AI: Act rationally by maximizing your expected utility!
Today

- Some examples of modern AI applications
- How do they all fit together?
- How do we formally define problems in AI?
- Course outline
Natural Language

- Speech technologies (e.g. Siri)
  - Automatic speech recognition (ASR)
  - Text-to-speech synthesis (TTS)
  - Dialog systems
Natural Language Video
Natural Language

- Speech technologies (e.g. Siri)
  - Automatic speech recognition (ASR)
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  - Dialog systems

- Language processing technologies
  - Question answering
  - Machine translation

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

"Il est impossible aux journalistes de rentrer dans les régions tibétaines"

"It is impossible for journalists to enter Tibetan areas"

Philip Bruno, correspondent for "World" in China, said that journalists of the AFP who have been deported from the Tibetan province of Qinghai "were not illegal."

Facts: The Dalai Lama denounces the "hell" imposed since he fled Tibet in 1959

Video: Anniversary of the Tibetan rebellion: China on guard

$77,147
The Great A.I. Awakening

How Google used artificial intelligence to transform Google Translate, one of its more popular services — and how machine learning is poised to reinvent computing itself.

By Gibson Lewis-Kraus  Dec. 14, 2016
Deep learning
[Math is a] common democrat lie. It can't make the budget great. I'll have the best economy. #debatenight

[This election is rigged] I will give every American a solid gold nuclear weapon, we're going to defeat the world.

I'm a Neural Network trained on Trump's transcripts. Priming text in []s. Donate (gofundme.com/deepdrumpf) to interact! Created by @hayesbh.

[We'll fix the economy by] selling out veterans. I will get the power, from some core of hell. I will be the most powerful. #debatenight
Vision (Perception)

- Object and face recognition
- Scene segmentation
- Image classification

Images from Erik Sudderth (left), wikipedia (right)
Object Tracking

object detection / 3D pose estimation

arbitrary view rendered with estimated 3D pose
<table>
<thead>
<tr>
<th>Question</th>
<th>Neural Net</th>
<th>Ground Truth</th>
</tr>
</thead>
<tbody>
<tr>
<td>What vegetable is on the plate?</td>
<td>broccoli</td>
<td>broccoli</td>
</tr>
<tr>
<td>What color are the shoes on the person's feet?</td>
<td>brown</td>
<td>brown</td>
</tr>
<tr>
<td>How many school busses are there?</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>What sport is this?</td>
<td>baseball</td>
<td>baseball</td>
</tr>
<tr>
<td>What is on top of the refrigerator?</td>
<td>magnets</td>
<td>cereal</td>
</tr>
<tr>
<td>What uniform is she wearing?</td>
<td>shorts</td>
<td>girl scout</td>
</tr>
<tr>
<td>What is the table number?</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>What are people sitting under in the back?</td>
<td>bench</td>
<td>tent</td>
</tr>
</tbody>
</table>
We won’t discuss NLP and perception directly, but we will cover:

- Bayes nets
- Supervised learning
- Deep learning
- Course outline
Robotics

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

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

- In this class:
  - We ignore mechanical aspects
  - Methods for planning
  - Methods for control

Images from UC Berkeley, Boston Dynamics, RoboCup, Google
Robot Laundry
Robot Soccer
Learning from demonstration
Learning from demonstration
Full body control of humanoids
...but still a long way to go
Robotics

We will cover several topics relevant to robotics:

- Planning and search
- Reinforcement learning
- Time-series analysis
- State estimation and filtering
Logic

- Logical systems
  - Theorem provers
  - NASA fault diagnosis
  - Question answering

- Methods:
  - Deduction systems
  - Constraint satisfaction
  - Satisfiability solvers (huge advances!)
Game Playing

- Classic Moment: May, '97: Deep Blue vs. Kasparov
  - First match won against world champion
  - “Intelligent creative” play
  - 200 million board positions per second
  - Humans understood 99.9% of Deep Blue's moves
  - Can do about the same now with a PC cluster

- Open question:
  - How does human cognition deal with the search space explosion of chess?
  - Or: how can humans compete with computers at all??

- 1996: Kasparov Beats Deep Blue
  “I could feel --- I could smell --- a new kind of intelligence across the table.”

- 1997: Deep Blue Beats Kasparov
  “Deep Blue hasn't proven anything.”

- Huge game-playing advances recently, e.g. in Go!

Text from Bart Selman, image from IBM’s Deep Blue pages
Course Topics

- **Part I: Making Decisions**
  - Fast search / planning
  - Constraint satisfaction
  - Adversarial and uncertain search
  - MDPs and Reinforcement learning

- **Part II: Reasoning under Uncertainty**
  - Bayes nets
  - Decision theory and value of information
  - Statistical Machine learning

- **Throughout: Applications**
  - Natural language, vision, robotics, games, ...
But how??
Designing Rational Agents

- An **agent** is an entity that *perceives* and *acts*.
- A **rational agent** selects actions that maximize its (expected) *utility*.
- Characteristics of the **performance measure, environment, actions, and sensing** dictate techniques for selecting rational actions.
- By then end of the course you should understand:
  - General AI techniques for a variety of problem types
  - How to recognize when and how a new problem can be solved with an existing technique
Pac-Man as an Agent

Agent

Sensors

? 

Actuators

Environment

Percepts

Actions

SCORE: 18

Pac-Man is a registered trademark of Namco-Bandai Games, used here for educational purposes
Pac-Man as an Agent
Reflex Agents

- Reflex agents:
  - Choose action based on current perceptions
  - May have memory or a model of the world’s current state
  - Do not consider the future consequences of their actions
  - Often referred to as a “policy”
  - Consider how the world IS

- Can a reflex agent be rational?
Planning Agents

- Plan ahead
- Ask “what if”
- Decisions based on (hypothesized) consequences of actions
- Must have a model of how the world evolves in response to actions
- Consider how the world WOULD BE
Quiz: Reflex or Planning?

Select which type of agent is described:

1. Pacman, where Pacman is programmed to move in the direction of the closest food pellet

2. Pacman, where Pacman is programmed to move in the direction of the closest food pellet, unless there is a ghost in that direction that is less than 3 steps away.

3. A navigation system that first considers all possible routes to the destination, then selects the shortest route.
Properties of task environment

- Fully observable vs. partially observable
- Single-agent vs. multi-agent
- Deterministic vs. stochastic
- Episodic vs. sequential
- Static vs. dynamic
- Discrete vs. continuous
- Known vs. unknown
Fully observable vs. partially observable

- Fully observable: agent’s sensors give it access to complete state of the environment at all times.
- Can be partially observable due to noisy and inaccurate sensors, or because parts of the state are simply missing from the sensor data.
- Example: Perfect GPS vs noisy pose estimation.
- Example: IKEA assembly while blindfolded.

Almost everything in the real world is partially observable.
Single agent vs. multi-agent

- Not multi-agent if other agents can be considered part of the environment
- Only considered to be multi-agent if the agents are maximizing a performance metric that depends on other agents’ behavior
- Single agent example: Pacman with randomly moving ghosts
- Multi-agent example: Pacman with ghosts that use a planner to follow him
Deterministic vs. stochastic

- **Deterministic**: next state of environment is completely determined by the current state and the action executed by the agent.
- **Stochastic**: actions have probabilistic outcomes.
- Strongly related to partial observability — most apparent stochasticity results from partial observation of a deterministic system.
- Example: Coin flip.
Episodic vs. sequential

- Episodic: agent’s experience is divided into atomic episodes; single percept and action each episode, and next episode does not depend on the actions taken in previous ones
- Sequential: current decision could affect all future decisions
- Example: Image classification vs. Chess
Static vs. dynamic

- **Static**: The environment does not change, except for actions taken by the agent.
- **Dynamic**: The environment continuously evolves without input from the agent.
- **Example**: Checkers vs. Pacman
Discrete vs. continuous

- Refers to state, how time is handled, and the percepts and actions of the agent
- Discrete: Finite category or integer
- Continuous: Real-valued quantity
- Percept example: Discrete colors vs. color spectrum
- Action example: Chess moves vs. steering angle
- State example: Pacman’s (x,y) position vs. robot’s joint angles
Known vs. unknown

- Agent’s state of knowledge about the “rules of the game” / “laws of physics”
- Known environment: the outcomes for all actions are given
- Unknown: agent has to learn how it works to make good decisions
- Possible to be partially observable but known (solitaire)
- Possible to be fully observable but unknown (video game)