How Minds Work

Minds, Agents, Senses, Actions

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Two Burning Questions for Me

- How do minds work?
  - Human minds
  - Animal minds
  - Artificial Minds
- How to make smart software agents?
  - Copy them after humans

Question: How do minds work? What would an answer be like?

A framework within which to understand the various mental processes about which one might become curious.

My answer will take most of the semester.

What is a *mind*?

A mind is a control structure for an autonomous agent.

What is an *autonomous agent*?

A system embedded in, and part of, an environment, that

- Senses its environment
- Acts on it
- Over time
- In pursuit of its own agenda
- So that its actions affect its future sensing

Examples of Autonomous Agents

- We humans
- Most (all?) animals
- Computer viruses
- Some mobile robots
- Autonomous software agents
- Some organizations

Environment?

- Physicalist assumption: There's a real world out there
- Cyberspace is part of the real world
- Artificial environments also exist
- Causality assumption: Causality operates, i.e., the universe is lawful

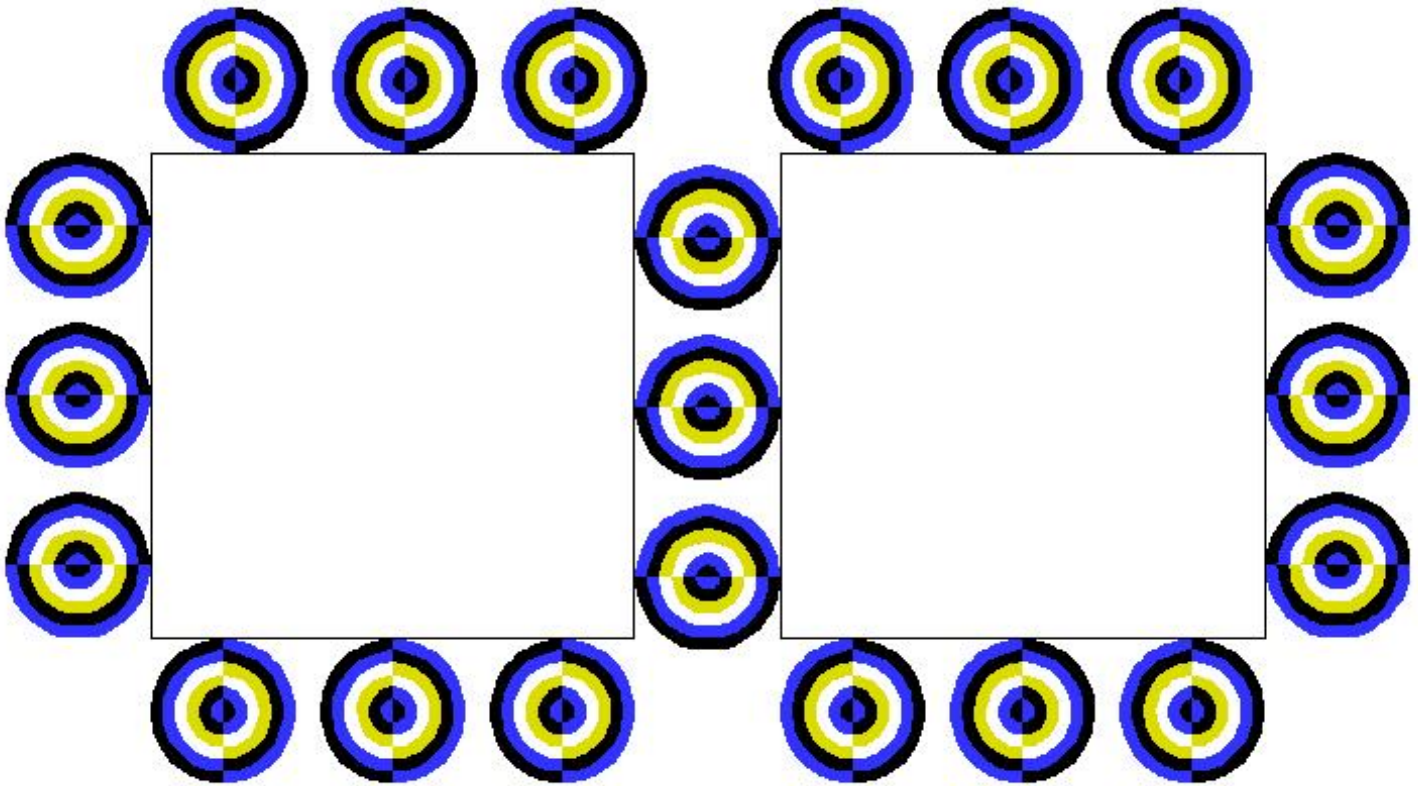
Sense the environment?

- 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

Spatially Sensitive Senses

- Sense organ movement produces apparent motion at its surface
- E.g. human vision—*press eyeball*
- Bacterium nutrient gradient sensing is not spatially sensitive
- Temperature sensing by a thermostat is not spatially sensitive

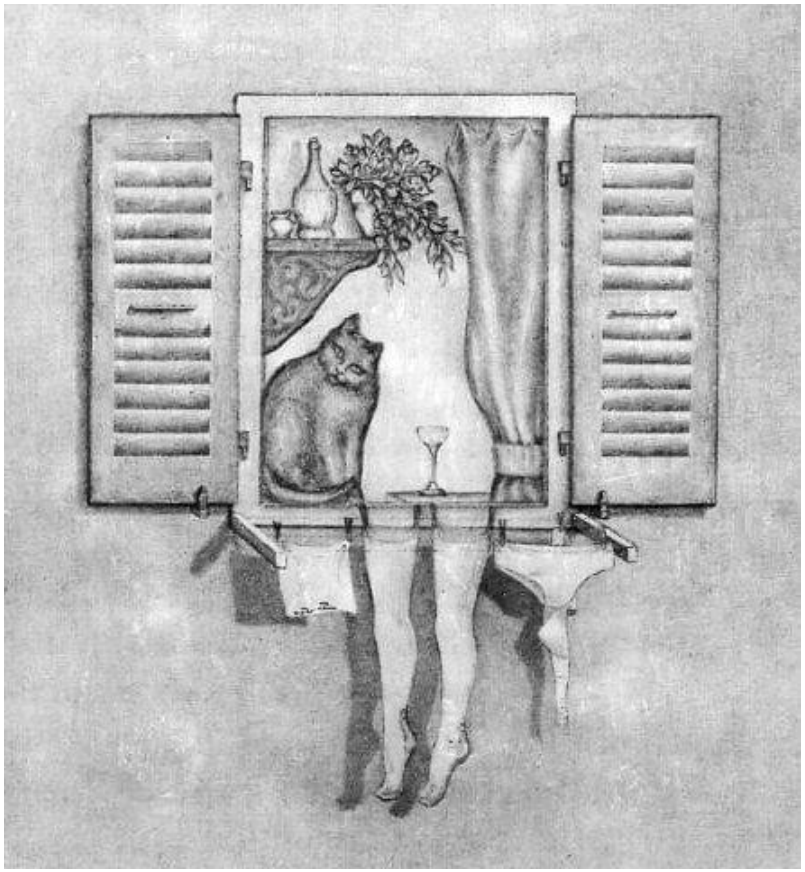
Illusory Motion



Illusory Woman

The apparent woman is produced by

- A potted plant
- A shelf
- A cat
- A wine glass
- A plate
- A clothesline
- A pair of stockings



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

Illusions of the senses tell us the truth about perception

For a website devoted to this proposition, go to

http://www.michaelbach.de/ot/index.html

The **only** question there is!

What do I do next?

For any autonomous agent

Cognition is in the service of action selection

Everything else is a side effect

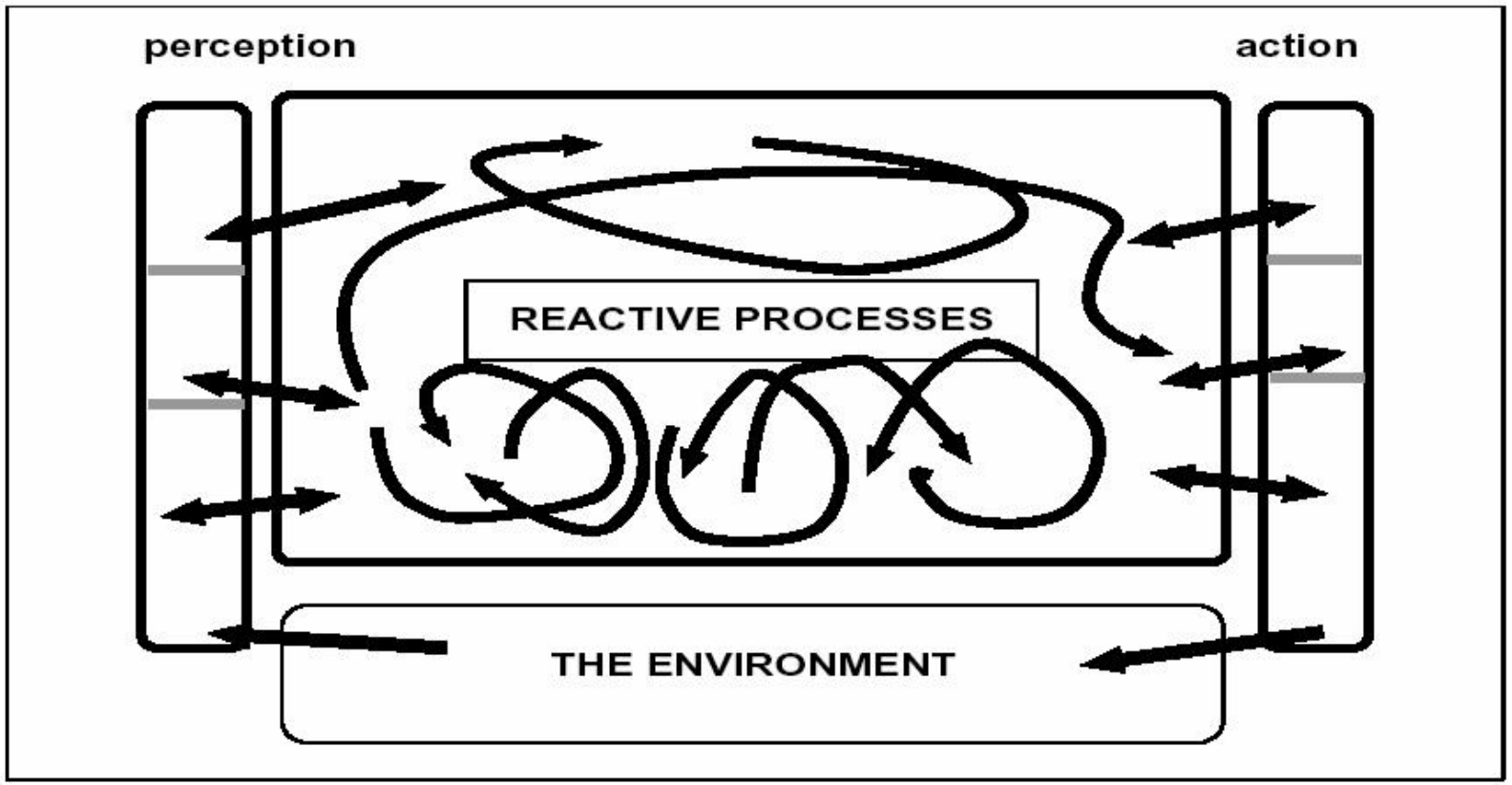
Its own agenda?

- Motivation must be built in
- Either by evolution or a designer
- Can be causally implemented
  as in a thermostat
- Implemented by feelings and emotions
  in humans and other animals

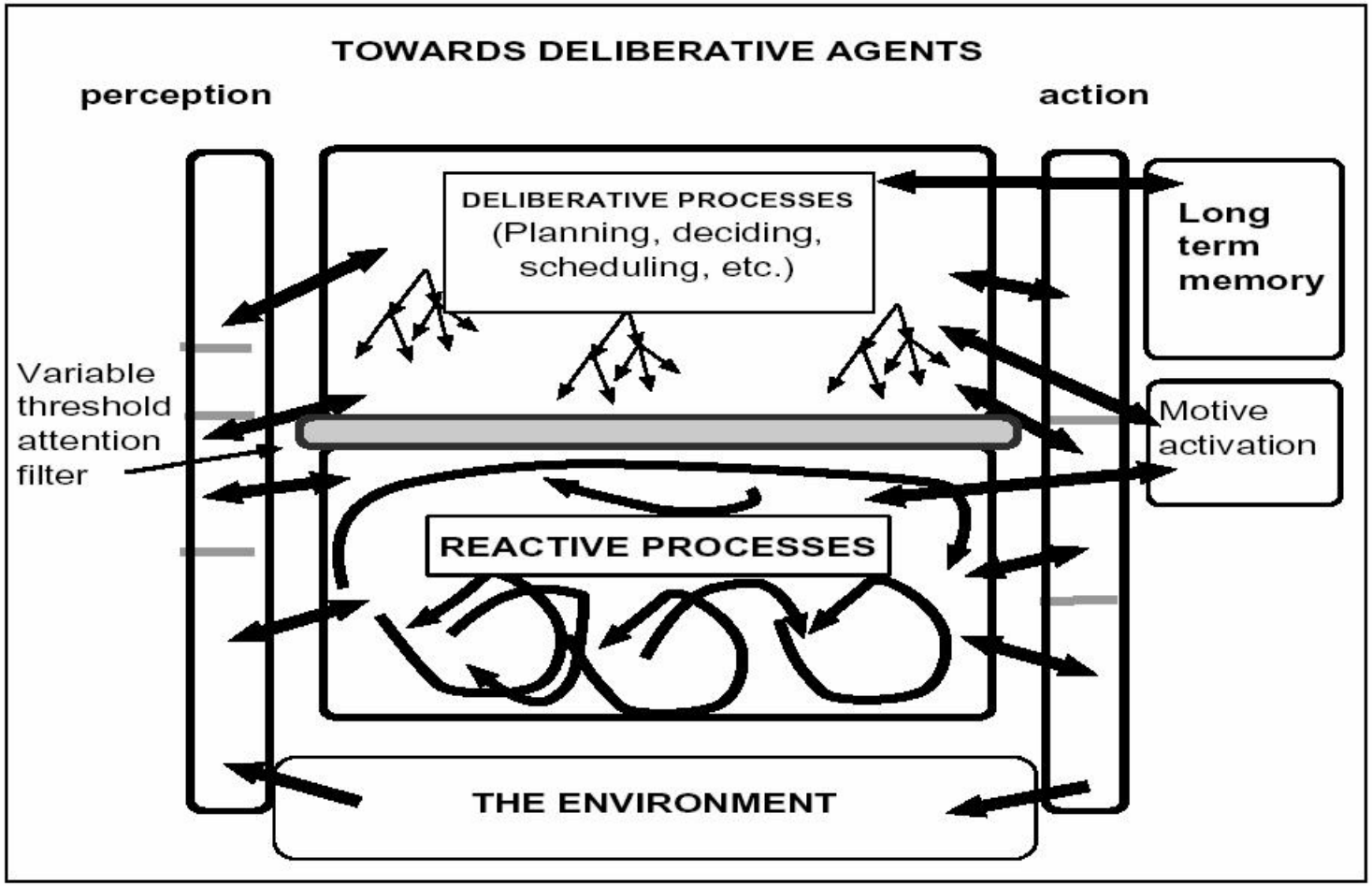
Actions affect sensing?

- Structural coupling to its environment
- Sensors must be appropriate to needs
- Effectors must be appropriate to needs
- Effectors must change the environment
- Sensors must record those changes

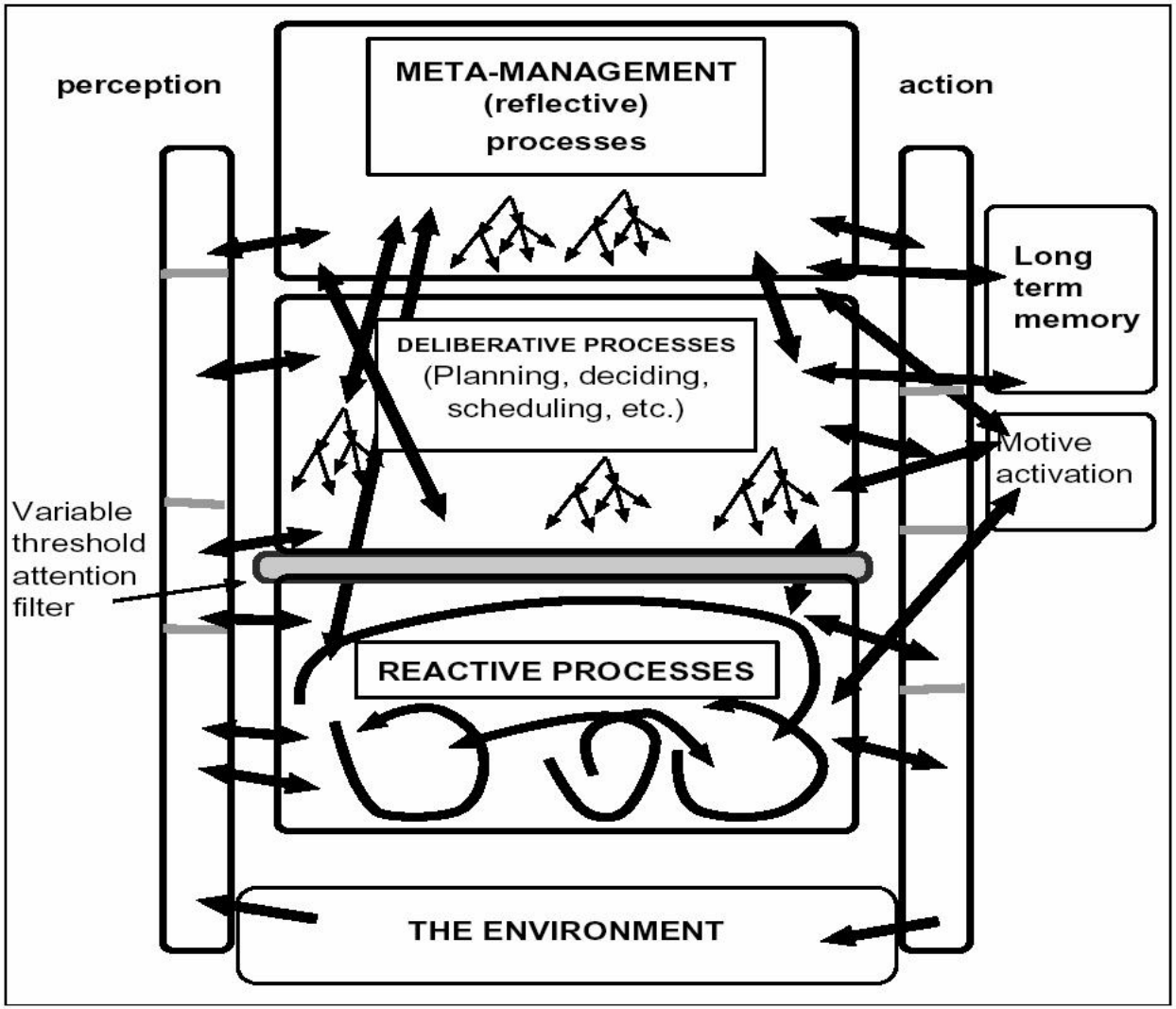
Reactive Agents à la Sloman



Add Deliberation



Add Meta-Management



Primitives

- Every autonomous agent must come equipped with
  - Primitive sensors—sensory receptors
  - Primitive effectors—motor output
  - Primitive motivators—of some sort
- These primitives put fundamental limits on what the agent can sense and do

Action Selection Paradigm of Mind

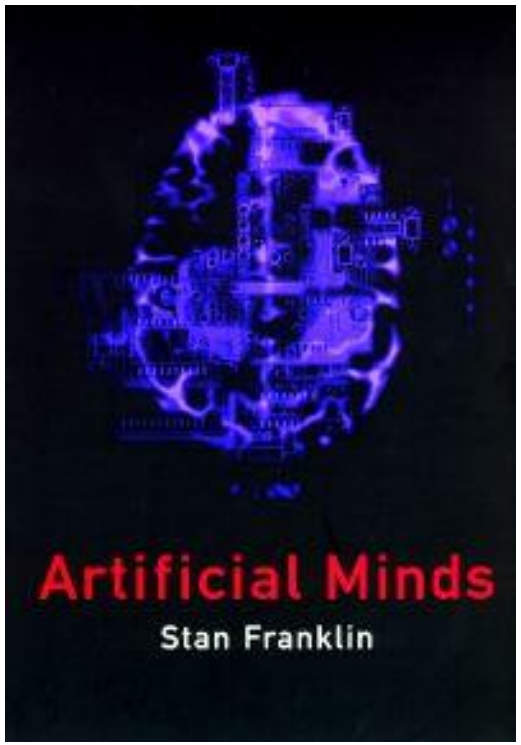
- Best viewed as degreed rather than as Boolean
- Aggregate rather than monolithic
- Enabled by disparate mechanisms
- Overriding task to produce the next action
- Operates on sensations to create information
- Reconstructs memories (prior information)
- Is implementable on machines

A Cognitive “Theory of Everything”

- Sensation
- Perception
- Feeling & Emotion
- Working memory
- Episodic memory
- Consciousness
- Learning
- Deliberation
- Volition
- Automization
- Action Selection
- Problem solving
- Self
- Metacognition

Readings in *Artificial Minds*

Action Selection Paradigm	**pp. 17-18**
Pandemonium Theory	**pp. 234-244**
Copycat Architecture	**pp. 347-362**
Schema Mechanism	**pp. 314-324**
Sparse Distributed Memory	**pp. 330-344**
Behavior Networks	**pp. 244-258**



MIT Press, 1995

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