Where are we?
For as long as people have made machines, they’ve wondered whether machines could be made intelligent.
Structure of the field
AI is fragmented:

- Natural language
- Vision
- Robotics
- Learning
- Planning
- Reasoning
- Knowledge representation
- Search
Natural language

Language processing technologies

- Question answering
- Machine translation
- Web search
- Text classification, spam filtering, etc.
Natural language

Language processing technologies

  Question answering
  Machine translation
  Web search
  Text classification, spam filtering, etc.

Speech technologies

  Dialog systems
  Automatic speech recognition (ASR)
  Text-to-speech synthesis (TTS)
Vision
Vision

cot(2)
Vision

Image classification
Vision

Face detection

Face recognition
Vision

Object tracking and behavior recognition
Robotics

Part mechanical engineering, part AI.

Reality is much harder than simulations!
RoboCup
RoboCup
RoboCup
Robotics

Part mechanical engineering, part AI.

Reality much harder than simulations!

In this class:

- We ignore mechanics
- Methods for planning
- Methods for control
What is AI?
<table>
<thead>
<tr>
<th>thinking humanly</th>
<th>thinking rationally</th>
</tr>
</thead>
<tbody>
<tr>
<td>acting humanly</td>
<td>acting rationally</td>
</tr>
</tbody>
</table>
cognitive science

thinking humanly  thinking rationally

acting humanly  acting rationally
cognitive science → thinking humanly → thinking rationally → acting humanly → acting rationally → laws of thought

“emulation” → thinking humanly → thinking rationally → acting humanly → acting rationally → laws of thought
cognitive science \rightarrow \text{thinking humanly} \rightarrow \text{thinking rationally} \rightarrow \text{laws of thought} \rightarrow \text{rational agents}

\text{“emulation”} \rightarrow \text{acting humanly} \rightarrow \text{acting rationally} \rightarrow \text{rational agents}
Intelligent agents and their environments
An *agent* acts in its *environment* according to what it has *perceived*.
A *rational agent* acts in its *environment* according to what it has *perceived* in order to *maximize* its *expected utility*.
Environment types
Environment types

Easy

Fully observable vs Partially observable

Hard
Environment types

Easy

Fully observable vs Partially observable

Hard
## Environment types

<table>
<thead>
<tr>
<th>Easy</th>
<th>Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Fully observable</em></td>
<td><em>Partially observable</em></td>
</tr>
<tr>
<td><em>Deterministic</em></td>
<td><em>Stochastic</em></td>
</tr>
</tbody>
</table>
Environment types

Easy

*Fully observable* vs *Partially observable*

*Deterministic* vs *Stochastic*

*Episodic* vs *Sequential*

Hard
Environment types

<table>
<thead>
<tr>
<th>Ease</th>
<th>Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully observable</td>
<td>Partially observable</td>
</tr>
<tr>
<td>Deterministic</td>
<td>Stochastic</td>
</tr>
<tr>
<td>Episodic</td>
<td>Sequential</td>
</tr>
<tr>
<td>Static</td>
<td>Dynamic</td>
</tr>
</tbody>
</table>
Environment types

<table>
<thead>
<tr>
<th>Easy</th>
<th></th>
<th>Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully observable</td>
<td>vs</td>
<td>Partially observable</td>
</tr>
<tr>
<td>Deterministic</td>
<td>vs</td>
<td>Stochastic</td>
</tr>
<tr>
<td>Episodic</td>
<td>vs</td>
<td>Sequential</td>
</tr>
<tr>
<td>Static</td>
<td>vs</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Discrete</td>
<td>vs</td>
<td>Continuous</td>
</tr>
</tbody>
</table>
Environment types

Easy

Fully observable vs Deterministic
Episodic vs Static
Discrete vs Single-agent

Hard

Partially observable vs Stochastic
Sequential vs Dynamic
Continuous vs Multi-agent
<table>
<thead>
<tr>
<th>Fully observable</th>
<th>vs</th>
<th>Partially observable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deterministic</td>
<td>vs</td>
<td>Stochastic</td>
</tr>
<tr>
<td>Episodic</td>
<td>vs</td>
<td>Sequential</td>
</tr>
<tr>
<td>Static</td>
<td>vs</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Discrete</td>
<td>vs</td>
<td>Continuous</td>
</tr>
<tr>
<td>Single-agent</td>
<td>vs</td>
<td>Multi-agent</td>
</tr>
<tr>
<td>Fully observable</td>
<td>vs</td>
<td>Partially observable</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----</td>
<td>----------------------------</td>
</tr>
<tr>
<td>Deterministic</td>
<td>vs</td>
<td>Stochastic</td>
</tr>
<tr>
<td>Episodic</td>
<td>vs</td>
<td>Sequential</td>
</tr>
<tr>
<td>Static</td>
<td>vs</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Discrete</td>
<td>vs</td>
<td>Continuous</td>
</tr>
<tr>
<td>Single-agent</td>
<td>vs</td>
<td>Multi-agent</td>
</tr>
</tbody>
</table>
Fully observable vs Partially observable
Deterministic vs Stochastic
Episodic vs Sequential
Static vs Dynamic
Discrete vs Continuous
Single-agent vs Multi-agent
Fully observable vs Partially observable

Deterministic vs Stochastic

Episodic vs Sequential

Static vs Dynamic

Discrete vs Continuous

Single-agent vs Multi-agent
The environment largely determines the agent design.
Agent types
Reflex agents

Agent

Sensors

What the world is like now

Condition–action rules

What action I should do now

Actuators

Environment
Reflex agents with state

- State
- How the world evolves
- What my actions do
- Condition–action rules
- What the world is like now
- What action I should do now
- Sensors
- Actuators
- Environment
Goal-based agents

Agent

- State
- How the world evolves
- What my actions do
- Goals

Sensors
- What the world is like now
- What it will be like if I do action A

Actuators
- What action I should do now

Environment
Utility-based agents

- State
- How the world evolves
- What my actions do
- Utility

- What the world is like now
- What it will be like if I do action A
- How happy I will be in such a state
- What action I should do now

Agent

Environment
Acknowledgments

The lecture incorporates material from:

Pieter Abbeel, Dan Klein, John DeNero, Stuart Russell, Kertrina Yim, et al., University of California, Berkeley

George Konidaris, Brown University