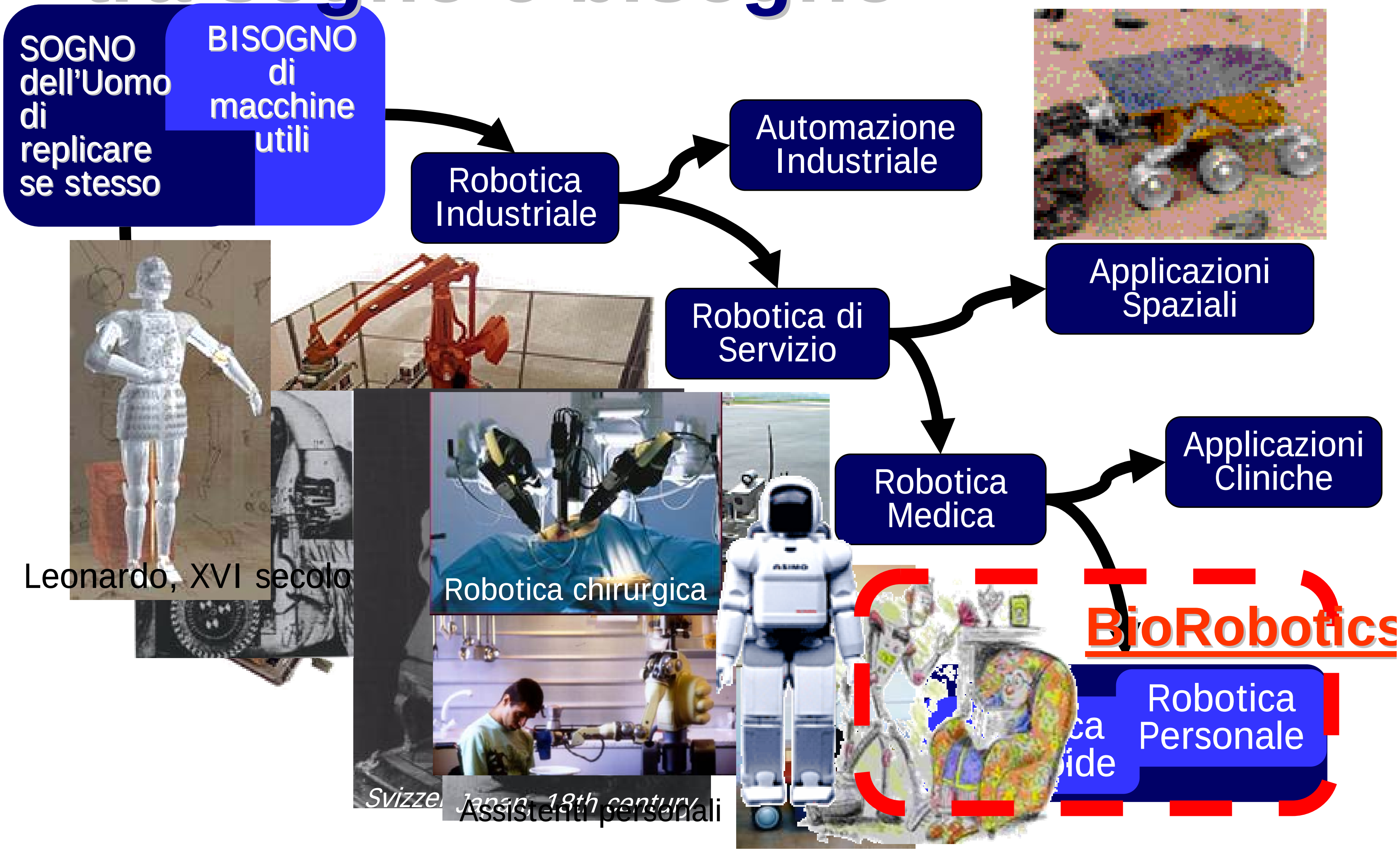
L'evoluzione della robotica tra sogno e bisogno

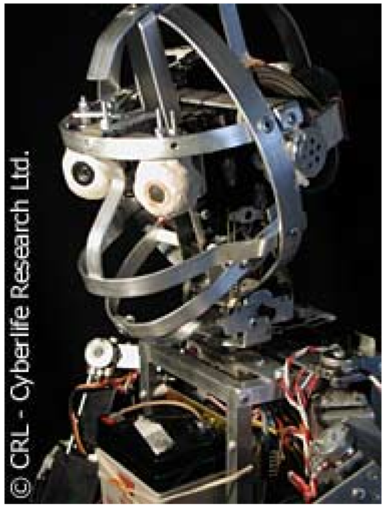


Esempi di robot umanoidi attuali





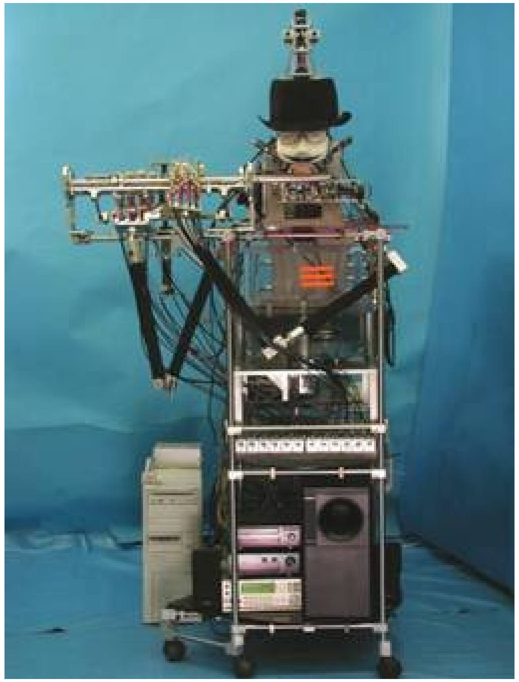




Robot umanoidi

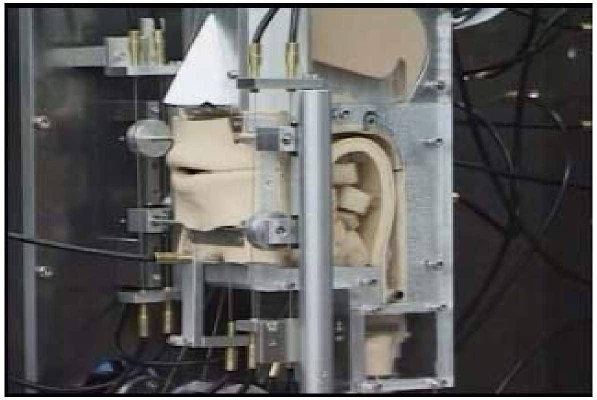
I robot umanoidi della Università Waseda di Tokyo

Robot flautista



Takanishi, A., Sonehara, M., Kondo, H., "Development of an anthropomorphic flutist robot WF-3RII", in *IEEE/RSJ International Conference on Intelligent Robots and Systems, IROS 96*, 1996, 37-43

Robot parlante



Nishikawa, K.; Imai, A.; Ogawara, T.; Takanobu, H.; Mochida, T., Takanishi, A.; "Speech planning of an anthropomorphic talking robot for consonant sounds production", in *IEEE International Conference on Robotics and Automation ICRA 2002*, 2002, 1830 -1835

Robot emotivo

Miwa H., Okuchi T., Takanobu H., Takanishi A.; "Development of a New Human-like Head Robot WE-4", in *IEEE/RSJ International Conference on Intelligent Robots and Systems, IROS 2002*, pp.2443-2448, 2002

I robot della SONY

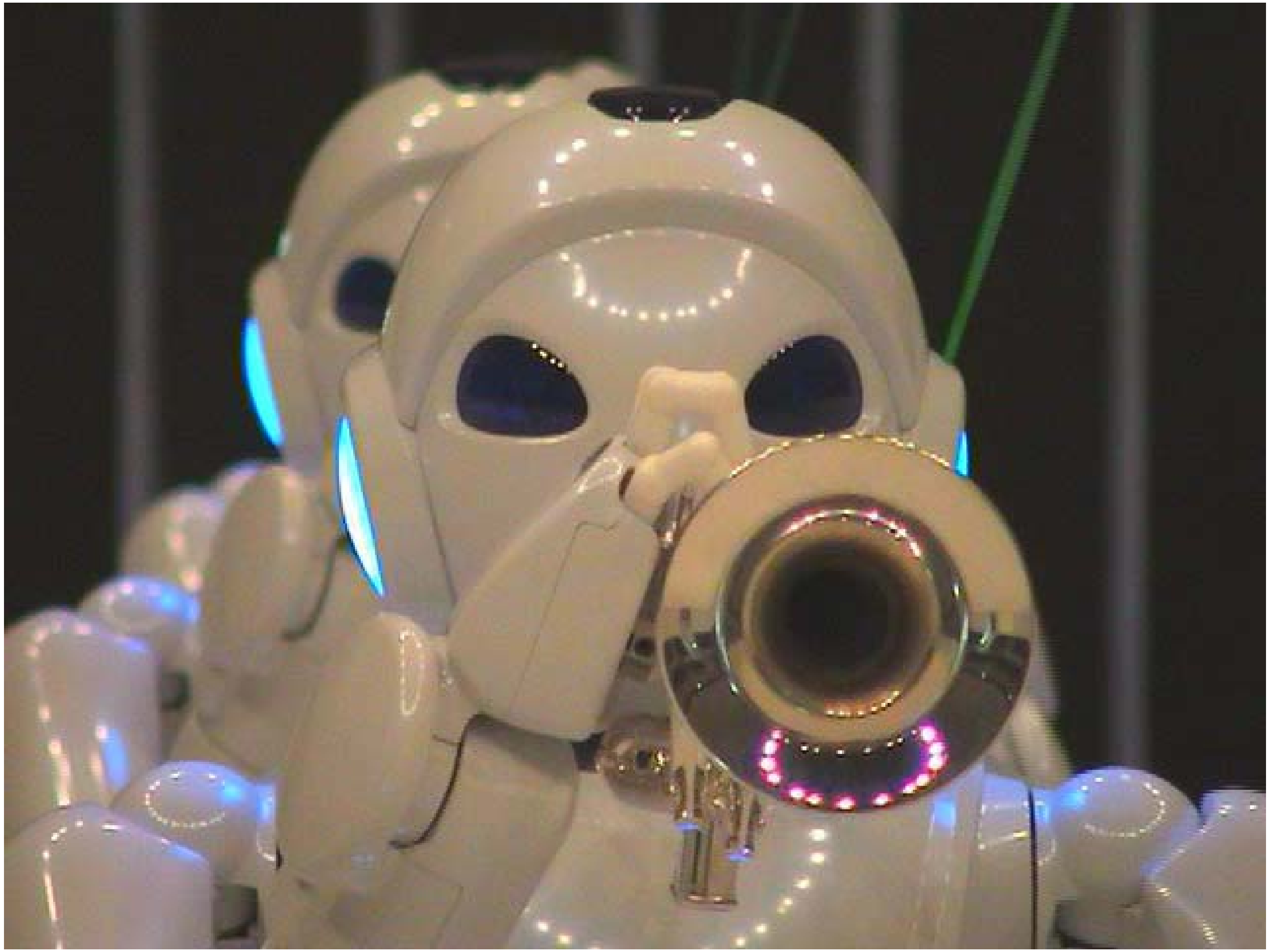
1999	2000		2001		2002

AIBO ERS 110	SDR 3 SONY Dream Robot	AIBO ERS 210	AIBO ERS 220	AIBO ERS 312	SDR-X4

Sales of Aibo (mar. 2000- feb. 2001)*:
7.214.000.000 Yen (**60 M€)**

(Source: Sony News and Information, Summary of Consolidated Results
http://www.sony.net/SonyInfo/News/)

Toyota Partner Robot



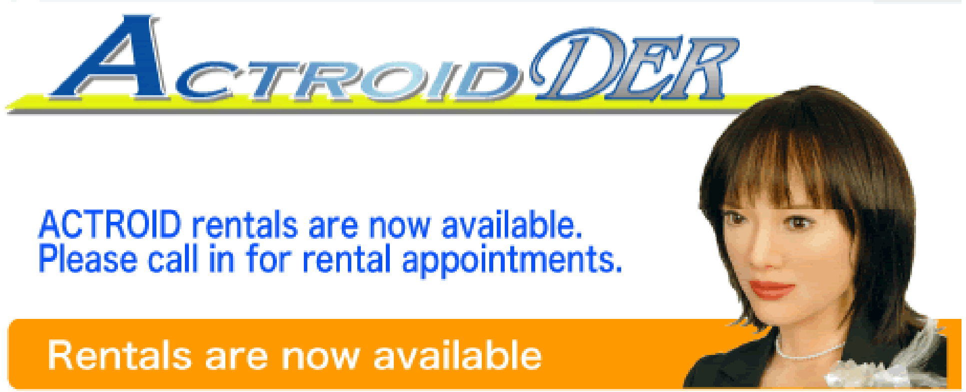
kokoro
a company of Sanrio Group

KOKORO COMPANY LTD

This robot has developed to recreate the human-like natural yet charming expressions with high functionalities retained.

Emphasizes on its own realistic presence with smooth gestures.

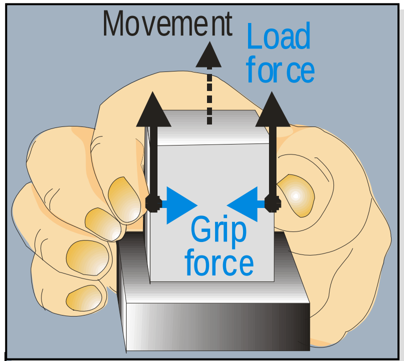
It has news hooks and high eye-catching effects. It can be utilized to play active part for many occasions as a chairperson with fluent narrations and booth bunny.



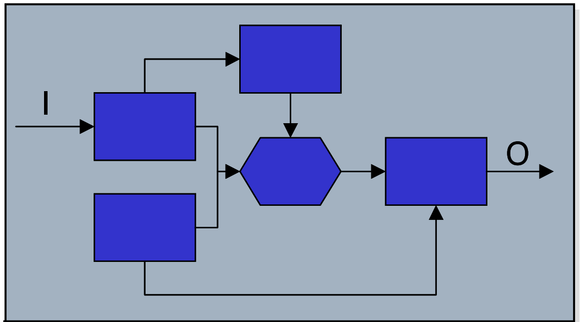
ARTS Lab

La nuova sfida: una squadra di calcio di robot umanoidi

Scienza Biorobotica

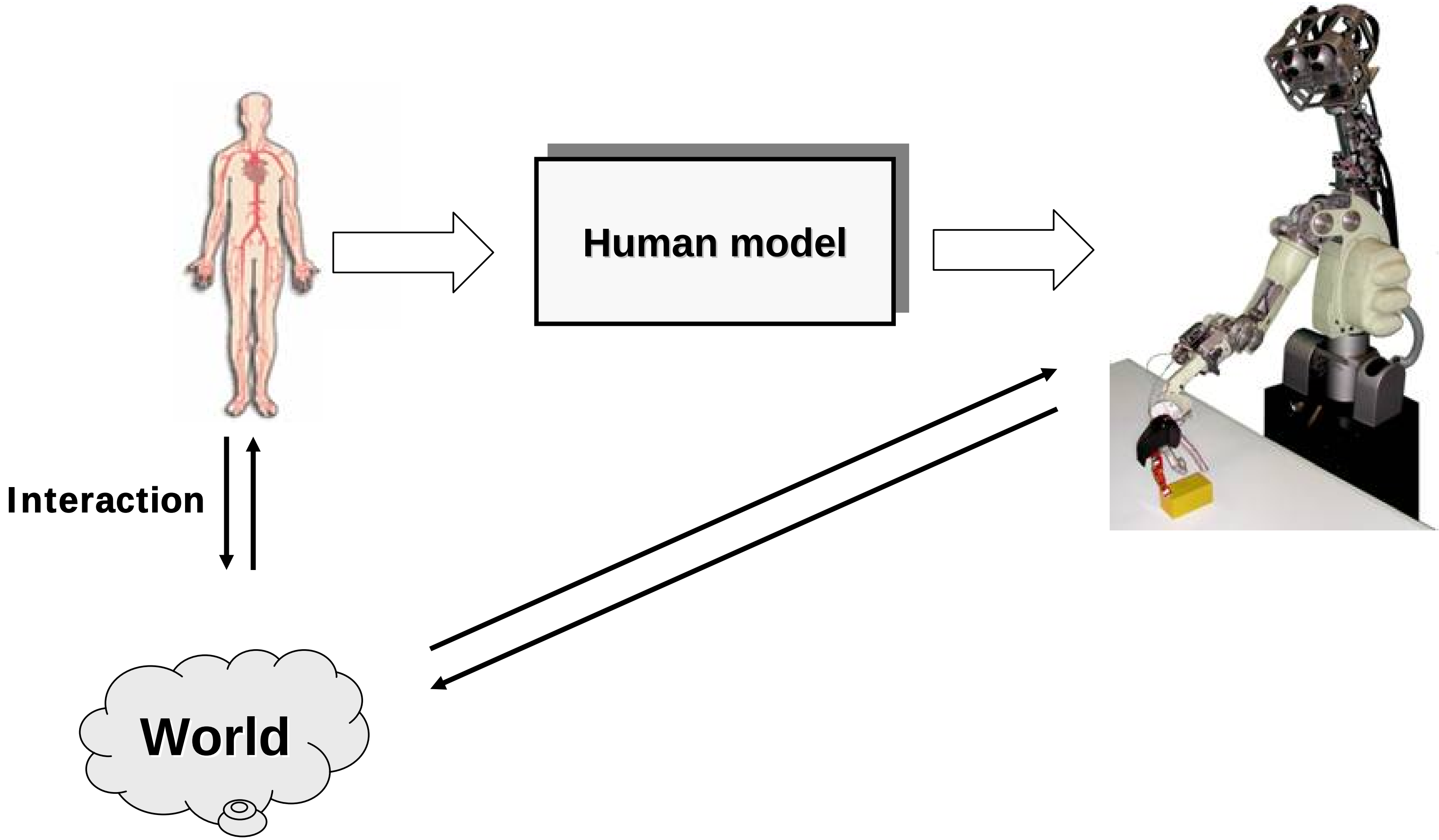


Fenomeno da studiare

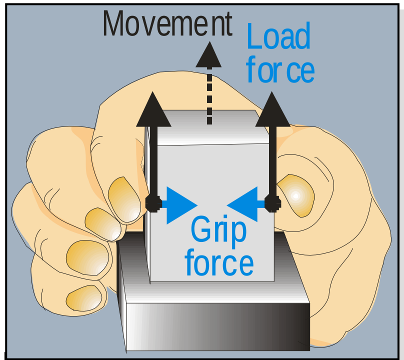


Ipotesi e modello teorico

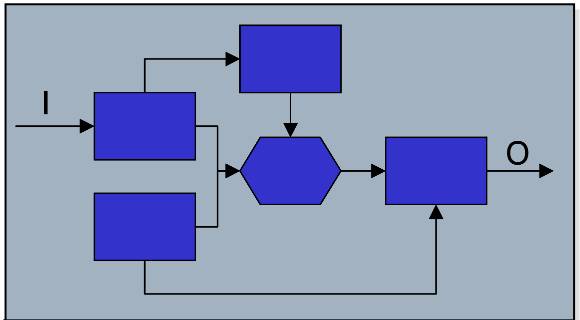
Biorobotica vs simulazione e modelli animali



Scienza Biorobotica

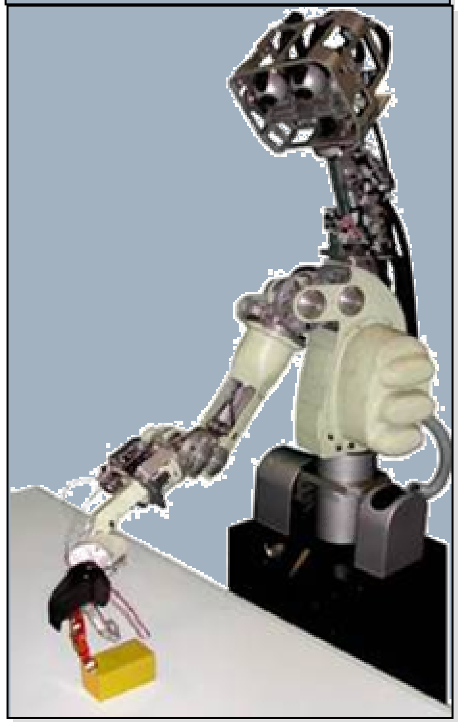


Fenomeno da studiare



Ipotesi e modello teorico

Implementazione in un robot



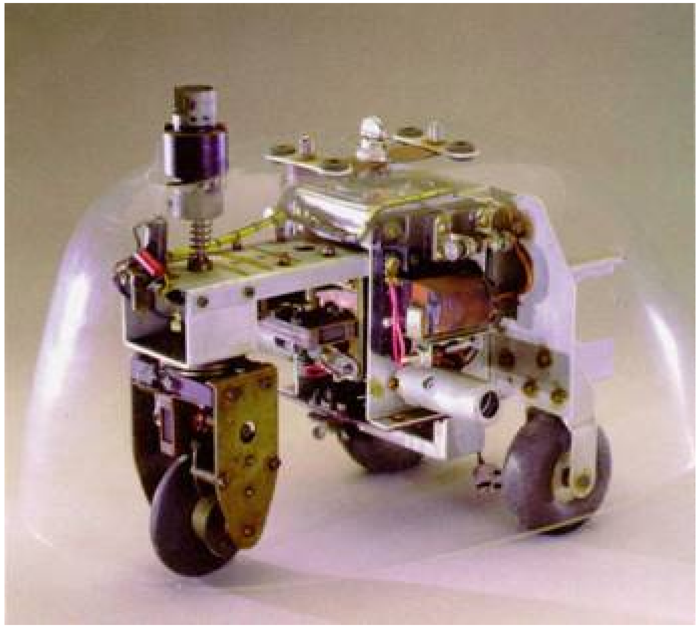
Validazione del modello

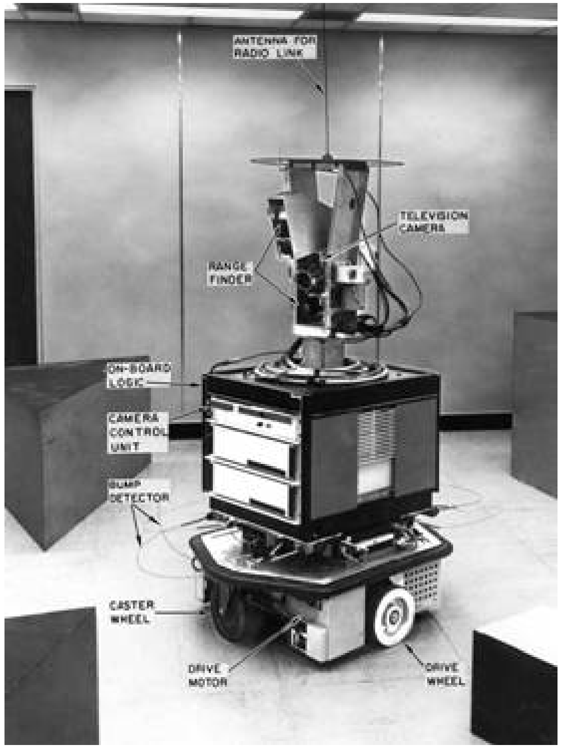
ESPERIMENTO
Confronto fra la prestazione del robot e quella del sistema biologico

Cybernetic Robotics

Turtle robots (The living brain, Grey Walter, 1950-1953): simple robotic models of ‘emerging’ behaviors

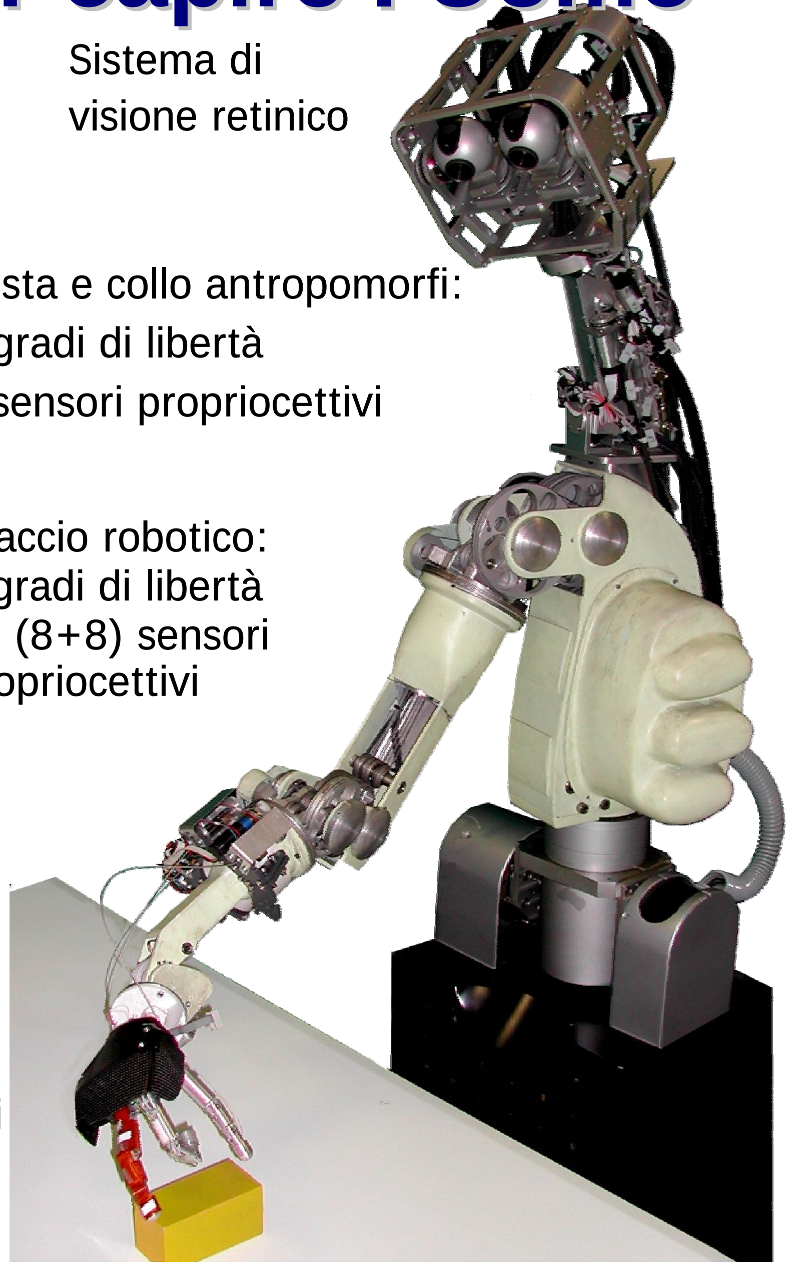
- Machina speculatrix, Machina docilis, etc.





Early robots (’80 / ’90)

Costruire l’umanoide per capire l’Uomo



Sistema di
visione retinico

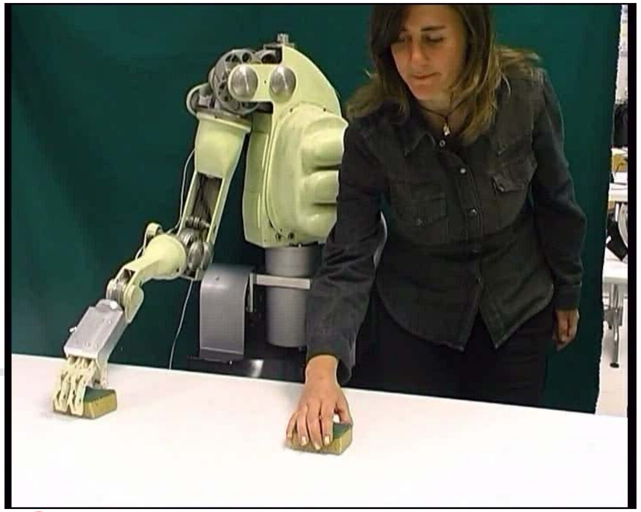
Testa e collo antropomorfi:
7 gradi di libertà
7 sensori propriocettivi

Braccio robotico:
8 gradi di libertà
16 (8+8) sensori
propriocettivi

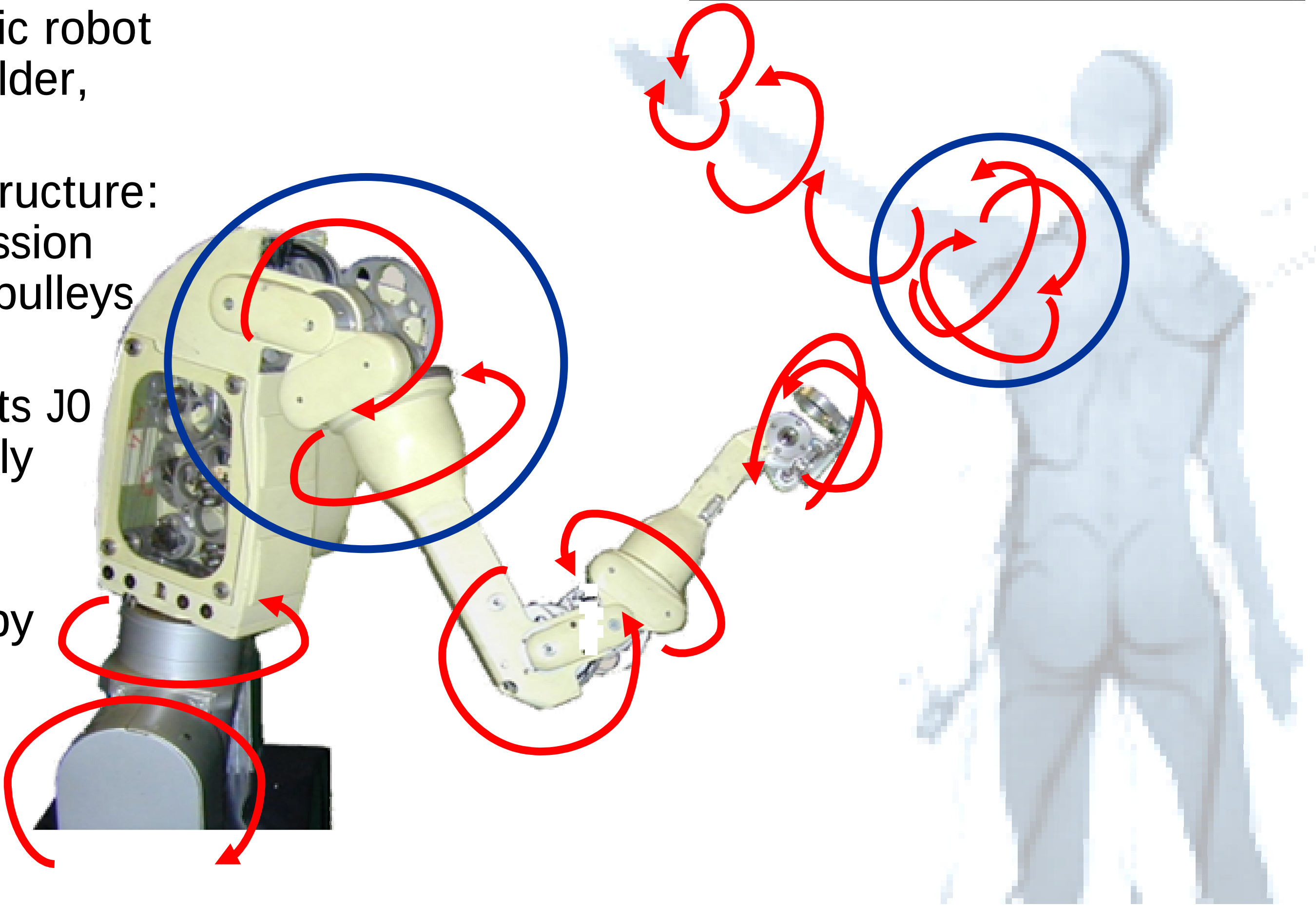
Gradi di libertà	25
Sensori propriocettivi	36
Sensori tattili	12
Sensori visivi	2

Mano biomeccatronica:
10 gradi di libertà
13 sensori propriocettivi
12 sensori tattili

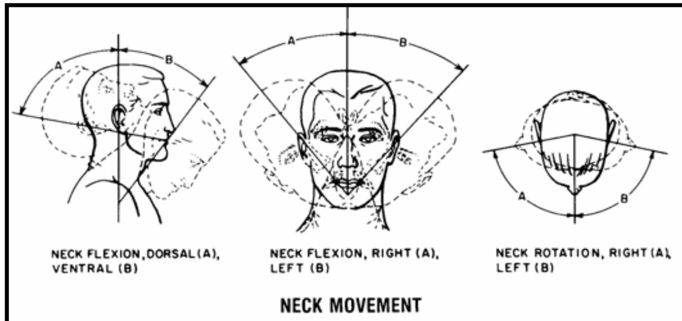
The Arm



- 8-d.o.f. anthropomorphic robot arm, composed of shoulder, elbow and wrist
- Mechanically coupled structure: the mechanical transmission system is realized with pulleys and steel cables
- Singularly actuated joints J0 and J1 by motors directly connected to their articulation axis
- Joints J2...J7 actuated by motors all installed on link 1



The Head



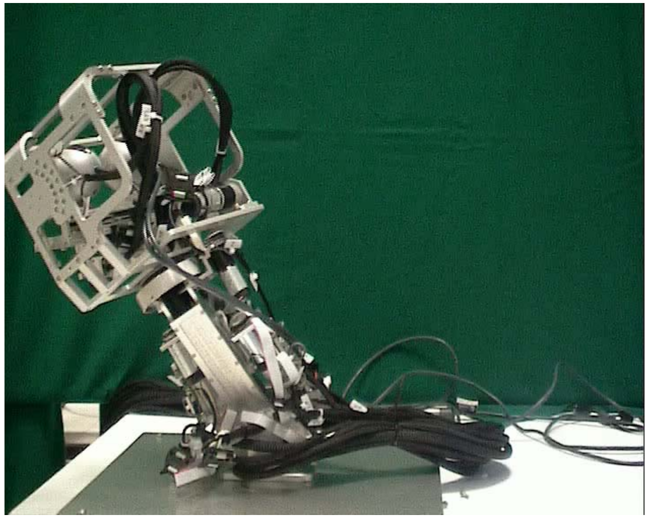
	Average	SD
Ventral flexion	60°	12
Dorsal flexion	61°	27
Right-left flexion	41°	7
Right-left rotation	79°	14

RANGE OF MOVEMENT AT THE NECK JOINT*
*Male civilians.

[Hamill et al., 1995]

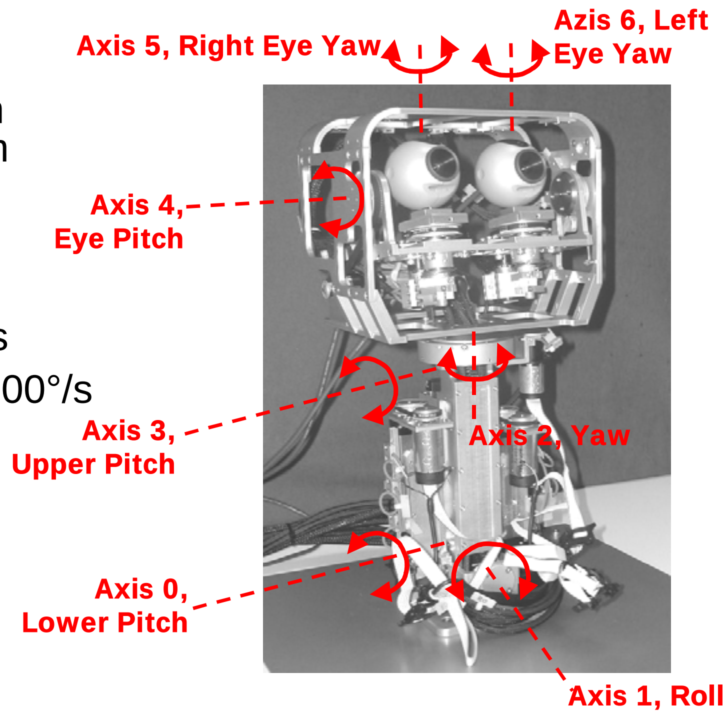
Human Specifications

- Two kinds of eye movements:
  - saccadic eye movements
  - smooth pursuit eye movements
- eyes have a common tilt movement and independent pan movements allowing vergence
- ranges of motion:
  - 120° for the tilt movements
  - 60° for the pan movements
- speed of eye movements: up to 600°/sec

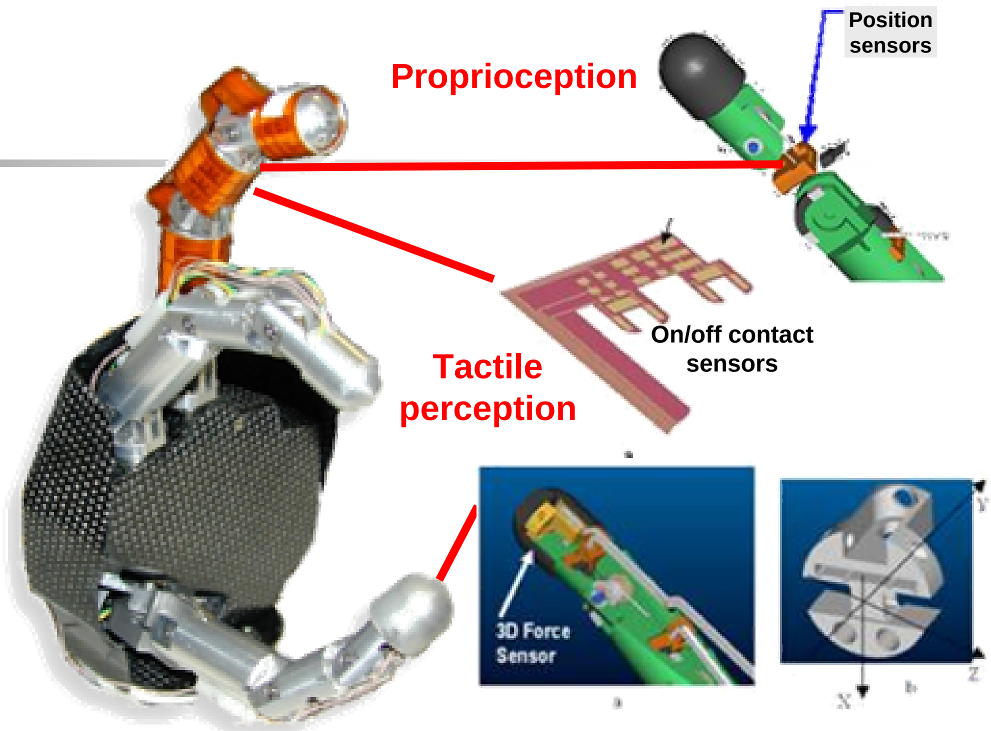


Head Specifications

- Dof: 7
- Dimension
  - neck: 200x100x100 mm
  - head: 180x200x150 mm
- Weight: 5.3 Kg
- Intraocular distance: variable from 60 to 100 mm
- Eye Pitch Axis: +47°, 600°/s
- Eye R/L Yaw Axis: +45°, 1000°/s
- Yaw: +100°, 170°/s
- Roll: +30°, 25°/s
- Upper Pitch: +30°, 120°/s
- Lower Pitch: +25°, 20°/s



The hand



Hand mechanical specifications

10 d.o.f.s; 6 underactuated, 4 motor actuated

- three identical underactuated 3 dofs fingers with cylindrical phalanges, driven by a single cable allowing flexion/extension
- a 2 DoFs trapezo-metacarpal joint at the base of the palm allowing thumb opposition movement (adduction/abduction) towards the other 2 fingers

Weight: about 400gr

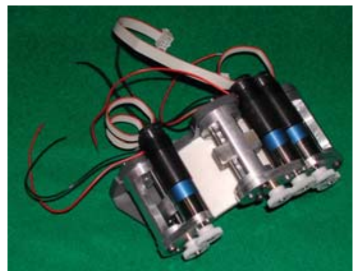
Dimension: similar to the human hand

Performances

- trapezo-metacarpal thumb joint abduction/adduction range: 0°-120°
- finger joints flexion range: 0-90°
- load weight: 350 gr
- grasping force: 35 N
- tip to tip force: 10 N
- closing time: 6 sec.

Proprioceptive System

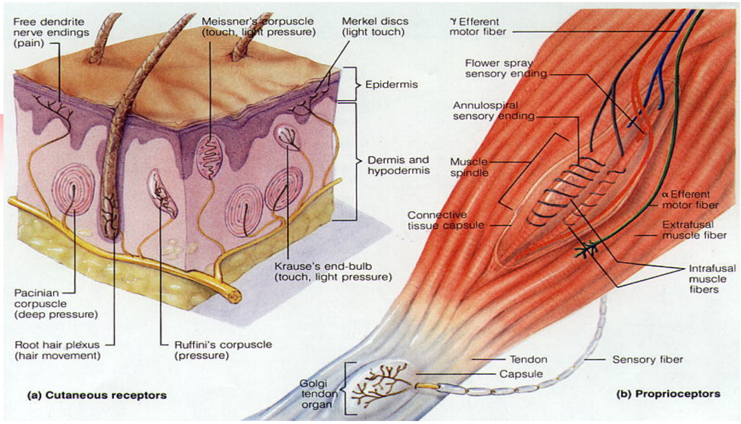
- 3 position Hall-effect sensors, one per phalanx, for each finger
- 4 motor encoders



Tactile System

- a 3D force sensor for each finger embedded in the fingertip providing the three force components of the contact
- 3 ON/OFF contact sensors for each finger

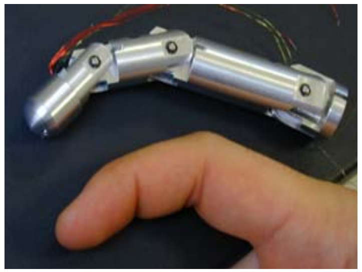
Natural and artificial tactile systems



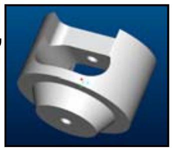
- The human hand has 3 major groups of somatosensory afferents:
    1. Tactile afferents in the skin
    2. Mechanoreceptors in the digital joints and associated tissues
    3. Stretch- and force-sensitive endings in the intrinsic and extrinsic muscles of the hand
- The glabrous skin has about 17,000 tactile units
- Several types of mechanoreceptors (Pacinian and Meissner corpuscles, Merkel's disks, Ruffini endings, etc.) for detecting intensity, pressure and acceleration stimuli

Proprioceptive system

9 Embedded Joint Angle Sensors
Operational range: 0 – 90 degrees,
Resolution: ~0.1 degrees.



Cable tension sensor
Operational range: 0 – 20 N,
output characteristic: linear,
resolution: ~20 mN



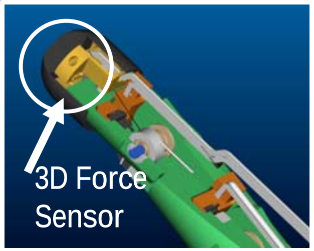
4 Encoders
Detection of the velocity of the actuators

1 accelerometer
Detection of the contact with the environment

Exteroceptive system

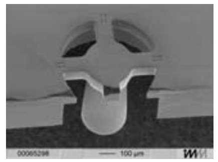
Distributed on/off contact sensor on flexible sheets
44 sensitive areas on each finger, 10 sensitive areas on the palm, 4 sensitive areas on the dorsum
(total: 149 sensors)

3D force sensor (force vector generator)



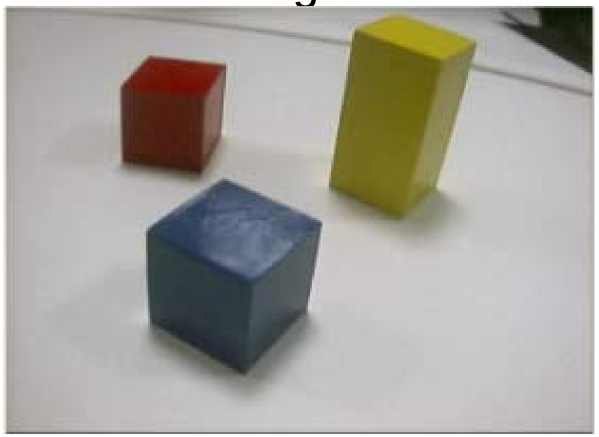
Integrated in the fingertips (sensitivity: ~1 mV/N, resolution: ~4.5÷6 mN)

Embedded in the hand artificial skin (micro-3D force sensors)



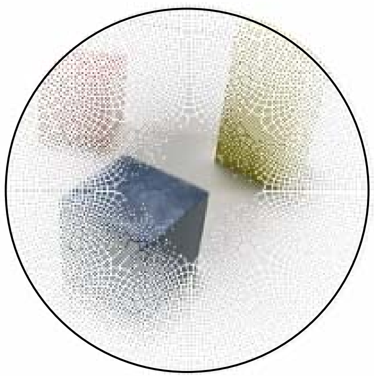
The Vision System: retina-like image processing

Standard image



Log-polar projection

Retina-like image



Visuo-motor co-ordination in face tracking

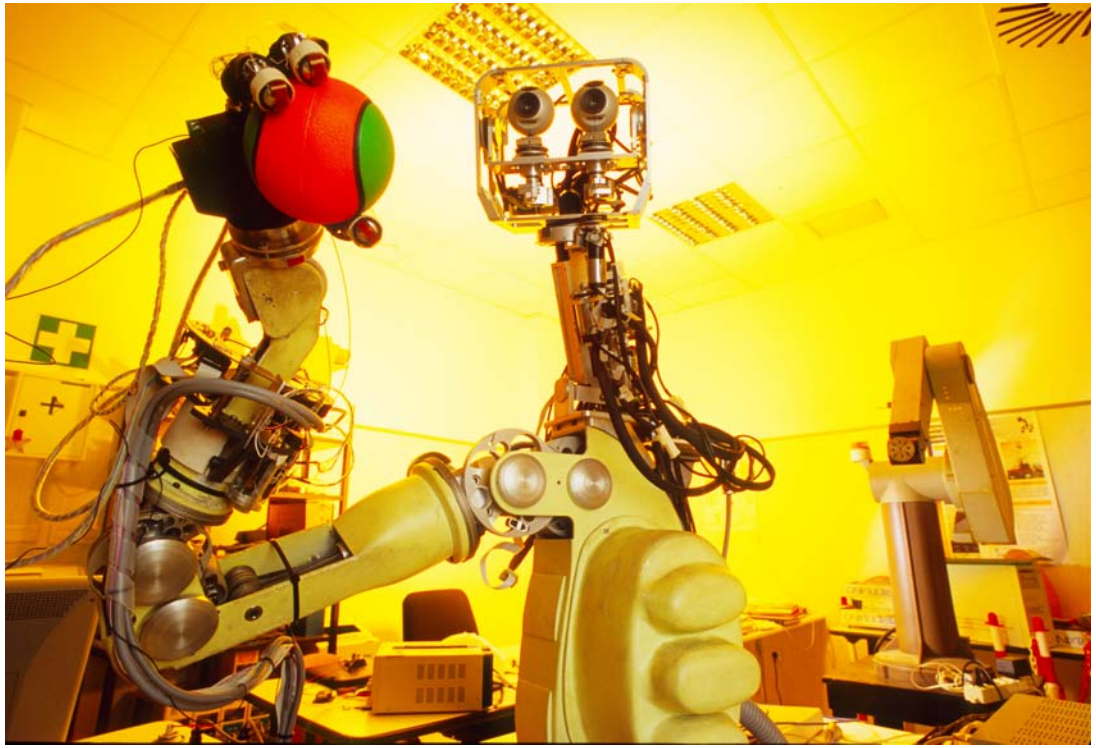
- Retina-like image (Giotto camera, University of Genova):
  - Fovea: 42 rings with resolution
  - Periphery: 110 rings, 252 pixels

$$r(\rho)=\left[\left(F-\tfrac{1}{2}\right)+\lambda\frac{1-\lambda^{\rho-F}}{1-\lambda}\right] \text{ if } \rho>F \quad r(\rho)=\left(\rho-\tfrac{1}{2}\right) \text{ if } \rho<F$$

G. Sandini, G. Metta, “Retina- like sensors: motivations, technology and applications”, in *Sensors and Sensing in Biology and Engineering*. T.W. Secomb, F. Barth, and P. Humphrey, Editors. Springer-Verlag. 2002.

Laschi C., Miwa H., Takanishi A., Guglielmelli E., Dario P., “Visuo-motor Coordination of a Humanoid Robot Head with Human-like Vision in Face Tracking” in *IEEE/ICRA2003, International Conference on Robotics and Automation, 2003*

Una piattaforma robotica per validare un modello dell'apprendimento della coordinazione senso-motoria per la presa nei neonati



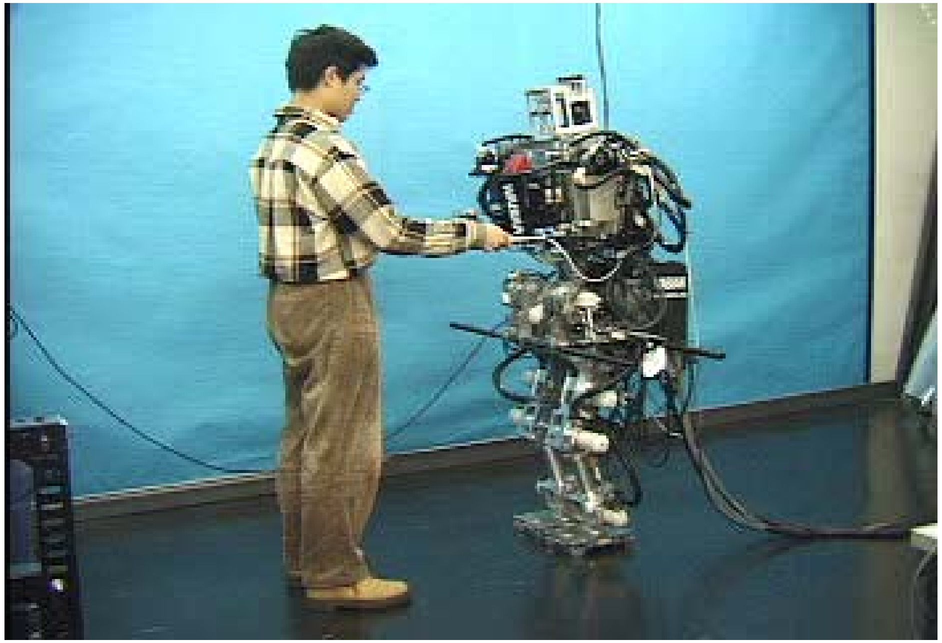
Obiettivi:

- Migliorare le conoscenze sulla connettività cerebrale (architettura) e sull'attività cerebrale (funzionalità), riguardo la coordinazione senso-motoria nella presa nei bambini
- Integrare una piattaforma robotica per la presa e la manipolazione per validare modelli neurofisiologici delle 5 fasi di apprendimento della coordinazione visuo-tatto-motoria nei neonati

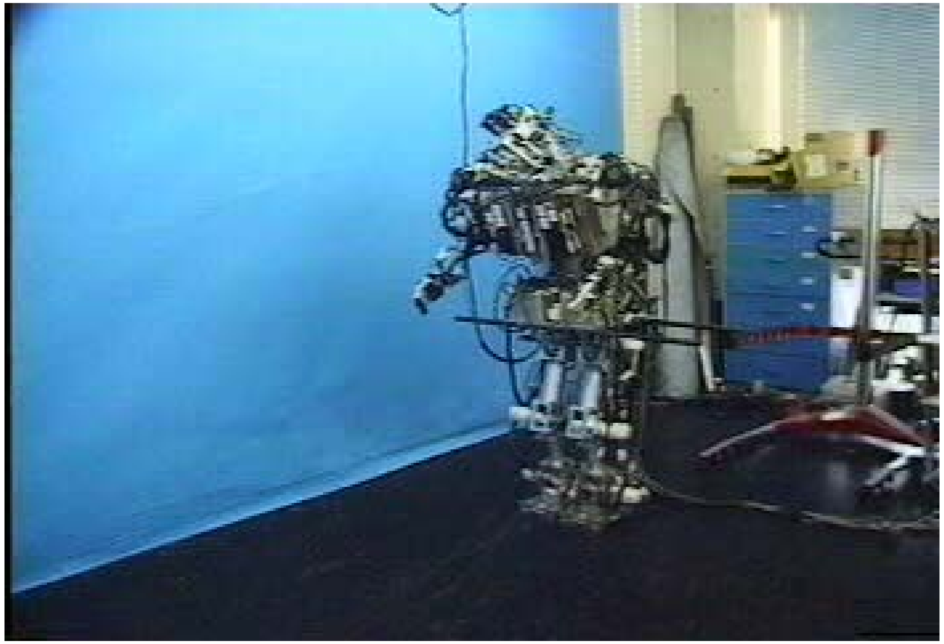
P. Dario, M.C. Carrozza, E. Guglielmelli, C. Laschi, A. Menciassi, S. Micera, F. Vecchi, "Robotics as a "Future and Emerging Technology: biomimetics, cybernetics and neuro-robotics in European projects", *IEEE Robotics and Automation Magazine*, Vol.12, No.2, June 2005, pp.29-43.

Bipedal Humanoid Robot WABIAN at Waseda University, Tokyo, Japan

WASEDA UNIV. HRI

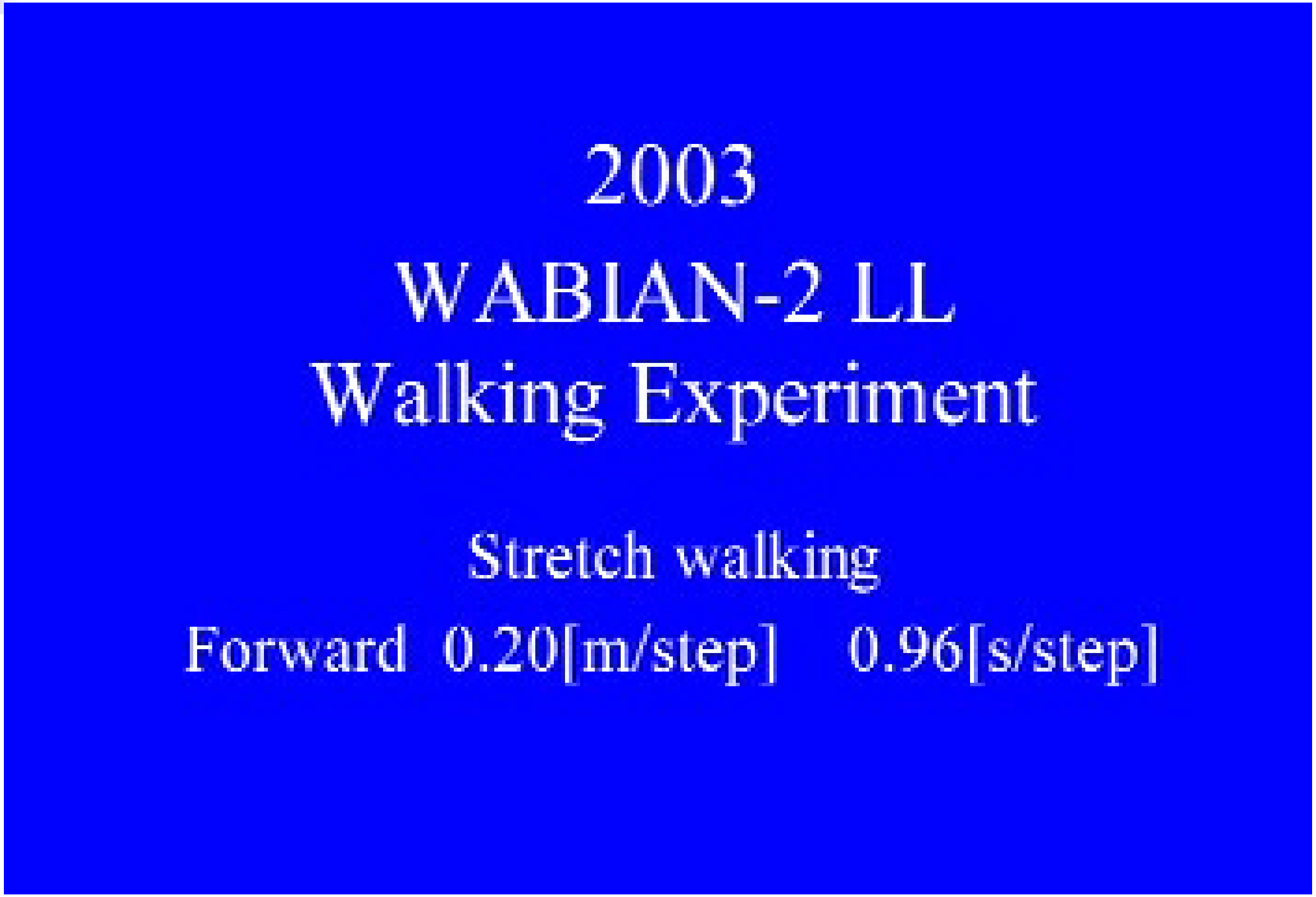


Interactive Dancing with Human



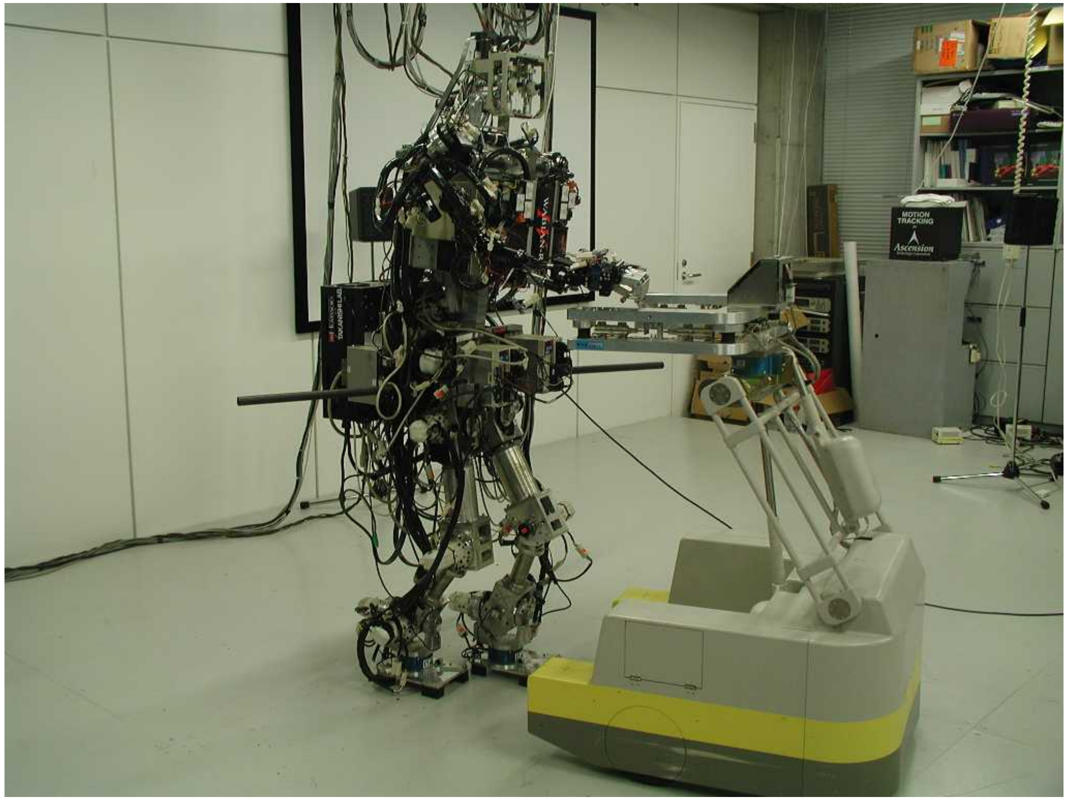
Emotion Expression Walking
(Happy Walk)

WABIAN-2LL: Human-like Knee Extended Gait to Simulate Human Biped Walking



Un robot umanoide come modello del cammino umano

Walking robot Wabian-2R



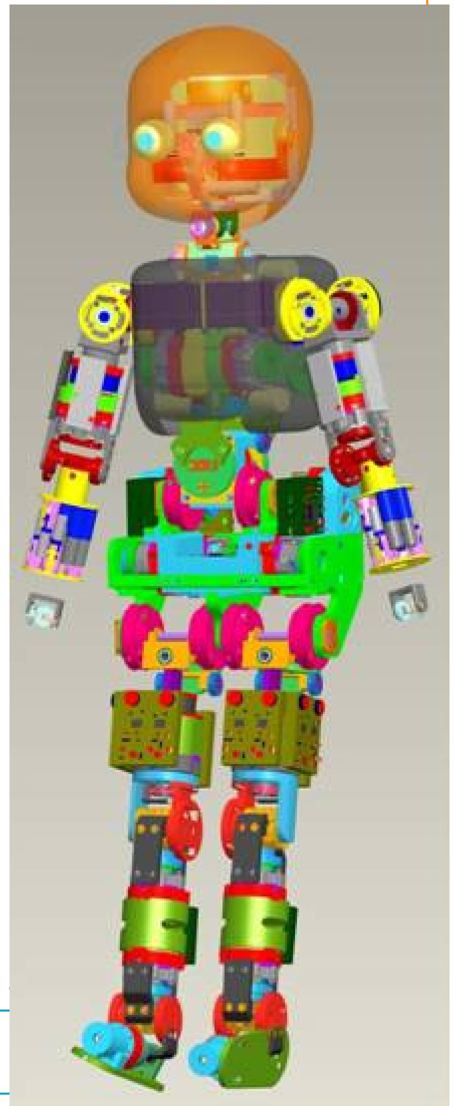
WABIAN come simulatore dell'Uomo e strumento per la progettazione e la valutazione quantitativa di sipositivi di supporto alla deambulazione

Università di Genova

RobotCub

Capire come il cervello degli esserei viventi trasforma l'input sensoriale in capacità motorie e cognitive, implementando modelli fisici di comportamenti senso-motori

EU RobotCub Project



G. Metta, G. Sandini, "Embodiment and complex systems. A commentary on Barbara Webb: Can robots make good models of biological behavior?", *Behavioral and Brain Sciences* 24(6) pp. 1068-1069, 2001.

ARTS Lab