Intelligent Control and Cognitive Systems

An Introduction to Artificial Intelligence and Cognition

Joanna J. Bryson
University of Bath, United Kingdom

Outline

- Last Time:
  - Defined intelligence in terms of behaviour. Talked about sensing for action.
- This time:
  - Why focus on action? What about cognition?
  - Intro to Cognitive Architectures.

Coursework

- Academic writing is part of what you learn here.
  - Hypothesis & outcome are introduced in the Introduction, Approach describes experiments. Titles communicate results.
- The robot is there so you can learn, and to give you something to do write about.
  - The coursework is marked for writing science, and understanding of material.

Resources

- Lots of books in the library (many on LEGO robots!)
- Russel & Norvig is the ultimate AI textbook (for the last decade), though comes from a CMU & Stanford prespective.
- Norvig & Thrun's Stanford AI lectures are available on line.

Quick History of AI

- Early 20c Turing invents CS to solve AI.
- Dartmouth Conference (1956) John McCarthy, Marvin Minsky, Nathaniel Rochester & Claude Shannon proposed, Alan Newell, Herbert Simon & Oliver Selfridge (among others) attended.
  - Proposal used the phrase "artificial intelligence", apparently for the first time.

The Dartmouth Proposal

We propose that a 2 month, 10 man study of artificial intelligence be carried out...

McCarthy & Minsky et al 1956

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McCarthy & Minsky et al 1956

The Summer Vision Project

The summer vision project is an attempt to use our summer workers [11 UGs] effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which allow individuals to work independently and yet participate in the construction of a system complex enough to be real landmark in the development of "pattern recognition"... The primary goal of the project is to construct a system of programs which will divide a vidisector picture into regions such as likely objects, likely background areas and chaos. We shall call this part of its operation FIGURE-GROUND analysis. It will be impossible to do this without considerable analysis of shape and surface properties, so FIGURE-GROUND analysis is really inseparable in practice from the second goal which is REGION DESCRIPTION. The final goal is OBJECT IDENTIFICATION which will actually name objects by matching them with a vocabulary of known objects.

Papert & Minsky (w/ Sussman) MIT 1966

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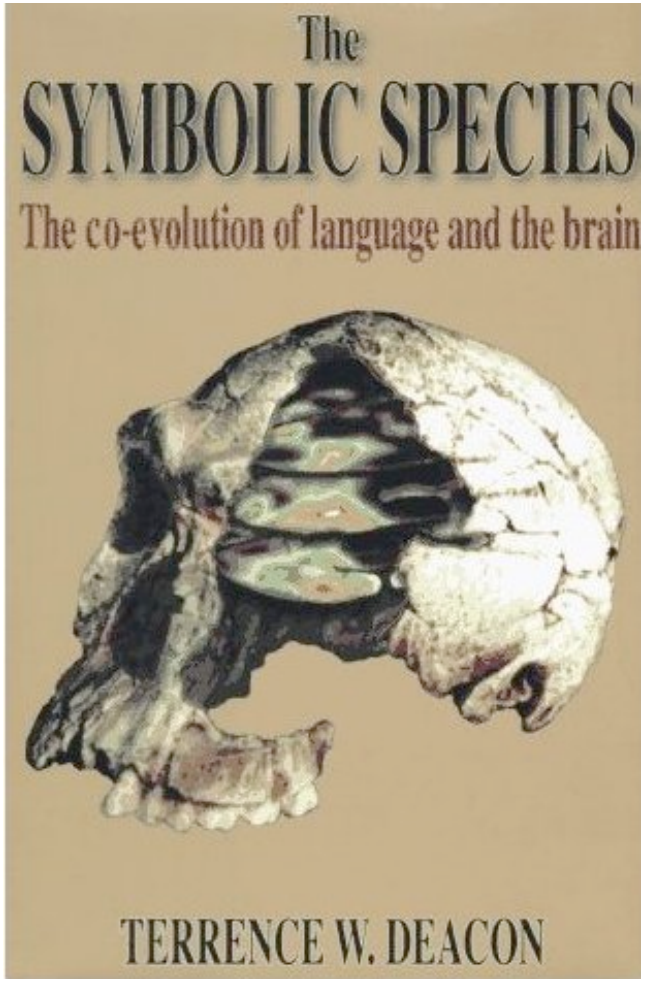
The CMU Perspective

- Physical Symbol System Hypothesis (Newell & Simon 1963) "A physical symbol system has the necessary and sufficient means for general intelligent action." Implies:
  - Human thinking is a kind of symbol manipulation (because a symbol system is necessary for intelligence).
  - Machines can be intelligent (because a symbol system is sufficient for intelligence).

Symbols



- Symbols (and sometimes Language) have been thought to define intelligence for a long time.
- Brooks (1991) was a significant challenge to this (more next week).

Mind uploading / whole brain scanning

AI Heaven

- If intelligence is just symbol systems, and we're all Turing compatible...
  - Cartesian dualism should hold.
- We can upload our brains & "live" forever.

cf. Minsky, Vinge.

"New AI" (1986)

- AI "wasn't working" (more on this later in the course).
- Refocus attention on behaviour, robots.
- Produced first robots that could operate at animal-like speeds.

Genghis, MIT 1986

New AI

Functionalist Assumption: All we care about is producing intelligent behaviour.

- Physical Symbol System Hypothesis (Newell & Simon 1963); Qualia, Chalmers "hard problem" (1995) **Build thinking first.**
- Consciousness as epiphenomena (Churchland 1988, Brooks 1991).

We'll build it if we need it.

Newer New AI

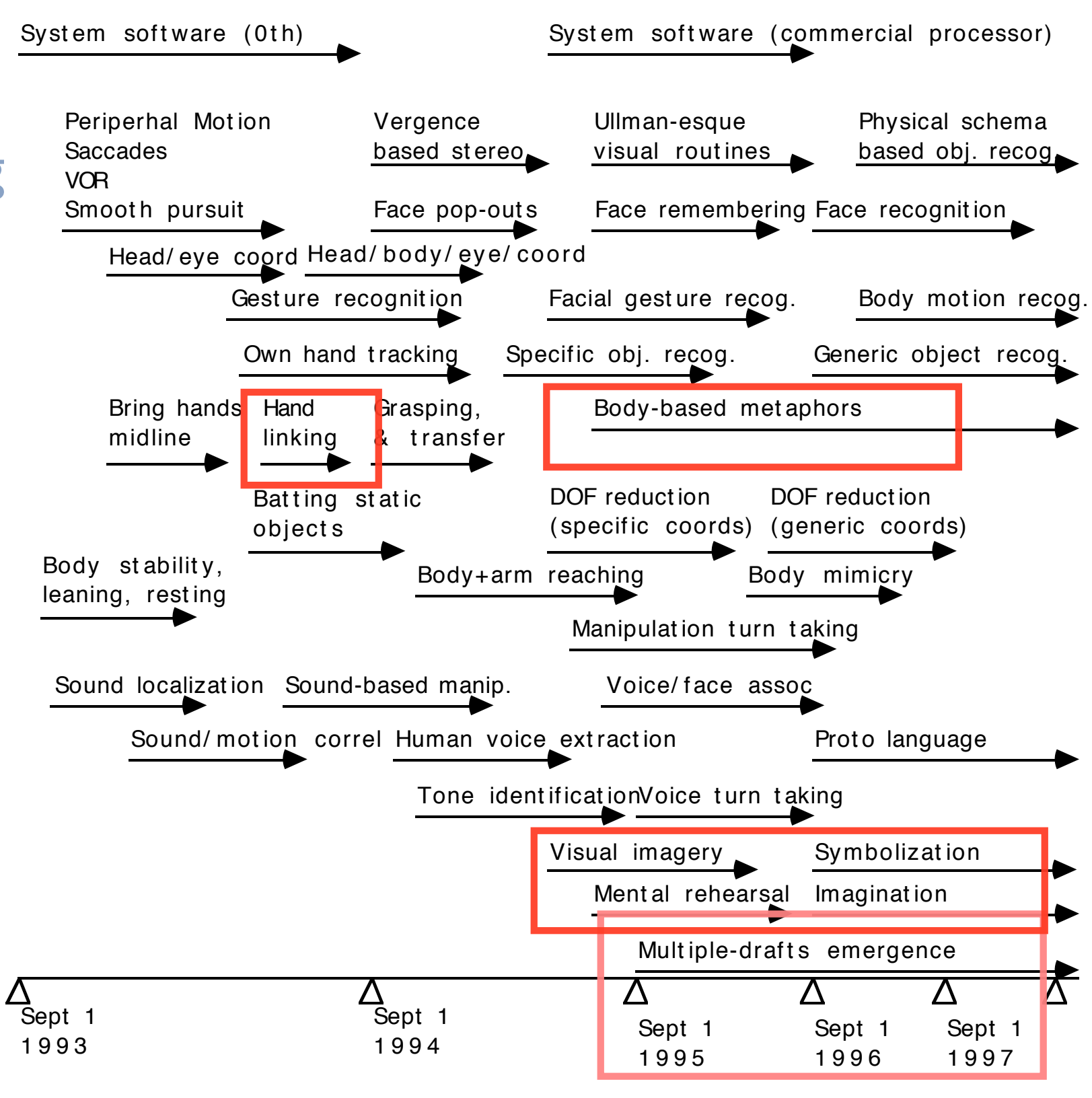
Functionalist Assumption: All we care about is producing intelligent behaviour.

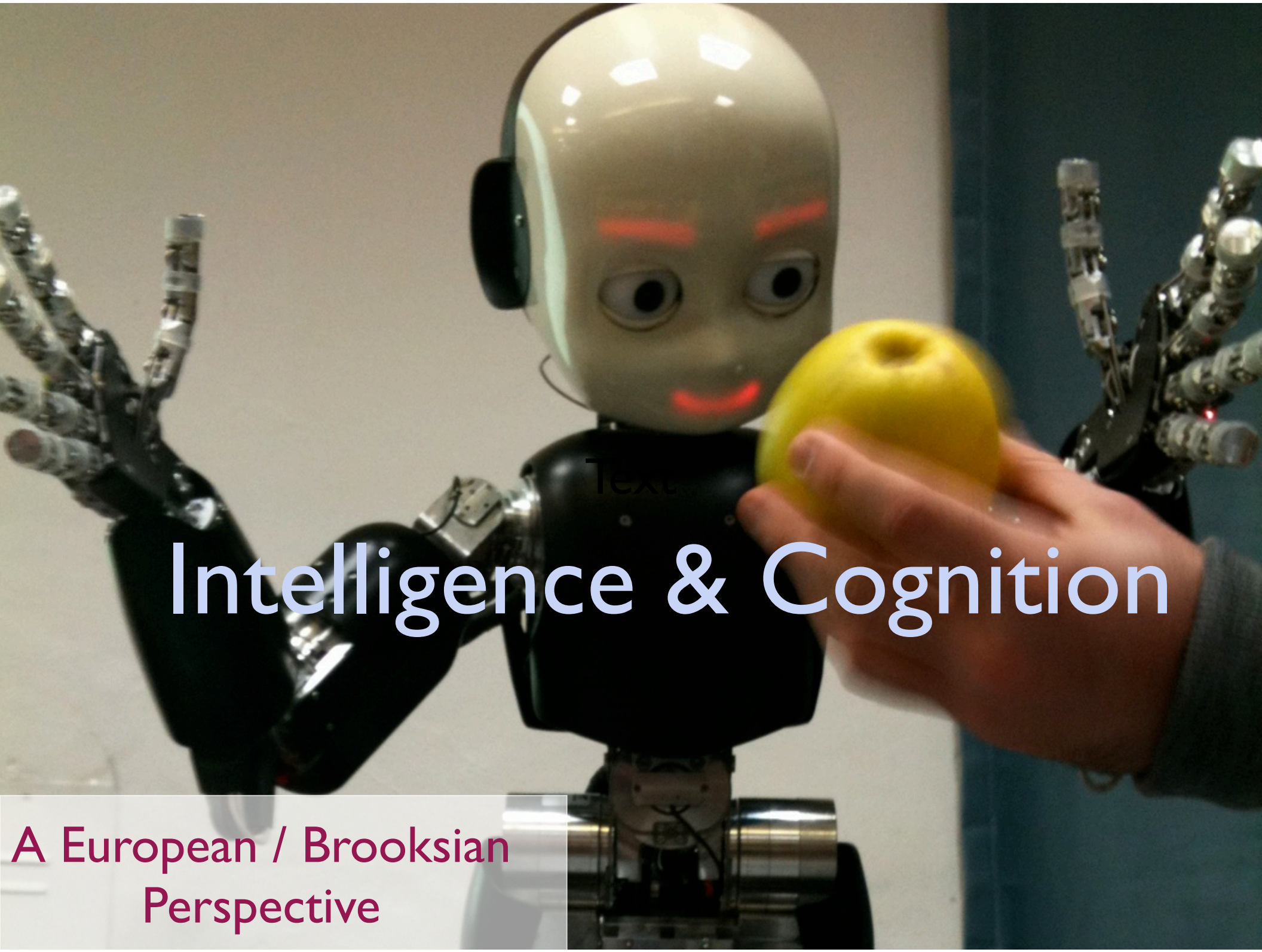
- Physical Symbol System Hypothesis (Newell & Simon 1963); Qualia, Chalmers "hard problem" (1995). **Build thinking first.**
- Consciousness as epiphenomena (Churchland 1988, Brooks & Stein 1993).

We'll build it to see if we need it.

(Bias alert: Stein was my PhD supervisor)

"Building Brains for Bodies", Brooks & Stein (1993), MIT AI lab tech report 1439.





Intelligence & Cognition

A European / Brooksian Perspective

Intelligence

- What matters is expressing the right behavior at the right time: action selection.
- Finding the right action requires search.
- Search is intractable.
- Corollary 1: This is why we all act stupid.
- Corollary 2: Culture / concurrency is what makes humans so smart.

Why is it hard to be smart?

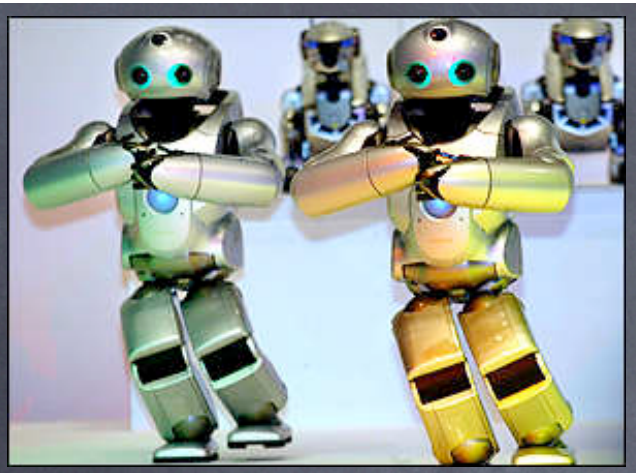
- Pretend someone handed you a robot brain brick, and it came with 100 things it knew how to do without being told.
- For example, eat, sleep, turn right, turn left, step forward, step backward, pick things up, drop them...
- Now pick a goal for your robot.
- For example, flying to Osaka.

Sanyo robot watchdog

The hardness of smartness (2)

- Suppose you can't be bothered to tell your robot exactly how to get to Osaka, so you have it guess.
- If getting to Osaka is a built-in primitive, the robot may have to try 100 different things.
- If it requires two steps, the robot may have to try each thing after each thing:

$$100^2 = 10,000$$



The hardness of smartness (3)

- If the robot doesn't know how many steps it takes to go to Osaka, it might get caught in an infinite loop.
- For example, it might eat, sleep, work, eat, sleep, work, eat, sleep, work... and never buy a passport.
- When computer scientists say "hard" they mean "pretty much intractable."

Sony SDR-4Xs. Pictures from BBC

Intelligence & Design

- Combinatorics is the problem, search is the only solution.
- The task of intelligence is to focus search.
  - priors
  - Called bias (learning) or constraint (planning).
  - Most `intelligent' behavior has no or little real-time search (non-cognitive) (c.f. Brooks IJCAI91).
- For artificial intelligence, most focus from design.

Intelligence

- What matters is expressing the right behavior at the right time: action selection.
- Conventional AI planning searches for an action sequence, requires set of primitives.
  - That set of primitives came from search by the system's designers.
  - ∴ Building AI requires tradeoffs between search by designers & computers.

What About Learning?

- A learning system consists of a representation (state) and an algorithm for changing the values in that representation.
- Learning searches for the right parameter values, requires primitives *and* parameters.
  - No learning algorithm automatically generates AI through invocation.
  - Evolution and development are just special kinds of learning.

What About Cognition

Definition:

Cognition is on-line (real-time) search.

Consequence:

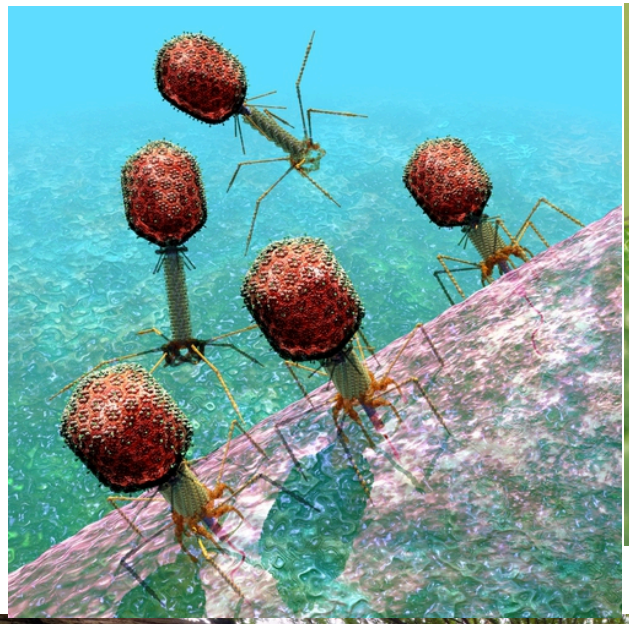
Cognition is bad.

Cognition

- Why is cognition / individual search bad?
  - Slow
  - Uncertain
- Unpopular in most species.
  - e.g. Plants

Cognition

- When is cognition useful?
  - Dynamic environments – change faster than learning or evolution can adapt.
    - Note this depends on lifehistory.
  - Baldwin Effect – fast & noisy search facilitates (speeds up) slower & more reliable learning processes (Baldwin 1896, Hinton & Nowlan 1987).



Why History Matters

- A lineage is a type of state – a set of data forming a preexisting solution, that then gets improved upon, e.g. through
  - innovation – Generate
  - selection – Test

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(interactive)

Why Cognitive Systems?

- What artefacts need to be cognitive?
- What artefacts need to adjust in real time?
- (possible answers…) traits:
  - Proactive, interactive, sensing, mapping...
- examples:
  - Smart homes, personal digital assistants / phones, drones.

Summary

- The history of AI through about 1995.
  - More contemporary stuff later in the course
- Introduction to "New AI" and Systems AI.
  - Introduction to discussion of academic / scientific lineages, including mine.