?

Q: manufacturing robot is…?
How to categorize task environment?

Fully Observed vs Partially Observed

Single-Agent vs Multi-Agent

Deterministic vs Stochastic
- whether next environment state completely depends on current state and agent action
How to categorize task environment?

Fully Observed vs Partially Observed

Single-Agent vs Multi-Agent

Deterministic vs Stochastic
- whether next environment state completely depends on current state and agent action

Q: a place with fixed dirt is…?
How to categorize task environment?

Fully Observed vs Partially Observed

Single-Agent vs Multi-Agent

Deterministic vs Stochastic
- whether next environment state completely depends on current state and agent action

Q: a place with fixed dirt is…?

Q: a place with random dirt is…?
How to categorize task environment?

- Fully Observed vs Partially Observed
- Single-Agent vs Multi-Agent
- Deterministic vs Stochastic
- Episodic vs Sequential
  - whether next episode depends on actions in previous episodes
How to categorize task environment?

Fully Observed vs Partially Observed

Single-Agent vs Multi-Agent

Deterministic vs Stochastic

Episodic vs Sequential
  - whether next episode depends on actions in previous episodes

Q: a defect detection pipeline is …?
How to categorize task environment?

**Fully Observed vs Partially Observed**

**Single-Agent vs Multi-Agent**

**Deterministic vs Stochastic**

**Episodic vs Sequential**

- whether next episode depends on actions in previous episodes

Q: a chess game is …?
How to categorize task environment?

- Fully Observed vs Partially Observed
- Single-Agent vs Multi-Agent
- Deterministic vs Stochastic
- Episodic vs Sequential
- Known vs Unknown
  - whether or not outcomes of all actions are known to the agent
How to categorize task environment?

**Fully Observed vs Partially Observed**

Q: a dirt cleaner is …?

**Single-Agent vs Multi-Agent**

**Deterministic vs Stochastic**

**Episodic vs Sequential**

**Known vs Unknown**
- whether or not outcomes of all actions are known to the agent
How to categorize task environment?

Fully Observed vs Partially Observed

Single-Agent vs Multi-Agent

Deterministic vs Stochastic

Episodic vs Sequential

Known vs Unknown
- whether or not outcomes of all actions are known to the agent

Q: a solitaire card game is …?
How to categorize task environment?

- Fully Observed vs Partially Observed
- Single-Agent vs Multi-Agent
- Deterministic vs Stochastic
- Episodic vs Sequential
- Known vs Unknown
- Static vs Dynamic
  - whether or not the environment is changing
How to categorize task environment?

- Fully Observed vs Partially Observed
- Single-Agent vs Multi-Agent
- Deterministic vs Stochastic
- Episodic vs Sequential
- Known vs Unknown
- Static vs Dynamic
  - whether or not the environment is changing

Q: can you give an example?
How to categorize task environment?

Fully Observed vs Partially Observed
Single-Agent vs Multi-Agent
Deterministic vs Stochastic
Episodic vs Sequential
Known vs Unknown
Static vs Dynamic
Discrete vs Continuous
- whether agent percepts are continuous or discrete in time dimension
Summary of Task Environment Categorization

Fully Observed vs Partially Observed
Single-Agent vs Multi-Agent
Deterministic vs Stochastic
Episodic vs Sequential
Known vs Unknown
Static vs Dynamic
Discrete vs Continuous

Read [AIMA] Section 2.3.2. for more examples of task environment categorization.
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What is an intelligent agent?

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Four Types of Agent Program

Simple Reflex

Model-based Reflex

Goal-based Reflex

Utility-based Reflex

* different programs have different methods of selecting actions...
Simple Reflex Agent

Agent selects action based on current percept, e.g. brake at red light.
Model-based Reflex Agent

Agent keeps track of percept history as an internal state, e.g., change lane.
Goal-based Reflex Agent

Agent selects goal-oriented action, e.g., to Laramie!
Utility-based Reflex Agent

Agent selects action that makes it “happy”, e.g., shortest path to Laramie!
Utility-based Reflex Agent

Agent selects action that makes it “happy”, e.g., shortest path to Laramie!

Sometimes agent can only maximize expected utility…

Can you give an example?
Schematic Diagrams of Four Agent Program Types

**Simple**
- **Agent**
  - Sensors: What the world is like now
  - Condition-action rules: What action I should do now
  - Actuators

**Model**
- **Agent**
  - State: How the world evolves
  - Condition-action rules: What action I should do now
  - Actuators

**Goal**
- **Agent**
  - State: How the world evolves
  - What my actions do: What it will be like if I do action A
  - Goals: What action I should do now
  - Actuators

**Utility**
- **Agent**
  - State: How the world evolves
  - What my actions do: What it will be like if I do action A
  - Utility: How happy I will be in such a state
  - Actuators
Four Types of Agent Program

Simple Reflex

Model-based Reflex

Goal-based Reflex

Utility-based Reflex

* different programs have different methods of selecting actions...

An agent can be programmed to select actions.

It can also learn how to select actions.
Learning Agent
Summary

Agent

Agent Function

Rational Agent (Performance Measure)

Task Environment (PEAS)

Agent Program + Four Types (SMGU)