
人工智能
上海
The
ShanghAI
Lectures
授课

The ShanghAI Lectures

An experiment in global teaching

Fabio Bonsignorio
The BioRobotics Institute, SSSA and Heron Robots

Today from the BioRobotics Institute, Pontedera (PI)

欢迎您参与
“来自上海的人工智能系列讲座”

Lecture 4

Intelligent Systems: Properties and Principles (continued)

Evolution: Cognition from Scratch

17 November 2016

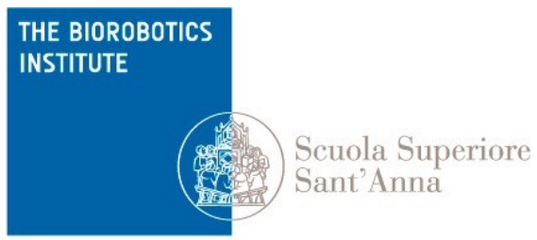
skype: PhD.Biorobotics

(only for lecture sites connected by streaming or …emergencies :-))

ISTITUTO DI BIOROBOTICA
Scuola Superiore Sant'Anna

The need for an embodied perspective

- “failures” of classical AI
- fundamental problems of classical approach
- Wolpert’s quote: Why do plants not have a brain? (but check Barbara Mazzolai’s lecture at the ShanghAI Lectures 2014)
- Interaction with environment: always mediated by body



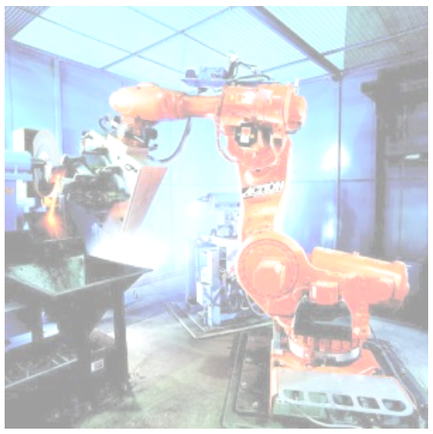
“English Room” thought experiment

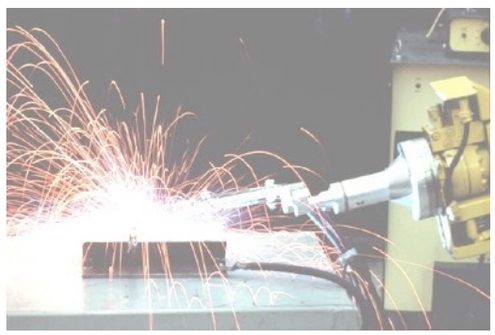
- “this is Spanish for me” (in Austria to say a speech is impossible to understand) - (funny for me, for an Italian Spanish is quite easy :-))

Successes and failures of the classical approach

successes	failures
applications (e.g. Google)	**foundations of behavior**
chess	**natural forms of intelligence**
manufacturing	**interaction with real world**
(“controlled”artificial worlds)	

Industrial robots vs. natural systems





robots

principles:
- **low precision**
- **compliant**
- **reactive**
- **coping with uncertainty**

humans

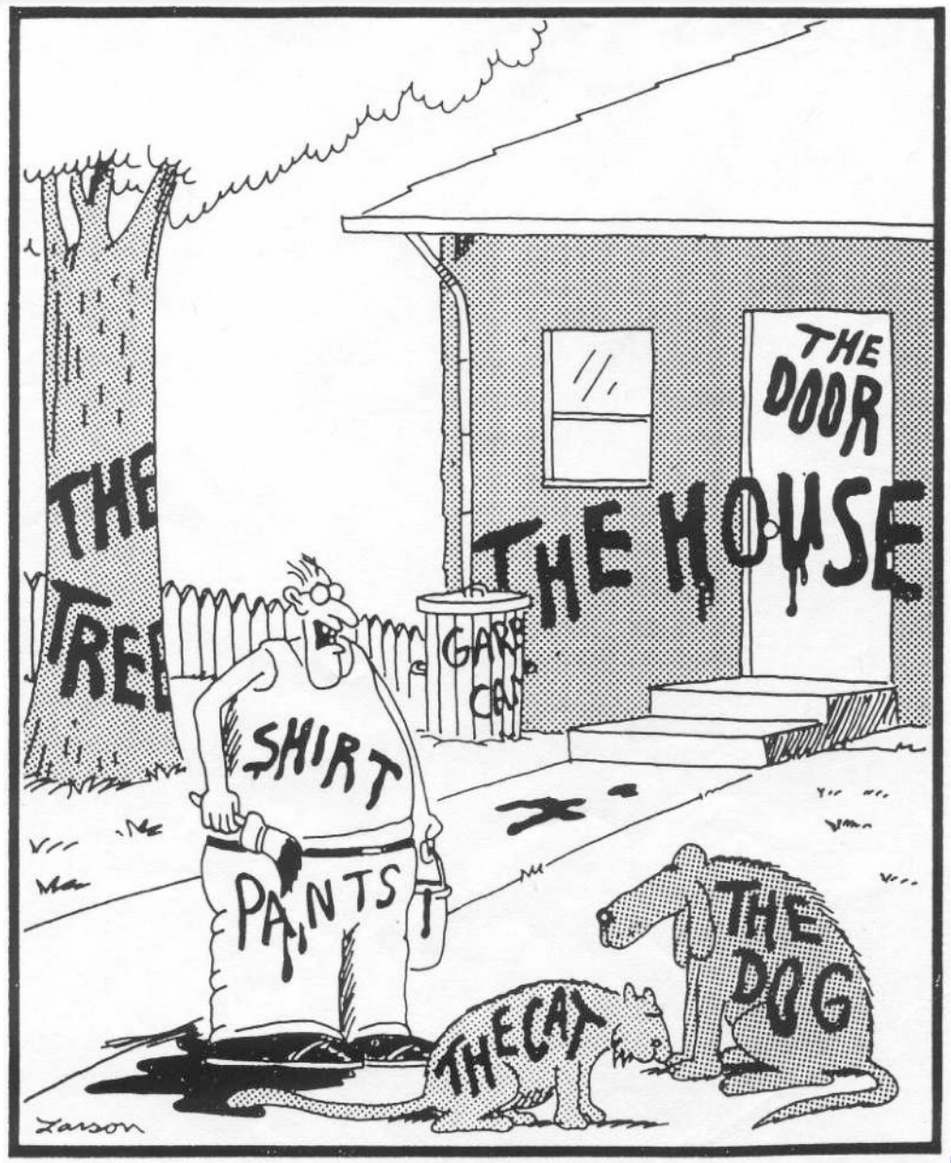
→ **no direct transfer of methods**

The “symbol grounding” problem

real world: doesn’t come with labels …

How to put the labels??

Gary Larson



“Now! ... *That* should clear up a few things around here!”

Two views of intelligence

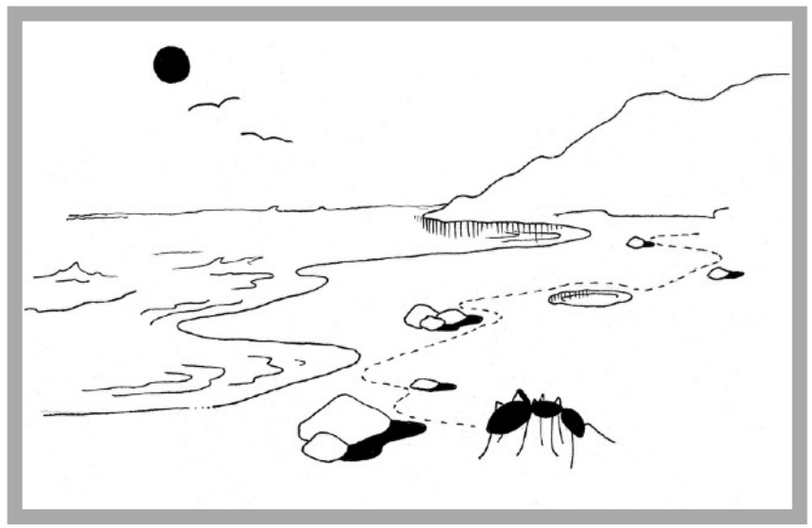
classical:
cognition as computation

embodiment:
cognition emergent from sensory-motor and interaction processes

The need for an embodied perspective

- **“failures” of classical AI**
- **fundamental problems of classical approach**
- **Wolpert’s quote: Why do plants not …? (stay tuned for Barbara Mazzolai’s lecture…)**
- **Interaction with environment: always mediated by body**

“Frame-of-reference” Simon’s ant on the beach

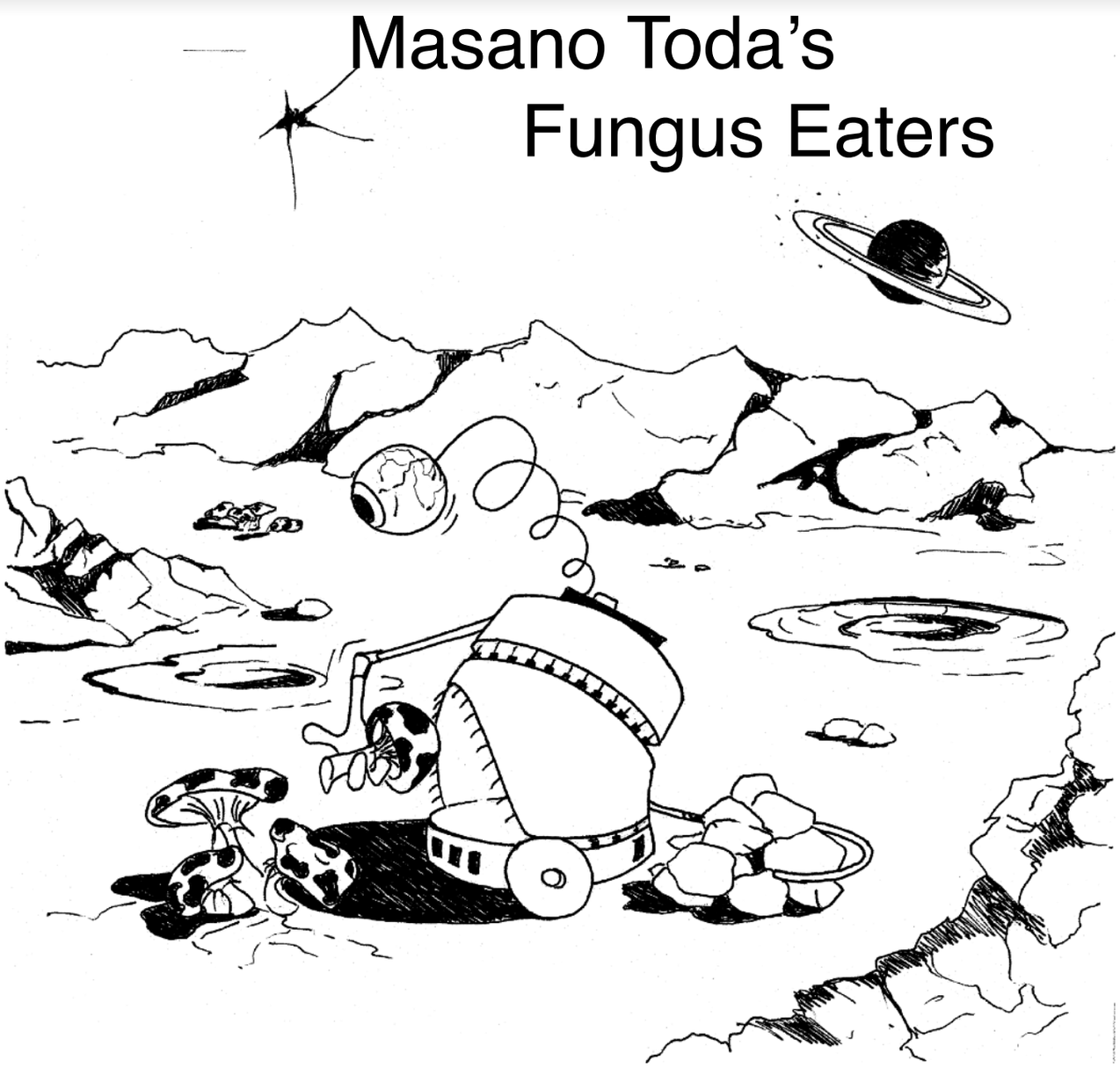


- **simple behavioral rules**
- **complexity in interaction, not — necessarily — in brain**
- thought experiment: **increase body by factor of 1000**

Today's topics

- short recap
- **characteristics of complete agents**
- illustration of design principles
- parallel, loosely coupled processes: the "subsumption architecture"
- case studies: "Puppy", biped walking
- "cheap design" and redundancy

Complete agents



Properties of embodied agents

- 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

Complex dynamical systems

non-linear system - in contrast to a linear one

—> Any idea?

Complex dynamical systems

concepts: focus box 4.1, p. 93, “How the body …”

- dynamical systems, complex systems, non-linear dynamics, chaos theory
- phase space
- non-linear system — limited predictability, sensitivity to initial conditions
- trajectory

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Design principles for intelligent systems

Principle 1: Three-constituents principle

Principle 2: Complete-agent principle

Principle 3: Parallel, loosely coupled processes

Principle 4: Sensory-motor coordination/ information self-structuring

Principle 5: Cheap design

Principle 6: Redundancy

Principle 7: Ecological balance

Principle 8: Value

Three-constituents principle

define and design

- **“ecological niche”**
- **desired behaviors and tasks**
- **design of agent itself**

design stances

scaffolding

Complete-agent principle

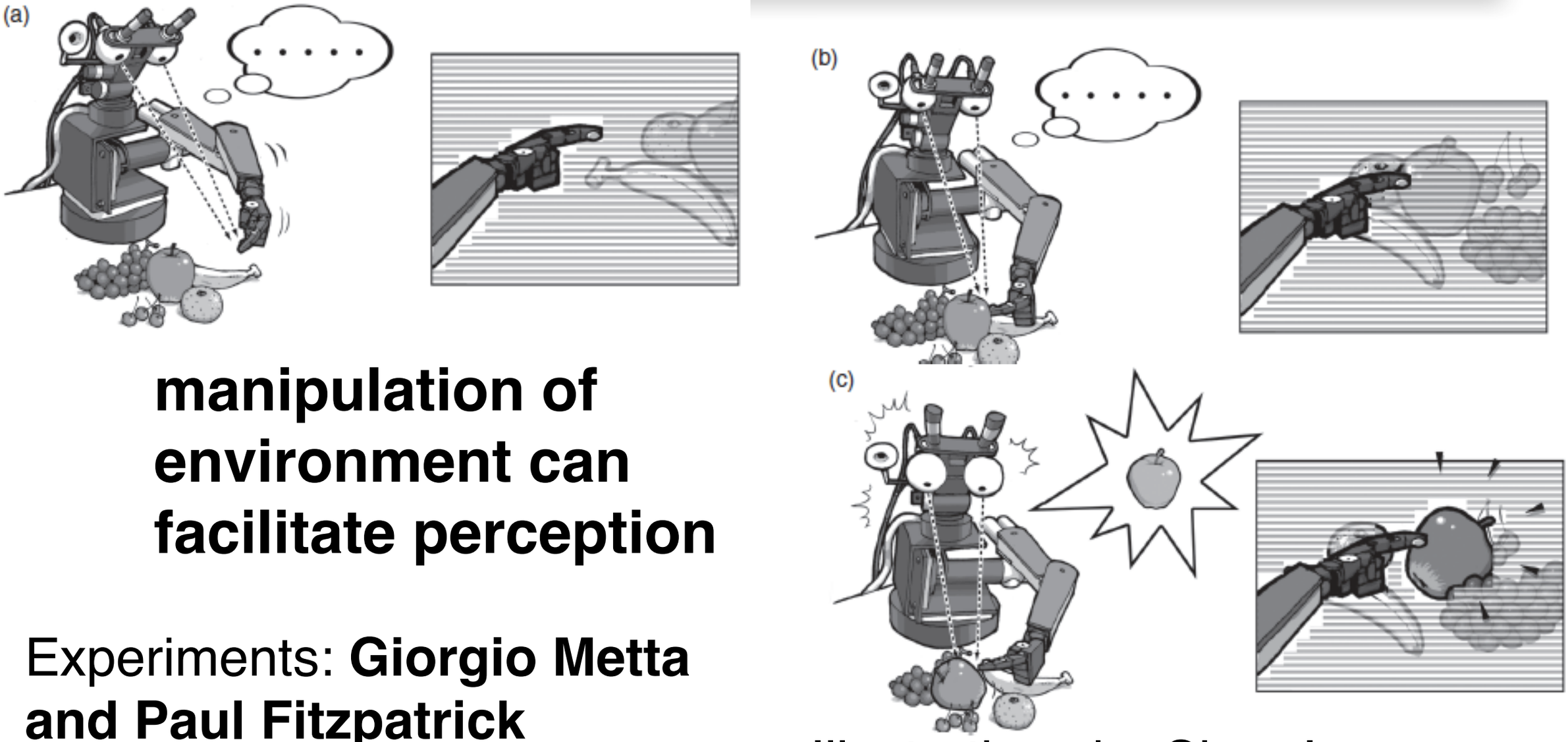
- always think about complete agent behaving in real world
- isolated solutions: often artifacts — e.g., computer vision (contrast with active vision)
- biology/bio-inspired systems: every action has potentially effect on entire system

can be exploited!

Recognizing an object in a cluttered environment

manipulation of environment can facilitate perception

Experiments: **Giorgio Metta and Paul Fitzpatrick**



Illustrations by Shun Iwasawa

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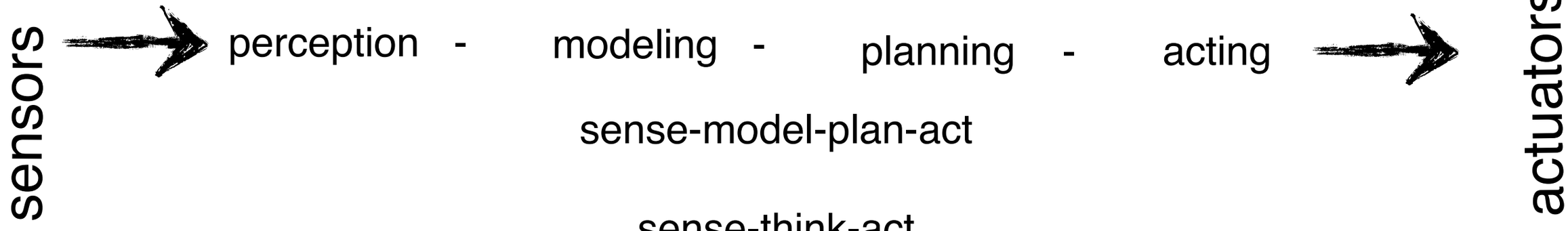
Parallel, loosely coupled processes

intelligent behavior:

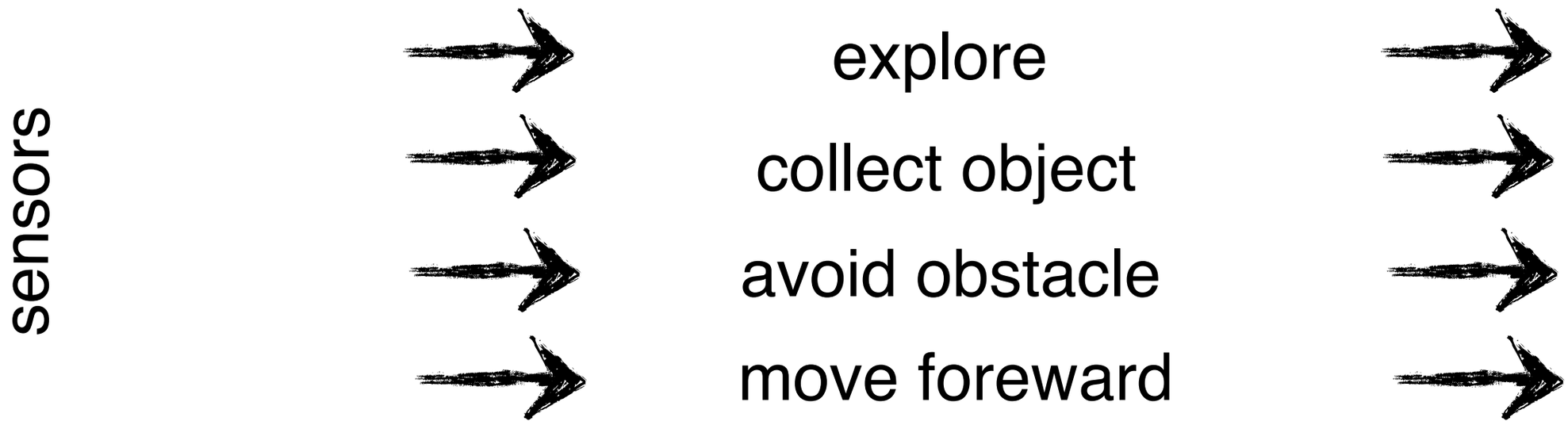
- **emergent from system-environment interaction**
- **based on large number of parallel, loosely coupled processes**
- **asynchronous**
- **coupled through agent's sensory-motor system and environment**

The subsumption architecture

classical, cognitivistic



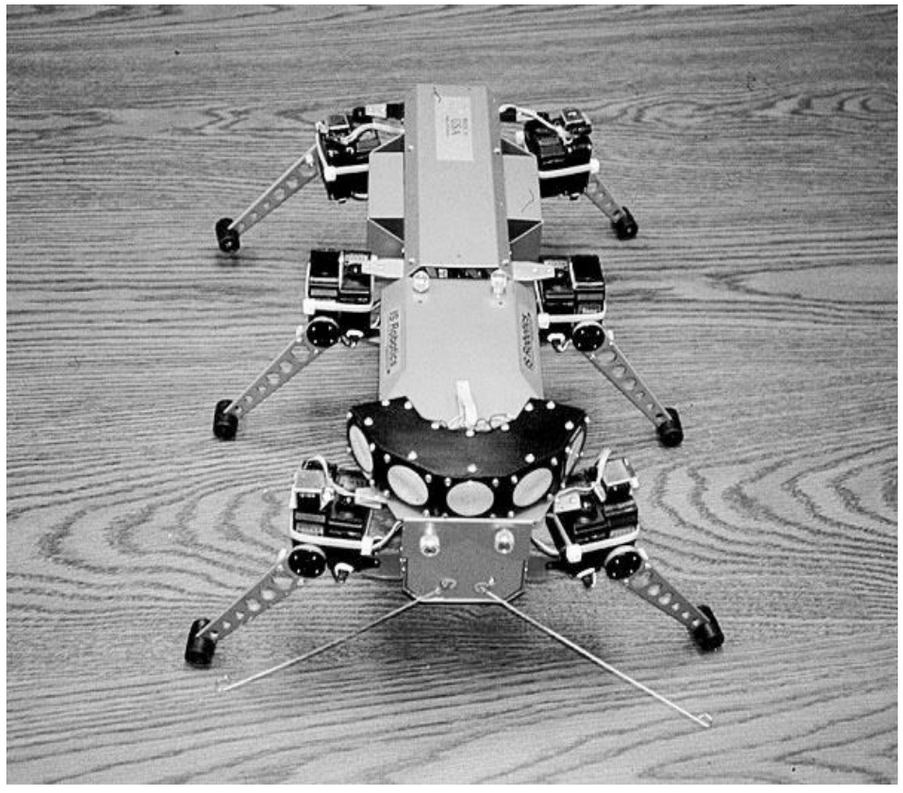
“behavior-based”, subsumption



Mimicking insect walking

- **subsumption architecture well-suited**

six-legged robot “Ghenghis”

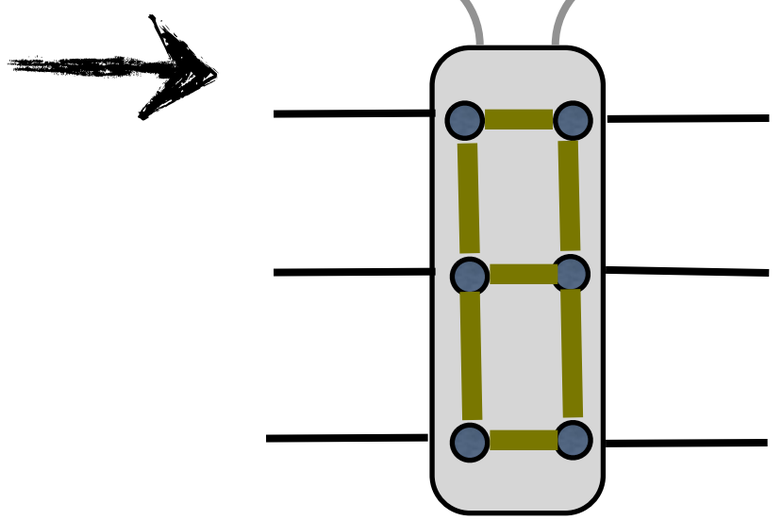


Insect walking

Holk Cruse, German biologist

- **no central control for leg coordination**
- **only communication between neighboring legs**
- **global communication: through interaction with environment**

neural connections



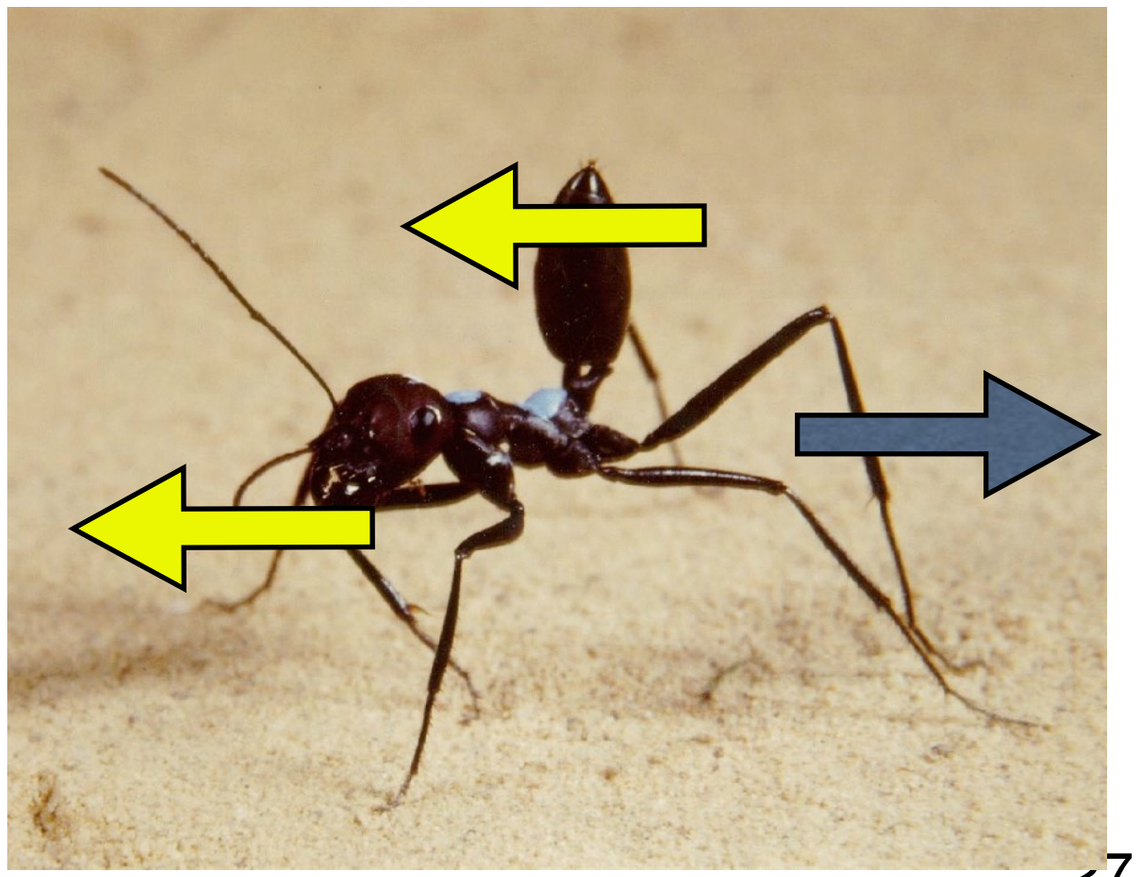
Communication through interaction with

- **exploitation of interaction with environment**

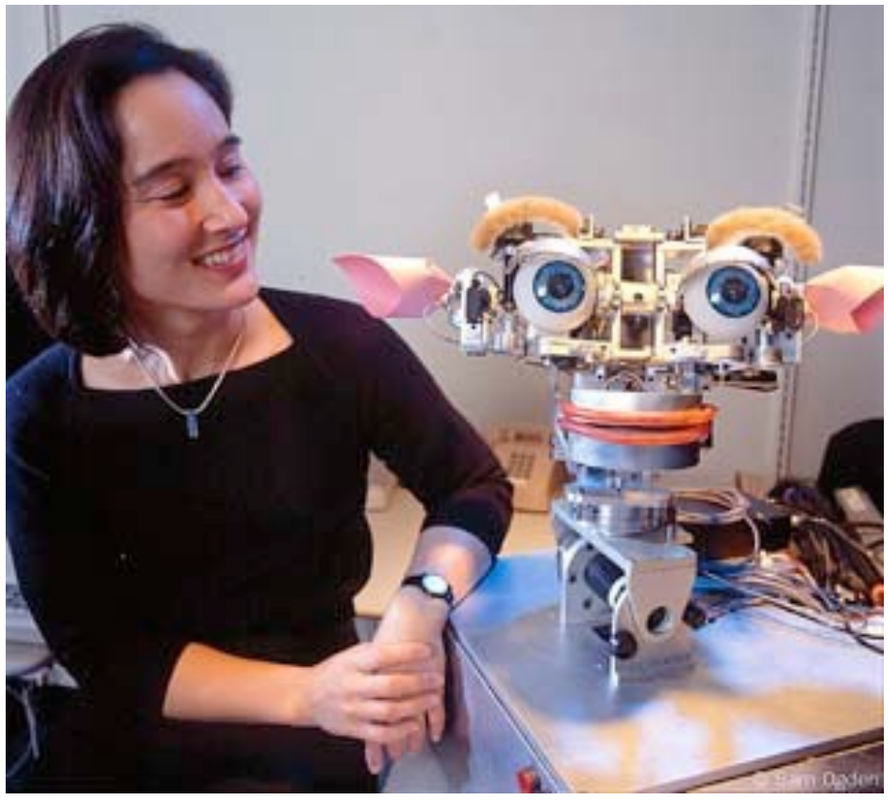
→ **simpler neural circuits**

angle sensors in joints

"parallel, loosely coupled processes"



Kismet: The social interaction robot



Cynthia Breazeal, MIT Media Lab
(prev. MIT AI Lab)

Kismet: The social interaction robot

Video “Kismet”

Cynthia Breazeal, MIT Media Lab
(prev. MIT AI Lab)

Kismet: The social interaction robot

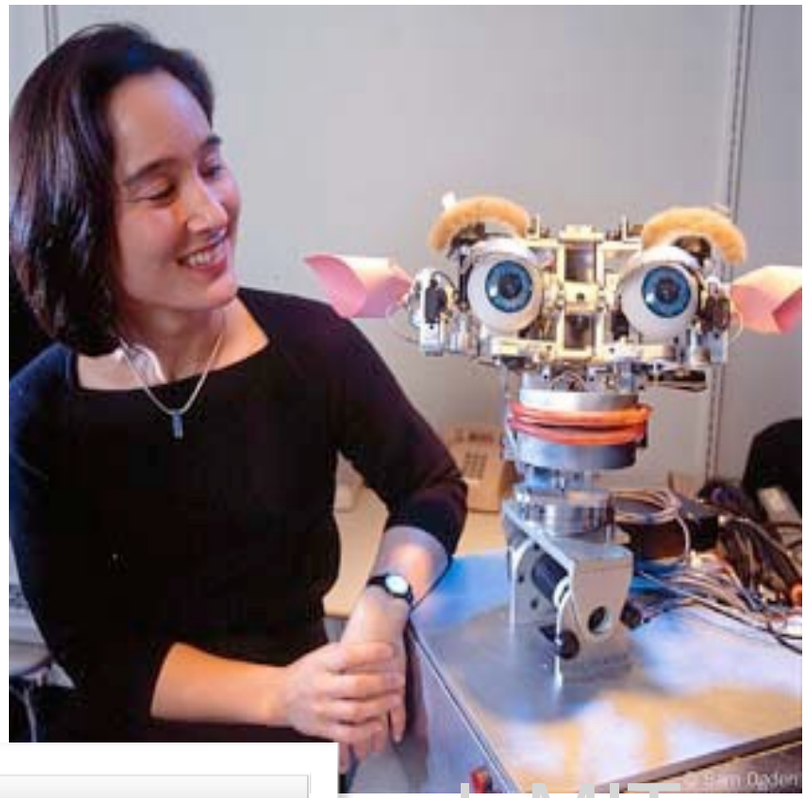
Reflexes:

- turn towards loud noise

- turn towards moving objects

- follow slowly moving objects

- habituation



principle of “parallel, loosely coupled processes”

eal, MIT

lab (prev. MIT AI Lab)

Kismet: The social interaction robot

Reflexes:

- turn towards loud noise

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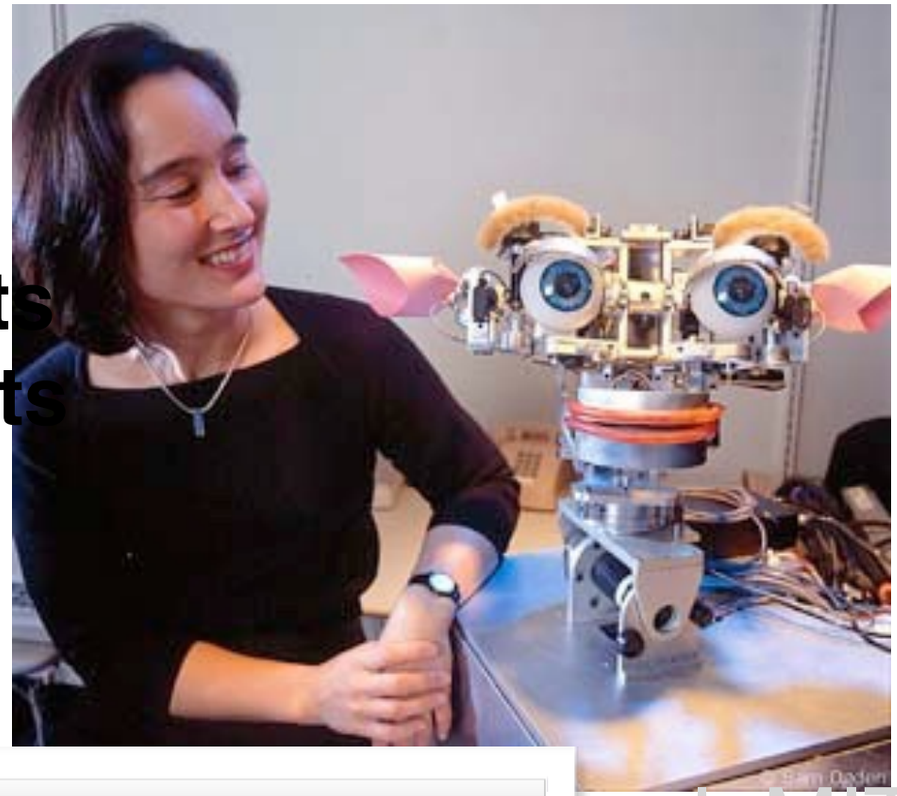

social competence: a collection of reflexes ?!?!???

zeal, MIT

lab (prev. MIT AI Lab)

Scaling issue: the “Brooks-Kirsh” debate

insect level —> human level?

David Kirsh (1991): “Today the earwig, tomorrow man?”

Rodney Brooks (1997): “From earwigs to humans.”

Scaling issue: the “Brooks-Kirsh” debate

insect level —> human level?

David Kirsh (1991): “Today the earwig, tomorrow man?”

Rodney Brooks: “Fast, cheap and out of control” to humans

volunteer for brief presentation on the “Brooks-Kirsh” debate - or generally, scalability of subsumption (on a later date)

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- **case studies: "Puppy", biped walking**
- "cheap design" and redundancy

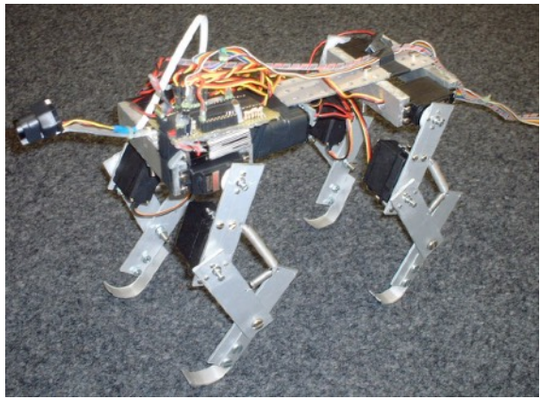
Case study: “Puppy” as a complex dynamical

- **running: hard problem**
- **time scales: neural system — damped oscillation of knee-joint**
- **“outsourcing/offloading” of functionality to morphological/material properties**

morphological computation

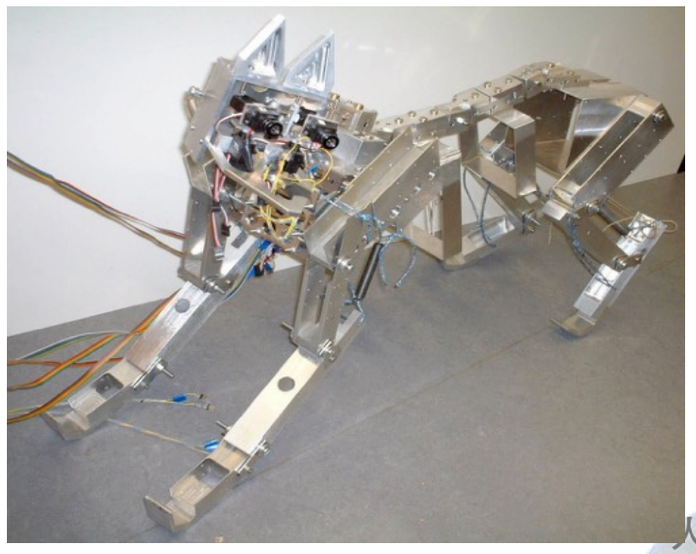
Recall: “Puppy’s” simple control

rapid locomotion in biological systems



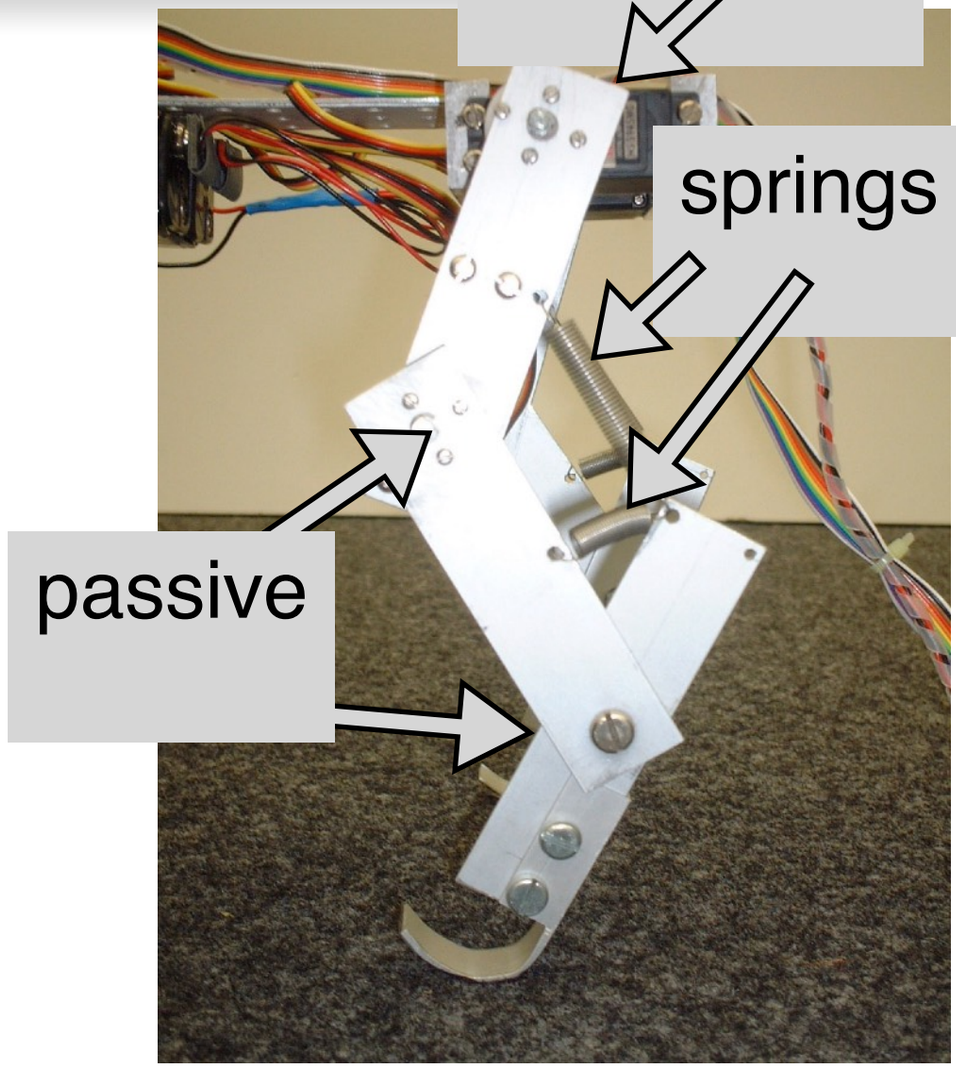
recall: emergence of behavior

Design and construction:
Fumiya Iida, AI Lab, UZH and ETH-Z



Emergence of behavior: the quadruped “Puppy”

- **simple control (oscillations of “hip” joints)**
- **spring-like material properties (“under-actuated” system)**
- **self-stabilization, no sensors**
- **“outsourcing” of functionality**



→ morphological computation

Self-stabilization: “Puppy” on a treadmill

Video “Puppy” on treadmill

Self-stabilization: “Puppy” on a treadmill

Video “Puppy” on treadmill slow motion

- **no sensors**
- **no control**

self-stabilization

Self-stabilization: “Puppy” on a treadmill

Video “Puppy” on treadmill slow motion

- **no sensors**
- **no control**

→ self-stabilization

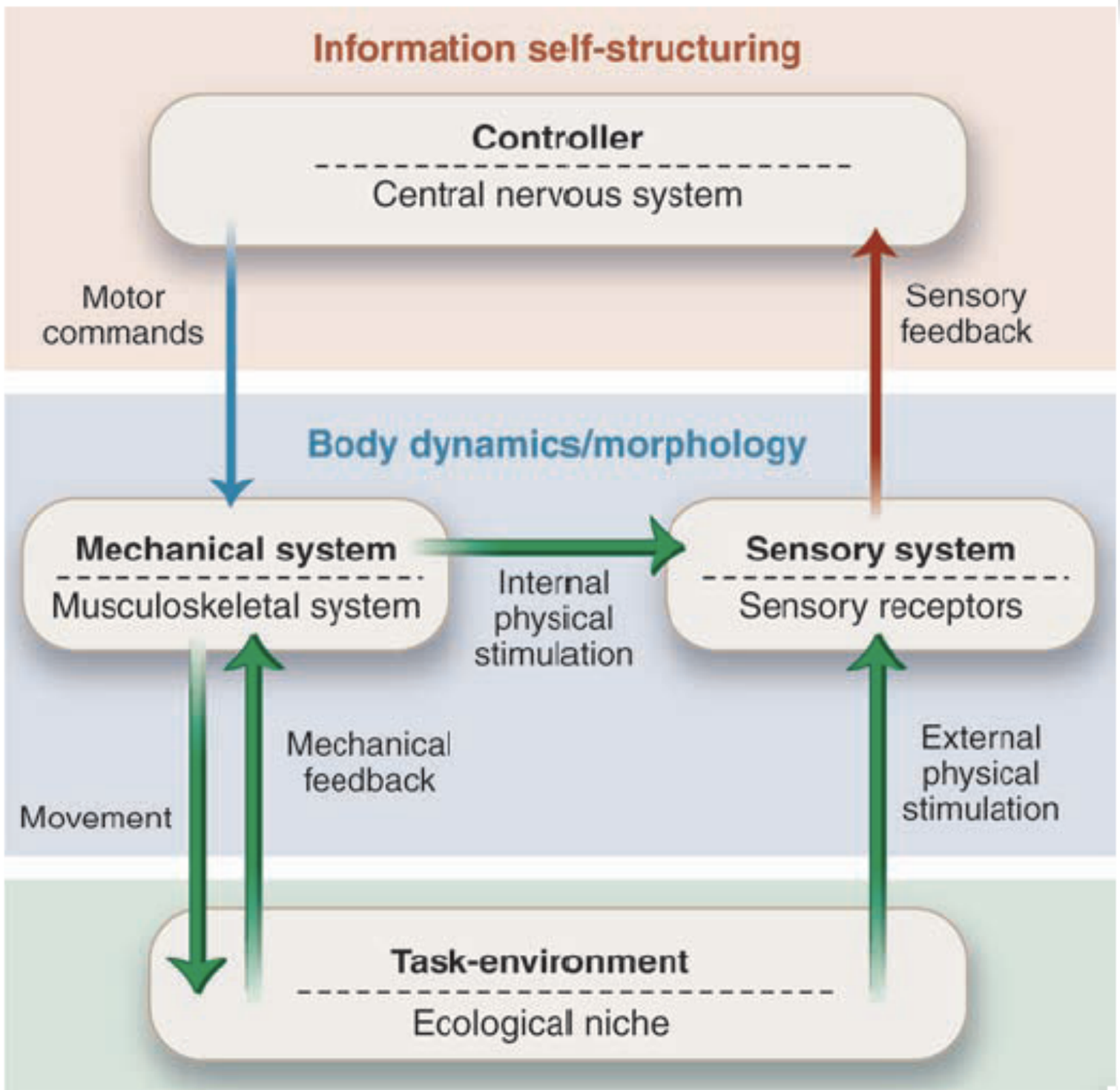
principle of “cheap design”

The memory of the aplysia

Video “the memory of the aplysia”

a small brain in a vat?

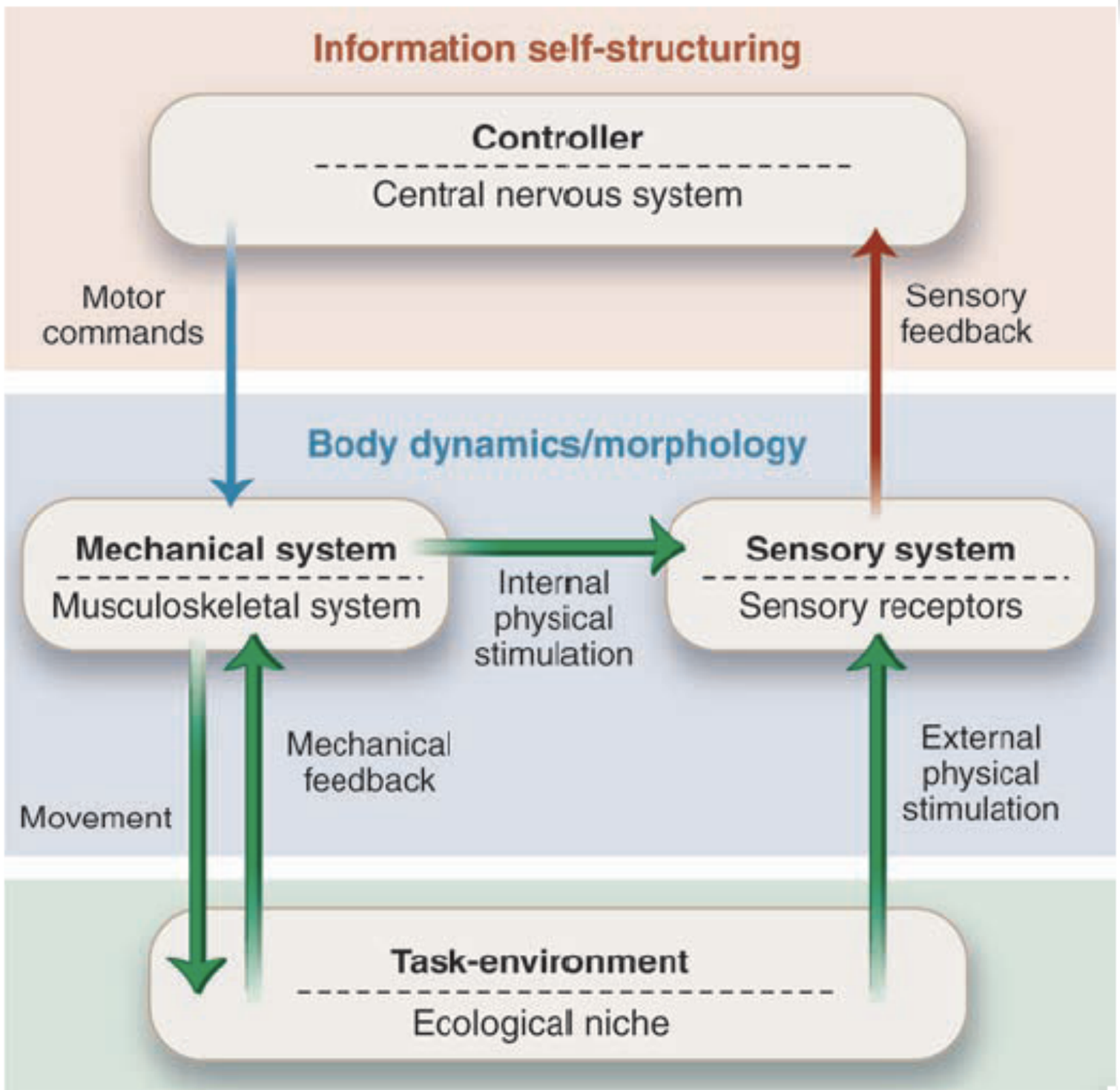
Implications of embodiment



"Puppy"

Pfeifer et al.,Science, 16 Nov. 2007

Implications of embodiment



"Puppy"

which part of diagram is relevant?

—>

Pfeifer et al.,Science, 16 Nov. 2007

How to quantify?

End of lecture 4

Thank you for your attention!

stay tuned for lecture 5

“Collective Intelligence: Cognition from Interaction”

Fabio Bonsignorio
Prof,the BioRobotics Institute, SSSA
CEO and Founder Heron Robots
Santander - UC3M Chair of Excellence 2010

Research interests

- embodied intelligence, cognition/AI and robotics

- experimental methods in Robotics and AI

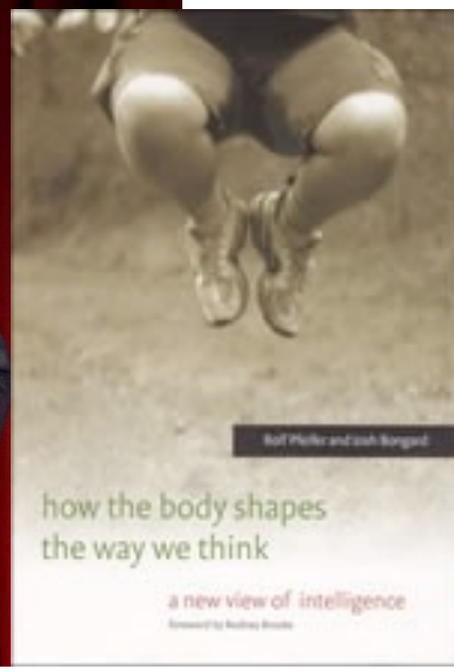
- Advanced approaches to Industry 4.0

- synthetic modeling of life and cognition

- novel technologically enabled approaches to higher education and lifelong learning

The ShanghAI Lectures
2013-2016

Rolf Pfeifer
Prof,
Institute for Academic Initiatives, Osaka University, Japan
Dept. of Automation, Shanghai Jiao Tong University, China
Prof Em.,Former Director AI Lab, Univ. of Zurich

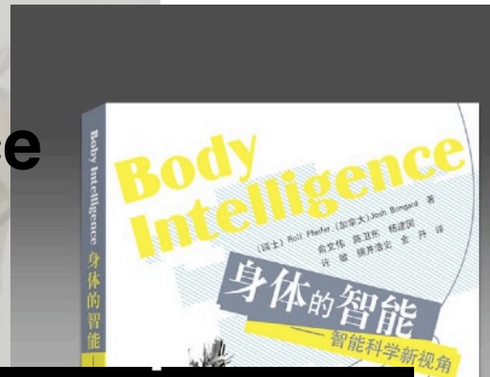


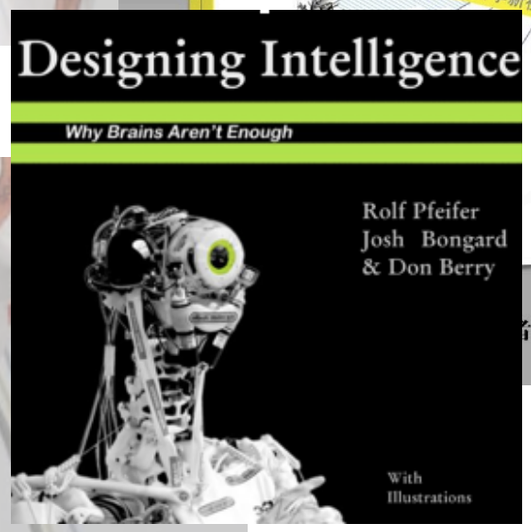
Research interests

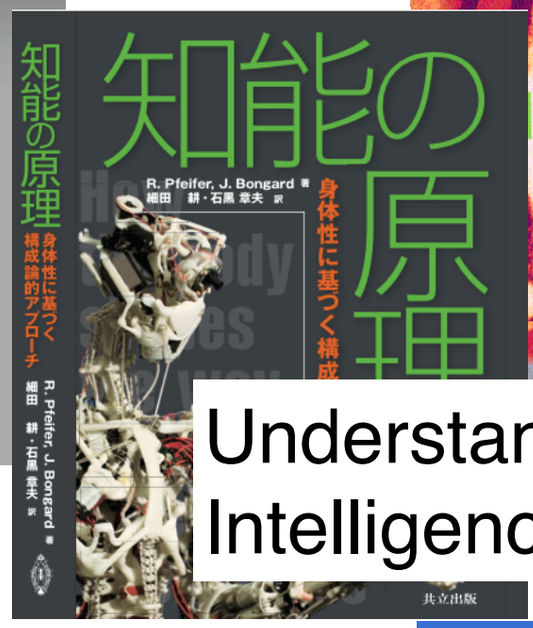
- **embodied intelligence**
- **bio-inspired robotics**
- **self-organization and emergence**
- **educational technologies**

How the body shapes the way we think

MIT Press







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Understanding Intelligence

DI BIOROBOTICA

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