

Development of interactive autonomous robots

Autonomous robots

- **Two types of advanced information infrastructures**
 - **Sensor networks (computer networks)**
 - **Communication by sending data**
 - **Environmental recognition by sensor networks**
 - **Autonomous robots**
 - **Multi-modal communication by an advanced human interface**
 - **Bidirectional recognition between robots and humans**
- **The robot supports multi-modal and low-level communication as a partner**

Interaction with humans



How does the robot support communication?



Elderly people in a nursing home

Comments of a medical doctor

Robots provide a new method of psychotherapy

The old or infirm hesitate to talk with humans

They feel a barrier against complex humans

The robot is simpler than people

The robot is less than a human but more than dog?

- Elderly / young people do not hesitate to interact with the robot.
- The symptoms of mental illness improve temporarily.



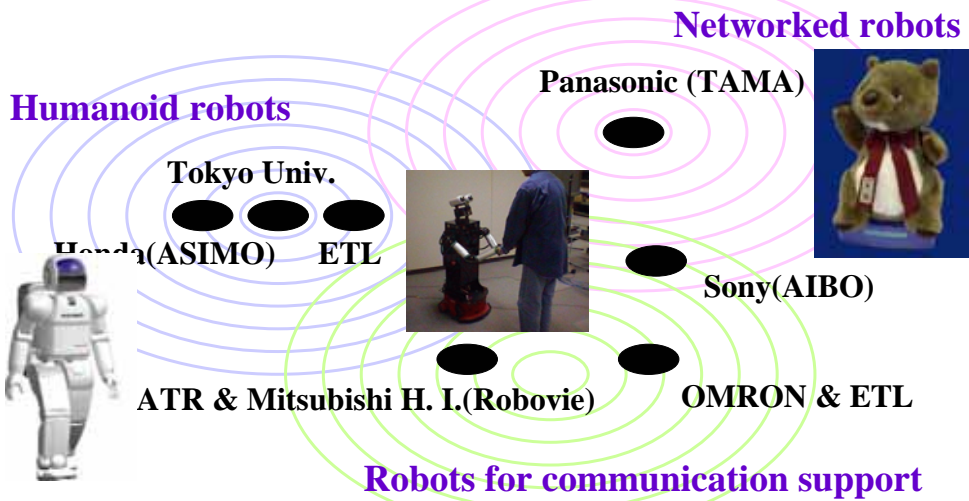
The robot can support low-level communication

Robots as a new information infrastructure for supporting low-level communication

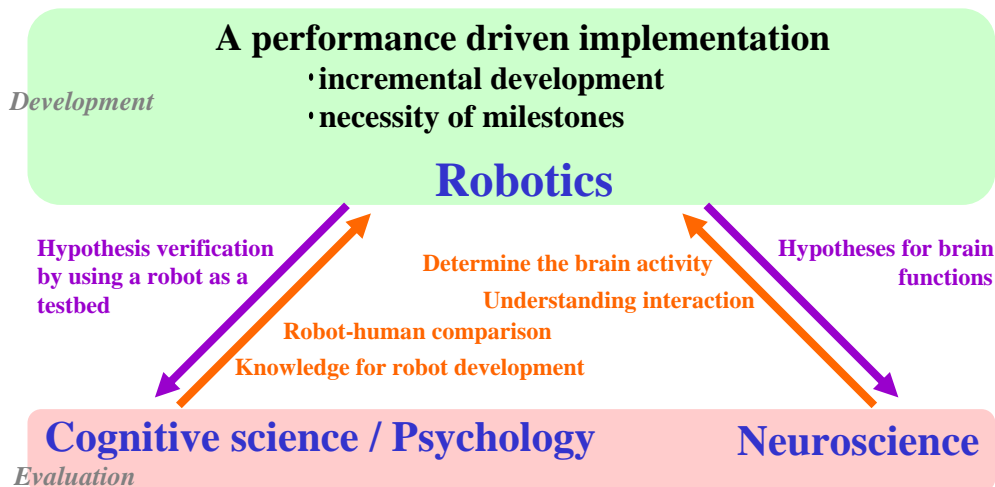


New wave of robotics in Japan

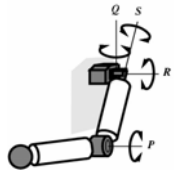
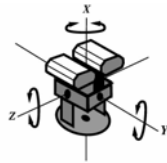
- Robots connecting people -



Interdisciplinary research approach to developing interactive humanoid robots



Robovie



[Hardware]

Size: 120cm height, 40cm diameter and 40Kg. weight

Two arms (4*2 DOF) with tilted shoulder joints

A head (3 DOF)

Two eyes (2*2 DOF for gaze control)

A mobile platform (2 driving wheels and 1 free wheel)

Skin sensors covering the whole body (original)

10 tactile sensors around the mobile platform

An omnidirectional vision sensor

Two microphones to listen human voices

24 ultra-sonic sensors for detecting obstacles

4 hours battery life, autonomous charge function

[Computing resources]

Pentium III PC on board

The operating system: Linux

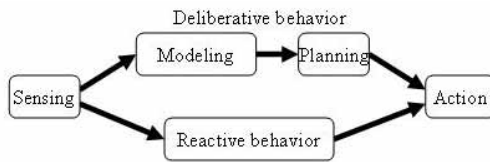
Simple mechanism, many sensors, long battery life

How can we program an interactive robot?

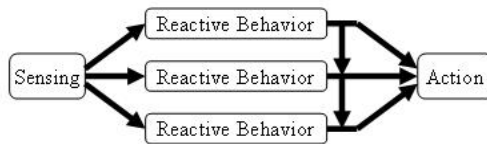
1. Limited implementation of sensory data
2. Limited behaviors in a situation
3. Partial orders among behaviors
(behavior sequence consists of 2-10 behaviors)

➡ Constructive approach

Robot Architecture



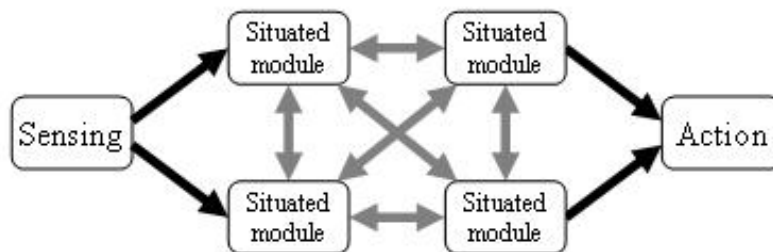
- Delayed actions
- Intermediate representation



- Deliberative behavior
- Network design

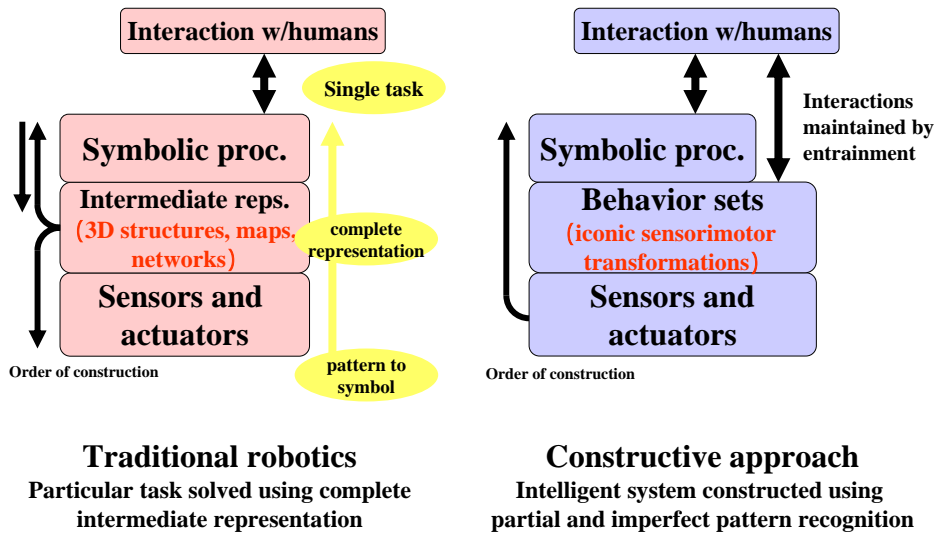
The problem is the complete network for limited applications.

Robot Architecture



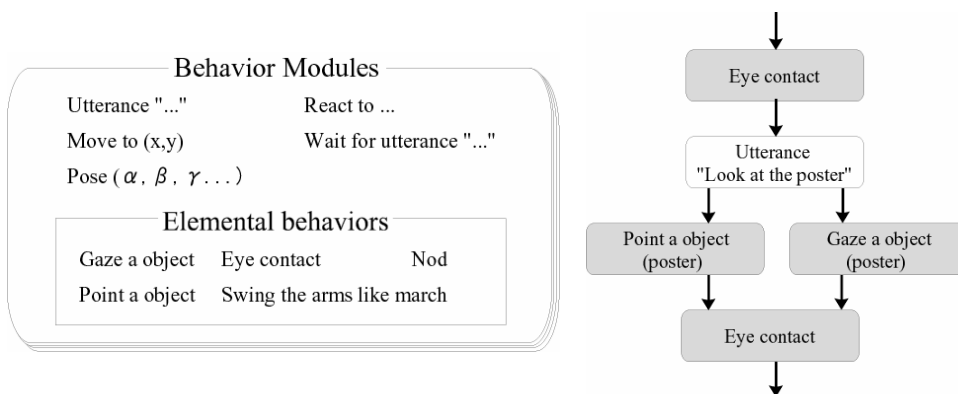
**How to obtain the complete network for interaction?
How to obtain the proper intermediate representation?**

Comparison to traditional robotics



Behavior modules

execute simple tasks in a particular situation



Knowledge from Cognitive Science

- Rich robot behaviors induce various human communicative gestures that help utterance understanding.
- Attention expression by the robot guides the human's focus to the robot attention.
- The robot's eye contact indicates its intention to communicate.
- Sharing of a joint viewing point and a proper positional relation establish a situation where the human can easily understand the robot's utterance.



Interactive behaviors

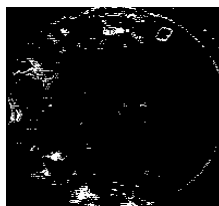
Elemental Behavior

for mutual entrainment

Eye contact



Omnidirectional image



Skin color regions



Moving regions



Face region

Situated visual recognition

The robot generates a situation by taking an action

Example: Paper-scissors-rock

- Say "Let's play paper-scissors-rock"
- Look at the hand
- Detect moving object



Various action-sensing heuristics...

➔ How to formalize...



Episode rules

Grammar of episode rules

Basic structure of episode

1. <ModuleID=result_value>...<...>NextModule

OR

2. (<ModuleID1=result_value1>|<ModuleID2=result_value2>)...

Repetition

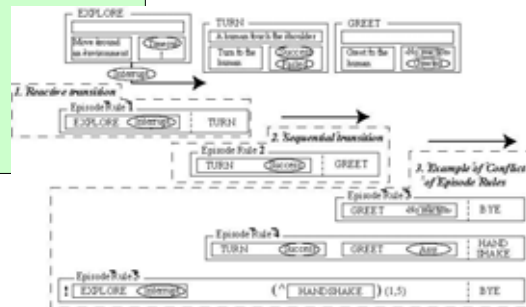
3. (...){n,m}...

Negation of the episode rule

4. !<...>NextModule

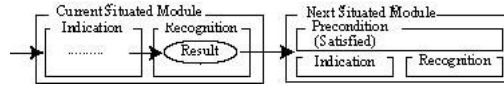
Negation of the behavior and the result value

5. ^<ModuleID=^result_value>NextModule

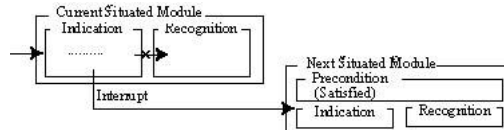


Three types of state transitions

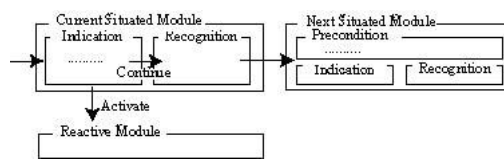
Behavior sequence transitions



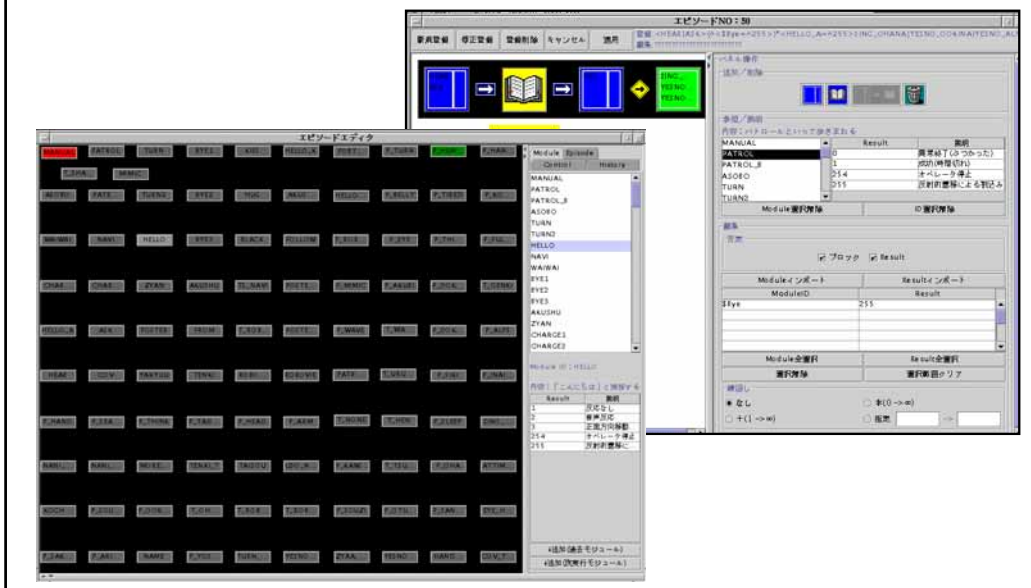
Interruption-driven transitions



Reactive transitions to a reactive module



Episode Editor



The architecture

Tasks

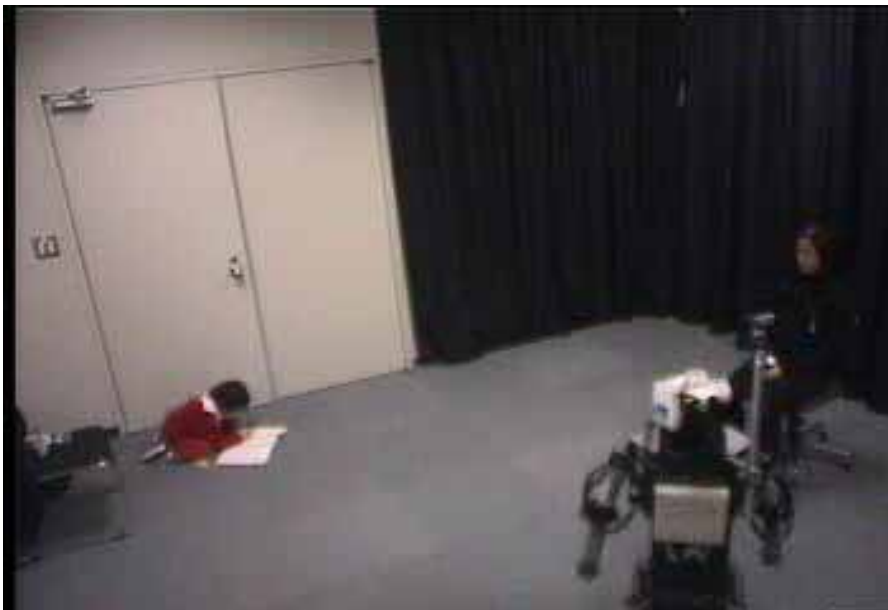
Episode rules (700)

Behaviors (100)

Elemental behaviors

Reactive modules

Interaction with humans



Episode editor (Viewer)



Relationship among behaviors for two different subjects



Subject 1



Subject 2

Development

Remained problems and
on going research projects

- **Hardware for practical use**
- **Ideal mechanism as an interactive robot**
- **Soft skin for interaction**

Hardware for practical use



An ideal mechanism for supporting our everyday life

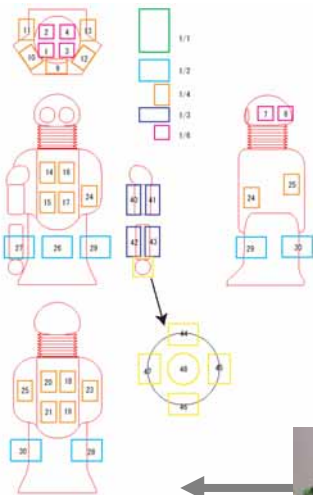


3 DOF for the waist

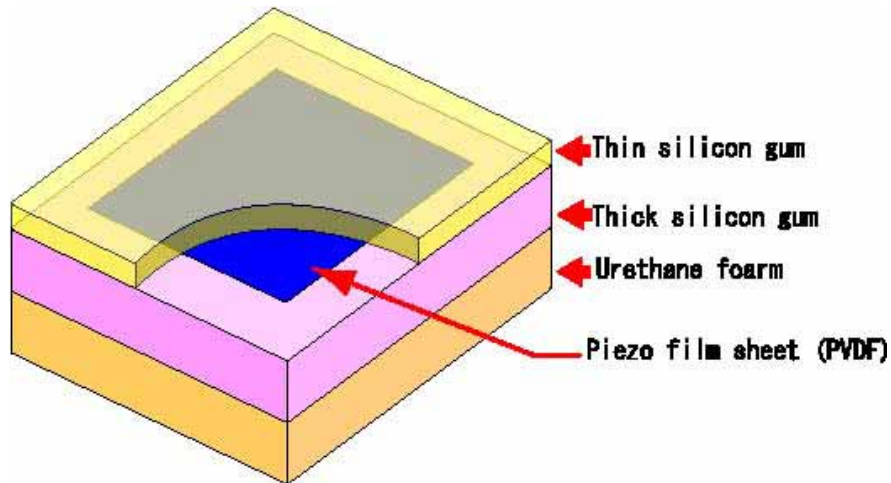
Wheeled inverted pendulum



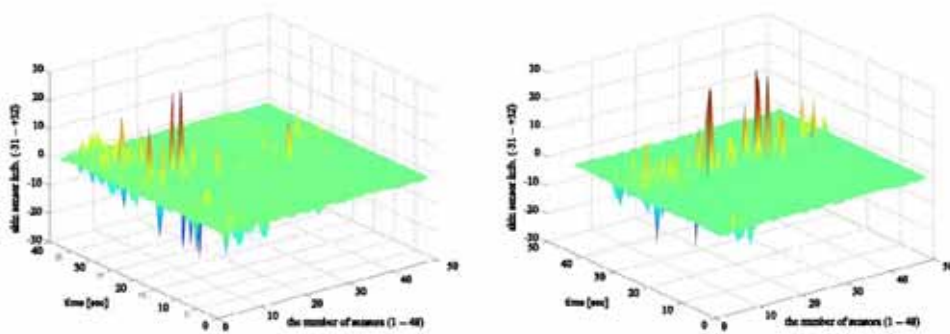
Soft skin for interaction



Soft skin for interaction

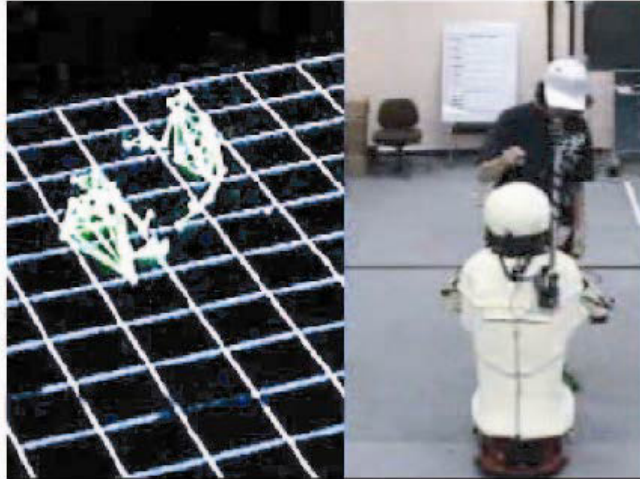


Adult and child



Hags by an adult and a child

Mapping between interactions and sensor patterns



Postures and positions of human and robot by 3-D motion capture device.

Interaction between human and robot in Real world.

References

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