Cognition, Computing and Cybernetics

The emergence of sensory approaches

Von Uexküll and the Umwelt

- All creatures have different lived experiences formed by their sensory capacity - this is their umwelt or their life world or experience world
- Cognition between species is radically different
- Different species do not share umwelts
- For example, we can’t see the world as bees to or navigate by magnetic polls like birds

Objectivity and Experience World

- Various sensorimotor behaviors of creatures can be viewed as internally separate and latent until stimulated by the environment

- Integral selfhood is illusory

- Robotic architecture called subsumption by Rodney Brooks in the 80’s takes this approach vs a cognitivist approach to robotics. (The robot isn’t forming a mapping of the world and then trying to navigate but rather it’s sensing and responding to the environment)

Subsumption architecture

Subsumption **architecture** is a reactive **robotic architecture** heavily associated with behavior-based **robotics** which was very popular in the 1980s and 90s. The term was introduced by **Rodney Brooks** and colleagues in 1986.

Subsumption architecture is a control architecture that was proposed in opposition to traditi onal AI, or GOFAI. Instead of guiding behavior by symbolic mental representations of the wor ld, subsumption architecture couples sensory information to action selection in an intimate a nd bottom-up fashion.

Subsumption architecture attacks the problem of intelligence from a significantly different perspective than traditional AI. Disappointed with the performance of Shakey the robot and similar conscious mind representation-inspired projects, Rodney Brooks started creating robots based on a different notion of intelligence, resembling unconscious mind processes. Instead of modelling aspects of human intelligence via symbol manipulation, this approach is aimed at real-time interaction and viable responses to a dynamic lab or office environment.

Frog’s Eyes

- Frogs have eye cells which detect and process movement without using their brains
- These eyes contain processing in the body
- Higher level mental pattern recognition occurs in the eye itself
- Establishes sense organs are not dumb processors but have capacity to process information
- This paper unseats the Cartesian idea of “I think therefore I am” at a cellular level.
- Perception and what we we call thinking are distributed thought the bodily tissue

- J. Y. Lettvin, H. R. Maturana, W. S. McCulloch and W. H. Pitts, "What the Frog's Eye Tells the Frog's Brain," in *Proceedings of the IRE*, vol. 47, no. 11, pp. 1940-1951, Nov. 1959.

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How does this connect to computing?

- Ross Ashby, British Neurologist and cybernetician, cites this study as catalyst for his paper Design for a Brain
- It ushers in a way of seeing the world as process based and embedded in a living environment
- Maturana later establishes autopoietic biological theory. This approach to how the body and brain works goes on to help shape the entire field of user experience. It influences J.J. Gibson in his development of an ecological approach to vision
- From Gibson’s book, the entire field of user experience evolves
- All of this thinking is harkening back to Merleau Ponty, Edmund Husserl and Martin Heidegger.

- https://openlibrary.org/books/OL5791995M/Design_for_a_brain

Autopoiesis

- The term autopoiesis (from Greek αὐτο- (auto-), meaning 'self', and ποίησις (poiesis), meaning 'creation, production') refers to a system capable of reproducing and maintaining itself. The original definition can be found in Autopoiesis and Cognition: the Realization of the Living (1st edition 1973, 2nd 1980 Maturana and Varla)

- This term shows up again in cybernetics

- Cognition is a biological phenomenon and can only be understood as such

- Autopoietic theory constructs a framework that's diametrically different from the cognitivist / computational conceptions

- Autopoietic biology sees the organism as a closed system, perturbed by outside influences

- Key ideas: Operational closure "It is the circularity of its organization that makes a living system a unit of interactions"

- structural coupling, the autopoietic notion of cognition, and the question of the observer

Autopoiesis vs. Cognivist

- Cognivist view: cognition is the correct identification of things objectively in the world.
- Autopoietic biology: “For every living system the process of cognition consists in the creation of a field of behavior through its actual conduct in its closed domain of interactions, and not in the apprehension or the description of an independent universe. Our cognitive process (the cognitive process of the observer) differs from the cognitive process of other organisms only in the kind of interactions into which we can enter and not in the nature of the cognitive process itself.”

Autopoiesis

- Self-Organization and the holism of the organism.
- Autopoiesis means self-making and is essentially a systems-theoretic description of the phenomenon of life as defined by a network of processes that regenerate themselves.
- In autopoiesis, as in cybernetics, self organizing systems are understood to be fundamentally conservative in the sense that they push toward prior equilibrium (i.e., ho meostasis), correcting for perturbations and attempting to return to equili brium.

homeostasis and homeorhesis

- Homeorhesis, loosely put, is homeostasis with teleology (the explanation of phenomena in terms of the purpose they serve rather than of the cause by which they arise)
  where teleology is used in cybernetic terms.

- homeostasis
  described the way an organism maintained its coherence while adapting to its environment, a concept similar to autopoiesis. |

  https://www.youtube.com/watch?v=Iz0Q9nTZCw4

Structural Coupling and Feedback

- In autopoietic biology, interaction with the environment is seen in termsof structural coupling, a concept closely rela ted to what cyberneticians called feedback loops and to s ensorimotor loops in contemporary cognitive science.

- Living systems have inputs and outputs.

Reality and the Observer

- No description of absolute reality is possible
- Objectivity is a subject's delusion that the observing is done without her/them/him
- The environment as we perceive it is our own invention

An Ecological Theory of Vision

- JJ Gibson’s theory of vision
- The organism responds to sensations on its retina, not to "objects in the world.
- Gibson's attention to the temporality of vision led to the notion that awareness of the speed and direction of movement is given by immediate experience of the ambient optic array. He proposed that animals guide their movement toward some goal by optic flow.
- Gibson's notion of perception systems is a dynamical and embodied conception that e mphasizes the role of the Individual's self-directed movements in revealing environmental structure. This makes vision in Gibson terms em bodied and proprioceptively integrated.

An Ecological Theory of Vision

- Gibson coins the fundamental idea of affordance. This term and concept is the bedrock of user centered design

- The world is not bits of information. It is a relationship between the world and the perceiver.

- Affordance is a relational concept.

- For Gibson, affordances are not mental constructions
  they exist objectively as optical (or other sensory) Information about the environment. An object might afford eating or sitting on for one individual or species, but not for another.

- Affordances are umwelt-specific.

Ready to Hand vs Present to Hand

- Heidegger’s understanding of embodied experience in the world
- For example a tool is ready to hand when you just use it. For example, think of your glasses. How often are you aware you are using them?
- Present to hand is when the tool itself sticks out and draws your attention to it. For example, the weight of your glasses makes you aware you’ve warn them all day.
- it is well known that consciously thinking about what you are doing will ruin it. In fact, in most of the embodied activities we perform (eg, driving or typing), the conscious mind only intervenes when some thing goes wrong.
- As Hubert Dreyfus has elucidated (following Heidegger and Merleau Ponty), the process of learning skills, even mental skills like chess, is a process of transition from laborious rule-following to the development of "muscular gestalts" (Dreyfus 1996).
- Achieving such muscular gestalts constitutes expertise and facilitates the sensation of " flow" celebrated by Csikszentmihalyi.

Flow

- https://www.ted.com/talks/mihaly_csikszentmihalyi_on_flow?language=en
- This idea becomes embedded in game design and also user experience design

Paul Bach-y-Rita

- TVSS - seeing with the tongue
- Early researcher in sensory subsection and neuroplasticity
- Our sensory experiences can be substituted for each other with training and our brains are plastic enough to allow for this

Morphological Computing

- The physical structure of a fly's eye or a bat’s
  has been shown to perform computational work. The materiality of the
  physical structure does real data processing long before a neuron gets a look in.

- Such realities, found all over the biological world,
  undermine conventional Cartesian/cognitivist assertions that thinking (as
  in reasoning on symbols) occurs exclusively bio-electrically in gray matter
  in the skull while the rest of the body is a mere meat marionette.

- The biomemetic and reactive turn in robotics in the late 1980s showed that embr
  acing more holistic and situated models provided an alternative to the cognitivist
  paradigm that plagued robotics and AI

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What was Cybernetics

- A radically interdisciplinary movement that emerged after WW2
- In the US, it arose out of military research, in the UK out of neuroscience
- A science of systems with research into system, feedback and homeostatic and other key ideas
- Abstraction notions of systems, organization and control