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# Lecture 3

## Embodied Intelligence: Designing autonomous agents

# Questions from last week?

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# Assignments (last week)

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## *Reading (“Understanding Intelligence”)*

- Chapters 2: “Foundations of Classical Artificial Intelligence and Cognitive Science” and
- Chapter 3: “The Fundamental Problems of *Classical AI and Cognitive Science*”

## *Exercise 2*

familiarize yourself with the basic ideas of the classical approach

*Special Assignment for Munich:* prepare a short presentation on “Frame Problem” for next week (5-7 minutes)

# Munich students

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*Special Assignment for Munich:* short presentation on  
“Frame Problem” (5-7 minutes)

--> switch to Munich

# Today's topics

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- Case study on embodiment
- The fundamental problems of the classical approach (finish up)
  - frame problem: Munich
  - symbol grounding problem: Karakuri Ningyo
  - embodiment and situatedness (reading)
  - homunculus problem (reading)
- Embodied Cognitive Science: Designing autonomous agents
  - autonomy
  - Mars Sojourner (video clip)
- The Latest from Japan



Today:

Presentation Prof. Masayuki Inaba  
Dept. of Mechano-Informatics  
The University of Tokyo

The Latest from Japan

# Fundamental Problems of Classical AI

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- the “Symbol Grounding Problem” (later today)
- the “Frame Problem” (Munich)
- the problems of embodiment and situatedness (reading)
- the “homunculus problem” (reading)

# The “frame problem” --> Munich

*Daniel Dennett*

*American philosopher (“philosophy of mind”)*

R1

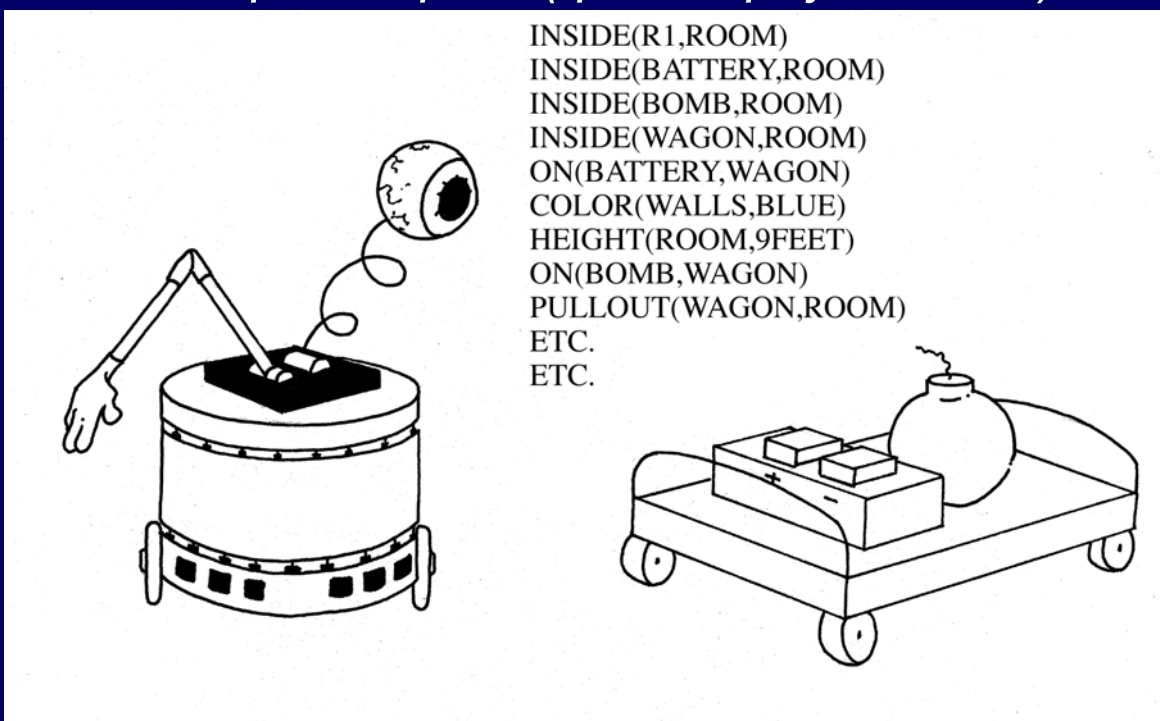
“robot”

R1D1

“robot deducer”

R2D1

“robot-  
relevant-deducer”

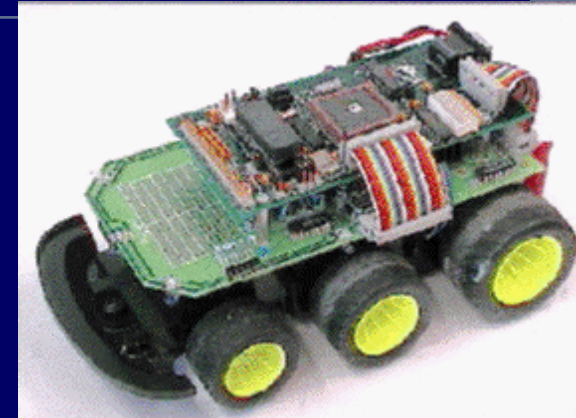


*Isabelle Follath*

# Case study on embodiment

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# The „Didabot“ experiment



“Didabot”:  
simple robot for  
didactical purposes

arena with Styrofoam cubes

Experiment by René te Boekhorst and Marinus Maris

© Rolf Pfeifer

# „Didabot“ experiment – overview



# „Didabot“ experiment – overview



# „Didabot“ experiment – overview



# „Didabot“ experiment – overview



# „Didabot“ experiment – overview



# „Didabot“ experiment – overview



# „Didabot“ experiment – overview



# „Didabot“ experiment – overview



# What are the robots doing?

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# What are the robots really doing?

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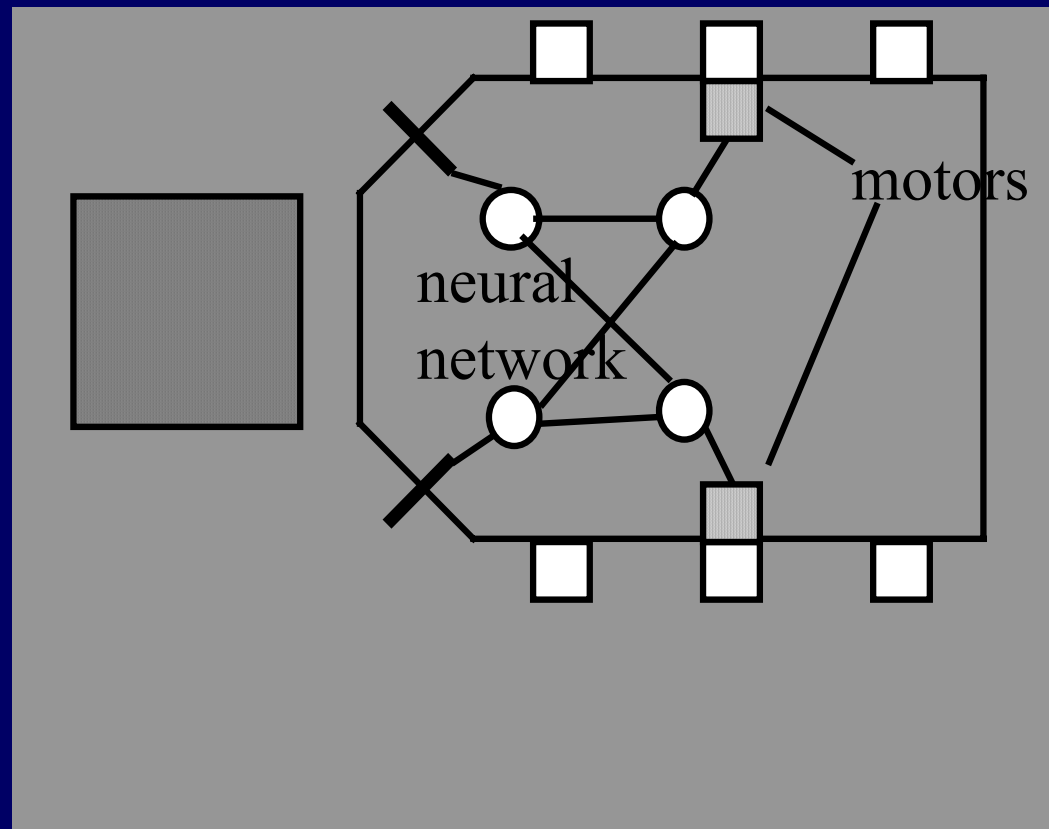
# What are the robots really doing?

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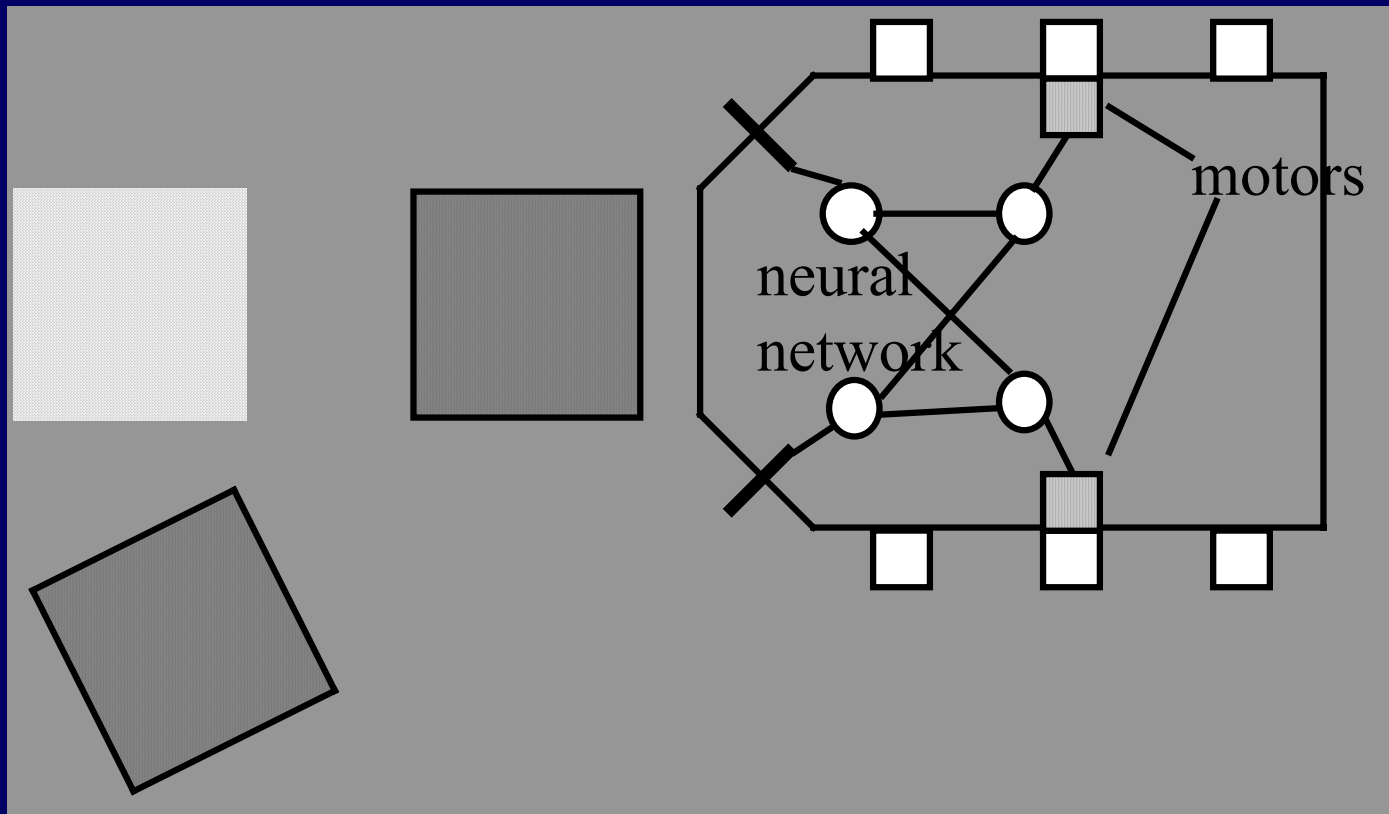
(underlying mechanisms)

- sensory stimulation on left → turn right
- sensory stimulation on right → turn left
- (obstacle avoidance)

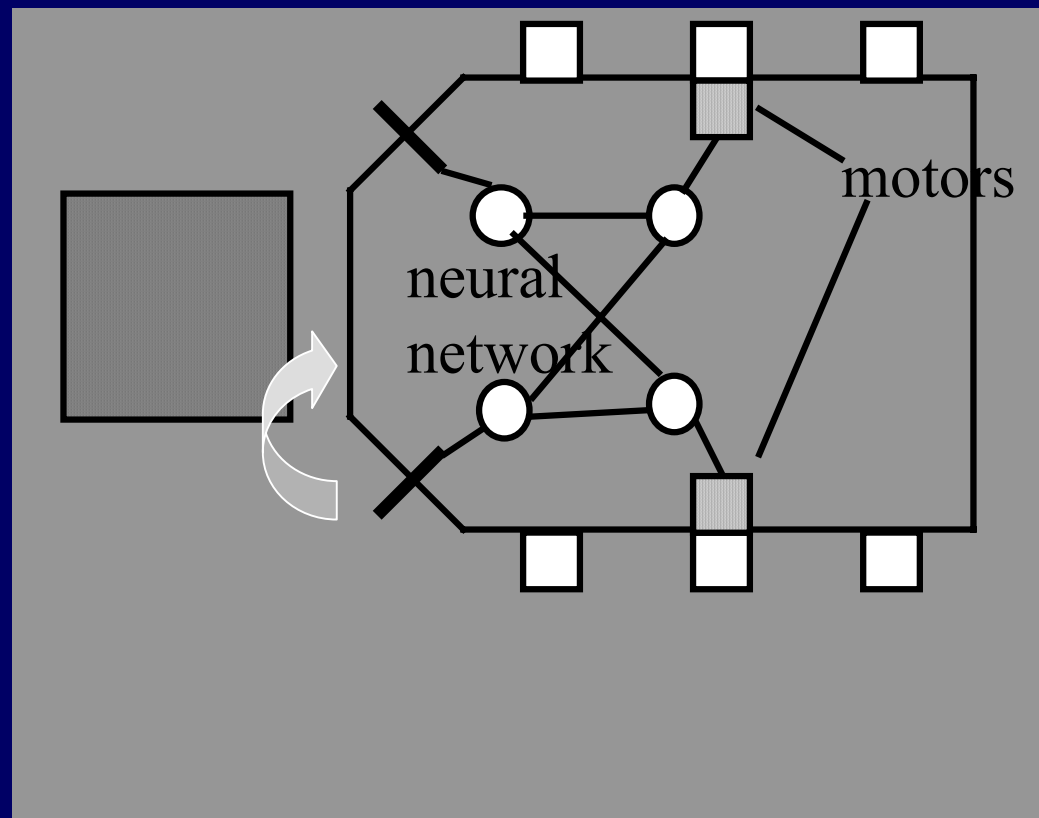
# Explanation



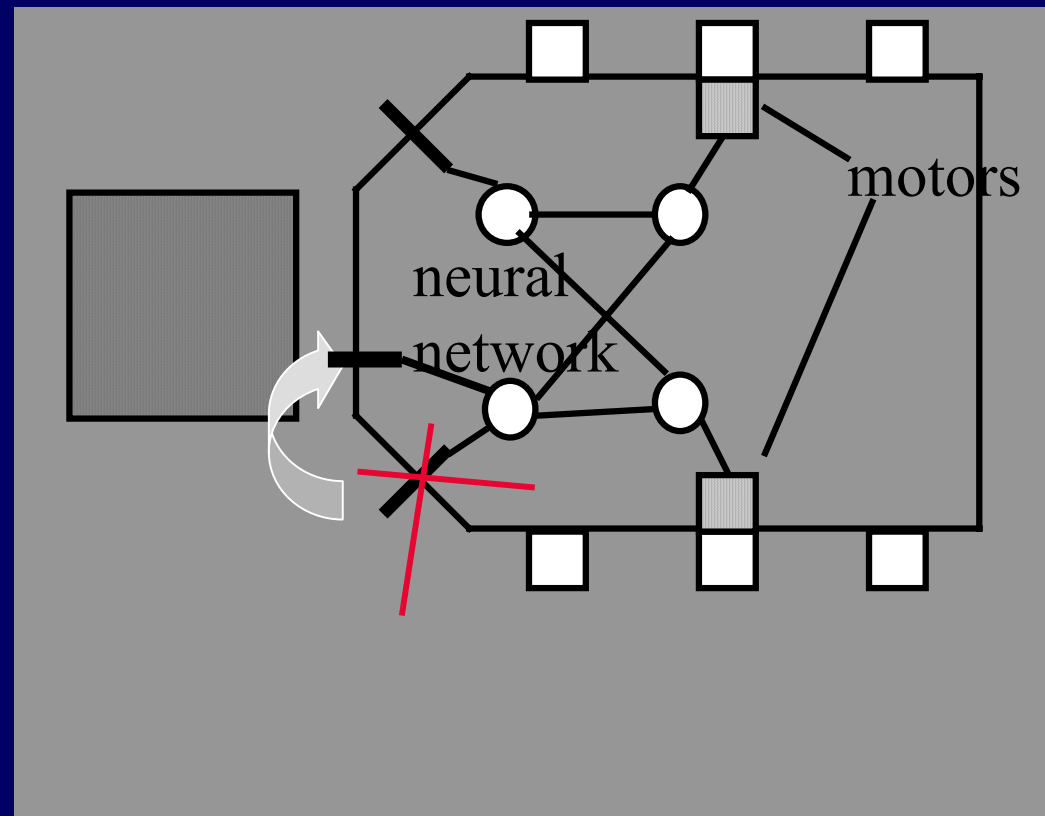
# Explanation



# Changed morphology (sensor position)



# Changed morphology (sensor position)



# Didabots: Summary

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- frame-of-reference
- interdependence morphology – behavior
- exploitation of “ecological niche”
- “cheap design”
- self-organization – emergence

# The principle of “cheap design”

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## ***Intelligent agents:*** “cheap”

- exploitation of ecological niche
- parsimonious
- exploitation of specific physical properties of interaction with real world

# Didabots – real ants



styrofoam  
cubes



ERIC BONIBAU AND GUY THIÉBAULT

dead  
ants

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-

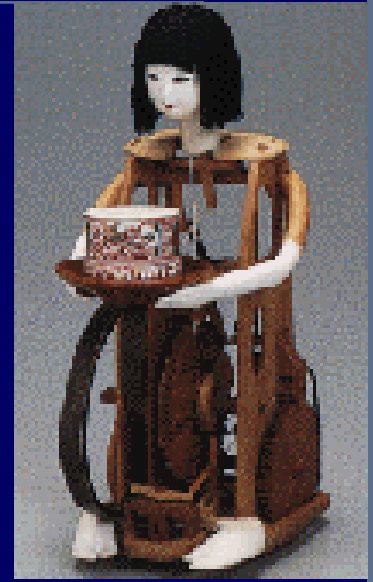
# Symbol Grounding

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# Karakuri ningyo - からくり人形



*first  
performance:  
1762 in Kiryu  
Japan*



*tea-serving robots*



# Karakuri ningyo - からくり人形

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“Japan’s love of robots lies in the history of the Karakuri Ningyo.” *Kirsty Boyle*

# Karakuri ningyo - からくり人形

“Japan’s love of robots lies in the history of the Karakuri Ningyo.” *Kirsty Boyle*



***Karakuri ningyo  
with Sony’s AIBO robot***

# Demo of Karakuri

Karakuri ningyo - からくり人形

“Japan’s love of robots lies in the history of the Karakuri Ningyo.”



*Karakuri ningyo  
with Sony’s AIBO robot*

# Karakuri ningyo - からくり人形

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1603 - 1867 Edo Period: two and a half centuries of isolation and stability --> accumulation of wealth

During the 18th, 19th and early 20th centuries, wealthy textile manufacturers commissioned the creation of various mechanical dolls and the stages needed for their performances which were part of the lively entertainment during festivals and shrine events.

about Karakuri: <http://www.karakuri.info>

Edo Period: <http://www.japan-guide.com/e/e2128.html>

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# Designing a tea-serving robot

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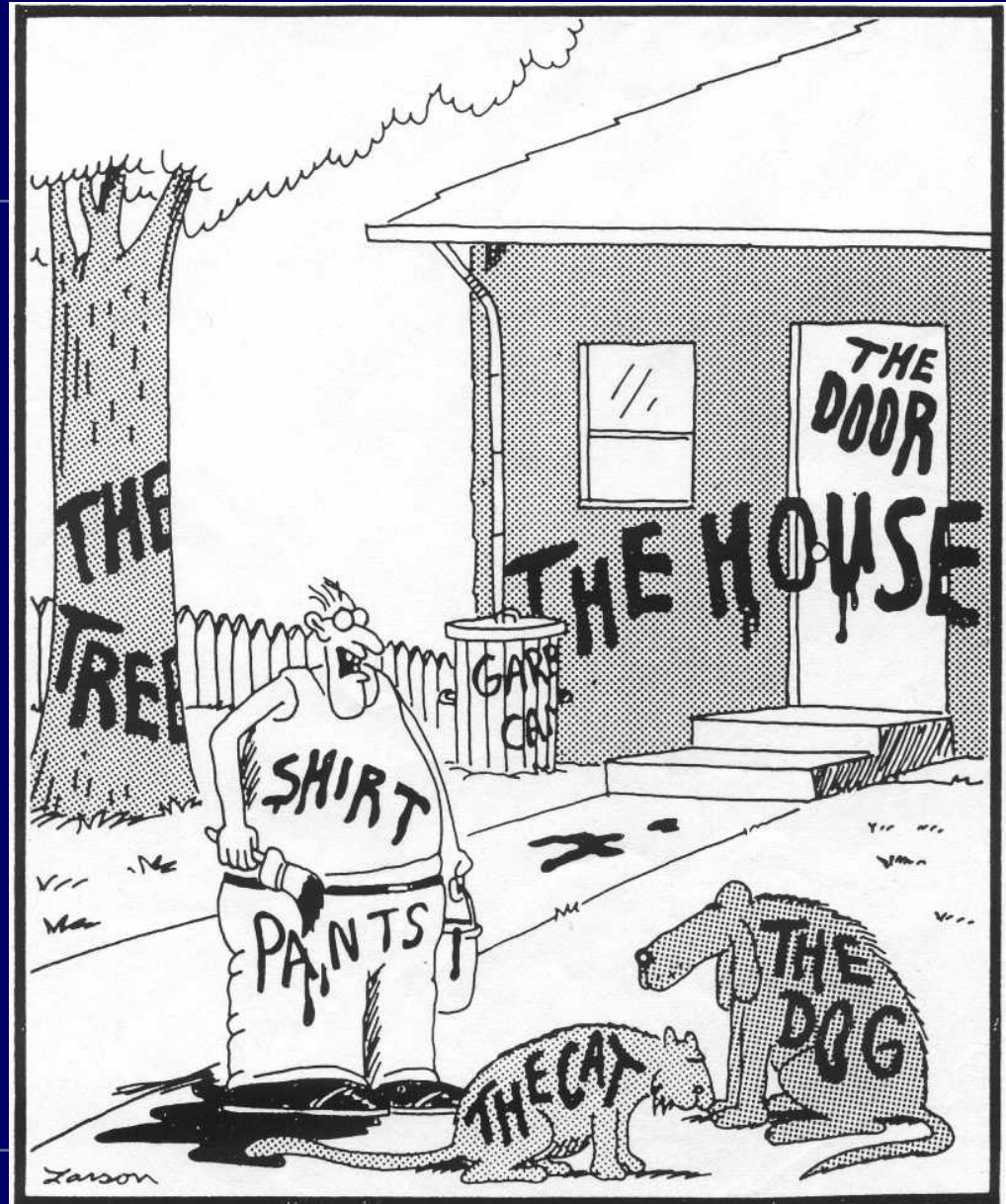
# Designing a tea-serving robot

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# Designing a tea-serving robot

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# Symbol Grounding



Gary Larson

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

# Embodied intelligence

## Designing autonomous agents

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# Autonomy

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# Autonomy

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# Mars Sojourner

***4 December 1996:  
Launch of Pathfinder spacecraft***

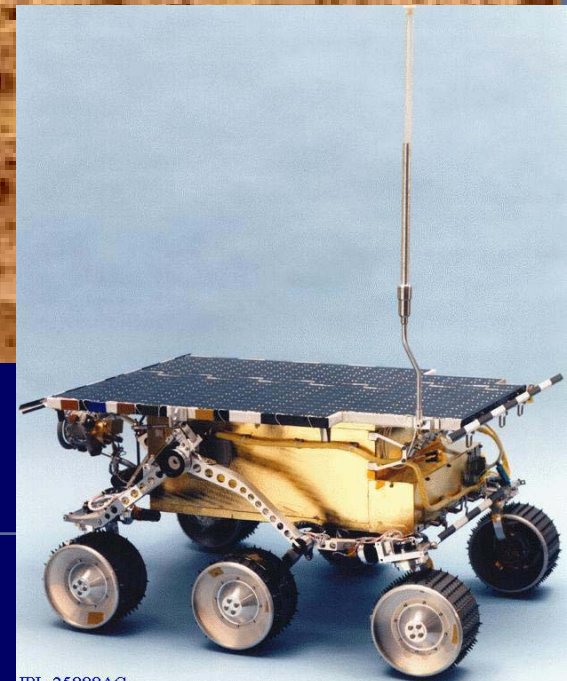
***4 July 1997: Landing on Mars***

***11kg, 63x48cm  
solar panel and batteries  
6 wheels  
many sensors***



JPL-25888AC

# Mars Sojourner



*Mars Sojourner's "ecological niche"*

### Mars Sojourner

***4 December 1996:  
Launch of Pathfinder spacecraft***

***4 July 1997: Landing on Mars***

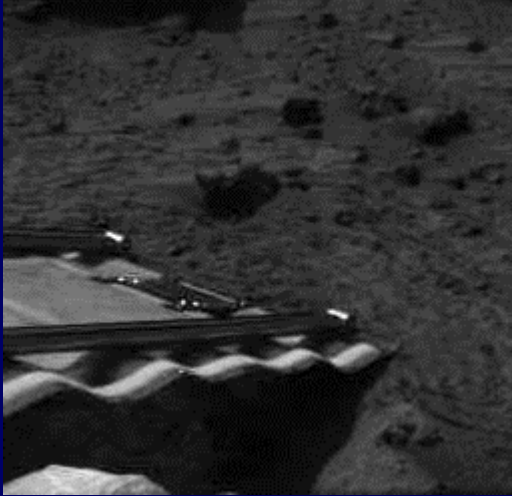
***11kg, 63x48cm  
solar panel and batteries  
6 wheels  
many sensors***



JPL-25888AC

# Images of Mars Sojourner

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*from 1997*

# Images of Mars Sojourner

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*from 1997*

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# Images of Mars Sojourner



*from 1997*

# Images of Mars Sojourner

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*from 1997*

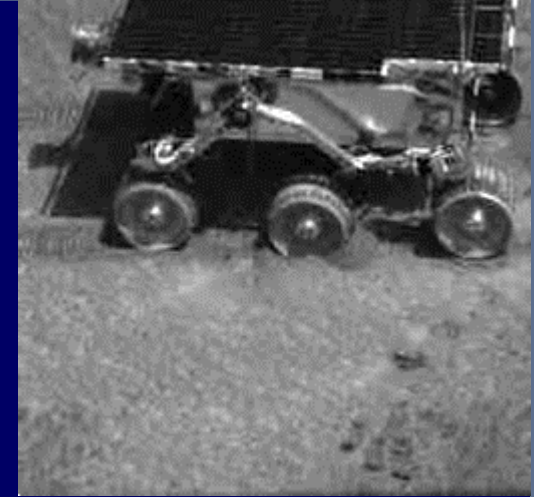
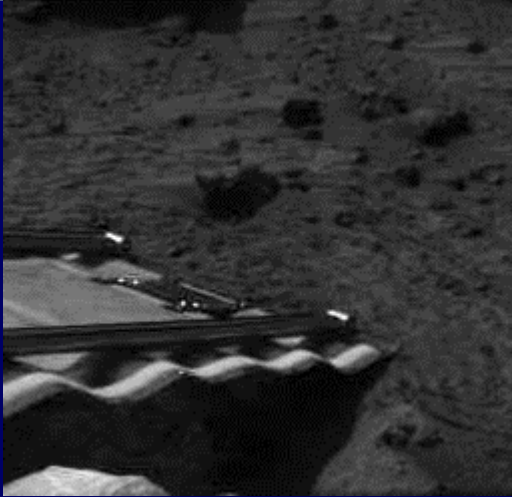
# Images of Mars Sojourner

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*from 1997*

# Images of Mars Sojourner



*from 1997*

# Autonomy of Mars Sojourner?



# Complete autonomous agents

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# Masanao Toda's "Fungus Eater"

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- 1960s
- Institute for Advanced Studies
- cognitive psychology --> fragmentation
- alternative: simple but complete, distant planet

# Rhinogrades (Stümpke)

*Nasobema  
lyricum*

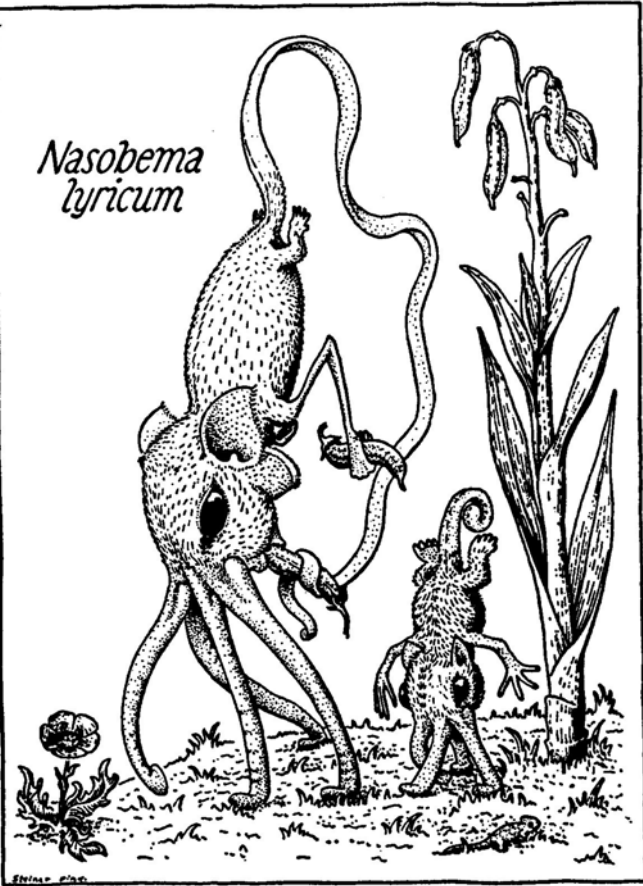


PLATE X

# Rhinogrades (Stümpke)

*Nasobema lyricum*



PLATE X

*Hopsorrhinus aureus*

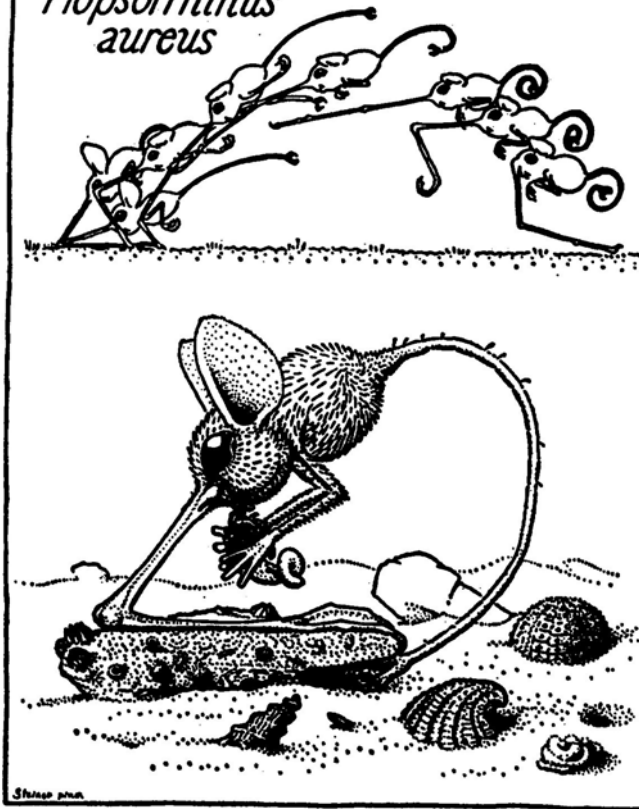


PLATE VI

# Rhinogrades (Stümpke)

*Nasobema lyricum*



PLATE X

*Hopsorrhinus aureus*

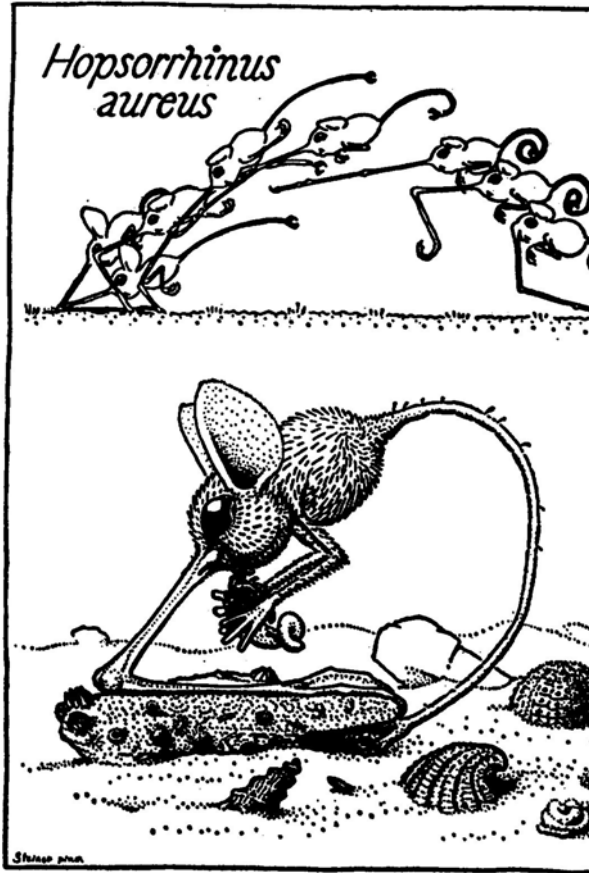


PLATE VI

*Ranunculonasus pulcher*

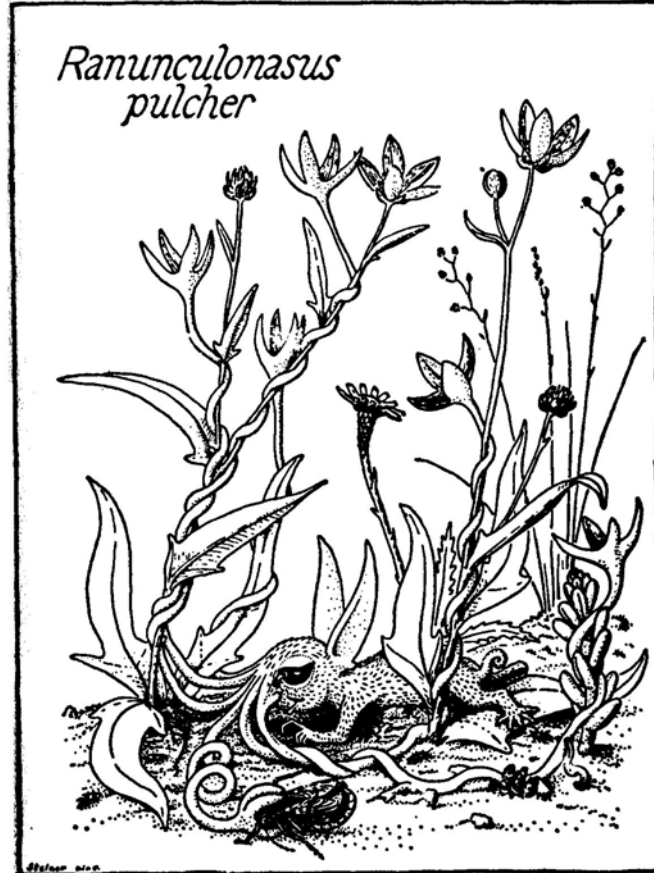
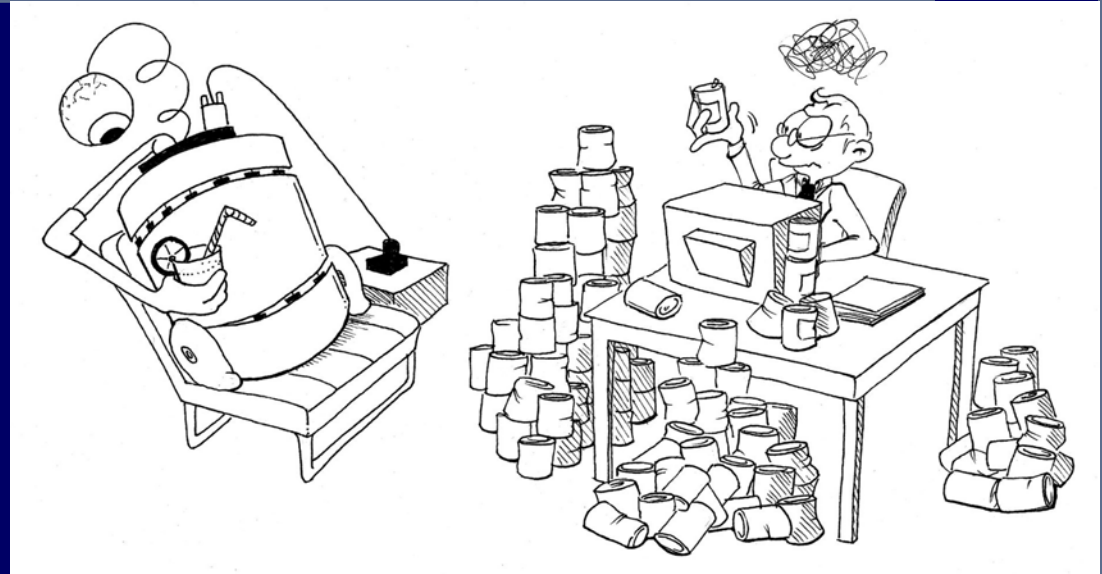


PLATE XIII

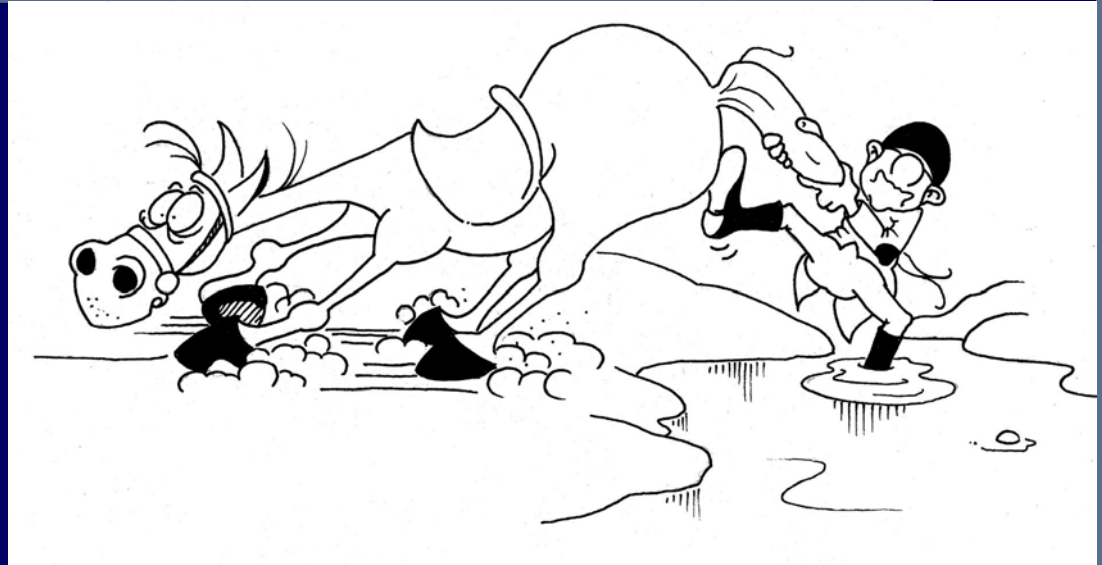
# Masanao Toda's "Fungus Eater"



# Self-Sufficiency



# Autonomy and Situatedness



Ecological Niche --> special assignment  
for Warsaw (next week)

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Next:

The Latest from Japan



Today:

Presentation Prof. Masayuki Inaba  
Dept. of Mechano-Informatics  
The University of Tokyo

The Latest from Japan



Today:

Presentation Prof. Masayuki Inaba  
Dept. of Mechano-Informatics  
The University of Tokyo

The Latest from Japan

***Introduction by***

***Prof. Yasuo Kuniyoshi***

# Assignments

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- Read chapter 4 of “Understanding Intelligence”
- Exercise 3
- *Special Assignment for Warsaw-participants for next week:* prepare a short presentation on the concept of ecological niches and how this applies to robots.

*Inspiration:*

David McFarland, Oxford University, one of the leading ethologists (Focus 4.1)