The IDA & LIDA Models

Stan Franklin
Computer Science Division &
Institute for Intelligent Systems
The University of Memphis
IDA: an Intelligent Distribution Agent

- Dialogue with sailors
- Read personnel data
- Check job requisition lists
- Enforce Navy policies
- Choose jobs to offer members
- Negotiate with them about jobs
Who’s IDA

• Autonomous software agent
  – Environment—real world (computer, Java VM, network)
  – Senses—strings of characters
  – Actions—natural language email, many internal actions
  – Drives—to find and negotiate new jobs for sailors

• Supported by the US Navy

• Computational IDA
  – Complete, up and running
  – Tested, demonstrated, approved by the Navy
The IDA Model

- Conceptual model of cognition
- Computational model plus additional designed but unimplemented cognitive processes
- A general model such as SOAR, Act-R, C&I
- Models a broad swath of cognitive functions
- A functional integrative theory (FIT), producing empirically based, qualitative hypotheses about how minds work
The IDA Model’s Cognitive Functions

- Perception
- Working memory
- Episodic memory
- Long-term memory
- Consciousness
- Action selection
- Emotion
- Deliberation
- Volition
- Metacognition
- Automization
- Non-routine problem solving
- Language generation and understanding
IDA’s Architecture

- Metacognition
- Database Perception
- Constraint Satisfaction
- Deliberation
- Negotiation
- Problem Solving
- Behavior Net
- ‘Consciousness’
- Perception
- Working Memory
- Episodic Memory
- Emotions
- Expectation & Automization
Cognitive Cycles

• Every autonomous agent operates by frequent iteration of sense-process-act cycles
Human Memory Systems

- Memory Systems
  - Sensory Memory
  - Working Memory
  - Transient Episodic Memory
  - Long-term Memory
    - Perceptual Memory
    - Declarative Memory
      - Autobiographical Memory
      - Semantic Memory
    - Procedural Memory
IDA’s Cognitive Cycle

• Every autonomous agent must frequently sample its environment and act on it
• Cognition is the process of interpreting incoming stimuli and selecting actions
• The cognitive cycle fleshes out the stimulus–cognition–action process
• Provides a tool for the fine-grained analysis of various cognitive tasks
Cognitive Cycles

- In humans each cognitive cycle takes about 200ms
- An automatized cycle would take less time
- Cognitive cycles can cascade
- Cycles must maintain the seriality of consciousness
- Unconscious activity on each side of the conscious broadcast can operate in parallel
- Humans might have five to ten cognitive cycles per second
Steps in the Cognitive Cycle

1. Perception
2. Working memory
3. Local associations
4. Competition for consciousness
5. Conscious broadcast
6. Learning & recruiting resources
7. Setting goal-context hierarchy
8. Action chosen
9. Action taken
Perceiving

- Preconscious perception
- External or internal stimuli
- Construction of meaning
  - Identification
  - Categorization
  - Relations
- Includes feelings and emotions
- Filtering process produces a percept
Store Percept in Working Memory

- Percept stored in preconscious buffers of Working Memory
  - Visuo-spatial sketchpad
  - Phonological loop
- Buffers may contain earlier contents also
- Decay time measured in tens of seconds
Local Associations

• Contents of preconscious Working Memory buffers serve as a cue
• Retrieves local associations from
  – Transient episodic memory
  – Declarative memory
• Contents of WM plus these associations enter
  – Baddeley’s episodic buffer
  – Ericsson and Kintsch’s Long-term Working Memory
• May include feelings, emotions, actions
Competition for Consciousness

- Attention codelets view LTWM
- Form coalitions with information codelets
- Vie to bring various portions of contents to consciousness
- Coalition from a previous cycle can win

Factors include
- Relevancy
- Importance
- Urgency
- Insistence
- Recency
Conscious Broadcast

- Coalition with highest average activation is chosen
- Is said to be in the spotlight, or to occupy the global workspace
- The information content of the coalition is broadcast to all codelets
- GW theory postulates this broadcast as the moment of phenomenal consciousness
Setting Goal Context Hierarchy

- Relevant behavior codelets respond to broadcast
- Instantiate goal context hierarchy (behavior stream) if needed
- Bind variables using information from conscious broadcast
- Send environmental and feeling activation to appropriate behaviors
Action Chosen

• Behaviors (goal contexts) get activation from
  – Drives (feelings and emotions)
  – Environment
  – Other behaviors

• The single behavior is chosen that
  – Is executable
  – activation over threshold
  – higher activation than other such behaviors
Action Taken

- Chosen behavior binds variables in its behavior codelets
- Then releases its behavior codelets along with at least one expectation codelet
- These behavior codelets perform the task of the behavior
- This action may effect the external or internal environment or both
- Action doesn’t occur when dreaming
Processes requiring multiple cycles

- Deliberation
- Volition
- Non-routine problem solving
- Language understanding & generation
- Metacognition
Consciously Mediated Action vs. Voluntary Action Selection

- Voluntary action selection
  - Go to the fridge for orange juice
  - Choice between go or wait, orange juice or coke or water
- Consciously mediated action
  - Find and grasp the handle
- Automatized, unconscious actions
  - Pull the refrigerator door open
IDA Totally Hand Crafted

LIDA — Learning IDA

LIDA is IDA with learning added
Learning occurs

- **Perceptual learning**
  - Identification, classification, relations

- **Episodic learning**
  - To transient episodic memory
  - Doesn’t happen during dreaming

- **Procedural learning**
  - Reinforces actions from previous cycles
LIDA Cognitive Cycle
Learning Mechanisms in the LIDA Technology

- Perceptual learning via a Slipnet
- Episodic learning via Sparse Distributed Memory
- Procedural learning via a Scheme Net
A mechanism for perceptual learning

- Semantic net with activation passing
- Nodes represent features, individuals, categories, relations (situations)
- Links, excitatory (isa), inhibitory (lateral)
- Total activation = current + base-level
- Percept composed of nodes over threshold
- Learning modifies base-level activation and creates new nodes and links
A mechanism for episodic learning

- Sparse distributed memory
  - Few hard locations, HUGE address space
  - Each hard location contributes to the encoding of many different events
  - Each event is encoded to many different hard locations
- Associative and content addressable
- Psychological properties
  - Knows when it doesn’t know
  - Tip of the tongue phenomena
A Mechanism for Procedural Learning

• Action selection via a scheme net
• Scheme (context, action, result, activation)
• Activation = current + base-level
• Learning reinforces base-level activation and creates new schemes
• Support multiple actions, both parallel and sequential
Modifying Base-level Activation
Decay Curve

- Low base-level activation — rapid decay
- Saturated base-level activation — almost no decay
Selectionist & Instructionalist Learning

• Selectionist Learning
  – selected for reinforcement from a redundant repertoire

• Instructionalist Learning
  – new representations constructed

• LIDA learns in both modes
LIDA Research Directions

• Domain-independent LIDA technology
  – Almost complete

• Control of real-world cognitive robots
  – Collaboration with roboticists (Kawamura, etc.)

• Cognitive software agent controller for an image database
  – DARPA funding pending
Learning

- Consciousness suffices for learning
- Learning rate rises with arousal (feelings and emotions)
- Learning occurs quickly and easily, but decays rapidly
Email and Web Addresses

• Stan Franklin
  – franklin@memphis.edu
  – www.cs.memphis.edu/~franklin

• “Conscious” Software Research Group
  – www.cs.memphis.edu/~csrg