

# The BioRobotics Institute

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## Embodied Intelligence in Natural and Artificial Agents

Robotics is coming of age

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RoboCom++ Embodied Intelligence in Natural and Artificial Agents WG Leader<sup>1</sup>

SPARC TG Benchmarking and Competitions<sup>2</sup>

IEEE RAS TC-PEBRAS<sup>3</sup>

Member SPARC Board of Directors<sup>4</sup>

The BioRobotics Institute, SSSA<sup>5</sup>  
and Heron Robots<sup>6</sup>

# The second wave: the success stories

DARPA (American Defense Advanced Research Projects Agency) challenges have demonstrated how current robots are becoming **more accurate, fast and dexterous in structured and unstructured environments.**

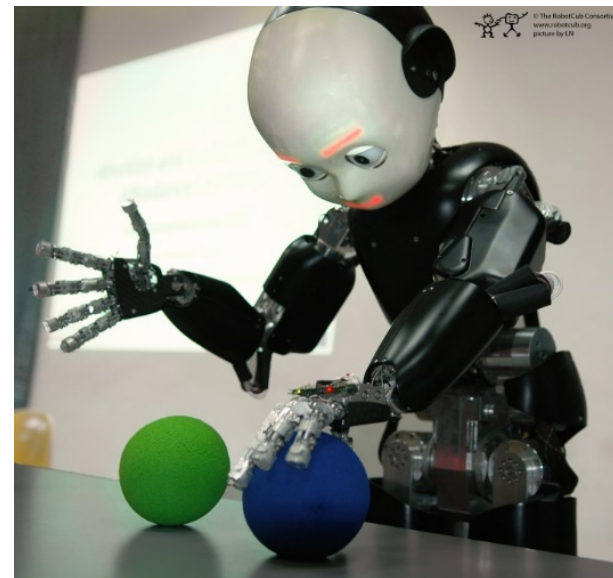
**According to H.Yanco a minimum of 9 people were needed to teleoperate latest DRC's robots!!! And...**



## Pursuing new frontiers: The robotics bottleneck

Today, more functionality means:

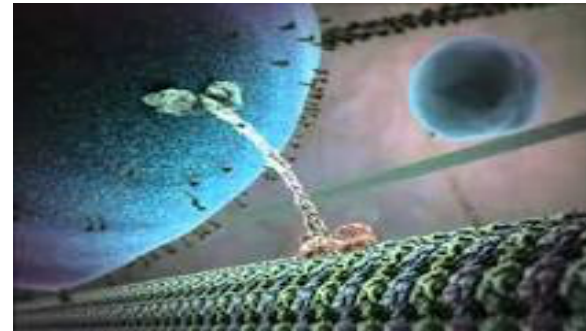
- **more** complexity, energy, computation, cost
- **less** controllability, efficiency, robustness, safety



# Is It Alive?

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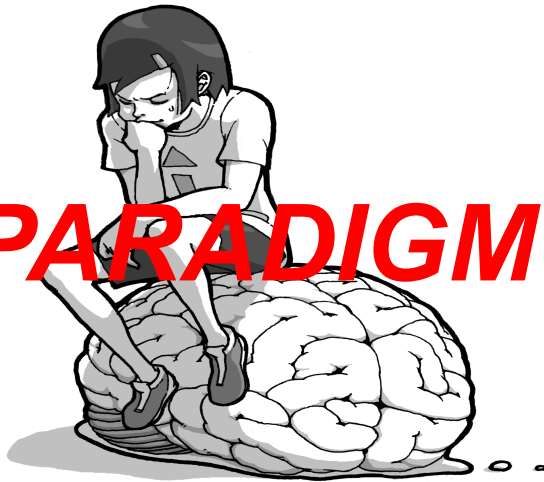
**Big Questions lie in front of us!**



# Embodied Intelligence or Morphological Computation: the modern view of Artificial Intelligence

## Classical approach

The focus is on the brain and central processing



## Modern approach

The focus is on interaction with the environment. Cognition is emergent from system-environment interaction



# PARADIGM CLASHES

# Definitions of intelligence

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“... there seem to be almost as many definitions of intelligence as there were experts asked to define it.” R.J. Sternberg

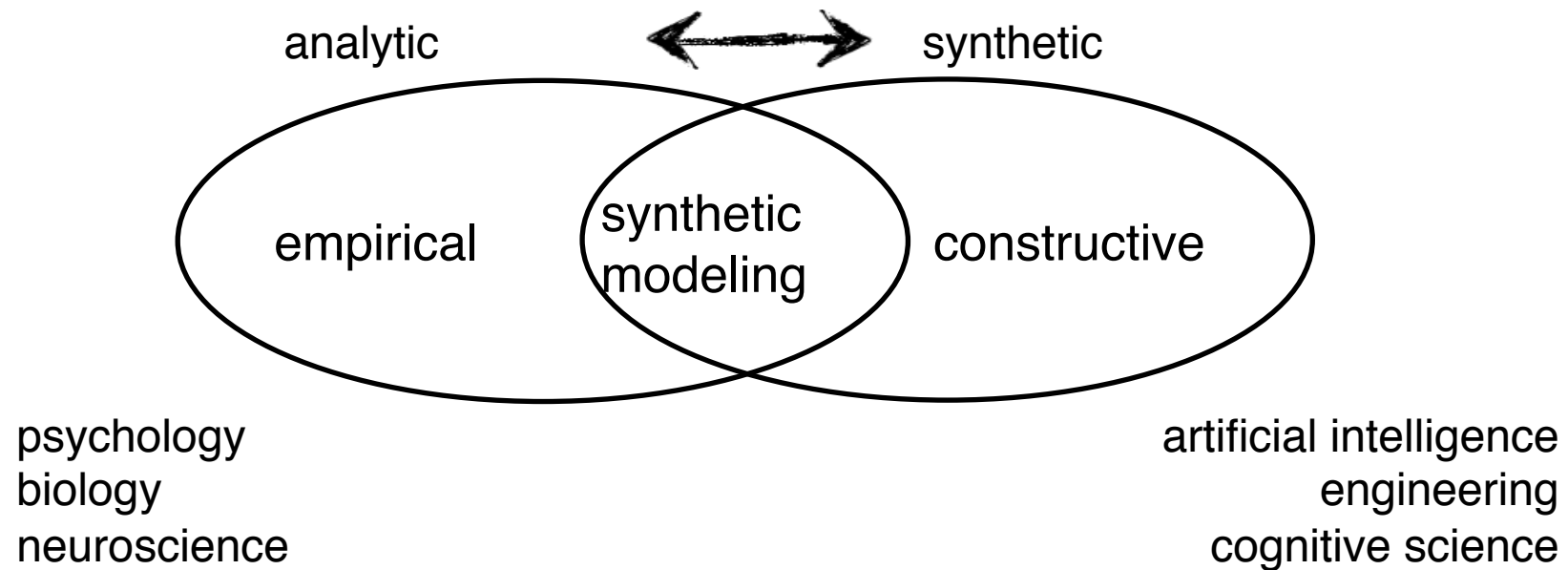
(Robert J. Sternberg, distinguished psychologist; famous book “Beyond IQ: A triarchic theory of human intelligence”, 1985)



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# How to study intelligence?



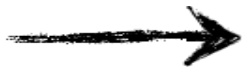
# The synthetic methodology

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Slogan:

“Understanding by building”

modeling behavior of interest  
abstraction of principles



robots as tools for scientific investigation

**abstractions, NOT copies of nature**



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# The need for an embodied perspective

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- “failures” of classical AI
- fundamental problems of classical approach
- Wolpert’s quote: Why do plants not ...?
- Interaction with environment: always mediated by body



# Life vs Cognition

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# Properties of embodied agents

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- subject to the laws of physics
- generation of sensory stimulation through interaction with real world
- affect environment through behavior
- complex dynamical systems
- perform morphological computation



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# Parallel, loosely coupled processes

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Intelligent behavior:

- emergent from system-environment interaction
- based on large number of parallel, loosely coupled processes
- asynchronous
- coupled through agent's sensory-motor system and environment

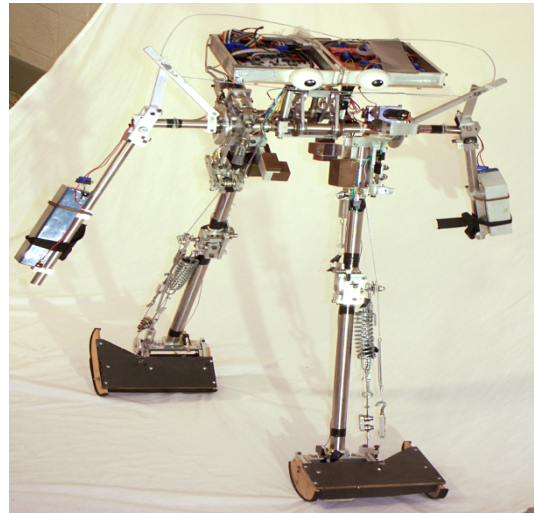


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# Embodiment examples

Conceptually different  
humanoid designs (mainly research)



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# Embodiment

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Does it mean ‘intelligence requires a body’???

The ‘ intelligent’ behavior results from the *interaction* of brain (biological neural processing), morphology, dynamics, materials, environment



# How to quantify?

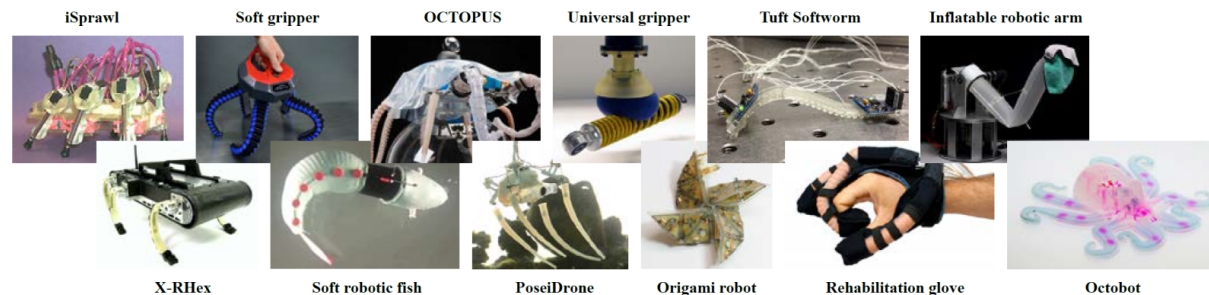
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# The marvellous progress of Robotics and AI...'Look Ma, No Hands' syndrome?

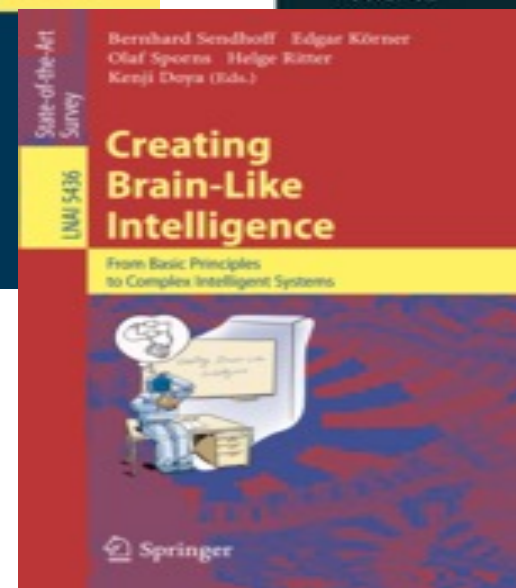
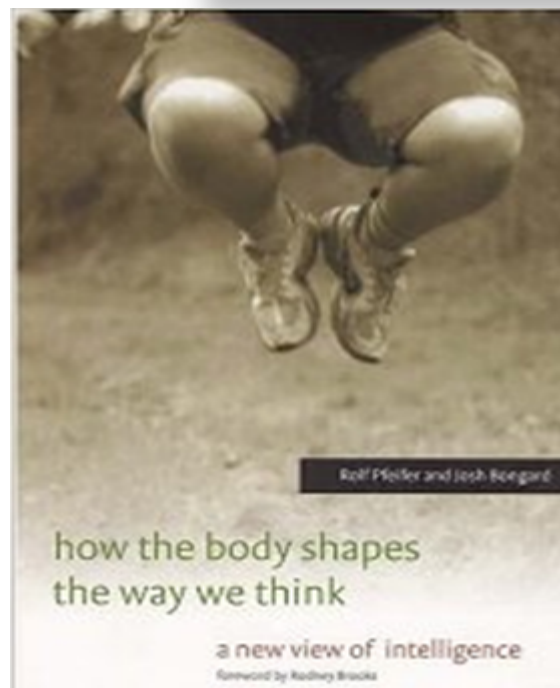


Mostly stiff  
Few selectively compliant elements

Entirely soft







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**Thank you for your  
attention**

