One Reason for Integrated Intelligences

- Today’s model: Software as tool
  The problems we are facing are getting harder
  We’re not getting any smarter
- Tomorrow’s model: Software as collaborator
### Another Reason: Understanding how Minds Work

**Unified Theories of Cognition**  
(Newell, 1990)

#### Time Scale of Human Action

<table>
<thead>
<tr>
<th>Scale (sec)</th>
<th>Time Units</th>
<th>System</th>
<th>World (theory)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^7$</td>
<td>months</td>
<td></td>
<td>SOCIAL BAND</td>
</tr>
<tr>
<td>$10^6$</td>
<td>weeks</td>
<td>Task</td>
<td>RATIONAL BAND</td>
</tr>
<tr>
<td>$10^5$</td>
<td>days</td>
<td>Task</td>
<td></td>
</tr>
<tr>
<td>$10^4$</td>
<td>hours</td>
<td>Task</td>
<td></td>
</tr>
<tr>
<td>$10^3$</td>
<td>10 min</td>
<td>Task</td>
<td></td>
</tr>
<tr>
<td>$10^2$</td>
<td>minutes</td>
<td>Task</td>
<td></td>
</tr>
<tr>
<td>$10^1$</td>
<td>10 sec</td>
<td>Unit task</td>
<td></td>
</tr>
<tr>
<td>$10^0$</td>
<td>1 sec</td>
<td>Operations</td>
<td></td>
</tr>
<tr>
<td>$10^{-1}$</td>
<td>100 ms</td>
<td>Deliberate act</td>
<td></td>
</tr>
<tr>
<td>$10^{-2}$</td>
<td>10 ms</td>
<td>Neural circuit</td>
<td></td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>1 ms</td>
<td>Neuron</td>
<td></td>
</tr>
<tr>
<td>$10^{-4}$</td>
<td>100 μs</td>
<td>Organelle</td>
<td></td>
</tr>
</tbody>
</table>
Today’s AI systems can be fast and effective.

But they are carefully designed for narrow niches, maintained by highly trained personnel.

What if AI systems were as robust, trainable, and taskable as dogs?
Summaries of One-pagers

• Organisms
  – Deliberative autonomy (Aha)
  – Data efficient learning (Chai)
  – Self-awareness (de Kleer)
  – Forms of integration (Fischer, Laird, Rosenbloom)
  – Interactive task learning (Chai, Laird)

• Knowledge
  – Commonsense (Chai, de Kleer, Muller)
  – Causality (Chai, de Kleer, Hunter)
  – Metaknowledge (de Kleer, Leake)
  – About people (Chai, Oh, Wilson)
More summaries

• Communication
  – Semantic perception (aha)
  – Grounding language (Chai, Oh)
  – Multimodal interaction (Chai, Coman, Oh, Wilson, Woolf)

• Use Scenarios
  – Life partners, DevOps (Aha)
  – Customer Service (Coman, Muller)
  – Design (de Kleer)
  – Assistants for comp. Sustainability (Fischer)
  – Eldercare (Oh, Wilson)
  – Mentor for everyone (Woolf)
Arcs of Progress

- Stretch goals to excite the imagination
- End state: 2040
- Identify milestones along the way
- Analysis of capabilities
2050 Goal

• AI tutors, coaches, partners, and mentors that support people who want to learn any area of science, at any level, any time

• One of the proposed tests in a suite to replace the Turing Test (AAAI 2015)
  – Daunting challenge
  – Clear benefits to society
  – Science Learning & Teaching Working Group: Ken Forbus, Peter Clark, Chen Liang, Nina N., Christian Lebiere, Gabor Melli, Jim Spohrer, Melanie Swan
There are Never Enough People to Help with Education

- Not enough teachers
- Not enough tutors
- Not enough teammates
- Not available when you need them
  - Finishing homework at 3am the night before it is due
- Not for as long as you need them
- Don’t know you like friends and family do
  - Shared experiences as a source of examples
Vision: AI Assistants for Learning Science

Now: CogSketch, Companions, PSLC, Cyc, IBM’s Watson, Semantic Web, new sensors...
Provide individual technologies and initial architectures

Multimodal Science Learners:
AIs that can learn science from people via reading, dialogue, sketching, and vision.

Barriers: Learning at scale, interactively, at human-like rates. Fluent communication.

Multimodal Science Tutors:
AIs that can help people learn science.

2050: AI tutors, coaches, & mentors that support people who want to learn any area of science, at any level, any time.
Dimension: Knowledge & Reasoning

- Depth of expertise
- Breadth of coverage
- Current state
  - 8th grade science tests, > 700 teams using statistical NLP and deep learning, 60% = best score
  - 4th grade science tests, AI2’s Aristo, statistical NLP + some reasoning, 70%
  - Multiple choice, no diagram
Dimension: Learning

• How easily can systems be instructed?
  – Human students don’t need millions of examples to learn algebra (or anything else)

• Learning by reading
  – Vary by grade levels
  – Multimodal: Diagrams are essential

• Interactive knowledge capture
  – Already can provide educational value, if students can learn by teaching AIs
Dimension: Communications

• Teaching, mentoring, coaching...
• Multiple modalities
  – Language, sketching, gesture
• Ability to learn rapidly from students
  – True Socratic dialogs
  – Software needs to keep up with culturally relevant examples
• Build up relationships over weeks, months, years
**Personal Assistant Arc**

- **1965**: Eliza chatbot
- **1970s**: Early ITS, partial-order planning
- **1980**: Discourse modeling
- **1990s**: Planning for (constrained) real-world applications
- **1998-1999**: Furby, AIBO interactive pets
- **2011, 2014**: Siri, Cortana, Alex (“smart control” of specific apps)
- **2030**: Usable levels of speech/NLP, integrated planning & decision making
- **2040**: Personalized integrated learning assistants for complex tasks

**Timeline:**
- 1965
- 1970
- 1980
- 1990
- 2000
- 2010
- 2020
- 2030
- 2040
What might you worry about?