Robots and AI

- Marr's 3-level of vision:

1) Computational or task analysis
2) Representation and algorithm
3) Implementation = Neuro-level

→ What kind of "levels": analysis, description, organizational, ontological...

↔ Relationship perception-action-brain/mind - strong interconnected

Evolutionary framework: low-level → High level

Classical AI

- *Abstract* (physical irrelevant)
- *Individual* (mind = locus of intelligence)
- *Rational* (reasoning → Intelligence)
- ***Detached*** (thinking separated from perception + action) (Smith 99 in Ekbia 08)

- **Classical** approach = "Sense-think-act" Perceptual mechanism → 3D visual scene = Input to reasoning/planning **centres** → Calculate the action + commands to motor → Action

vs.

- "**Interactive vision**" (Churchland, Ramachandran, Sejnowsky 94): Daily agent-environment interactions- independent of full 3D scene + low-level perception involves motor routines

- Real-world actions → Computations
- Rs = Not passive information but "direct recipe for action" (Clark 01)

I. Early Robots - Navigating with Maps

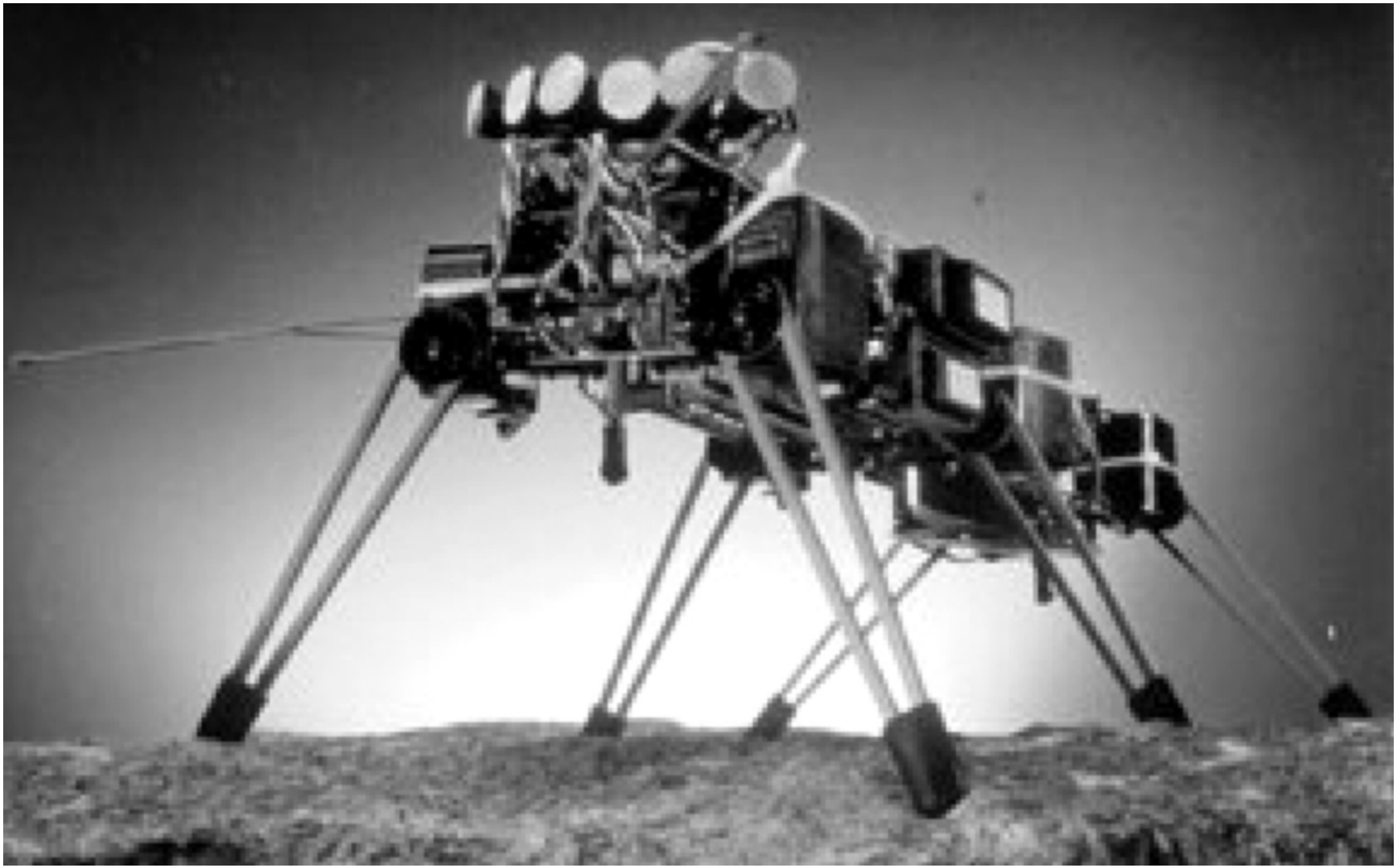
- Social insects: communication (honeybees)

SHRDLU

- Simulated robot (MIT) operated in a simulated blocks micro-world
- Graphic interface and a video screen that displayed its operations in a visual manner
- Written language interface - followed commands given in ordinary English + answered questions about its “motivations” for doing things in sequence

II. New Robots: Navigating Without Maps

- Toto: Robotic cat - navigates corridors without *a priori* map. Uses compass - keeps track of its ordered interactions with various landmarks (a wall on right, a corridor). Landmarks - used to construct a map = *not explicit*, but part of robot (Mataric 92)
- Luc Steels: Simulated society of robots …, self-organized into a path and attract other robots *Descriptions of paths - Not in robot* ('90)
- Genghis: Robotic insect - walks toward any moving source of infrared radiation, steers to keep its target in sight, scrambles over obstacles in its way, *no internal notion of "toward/ahead/over"* (Brooks 02 in Ekbea 08)



The robot Genghis.

Brooks ('97): "**The world is its own best model**"

1. *Situatedness*: Embedded in world, NOT deal with abstract descriptions (logical sentences, plans) vs. its sensors - "here and now" of world → Directly influences behavior
2. *Embodiment*: Physical body + Experiences world
3. *Intelligence*: "Intelligence - determined by dynamics of interactions with world"; Natural evolution: AI focus on "low-level" intelligence!
4. *Emergence*: Complex behavior should emerge as a result of interactions among simple/primitive tasks/modules:

"Intelligence is in eye of observer." (Ekbea '08)

Brooks ('91)

- Disembodied programs for reasoning and inference in abstracted subdomains of human cognition (natural language processing, visual scene analysis, logical problem solving) = Mistake

vs.

- Embedded in dynamic real-world situations, integrating perception and action in real time → Fluid embodied adaptive behavior (Wheeler 05)
- Insects

Rodney Brooks ('91) “new robotics”

- *“Subsumption architecture”*: Robot - **3 layers**
- Each layer - a function from input to motor act

↔ Separate control system (a layer = hard-wire finite state machine) for each task

- 3 layers: avoiding obstacles, moving randomly, moving toward a location
- Coordination between layers (external input - one device turns off another turns on) produces sequences of a serial processes
- Subsumption architecture = Decomposition of activities horizontally by task, not vertically by function↔ *NO central processor/R/modules*

Robot Herbert (Connell 1989)

- Collect soft drink cans on tables
- “Sense-think-act” view vs. Collection of sensors + Independent behavioural routines (ring of ultra-sonic sound sensors, robot halts in front of object)
- Difference: Random movement - interrupted if its visual system detects a “table-like outline” → New function: Sweeping surface of table - If detected → “Robot rotates until can is centred - field of vision”
- Arm - touch sensors skim table surface until a can encountered, grasped, collected
- Movement→ Perception =*Not passive* phenomena
- Perception and action - *Strong interconnected* (Clark 2001)

- ”Mirror neurons”: Neurons in monkey - action oriented, context dependent- implicated in both self-initiated activity + passive perception.” (Di Pellegrino et all 92)
- Neurons - activated monkey observes + performs an action

↓

Perception,action,cognition - interconnected

- Evolution line: Brain = “Organ of environmentally situated control”

Clark ('08)

- Honda's Asimo – Most advanced humanoid robot = "**Passive**-dynamic walker"

vs.

- **Active** robot = Environment is "incorporated" in robot's functions
- Pfeifer et al. (2006) - "**Ecological control**":

  "Part of 'processing' - by dynamics of agent-environment interaction, and *only sparse neural control* needs to be exerted when self-regulating and stabilizing properties of natural dynamics can be exploited."

Active robots

- Kuniyoshi et al. ('04): “Rolling and rising” motion
- Iida and Pfeifer’s ('04): Running robot Puppy
- Pfeifer and Bongard ('07) → Clark - Principle of **Ecological Balance**: Task environment **- match** between agent’s sensory, motor, neural systems + **task-distribution** between morphology, materials, control, environment
- “Matching” → Responsibility for adaptive response “not all processing is performed by brain, but by morphology, materials, environment → ‘Balance’/task-distribution between different aspects of an embodied agent” (Pfeifer et al. '06)

Toddler robot

- “Can learn to change speeds, go forward and backward, and adapt on different terrains, including bricks, wooden tiles…
- *Similar to a child* - learns to “complex evolved morphology and passive dynamics of its own body”
- Can exploit passive dynamics of its own body for controlling its movements

(Not for passive robots)

- Fitzpatrick et al. ('03) - BABYBOT platform: Information about object boundaries is furnished by “active object manipulation” (“pushing and touching objects in view”)

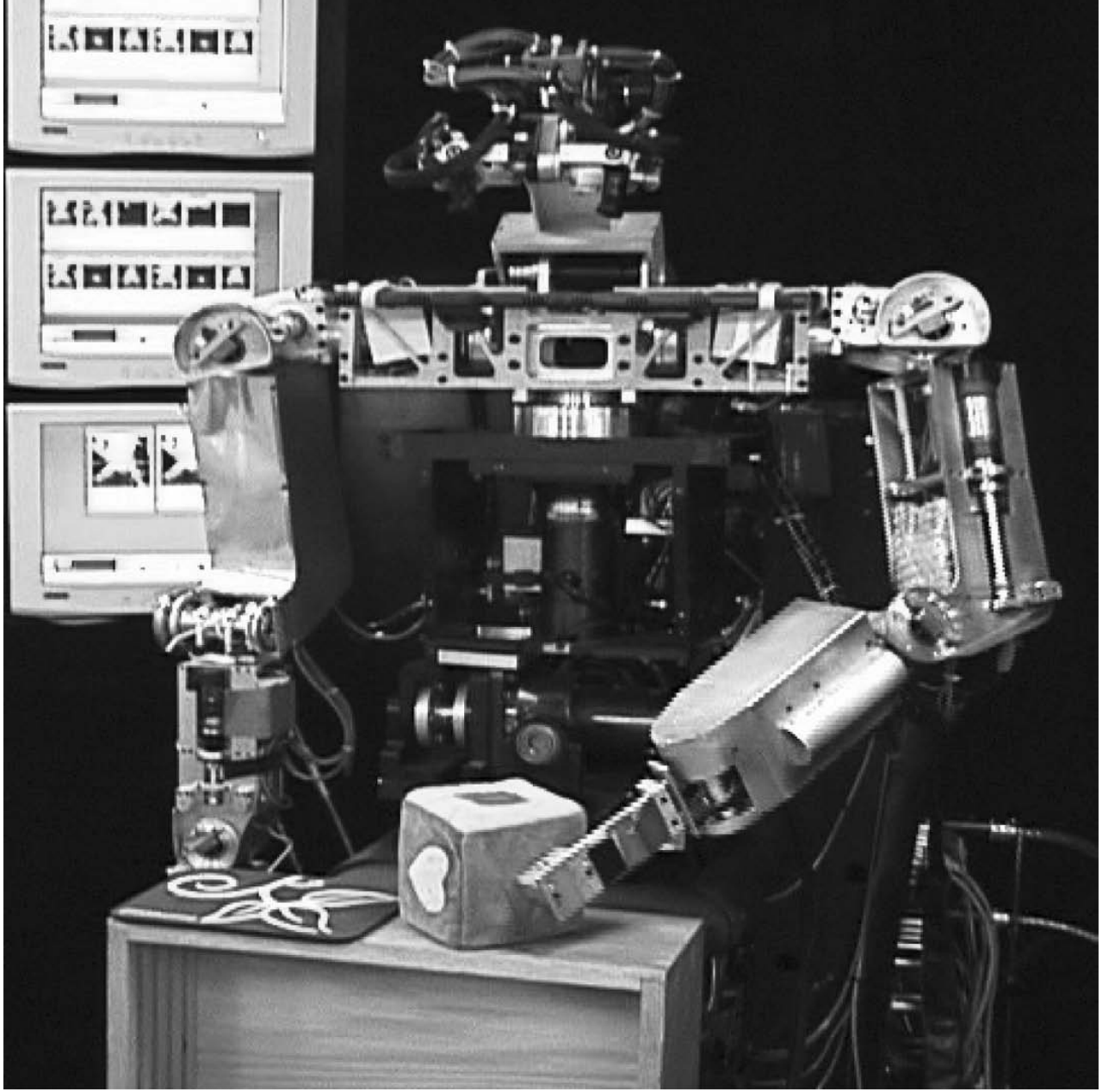
- “Learns about the boundaries by poking and shoving” + Uses motion detection to see its own hand–arm moving
- The infants “grasping, poking, pulling, sucking, and shoving create a rich flow of time-locked *multimodal* sensory stimulation.”

COG (Brooks' team - MIT)

- An upper-torso humanoid body that learns to interact with people *through "senses"*

Traits:

- *Embodied*–body/parts similar human body
- *Embedded* – it is "socialized" (minor)
- *Developing* – "baby" version Kismet
- *Integrated* – equipped with + to integrate data from various sensory organs (Ekbia '08)



COG (MIT)

“The distinction between us and robots is going to disappear.”

(Brooks '02)

COG

- … *cross-modal binding of incoming signals* - display common rhythmic signatures → Robot in learning about objects + its own body

Robot:

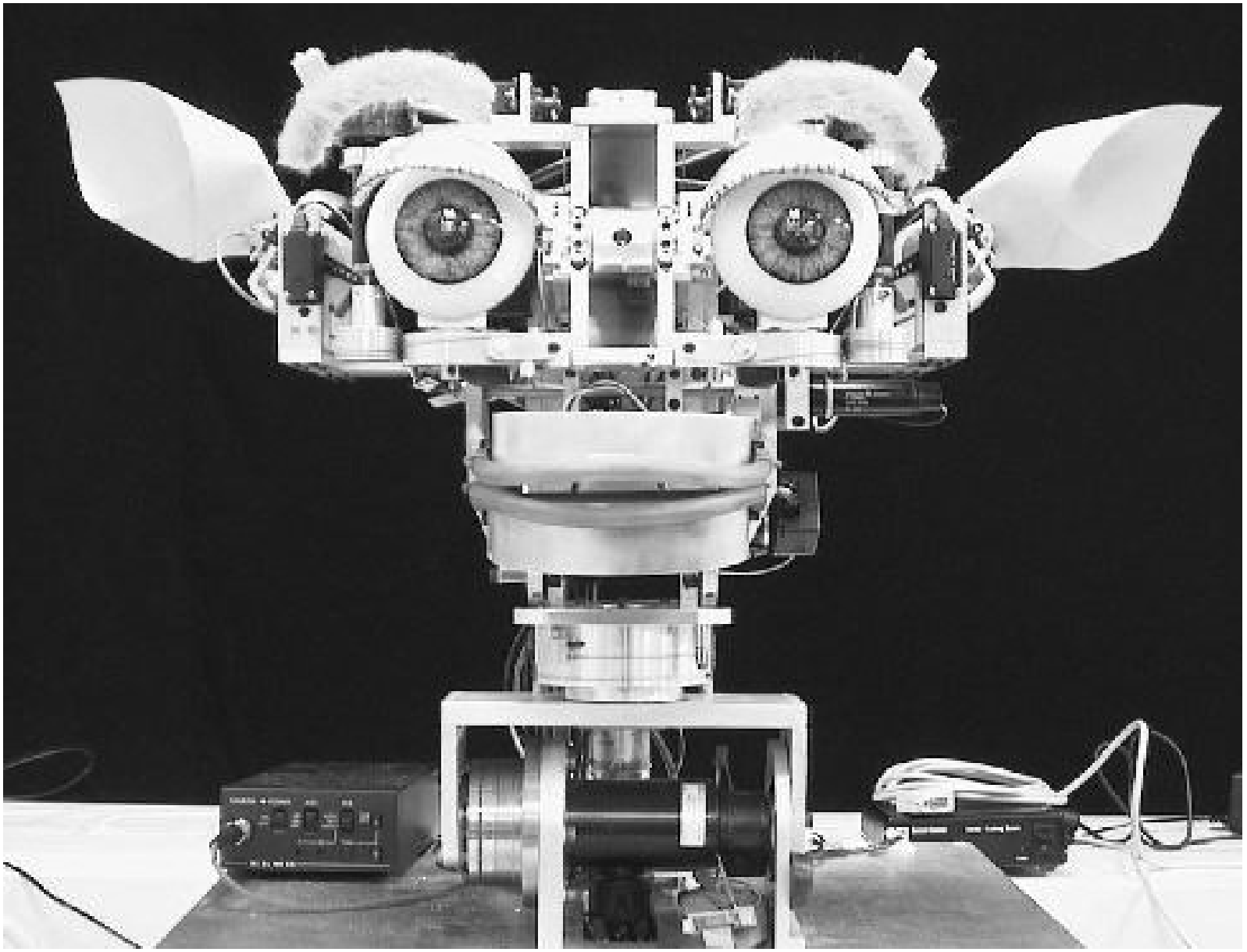
- Detects rhythmic patterns in sight, hearing …
- Deploys a binding algorithm to associate signals that display same periodicity
- Bindings → COG learn its own body parts by binding visual, auditory, proprioceptive signals (Fitzpatrick, Arsenio 04)

Cog group

- From *natural selection* to *child development*
- “Adult robots” from “baby robots”

Kismet:

- Social interaction robots-humans
- Eyebrows (each one with two degrees of freedom: lift and arc)
- Ears (2 degrees of freedom: lift and rotate)
- Eyelids + mouth (1 degree: open/close)
- Two micro-controllers (driving robot’s facial motors + “motivational system” (Ekbia 2008)



Kismet: emotive facial expressions indicative of anger, fatigue, fear, disgust, excitement, happiness, interest, sadness, surprise

- “Eye contact” with human being → Social interaction; Imitate the head-nodding
- Progressive development (imitation + joint attention)

- Decomposed them 4 stages:

(1) Eye contact

(2) Gaze-following

(3) Imperative pointing (trying to obtain an object that is out of reach by pointing at it

(4) Declarative pointing (drawing attention to a distant object by pointing at it) (Ekbia '08)

- Robot - learn using an “open-ended variety of internal, bodily, or external sources of order.” = “Natural-born cyborgs” → Body = “Key player on problem-solving”
- New trend in cognitive science: “*Loosing bonds between perception and action*”!
- *Hybrid model* = Relating sensori-motor information with cognition

- “Inner and outer elements (distributed problem-solving ensemble) must interact = Integrated cognitive whole” (Clark '08)

Wheeler: 2 Cartesian dogmas = Distinctions

(1) Mind-world

(2) Mind-body

- Rejects R + computation
- Primary function internal processes = For sensations + control action + basic sensoriomotor processes - not isolated higher processes = Heideggerian paradigm

(Husserl - phenomenology, Heidegger, Merleau-Ponty, Dreyfus, etc.)

Anti-representationalism - “2 treats to R against explanation of *online behaviour* needs “R”:

(1) If extra-factors are necessary to explain the behaviour of a system (“*non-trivial causal spread*”) → No R

(2) R view = “Homuncularity” - rejected: causal contribution of each component of a system is context-sensitivity and variable over time (“*continuous reciprocal causation*”)

- Ex-s: Brooks (1991) + Franceschini et al. ('92) with a robot with elementary motion detectors avoiding obstacles

- Clark and Wheeler: *Causal spread* ('99) = Internal elements depend upon certain causal factors external to system
- Ex: Computational neuroethology of robots (Dave Cliff, Cliff, Harvey and Husbads)
- Simulation of robot + room = Evolved to control robot moving in rooms

- Online-offline cognition blurred if we reject arbitrariness (different classes for same function) and homuncularity

Webb's cricket phonotaxis

- Male cricket's song has to be hear
- Identify, localize by female that has to locomote toward it
- Cricket anatomy + neurophysio. (ears + tracheal tube)
- "Vibration - greater at ear nearest to the sound source → Orientation and locomotion" (Clark)

- Cricket's tracheal tube transmits sounds of desired calling song frequency- phase shifts - Particular wavelength

Robot cricket

- No *general* mechanism for identifying direction sounds
- No *actively* discriminate song of its own species from other songs
- Other sounds - structurally no generating response

- No - general purpose capacities (pattern recognition + sound localization) to mate detection
- No model of its environment
- No apply logico-deductive inference --- no action plans
- No central sensory information store for integrating multimodel inputs
- No Rs - not necessary symbolic interpretation to explain how system functions

General ideas

- *A-life* = GA, CA, networks controller robots

- The pair *artificial life-biology* in parallel with *AI-psychology*

- Langton: S*ynthetic strategy* → "A-life" - synthetic approach for understanding evolution + operation living systems

→ Build simulated systems from components: what emerges

- A-Life contribute to theoretical biology by locating *life-as-we-know-it* within larger picture of *life-as-it-could-be* (Langton 1989 in Ekbea 2008)
- In contrast- biologists (+ psycho) → Analytic view = Decompozition + localization: starting with real organism - what components + functions + where - each process carried out (Bechtel 02)

- Relationship *life-mind* reflects *life-artificial*

→ Definition of Life = Obscure

Life – Properties:

- Autopoesis
- Autocatalysis elements
- Self-reproduction
- Genetics and metabolism
- Cluster concept – multiple features

Cellular Automata

http://mathworld.wolfram.com/CellularAutomaton.html