Class Discussion
Gene Lewis, SAIRG
“Instead of trying to produce a programme to simulate the adult mind, why not rather try to produce one which simulates the child's? If this were then subjected to an appropriate course of education one would obtain the adult brain.”

- Alan Turing
Challenges in Intelligence
a woman riding a horse on a dirt road  
an airplane is parked on the tarmac at an airport  
a group of people standing on top of a beach

Lake et al, “Building Machines that Learn and Think Like People”
Mnih et al, “Playing Atari with Deep Reinforcement Learning”

Lake et al, “Building Machines that Learn and Think Like People”
• Get the lowest possible score.
• Get closest to 100, or 300, or 1000, or 3000, or any level, without going over.
• Beat your friend, who’s playing next to you, but just barely, not by too much, so as not to embarrass them.
• Go as long as you can without dying.
• Die as quickly as you can.
• Pass each level at the last possible minute, right before the temperature timer hits zero and you die (i.e., come as close as you can to dying from frostbite without actually dying).
• Get to the furthest unexplored level without regard for your score.
• See if you can discover secret Easter eggs.
• Get as many fish as you can.
• Touch all the individual ice floes on screen once and only once.
• Teach your friend how to play as efficiently as possible.
Grounding as Extracted Structure
Zamir et al, “Taskonomy: Disentangling Task Transfer Learning”
Sax et al, “Learning to Navigate Using Mid-Level Visual Priors”
Pathak et al., "Curiosity-driven Exploration by Self-supervised Prediction"
Abramson et al, “Imitating Interactive Intelligence”
Structured Problem Solving
partially observed Markov decision process \( M = \{S, A, O, T, E, r\} \)

- \( S \) – state space  
  states \( s \in S \) (discrete or continuous)

- \( A \) – action space  
  actions \( a \in A \) (discrete or continuous)

- \( O \) – observation space  
  observations \( o \in O \) (discrete or continuous)

- \( T \) – transition operator (like before)

- \( E \) – emission probability \( p(o_t|s_t) \)

- \( r \) – reward function  
  \( r : S \times A \rightarrow \mathbb{R} \)

Levine et al, CS285 Lecture 4 Slides: “Introduction to Reinforcement Learning”
\begin{align*}
p(x | y) &= \frac{p(y | x) p(x)}{p(y)} \\
&= \frac{p(y | x) p(x)}{\int p(y | x') p(x') \, dx'}
\end{align*}

Thrun et al, Probabilistic Robotics
## Complementary Learning Systems

<table>
<thead>
<tr>
<th>Goals:</th>
<th>Remember <strong>Specifics</strong></th>
<th>Extract <strong>Generalities</strong></th>
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<tbody>
<tr>
<td>Example:</td>
<td>Where is car parked?</td>
<td>Best parking strategy?</td>
</tr>
<tr>
<td>Need to:</td>
<td>Avoid <strong>interference</strong></td>
<td>Accumulate experience</td>
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**Solution:**

1. **Separate reps** (keep days separate)
   - D1, D2, D3, ...
   - Overlapping reps (integrate over days)
     - PS (parking strategy)
     - D1, D2, D3, ...

2. **Fast learning** (encode immediately)
   - Slow learning (integrate over days)

3. **Learn automatically** (encode everything)
   - Task-driven learning (extract relevant stuff)

*These are incompatible, need two different systems:*

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<tr>
<th>System:</th>
<th>Hippocampus</th>
<th>Neocortex</th>
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Key Figure

Complementary Learning Systems (CLS) and their Interactions.

Connections within and among neocortical areas (green) support gradual acquisition of structured knowledge through interleaved learning.

Bidirectional connections (blue) link neocortical representations to the hippocampus/MTL for storage, retrieval, and replay.

Rapid learning in connections within hippocampus (red) supports initial learning of arbitrary new information.

Wayne et al, “Unsupervised Predictive Memory in a Goal-Directed Agent”
“A human being should be able to change a diaper, plan an invasion, butcher a hog, conn a ship, design a building, write a sonnet, balance accounts, build a wall, set a bone, comfort the dying, take orders, give orders, cooperate, act alone, solve equations, analyse a new problem, program a computer, cook a tasty meal, fight efficiently, die gallantly. Specialization is for insects.”

- Robert Heinlein
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Thank You