Does Robotics Really Need Embodiment?

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ShanghAI – Guest Lecture

- Has embodiment not won? – *No, not really!*
- Cognitivism has found ways to retreat and regroup at positions that have better fortification; compatible with embodiment, or just supplemented by embodiment (e.g. for 'grounding')
- AI without embodiment is still an option
- Technical AI and technical robotics do not share the grand old vision

"We won the war and now you are ahead"

Cognitivism:

Syntactic processing over symbolic representation is sufficient for intelligence, perhaps even necessary: (Newell and Simon 1976), its reproduction in computing machines will thus result in intelligence.

"Artificial intelligence is not the study of computers, but of intelligence in thought and action. Computers are its tools, because its theories are expressed as computer programs that enable machines to do things that would require intelligence if done by people." (Boden 1977: xi)

Cognitivism: AI & CogSci

- No *intentional* states (e.g. "I mean") through computation - 'Chinese room', 'encodingism', etc.
- 'Frame problem' – no decisions without too many representations (etc.)
- *Anti-representationalism*, sub-symbolic cognition: digital items like 'concepts', 'words' or 'phonemes' play little or no cognitive role
- Human cognition presupposes a human condition - Dreyfus
- Enaction, 'deep embodiment' - goal-dependent cognition (no cognition without a life)
- Cognition is largely the function of a body (Varela)

"Cognition is not Computation"

Mistake 1: [Throw baby out with bathwater]
"Cognitivism is false, *therefore* cognition is not computation and AI [via computers] won't work"

- **Two notions of computing:**
  - a) computing over representations (classical AI, 'cognitivism')
  - b) computing over meaningless syntactic tokens

Mistake 2: [Optimistic extrapolation]
"I am not making Mistake 1, *therefore* cognition might still be computation and AI [via computers] will work"

Two mistakes

- "cognition is inherently embodied insofar as its fundamental role is to modulate an animal's sensorimotor interaction with its environment" (Shanahan 2011)

- "By using the term *embodied* we mean to highlight two points: first, that cognition depends upon the kinds of *experience that come from having a body* with various sensorimotor capacities, and second, that these individual *sensorimotor capacities are themselves embedded* in a more encompassing biological, psychological, and cultural context.

- … sensory and motor processes, perception and action, are fundamentally inseparable in lived cognition." (Varela et al. 1991: 172f)

Classical Embodiment

- "Cartesian" centralized control is inefficient
- Simple local control exploiting body dynamics and interaction with environment
- "The Emergence of Cognition from the Interaction of Brain, Body, and Environment"
- "Cheap design"

1 million neurons, of which 200 descending to spinal cord (= walking not centrally controlled) [Roy E. Ritzmann]

Exhibit 1: Embodiment as offloading (Pfeifer)

- Seeing is a kind of *action* (and this explains 'how it feels') (O'Regan 2011)
- Perception as action requires a body (not just passive sensors)

Exhibit 2: Embodiment as enaction (O'Regan)

- Recognition tasks: Priming with certain pictures make button-pressing with the right hand faster. Why?
- Priming with 'elderly' words (or slow animals) make people walk a bit more slowly
- …

Exhibit 3: Embodiment shapes cognition (Cangelosi)

- "How can the meanings of the meaningless symbol tokens, manipulated solely on the basis of their (arbitrary) shapes, be grounded in anything but other meaningless symbols?"

  (Harnad 1990, 335) – based on (Searle 1980)

- Interacting playing robots generate symbols for objects in their environment. Solved! (Steels 2008)

Exhibit 4: Embodiment as grounding (Steels)

- Hardware matters for robot performance (more than we thought)
- Sensation is largely a kind of action (and thus needs a body)
- Large parts of the Brain deal with sensorimotor issues
- Representations need grounding
- Agents with different lives will not have human intelligence
- Handicapped humans can't think [???]
- Computers without bodies won't be intelligent

What was the argument, again?

- *Empirical thesis* (about natural cognitive agents, esp. humans). Cognitive, affective and bodily aspects are intertwined and inseparable.
- *Practical engineering thesis* (on how to best make artificial agents with certain abilities), "cheap design"
- *Conceptual thesis* (about the necessity of a body for cognition, or a particular body for particular forms of cognition)

Three Embodiment theses

- Computing
  - digital (discrete, token of a type)
  - algorithmic (precisely described step-by-step)
  - … i.e. syntactical
    - Multiply realizable
    - Non-cognitivist, non-embodied

Regrouping I:
Syntactic Computing

- Computational sufficiency thesis (CST): "… the right kind of computational structure suffices for the possession of a mind, and for the possession of a wide variety of mental properties."
  (Chalmers 1994, 2012; Shagrir 2012a, 2012b)
- Church-Turing Principle: "… everything that the laws of physics require a physical object to do can, in principle, be emulated in arbitrarily fine detail by some program on a general-purpose computer, provided it is given enough time and memory." (Deutsch 2012)
- ➔ simulate the brain
- (syntactic reproduction might just be sufficient)

Regrouping I contd.

The hard problem of symbol grounding

 "How does physics give rise to meaning [and other intentional phenomena]?"

The easy problem of symbol grounding

 "How can we explain and re-produce the behavioral ability and function of meaning [and other intentional phenomena] in artificial computational agents?"

 This is not a problem of principles. Get the best cognitive science and go for it!

Regrouping II: Grounding

Mistake 1: [Throw baby out with bathwater]

"Cognitivism is false, therefore cognition is not computation and AI [via computers] won't work"

Mistake 2: [Optimistic extrapolation]

"I am not making Mistake 1, therefore cognition might still be computation and AI [via computers] will work"

Reminder: Two mistakes

1. The *empirical thesis* is true (in degrees)
2. The *practical engineering* thesis is true (often)
3. The *conceptual thesis* is false (most likely, since syntax is often enough)

- The three theses are logically independent (i.e. a thesis on the one does not imply a thesis on the other)
  - AI and CogSci are not two sides of the same coin
  - Full scale AI may or may not require embodiment

Conclusion

Thank You!