How Minds Work

Sensing and Perceiving

Stan Franklin

Computer Science Division &

Institute for Intelligent Systems

The University of Memphis

Sense the environment?

- Humans: sight, hearing, touch, smell
- Other animals:
  - Bats, dolphins — echolocation
  - Sharks — electroreception
- Photo, mechano, chemo, electro, magneto reception
- Artificial senses, e.g. strings of characters

Sensory Receptors

- Transmute environmental energy (light, chemical, mechanical, magnetic, etc.) into internal (neural) signals
- Are directed by action
  - Saccades of the eyes
  - Sniff
  - Turing of an ear
  - Sending of an echolocation signal
- Can be internal, transmuting internal signals

We each create our own world

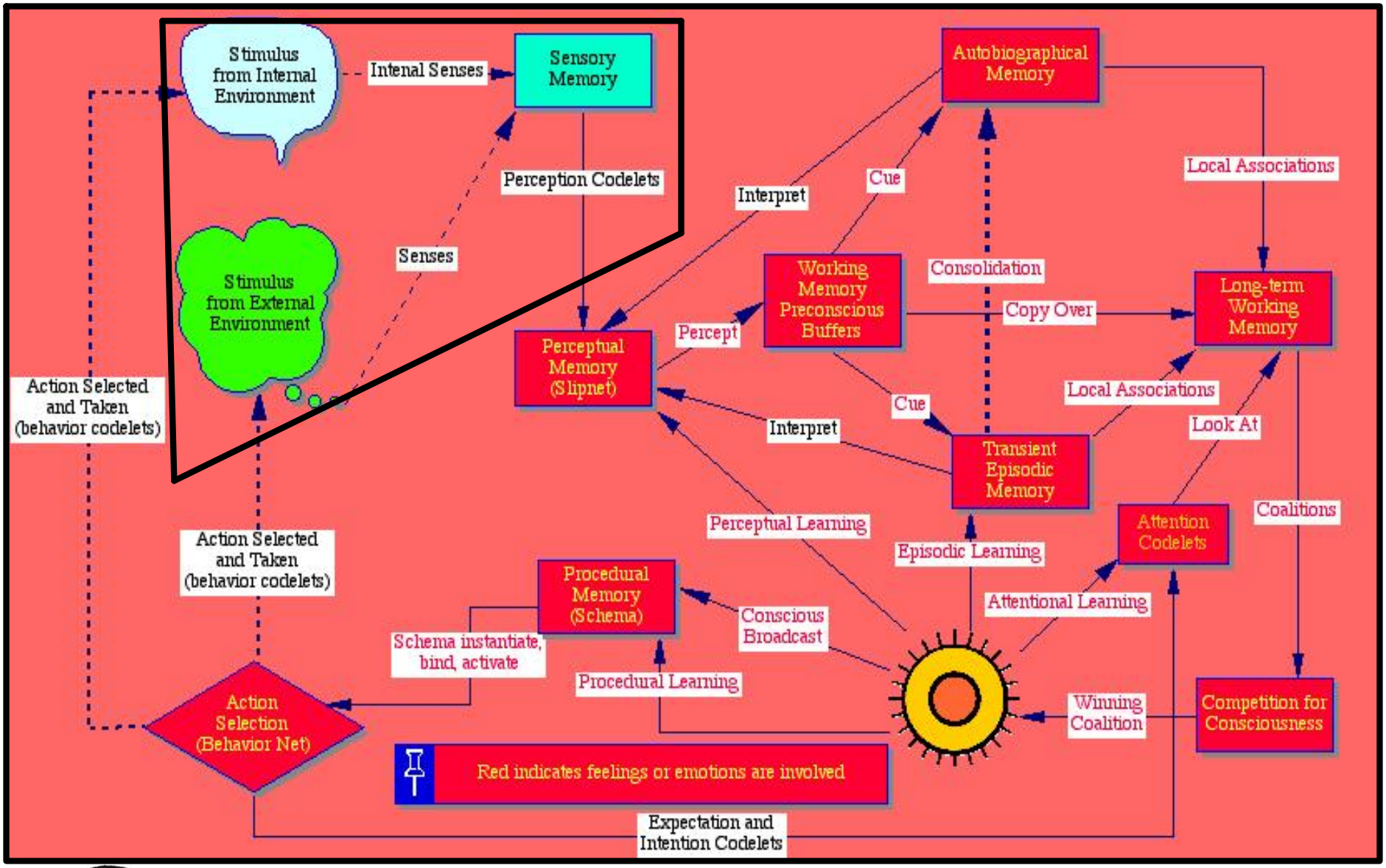
- There is no RED out there, only wavelengths of light
- There is no sound when the unattended tree falls in the forest, only vibrations in the air
- The smell of smoke is an inference drawn from molecules in the air

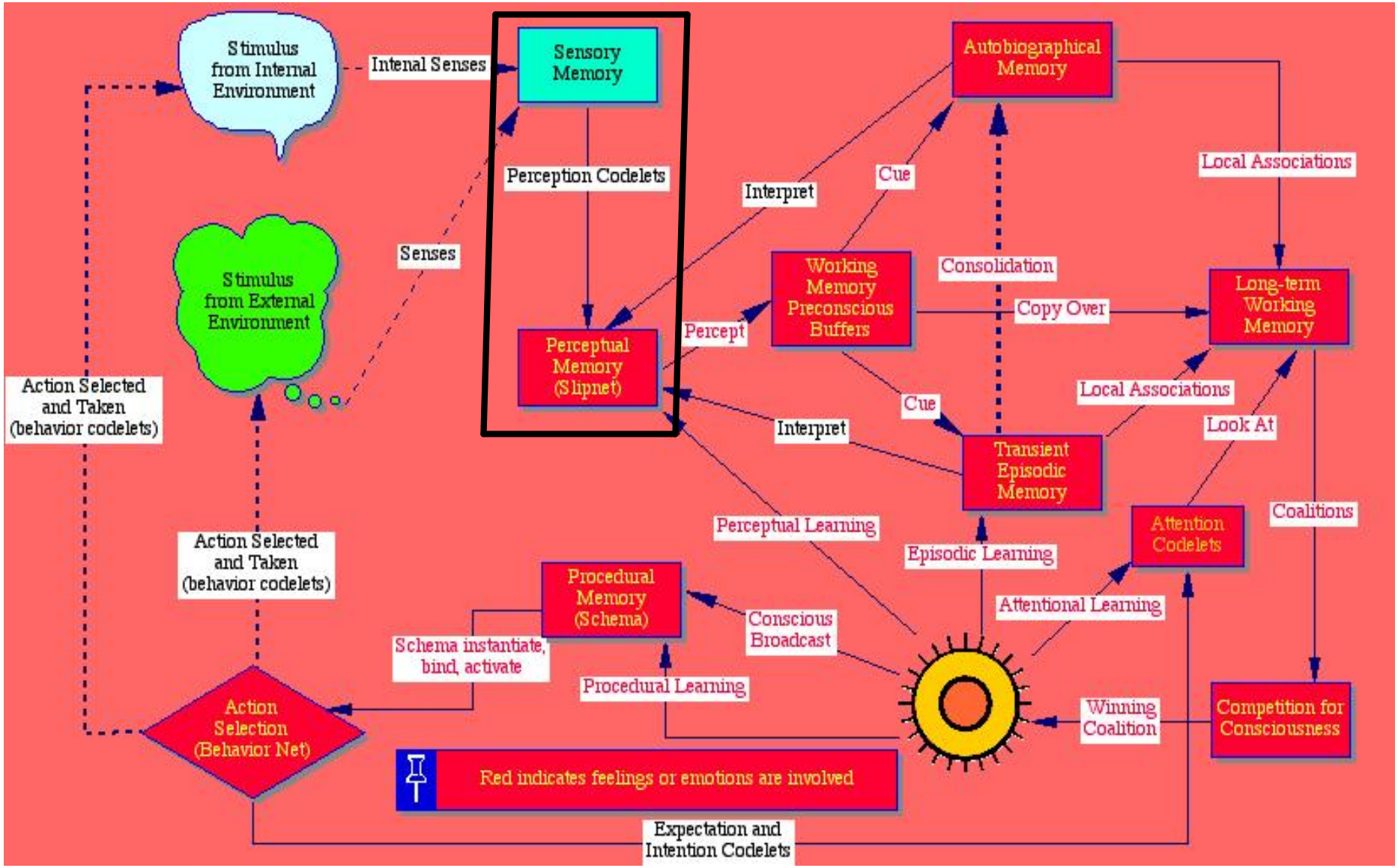
Codelets

- Small pieces of code each performing a simple, specialized task
- Many watch for a chance to act
- Most subserve some high level entity, e.g.
  - behavior
  - slipnet node
- Some codelets work on their own, e.g.
  - watching for incoming mail
  - checking for time and place conflicts
- Codelets do almost all the work

Perception in IDA's Cycle

- Input arrives through senses
- Specialized perception codelets find features and activate appropriate nodes in the slipnet
- Activation passes from node to node until the slipnet stabilizes
- Convergence of streams from different senses & chunking bits of meaning into larger chunks
- These larger chunks constitute the percept
- Sensory stimuli received and interpreted producing meaning


Stimulus from Internal Environment
Intenal Senses
Sensory Memory
Perception Codelets
Stimulus from External Environment
Senses
Autobiographical Memory
Local Associations
Interpret
Cue
Working Memory Preconscious Buffers
Consolidation
Copy Over
Long-term Working Memory
Percept
Perceptual Memory (Slipnet)
Action Selected and Taken (behavior codelets)
Cue
Local Associations
Interpret
Look At
Transient Episodic Memory
Perceptual Learning
Episodic Learning
Attention Codelets
Coalitions
Action Selected and Taken (behavior codelets)
Procedural Memory (Schema)
Conscious Broadcast
Attentional Learning
Schema instantiate, bind, activate
Procedural Learning
Action Selection (Behavior Net)
Winning Coalition
Competition for Consciousness
Red indicates feelings or emotions are involved
Expectation and Intention Codelets


Stimulus from Internal Environment
Intenal Senses
Sensory Memory
Perception Codelets
Autobiographical Memory
Local Associations
Interpret
Cue
Stimulus from External Environment
Senses
Working Memory Preconscious Buffers
Consolidation
Copy Over
Long-term Working Memory
Percept
Perceptual Memory (Slipnet)
Action Selected and Taken (behavior codelets)
Cue
Local Associations
Interpret
Look At
Transient Episodic Memory
Perceptual Learning
Episodic Learning
Attention Codelets
Coalitions
Action Selected and Taken (behavior codelets)
Procedural Memory (Schema)
Conscious Broadcast
Attentional Learning
Schema instantiate, bind, activate
Procedural Learning
Action Selection (Behavior Net)
Winning Coalition
Competition for Consciousness
Red indicates feelings or emotions are involved
Expectation and Intention Codelets

Perceptual Associative Memory

- Ability to interpret incoming stimuli by
  - recognizing individuals
  - categorizing them
  - noting situations
- Ubiquitous among animal species
- Animals of all sorts can identify food sources, potential mates, potential predators, etc.

Examples of PAM

- Pigeons – taught to categorize using such concepts as tree, fish, and human
- Honey bees – taught to identify letters independently of size, color, position or font
- African Grey Parrot (Alex) – can identify such features as size, number, color, and material of (sets of) objects never seen before

Distinct PAM Mechanism

- Developmental argument – infants who have not yet developed object permanence able to recognize and categorize
- Human amnesiacs – significant loss of new declarative memory, but mostly intact perceptual memory
- Rats in radial arm maze – recognize which arms to search (PAM) and remember in which they have already fed (episodic memory)
- Hippocampally excised rats lose their episodic memory but retain PAM

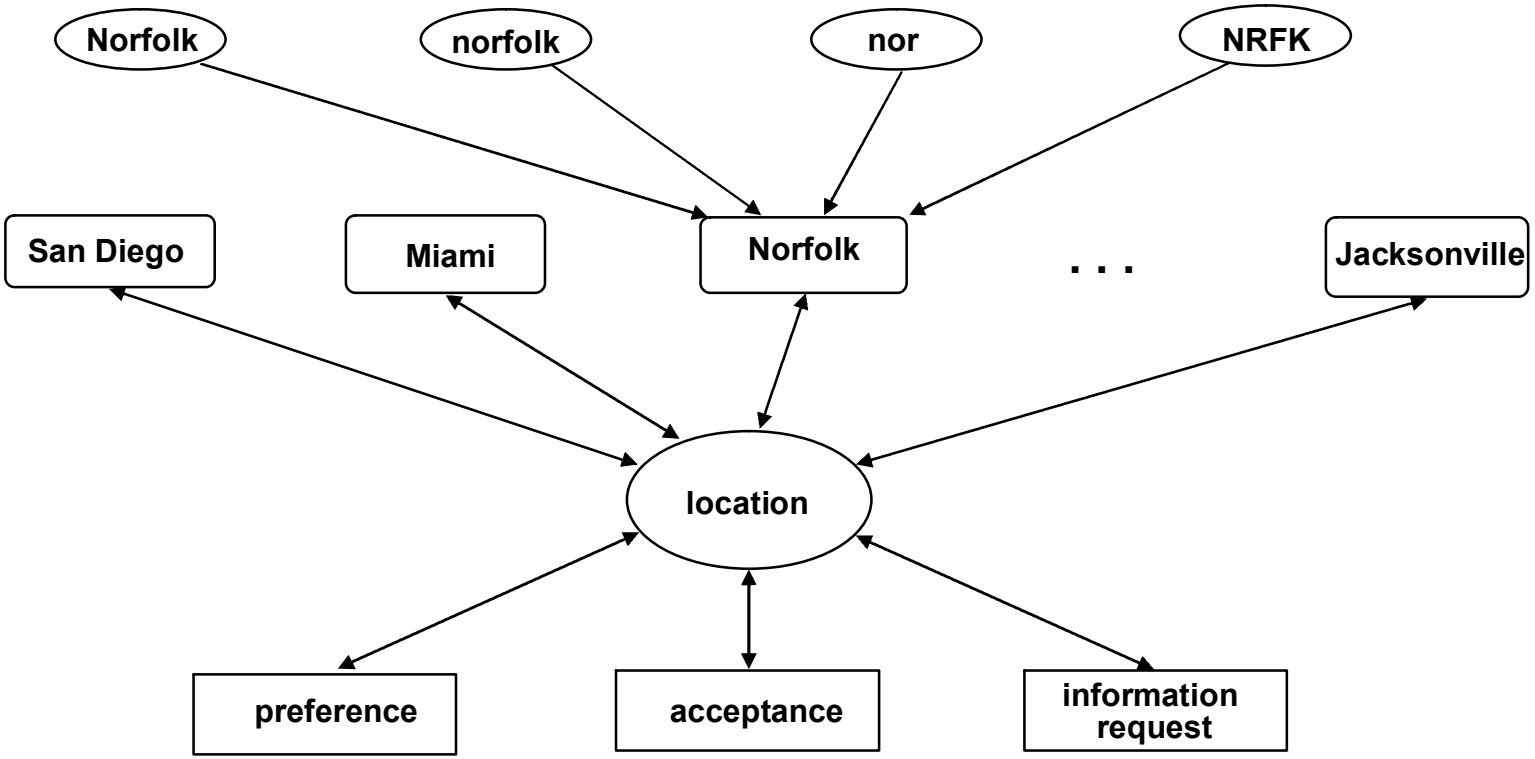
Perception in IDA

- IDA senses only strings of characters
- Perception mostly processes email messages
- Perception implemented with
  - perceptual codelets triggered by surface features
  - slipnet – a semantic net that passes activation
- Slipnet stores domain knowledge
- Perceptual codelets recognize particular pieces of text
- Together they allow IDA to recognize, categorize and understand

Example of Email Perception

- IDA receives message asking for a new job
- Perception recognizes
  - sailor's name
  - social security number
  - message is of please-find-job type
- Information constitutes the percept
- Percept written to working memory before becoming conscious

Perception via a Slipnet



PAM as a Slipnet

- PAM provides
  - short and long term perceptual memory
  - the beginnings of meaning
- PAM implemented as a semantic net with passing activation, a slipnet
- Slipnet consists of
  - Nodes with activation
  - Links that pass activation

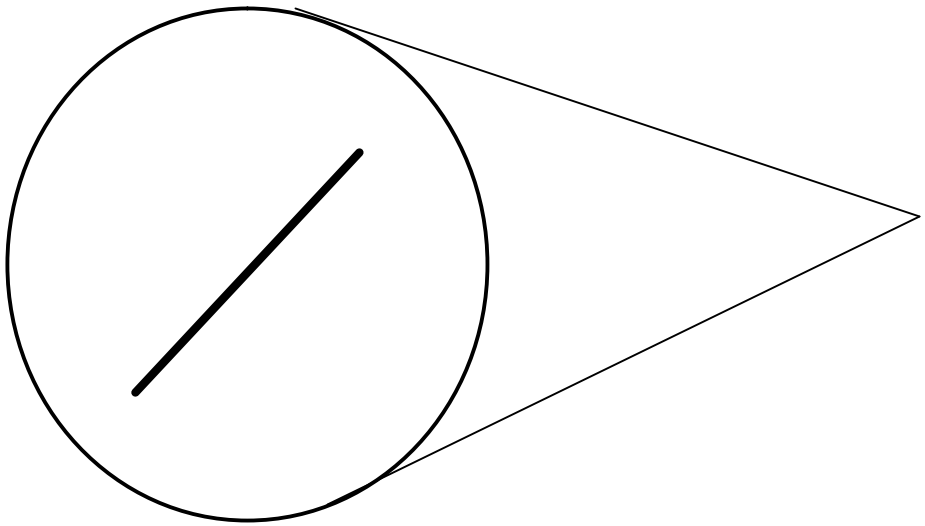
Nodes in PAM

- Nodes may represent
  - feature detectors (perceptual codelets)
  - individuals (a person or particular thing)
  - a category (chair, woman, animal)
  - situation (cup on a table)
  - a concept (democracy, justice)
  - an idea (“please find me a job”)
  - etc.

Primitive Feature Detectors

- Has a receptive field among the sensory receptors
- Reacts selectively to particular activity in its receptive field, the feature
- Activity varies smoothly with variation in the feature
- Primitive feature detector node = (identified with) perceptual codelet

Edge at Angle Detector



QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Receptive Field

Retinal Ganglion Cell

Nodes as Feature Detectors

- Primitive feature detectors
- Complex feature detectors
- Objects detect their features
- Categories detect features & members
- Situations detect objects and relations as features
- All slipnet nodes are feature detectors

Links in PAM

- Represent relations between nodes
  - feature of
  - category membership (isa)
  - category inclusion
  - logical
- Mostly feedforward in conceptual depth
- Moving inward links from more specific to more abstract
- Can be excitatory or inhibitory
- Lateral links can also exist

Activation Passing

- Starting with primitive feature detectors, nodes send activation along links to other nodes
- Slipnet passes activation until it stabilizes
- Nodes with activation above threshold become part of the percept

Readings

- Franklin, S. 2005. Perceptual Memory and Learning: Recognizing, Categorizing, and Relating. Symposium on Developmental Robotics; American Association for Artificial Intelligence (AAAI). Stanford University, Palo Alto CA, USA. March 21-23, 2005.

Email and Web Addresses

- Stan Franklin
  - franklin@memphis.edu
  - www.cs.memphis.edu/~franklin

- “Conscious” Software Research Group
  - www. csrg.memphis.edu/