The Soar Cognitive Architecture Towards Human-Level Intelligence Nate Derbinsky







A Short Guide to Grad School...



http://matt.might.net/articles/phd-school-in-pictures/

High School...



Specialization in College...



A Master's Deepens that Specialty...



Reading Research Papers...



Once at the Boundary, Focus...



Push for a Few Years...



Until the Boundary Gives Way...



Grad Student World View



The Big Picture





- Reasoning
- Planning
- Extracting patterns
- Machine translation
- Games

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Example: Cyc (cyc.com)



- >500K concepts, 5M facts, 1M rules
- Hybrid forward/backward inference (EECS 492/543)
- Applied to anti-terrorism, cyber-defense, disaster contingencies, ...

Step 1. Hypothetical Hacker sends an e-mail message to shandra.cyc.com

Step 2. Hypothetical Hacker lures the user of shandra.cyc.com to a particular website

Step 4. Hypothetical Hacker sends the data string to Real Player version 7.0 running on shandra.cyc.com

Step 9. Hypothetical Hacker uses hacker computer to log in remotely to a Cycorp LAN Windows NT user account via shandra.cyc.com

- Step 10. Hypothetical Hacker downloads MSIEXEC Exploit onto shandra.cyc.com
- Step 11. Hypothetical Hacker runs MSIEXEC Exploit on shandra.cyc.com

Step 12. Hypothetical Hacker gets access to a Cycorp LAN Windows NT system account

Step 3. Hypothetical Hacker contructs a data string longer than the memory buffer for Real Player version 7.0 can handle

Step 5. Hypothetical Hacker overflows the memory buffer for Real Player version 7.0 running on shandra.cyc.com

Step 6. Hypothetical Hacker installs a sniffer program on shandra.cyc.com

Step 7. Hypothetical Hacker waits for an entry of a computer password

Step 8. Hypothetical Hacker sniffs the login information for a Cycorp LAN Windows NT user account on the Cycorp LAN Windows NT account system





Example: AI-D (ai-d.org)

- Predict food shortages, post-disaster need, disease propagation, ...
- Distributed medical diagnosis
- Voice-based services for illiterate populations

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Example: Players

 Chess, Checkers, Poker, Jeopardy...

Example: Game Theory

 Applied to markets, auctions, P2P, and security/privacy









AI Assumptions

- Reasoning
- Planning
- Extracting patterns
- Machine translation
- Games

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Single, well-defined task Typically narrow in data type, amount, and learning

Short-term

Next Generation Tasks

- Cognitive Robotics
 - Long-term exploration
 - Search-and-rescue
 - Synthetic teammates (military, medical, ...)
 - Personal assistants (home, office, tutors, ...)
- Scientific Knowledge Discovery
- Resource Management (food, transport, ...)

Goal: Human-level Al

- Autonomous
- Long-term (and reactive)
- Multiple tasks
- Comprehensive learning (vs. laborious programming)
- Multi-modal perception and knowledge
- Robust (vs. optimal)



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Approach: Cognitive Architecture

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Goal. Develop and understand human-level intelligence across a diverse set of tasks and domains

Specification of those aspects of cognition that remain constant throughout the lifetime of an agent

- Memory systems of the agent's beliefs, goals, experience
- Knowledge representation
- Functional processes that lead to behavior
- Learning mechanisms

Prototypical Architecture X Declarative **Procedural** Learning Learning Declarative **Procedural Long-term Memory Long-term Memory** ЯX Action Selection **Short-term Memory** Knowledge Decision Application Ľ Perception •) Action Knowledge Action Search 21 January 27, 2018

Perception

Agent Definition



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Common Research Goals

Biological Plausibility

Psychological Plausibility

Agent Functionality













The Soar Cognitive Architecture

Created in 1982 by...



John Laird Professor Michigan



Allen Newell Founder of Al CMU



Paul Rosenbloom Professor USC, ICT

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Distinctive Characteristics

- Efficiently brings to bear large amounts of knowledge
- Diverse mechanisms that support general problem solving methods
- Public distribution and documentation
 - Major operating systems (Windows, OS X, Linux)
 - Many languages (C++, Java, Python, ...)

Select Applications (1)



R1-Soar Computer Configuration



NL-Soar Language Processing



Amber EPIC-Soar Modeling HCI



ICT Virtual Human Natural Interaction, Emotion



TacAir-Soar Complex Doctrine & Tactics



Urban Combat Transfer Learning



Soar Quakebot Anticipation



Haunt Actors and Director

Select Applications (2)



MOUTbot Team Tactics & Unpredictable Behavior



SORTS Spatial Reasoning & Real-time Strategy



Simulated Scout Mental Imagery



Splinter-Soar Robot Control



ReLAI Mental Imagery & Reinforcement Learning



Infinite Mario Hierarchical Reinforcement Learning

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iSoar Mobile Reinforcement Learning



RESTful Soar Web-based Gameplay, Probabilistic Learning

The Soar Cognitive Architecture $\sqrt[k]{x}$ |4 +7 +7 +7 21 **Procedural Semantic Episodic** Chunking RL XXX 🔕 » 🦽 ecision cedu **Short-term Memory** Spatial & Visual Processing Action Perception 🔊 💇 January 27, 2018 28

My Research



Goal. Explore and evaluate long-term declarative memory systems that are <u>effective</u> and <u>efficient</u> across a variety of tasks

Effective Memory

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Momento (2000)





Kim Peek



- American Savant
- "Photographic" memory
- Developmental disabilities
 - Autistic in movie





Rain Man (1988)

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Bob Petrella

- Fourth person diagnosed with superiorautobiographical memory
- 58, lives in LA, works as producer for the Tennis channel

CBS News, 60 Minutes (2010)

Limitless (2011)

Ex. Cognitive Capabilities

Virtual Sensing (Nuxoll & Laird, 2007)

Expands agent sensing beyond immediate perception via access to details of past situations

Action Modeling (Laird et al., 2010; Xu & Laird, 2010) Informs predictions about the result of actions in present or future situations based upon prior experience

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[Douglass et al., ICCM 2009]

SMem: Efficient Implementation

<u>Approach</u>

- Inverted Index (EECS 485)
- Statistical Query Optimization (EECS 484)
- Heuristic Search (EECS 492)

<u>Results</u>

- Over 100x faster queries on 3x more data¹
- Stable and efficient for real-world tasks (robotics² & mobile music³)
- Cognitively inspired and empirically functional biases⁴

Future Work

- Explore additional capabilities
- Evaluate on more tasks & data
 - 1. [Derbinsky, Laird, Smith; ICCM 2010]
 - 2. [Laird, Derbinsky, Voigt; BRIMS 2011]
 - 3. [Derbinsky, Essl; NIME 2011]

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4. [Derbinsky, Laird; AISB 2011]

Getting Involved

Download Soar (soar.googlecode.com)

- Binaries & source available
- Manual & tutorials
- E-mail support

Readings

- Unified Theories of Cognition
- Soar group publications

Soar Workshop (sitemaker.umich.edu/soar)

- Tutorials, talks
- Attendees from around the world

Thank You :)

Questions?

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