How Minds Work
Sensing and Perceiving

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Sense the environment?

• Humans: sight, hearing, touch, smell
• Other animals:
  – Bats, dolphins — echolocation
  – Sharks — electrorception
• 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
Sensing and Perceiving
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

- Norfolk
- norfolk
- nor
- NRFK
- San Diego
- Miami
- Norfolk
- Jacksonville

- Location
- Preference
- Acceptance
- Information Request

Sensing and Perceiving
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

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