BICA: Biologically-Inspired Cognitive Architecture

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26th Soar Workshop
Major New DARPA Project

• Goal: Capture the Magic of the Human Mind
  • Look beyond traditional AI
  • Computation and Psychology: Cognitive Architecture
  • Biology: Brain Computation

• Programmatic
  • Phase I: 13 months, started in October 2005
    A. Cognitive Architectures (4)
    B. Biologically-based Computation (8)
    C. Evaluation (1)
    D. Basic Research (3-4)
  • Phase II: 4-5 years, starting in ~March 2007
    • 2-3 (Big) Groups
Evaluation (Yearly)

• Cognitive Decathlon (details still up in the air)
  – Psychology Experiments Across the Frontiers of Cognition
    • Functional Integration, Flexibility, Metacognition, Social Embeddedness
    – Embedded within same environment as challenge problems

• Challenge Problems
  – Simulated robot embedded complex environment
  – Find IEDs in a (hot, dry, dusty) urban environment

• Emphasizing
  – Learning, learning, learning,
  – Vision, vision, vision,
  – Language, language
Four Possible Approaches

1. Cognitive architectures with
   a. added abstract biologically-inspired functions
   b. added perceptual-motor inputs and outputs
   c. biologically-inspired module implementation

2. Biological architectures, cognitively constrained
1a. CA with added abstract biologically-inspired functions

- Abstract functionality e.g., reinforcement learning, emotion
- But no direct connection to underlying computational process

Cognitive Architecture

+ Episodic, Semantic, Reinforcement Learning
+ Emotion
The Future for Soar-style Cognitive Architectures

- Generate coherent, purposeful behavior across a wide variety of tasks
- Use many sources and types of knowledge
  - Perception, personal history, facts, abstractions, skills, models, …
  - Gained by experience, observation, communication, and programming
  - Are immediately taskable
- Combine knowledge in novel ways to generate novel behavior
  - Not a slave to experience or current situation
  - Can use abstraction, hypothetical situations, internal simulation
- In real time using conventional computational hardware

But unable to achieve wild learning:
- ubiquitous automatic learning of unexpected types of regularities
- in noisy, feature-rich environments
- that combine with previously learned concepts and relations
- that give rise to hierarchies of new symbols, concepts, and relations
- that lead to prediction, anticipation, comprehension, …
1b. CA with added perceptual-motor I/O

- Brain-based computation for perception & motor control
- Cognitive architecture remains essentially unchanged
1c. CA with biologically-inspired module implementation

- Brain-based computation for existing CA components
- Retains overall structure of cognitive architecture

Component interaction:
Symbolic & non-symbolic

Cognitive Architecture
Replace with
Biologically Based Components
2. Biological architecture, cognitively constrained

- New architecture; biologically derived
- Cognitive functions emerge from component interactions
Nuggets and Coal

• Nuggets:
  – *Chance of a lifetime* to explore integration of brain-based computation and cognitive architecture.

• Coal
  – Incredible amount of work
    • Synthesizing different computational approaches
    • Managing large group across many institutions
    • Developing/Engineering tasks and agents