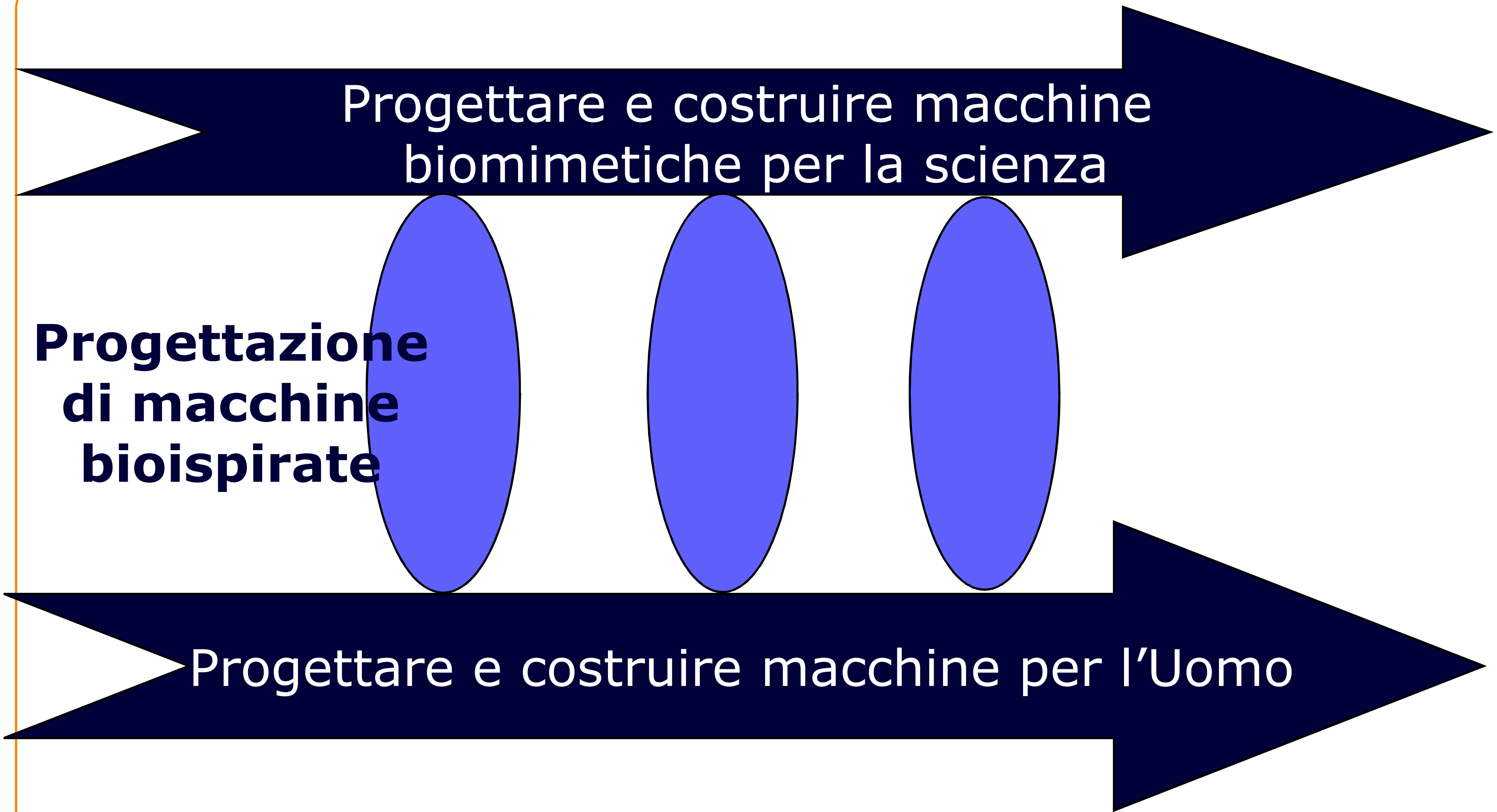
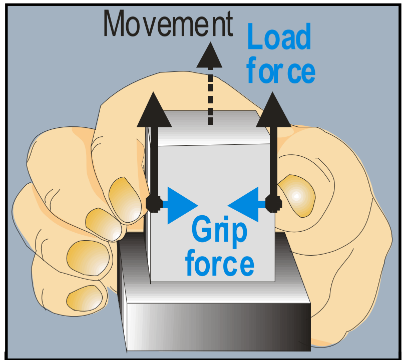
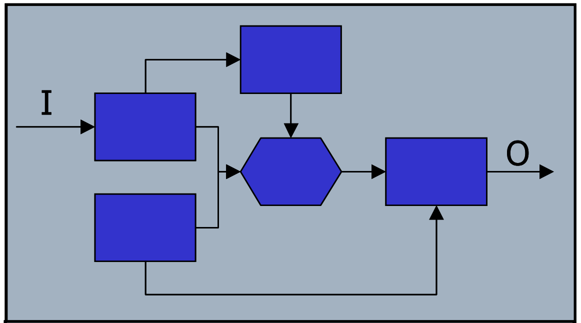
Scienza e Ingegneria Biorobotica



Scienza Biorobotica

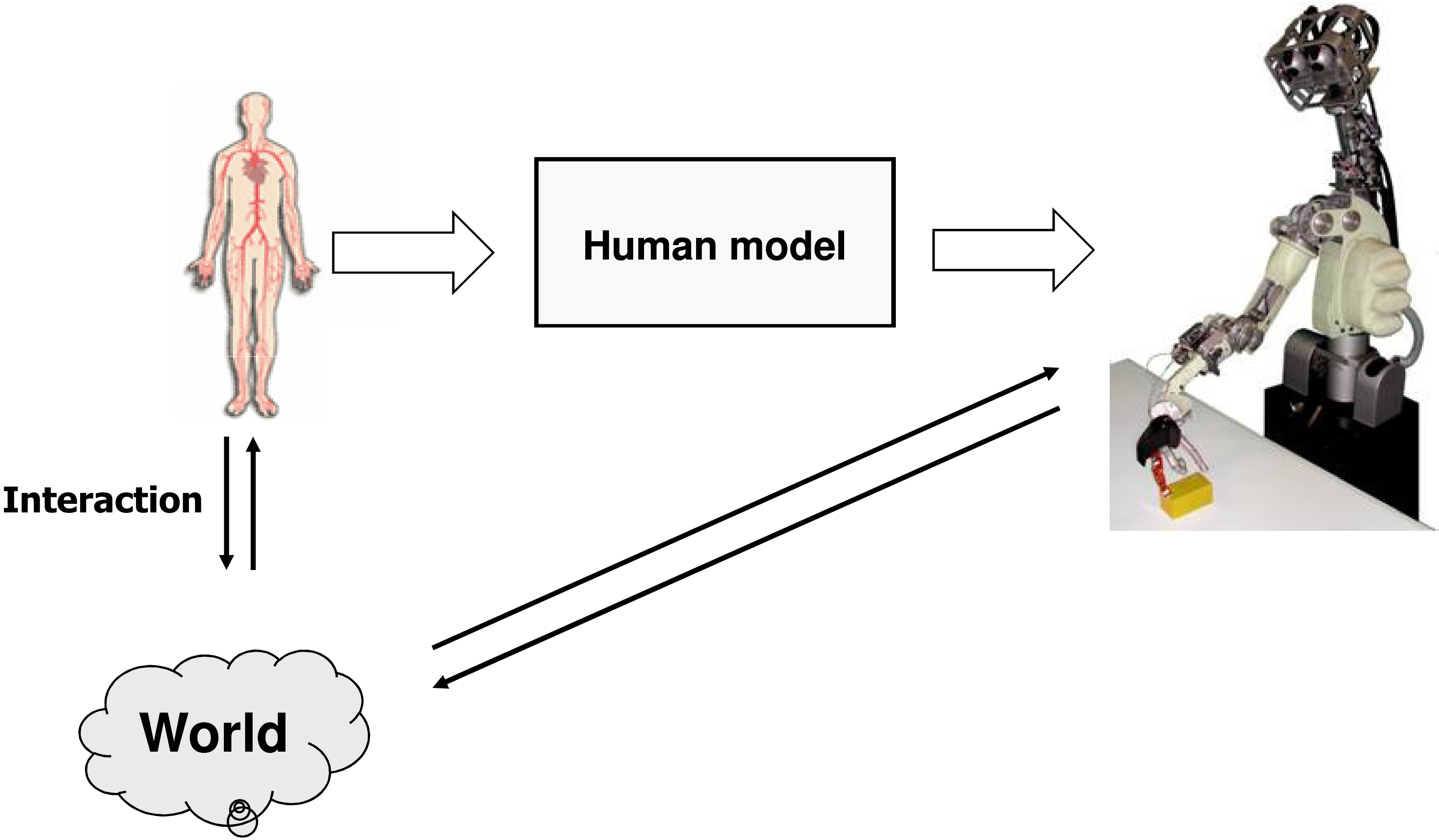


Fenomeno da studiare



Ipotesi e modello teorico

Biorobotica vs simulazione e modelli animali



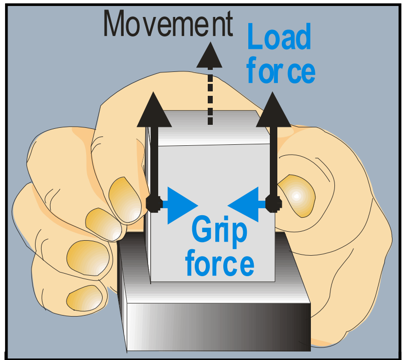
Biorobotic research at the AI Lab, MIT, USA

"Humanoid intelligence requires humanoid interactions with the world"

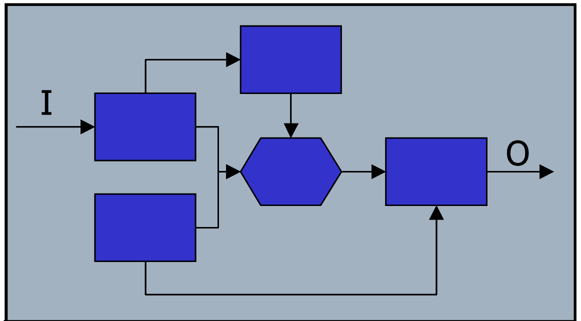
*"It turns out to be easier to build **real robots** than **to simulate complex interactions with the world**, including perception and motor control. Leaving those things out would deprive us of key insights into the nature of human intelligence".*

Rodney Brooks

Scienza Biorobotica

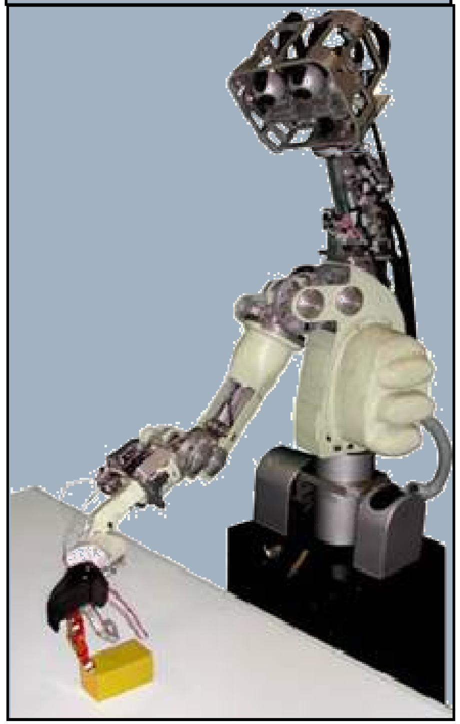


Fenomeno da studiare



Ipotesi e modello teorico

Implementazione in un robot



Validazione del modello

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

Biorobotics epistemology

Proto-Cybernetics **(J. Loeb 1905, 1912; H. S. Jennings 1906)**
Mechanicism Vs. Functionalism for studying the behavior of living organisms

If a machine is implemented on the basis of a theory of behavior, and ***it behaves according to what this theory allows to predict***, this test reinforces the proposed theory

Cybernetics **(Rosenblueth, Wiener, Bigelow 1943)**

Unified approach to the study of living organisms and machines

Purposive adaptive behaviors (in animals and humans) are produced by *feedback machines (teleology)*

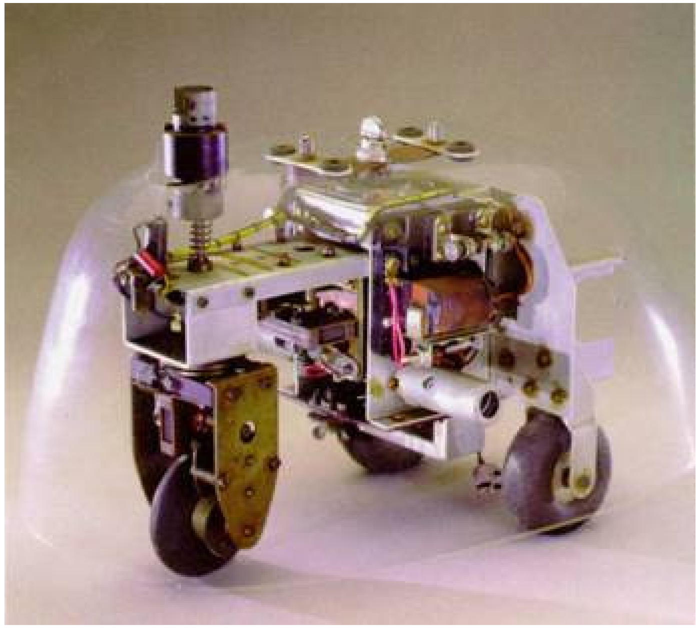
Machines as 'material models' useful for testing scientific hypotheses

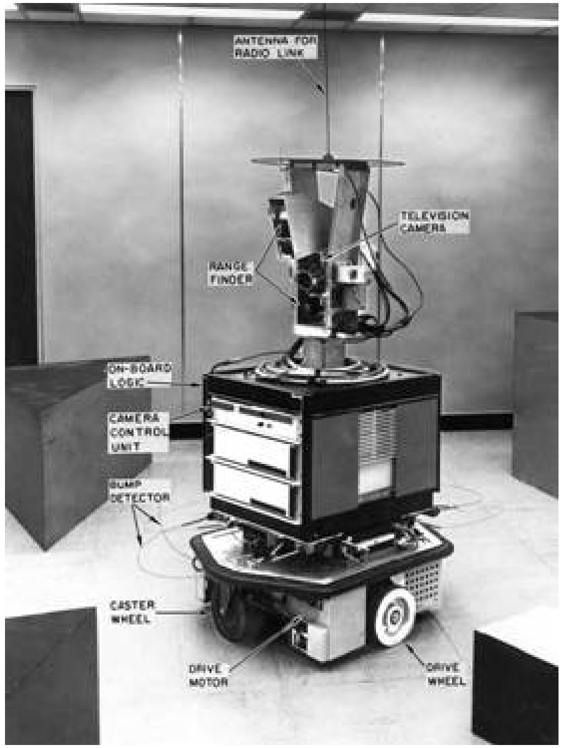
Machines are used for SCIENCE

Cybernetic Robotics

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

Machina speculatrix, Machina docilis, etc.





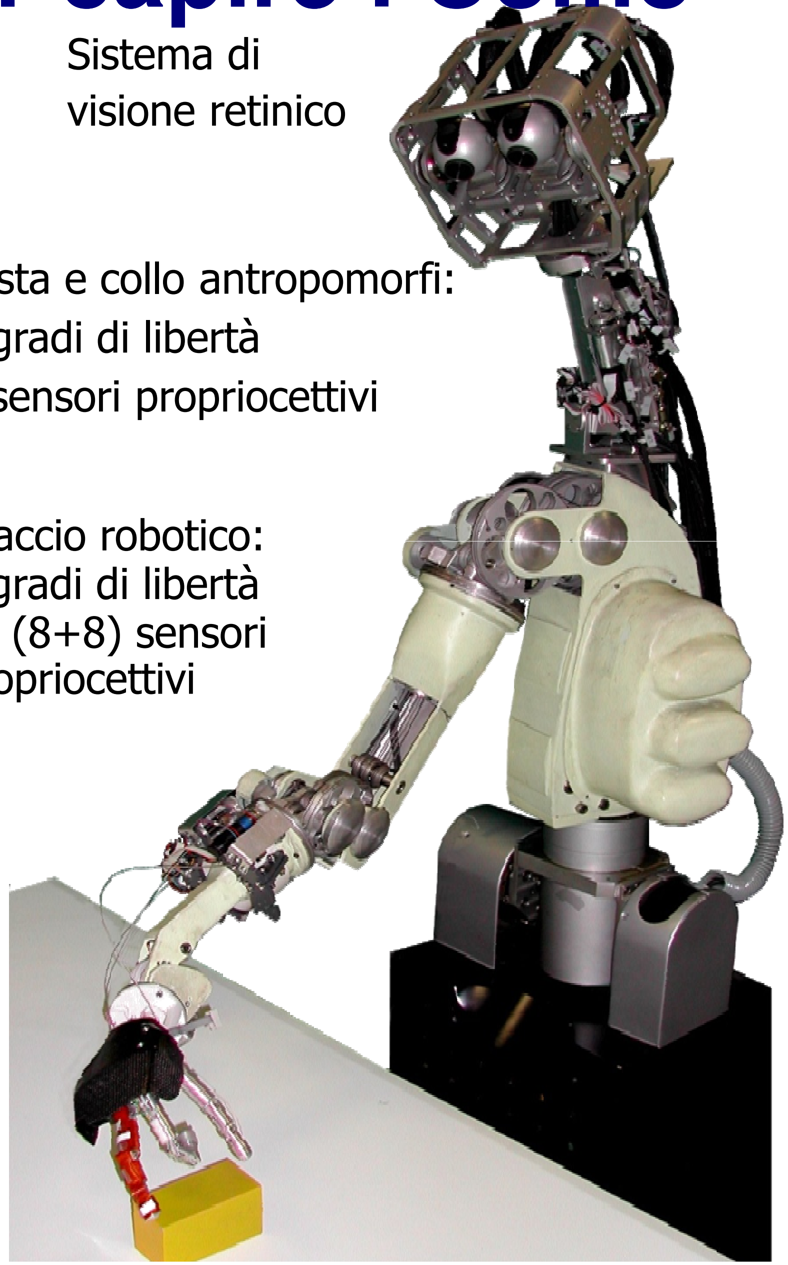
Early robots (’80/’90)

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



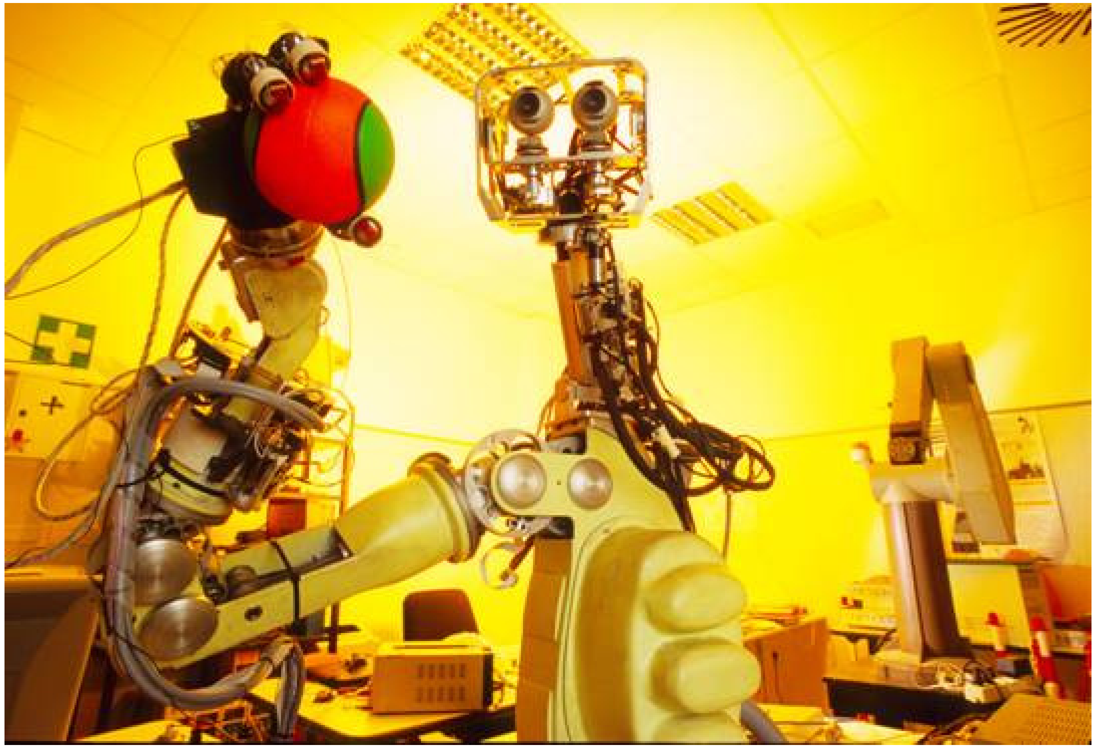
Gradi di libertà	25
Sensori propriocettivi	36
Sensori tattili	12
Sensori visivi	2

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

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



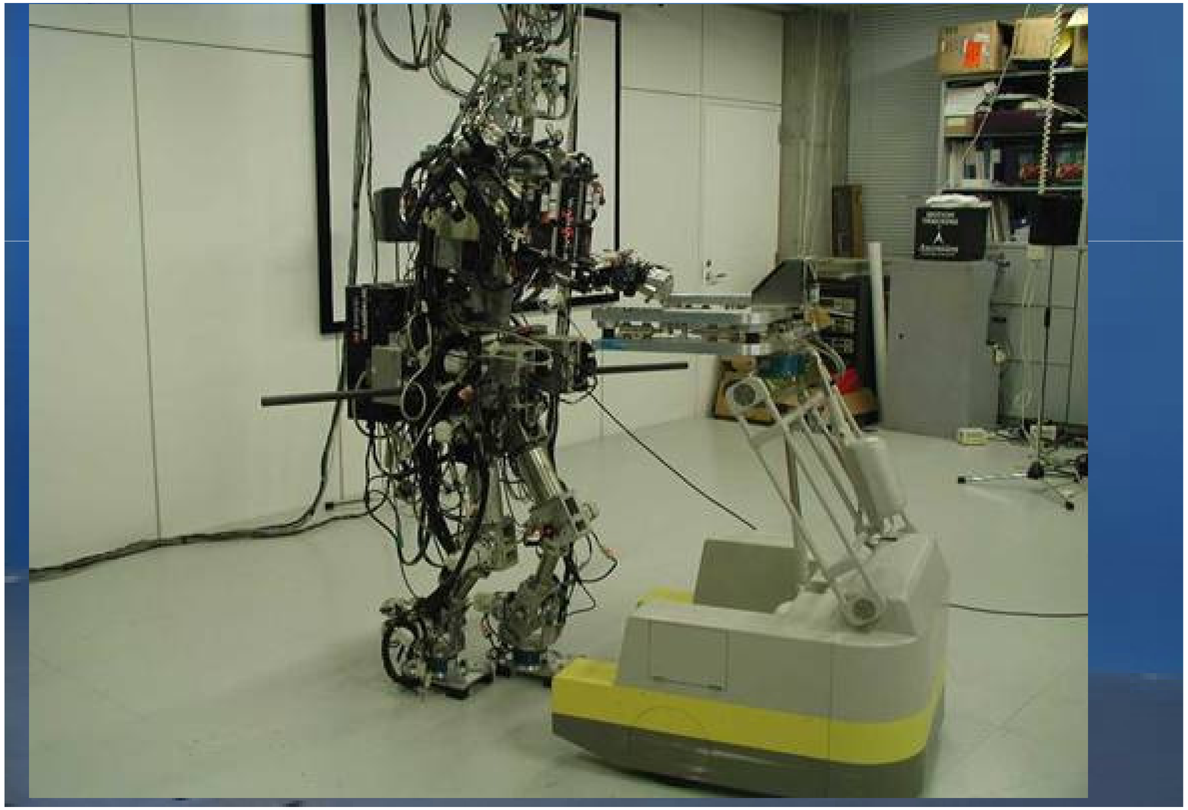
P. Dario, M.C. Carrozza, E. Guglielmelli, C. Laschi, A. Menciassi, S. Micera, F. Vecchi, "Robotics as a "Future and Emerging Technology: biomimetics, cybernetics and neuro-robotics in European projects", *IEEE Robotics and Automation Magazine*, Vol.12, No.2, June 2005, pp.29-43.

PALOMA EU IST-FET Project IST-2001-33073

ARTS Lab, Scuola Superiore Sant'Anna, Pisa

Un robot umanoide come modello del cammino umano

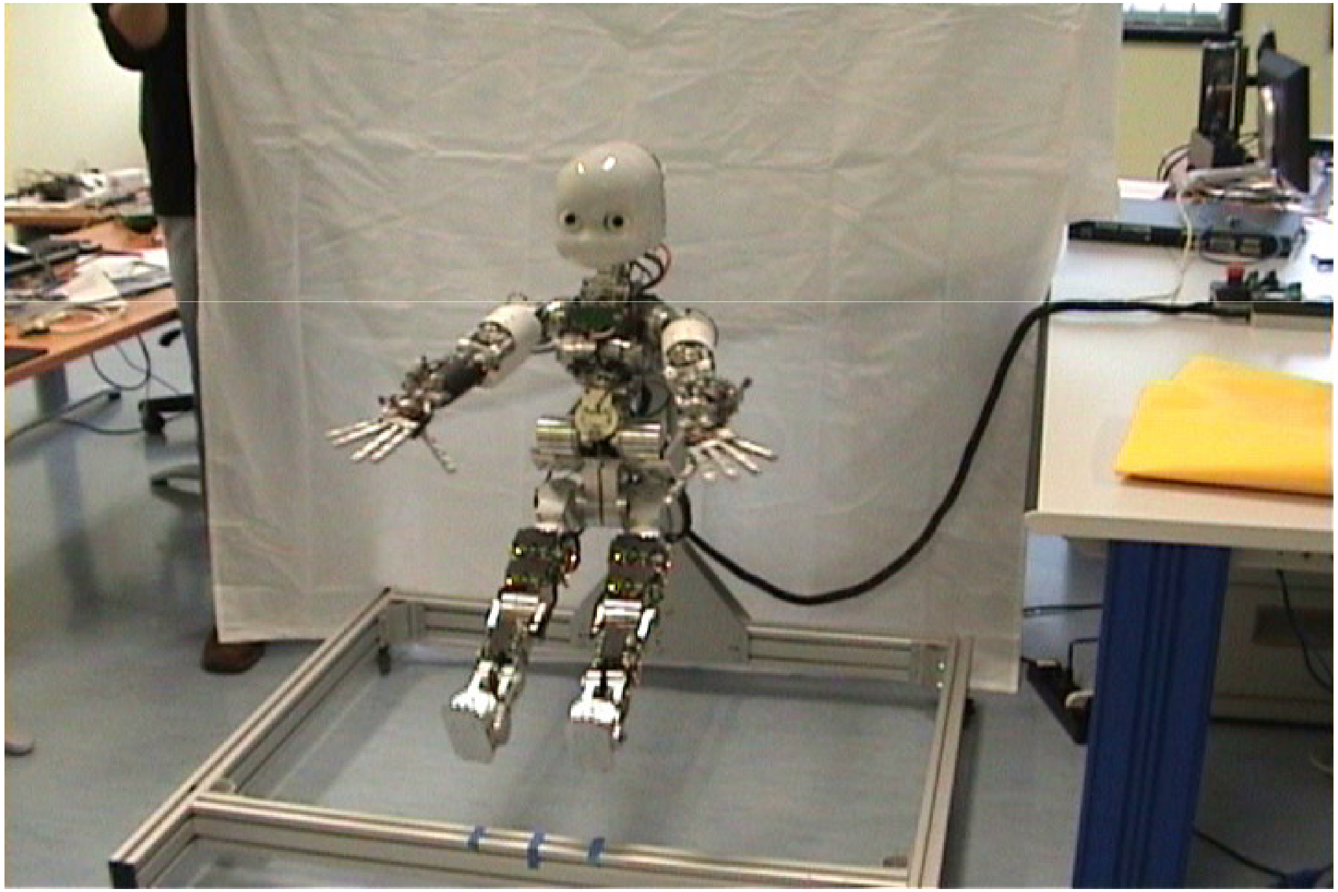
Walking robot Wabian-2R

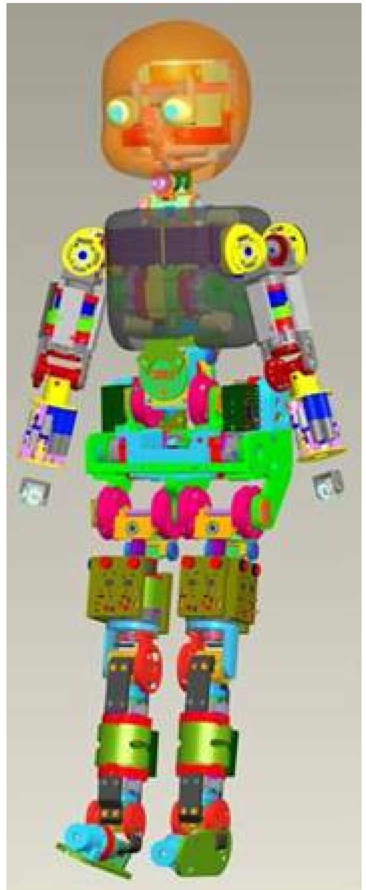


WABIAN come simulatore dell'Uomo e strumento per la progettazione e la valutazione quantitativa di sipositivi di supporto alla deambulazione

RobotCub Project

Objective: to understand how the brain of living systems transforms sensory input into motor and cognitive functions by implementing physical models of sensory-motor behaviours





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.

From Swimming to Walking with a Salamander Robot Driven by a Spinal Cord Model

Auke Jan Ijspeert,[1*] Alessandro Crespi,[1] Dimitri Ryczko,[2,3] Jean-Marie Cabelguen[2,3]

The **transition from aquatic to terrestrial locomotion** was a key development in vertebrate evolution.

An amphibious salamander robot demonstrates how **a primitive neural circuit for swimming can be extended by phylogenetically more recent limb oscillatory centers** to explain the ability of salamanders to switch between swimming and walking.

The model suggests **neural mechanisms for modulation of velocity, direction, and type of gait that are relevant for ALL tetrapods.**

9 MARCH 2007 VOL 315 SCIENCE www.sciencemag.org

CPG Model and the Robot

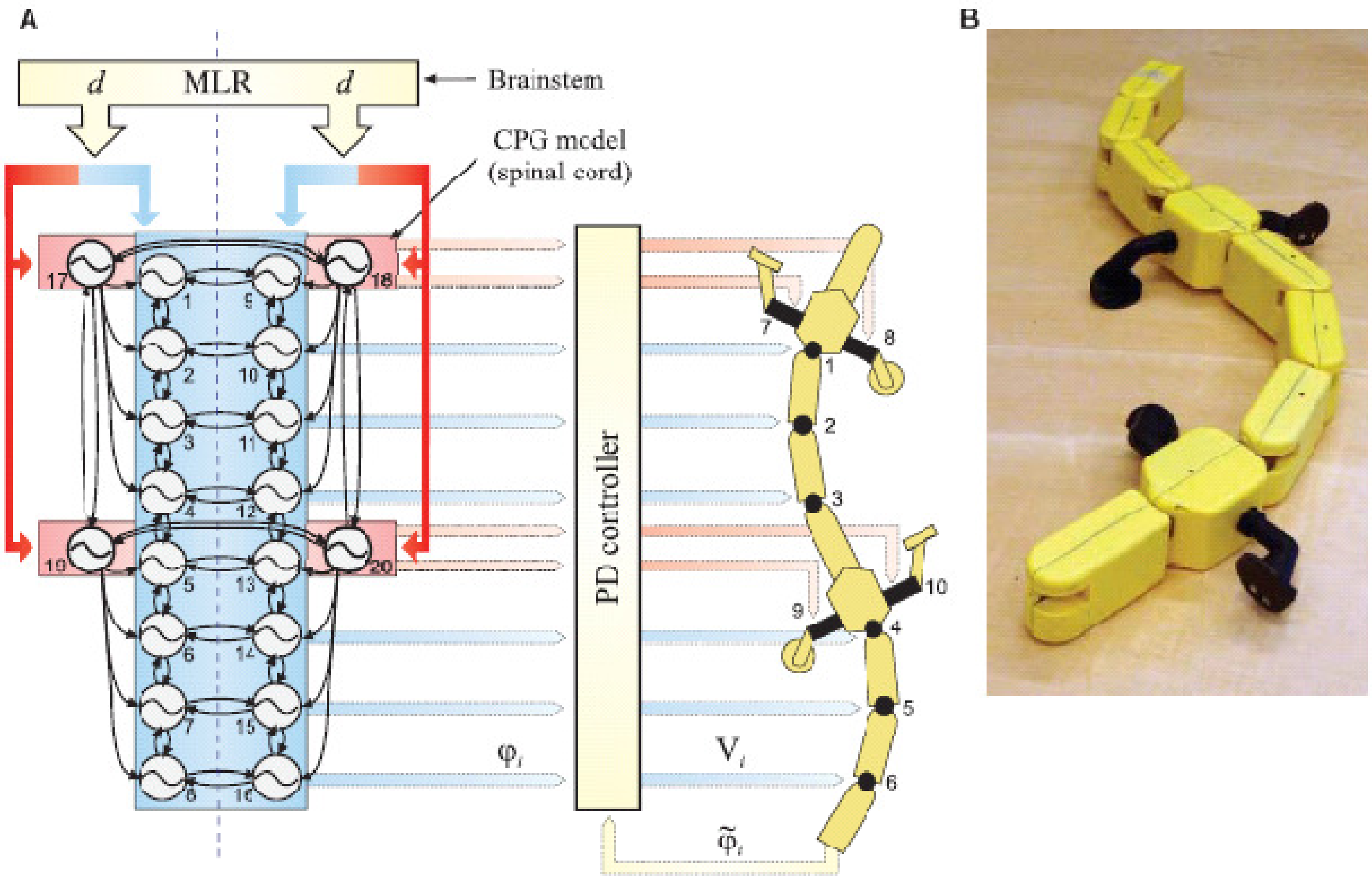
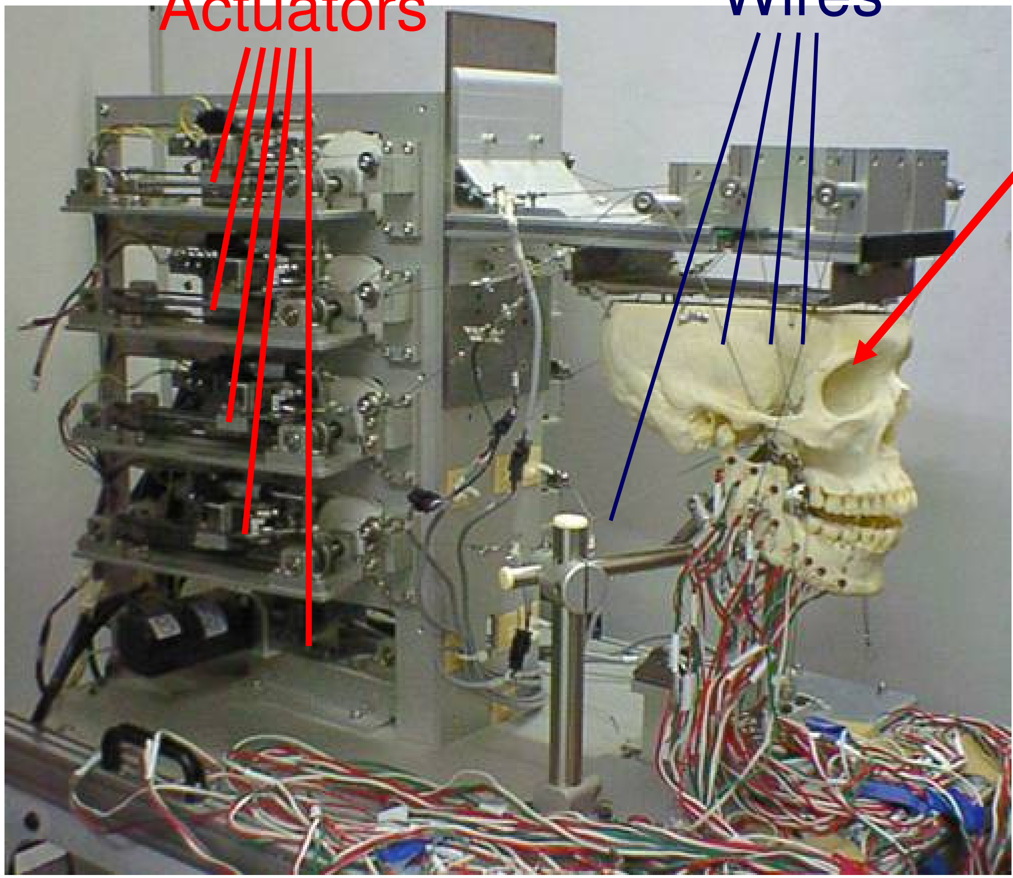


Fig. 1. Configuration of the CPG model (**A**) and salamander robot (**B**). The robot is driven by 10 dc motors, which actuate six hinge joints for the spine (black disks in the schematic view of the robot) and four rotational joints for the limbs (black cylinders). The CPG is composed of a body CPG—a double chain of 16 oscillators with nearest-neighbor coupling for driving the spine motors—and a limb CPG—4 oscillators for driving the limb motors. The outputs of the oscillators are used to determine the setpoints φ_i (desired angles) provided to proportional-derivative (PD) feedback controllers that control the motor torques (through their voltage V_i) given the actual angles $\tilde{\varphi}_i$. The CPG model receives left and right drives d representing descending signals from the MLR region in the brain stem. The velocity, direction, and type of gait exhibited by the robot can be adjusted by modifying these two signals.

Dental Robotics: Clarify Human Mastication with Mastication Scientists

WASEDA UNIV. HRI



Real Human Dry Skull

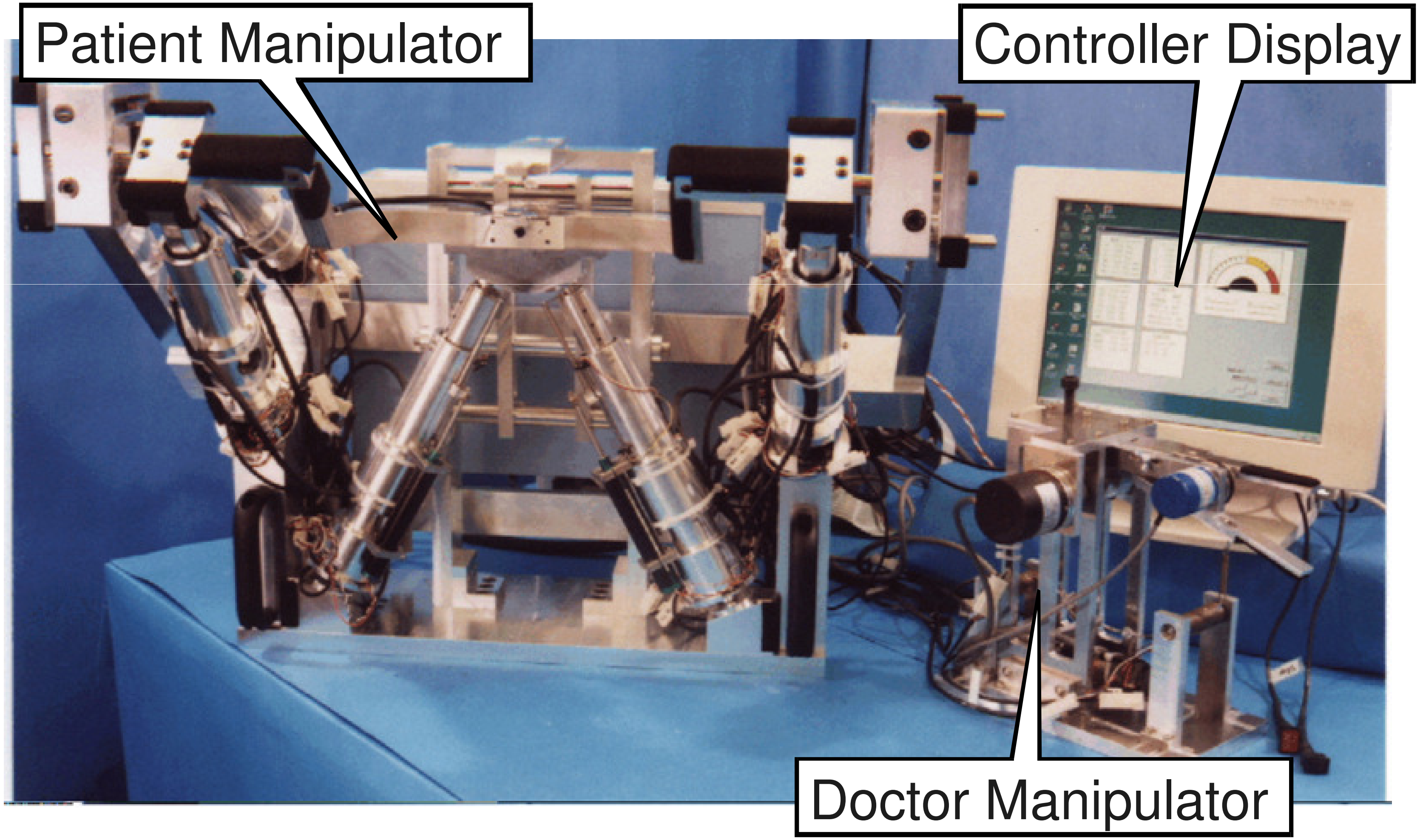
Height	: 510 [mm]
Width	: 450 [mm]
Depth	: 600 [mm]

9 DOF

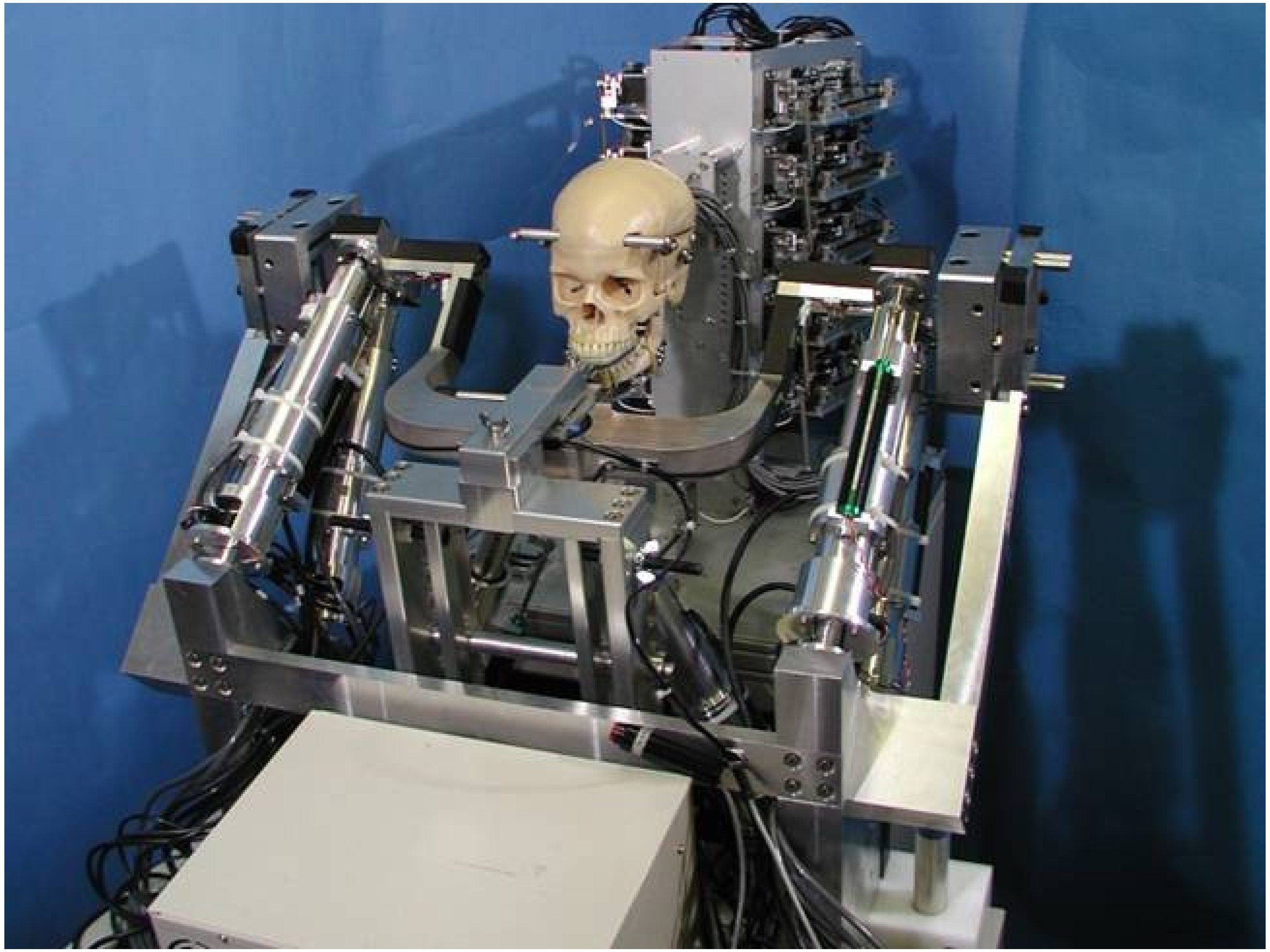
-9 AC Servo Motors
-Wire Drive
-Nonlinear Viscoelasticity

With OKINO Industries

Jaw Training Robot for TMD Patients Designed using Human Mastication Model

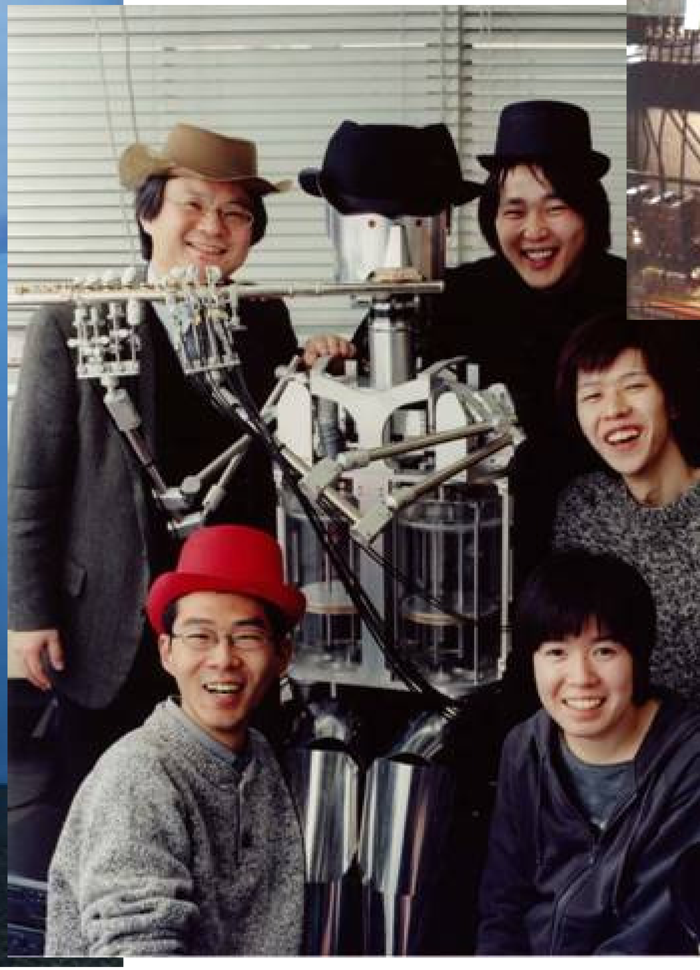


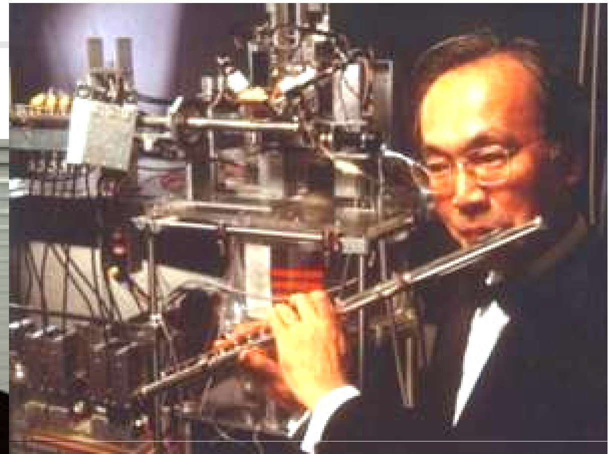
Jaw Training Robot and Patient Simulator Robot for Exploring New Robotic Treatment Methodology



Flutist Robot for Simulating Human Flute Playing:WF-4

WASEDA UNIV. HRI



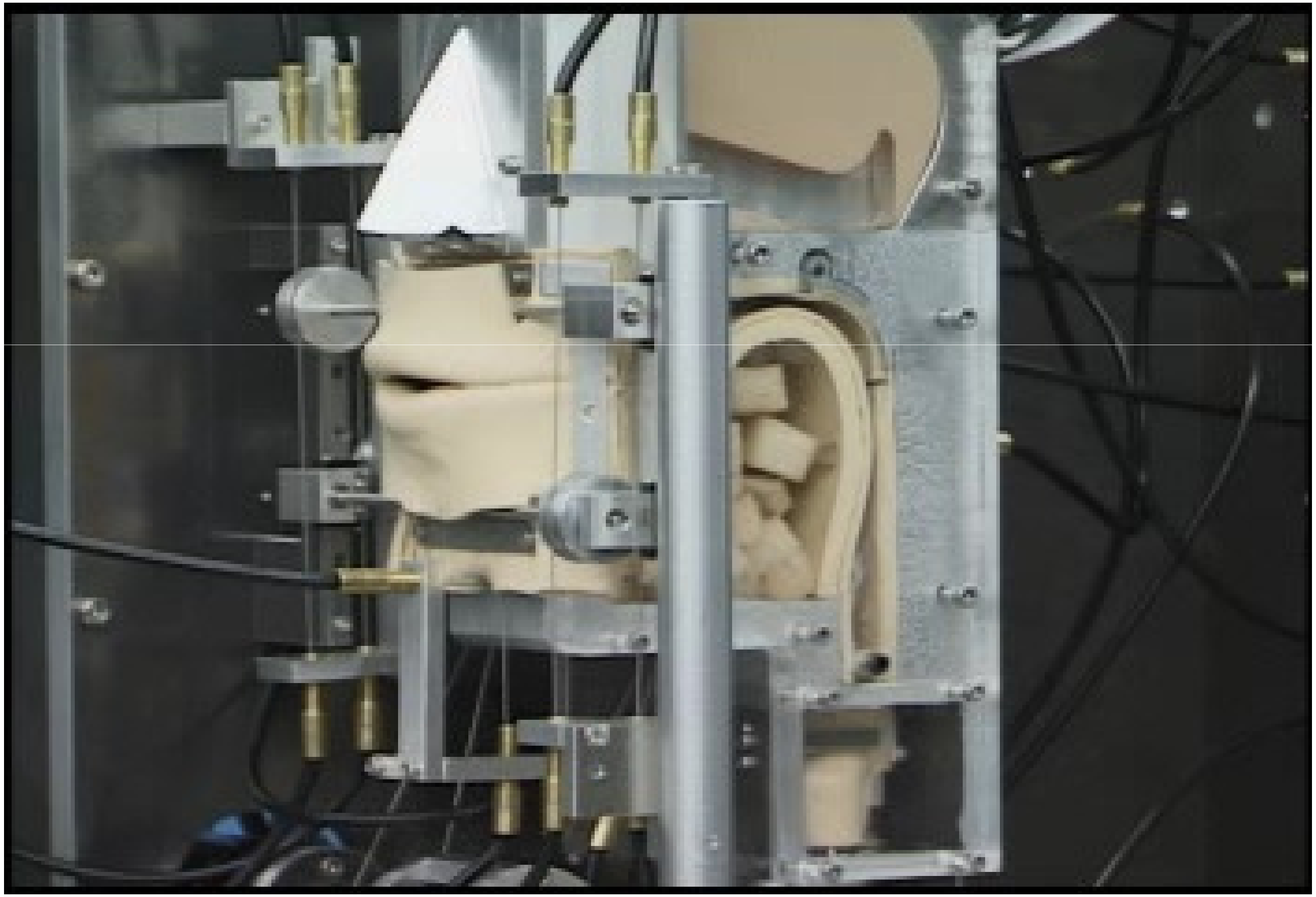


Professional Flutist: Mr. Kunimitsu Wakamatsu

SolidWorks

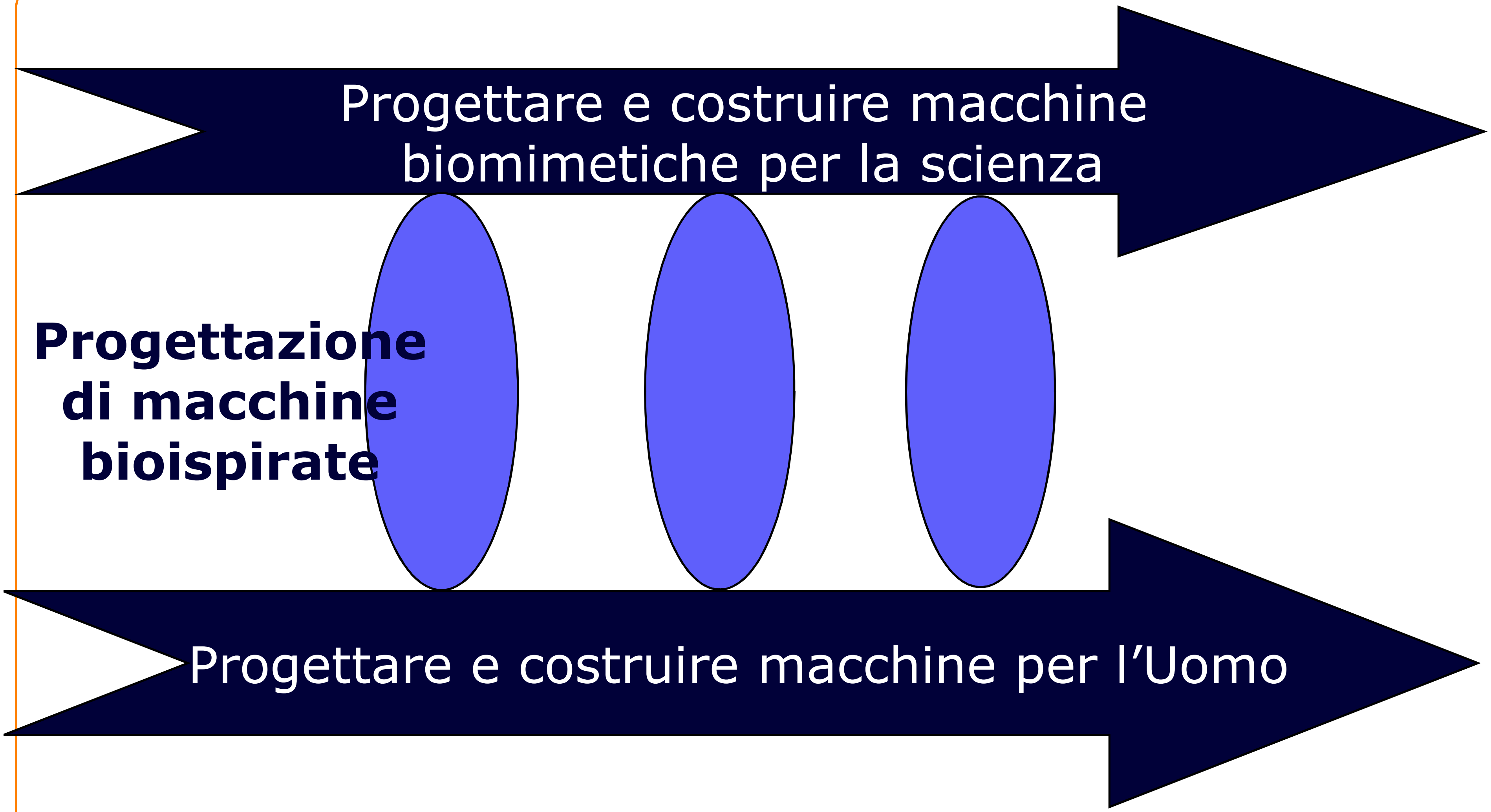
GIFU-WASEDA WABOT-HOUSE Project

Modeling of Human Speech Production Using Talking Robots: WT-3/4



Waseda Daigaku (Waseda University)

Scienza e Ingegneria Biorobotica



Ingegneria Biorobotica

Robotica in chirurgia

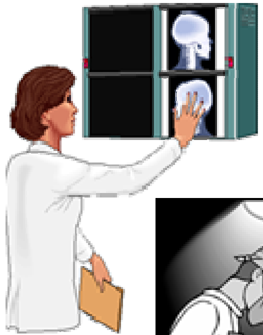
Il robot chirurgico “Da Vinci”

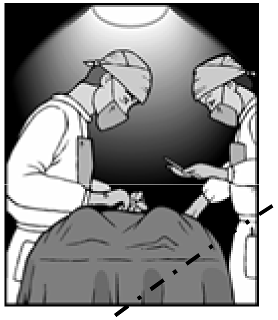
Da Vinci System, Intuitive Surgical Inc.

- Master-slave manipulator equipped with 2 articulated joints at the tip of the surgical instruments allowing 7 degrees of freedom
- Mimics the movements of surgeon's wrist and fingers in the abdominal or thoracic cavity

The Evolution of Surgery

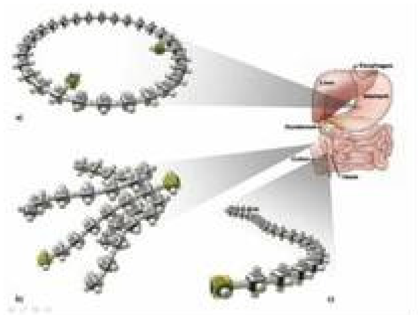
TRADITIONAL SURGERY



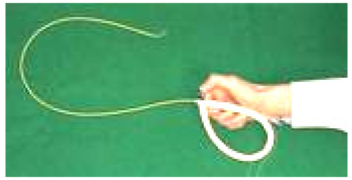


MINIMALLY INVASIVE SURGERY

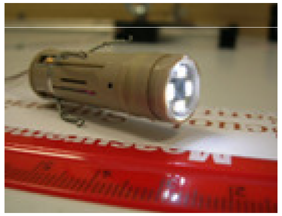
Da Vinci CAS system



ENDOLUMINAL SURGERY



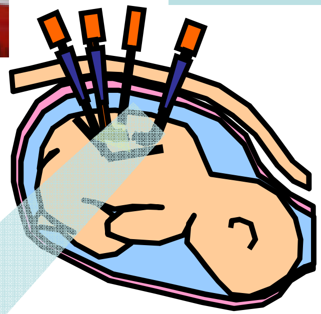
Micro-endoscope for spinal cord

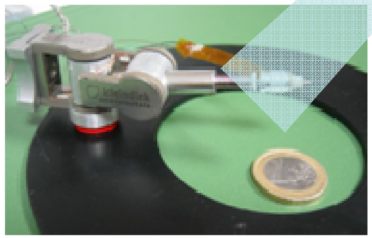


Endoscopic capsules

Reconfigurable surgical systems

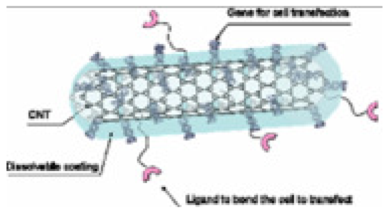
FETAL SURGERY





Force-feedback scissor for fetal surgery

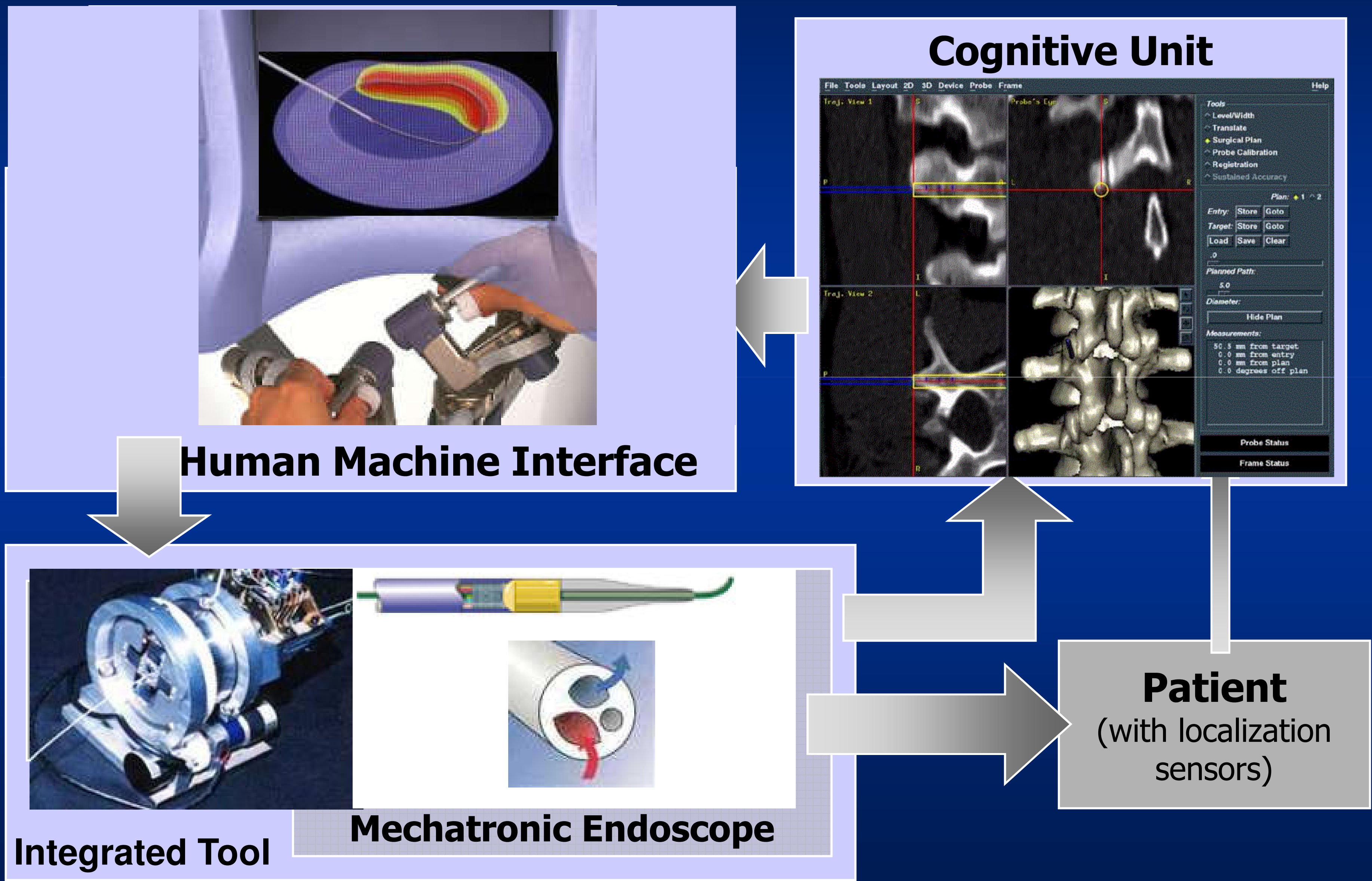
CELL SURGERY



Artificial virus for cell therapy

CRIM

A system for spinal endoscopy



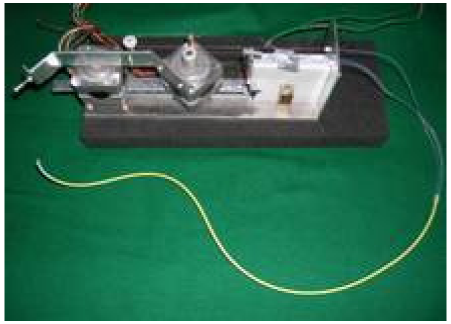
Information Society Technologies

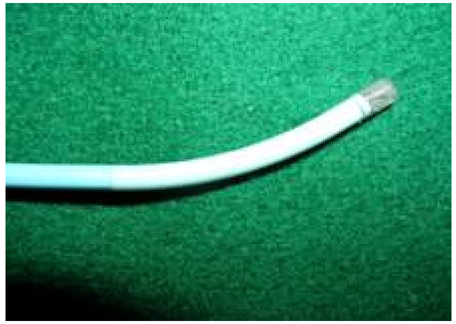
The MiNOSC robotic endoscopic platform

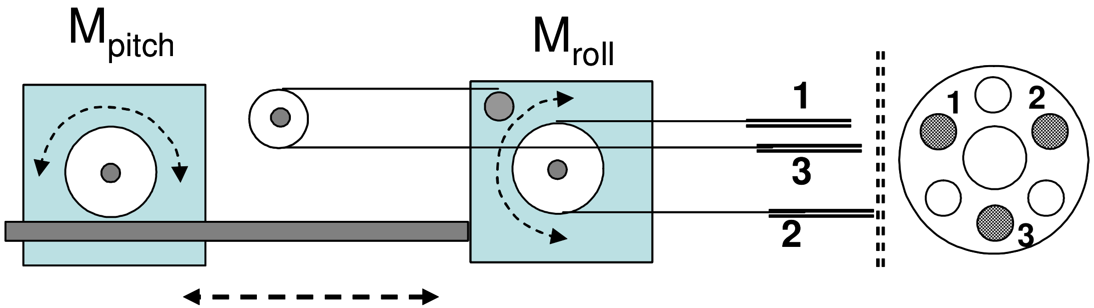
Neurobotics

The robot-assisted endoscopic platform is set in the operating room.

The motor unit and the steerable catheter tip







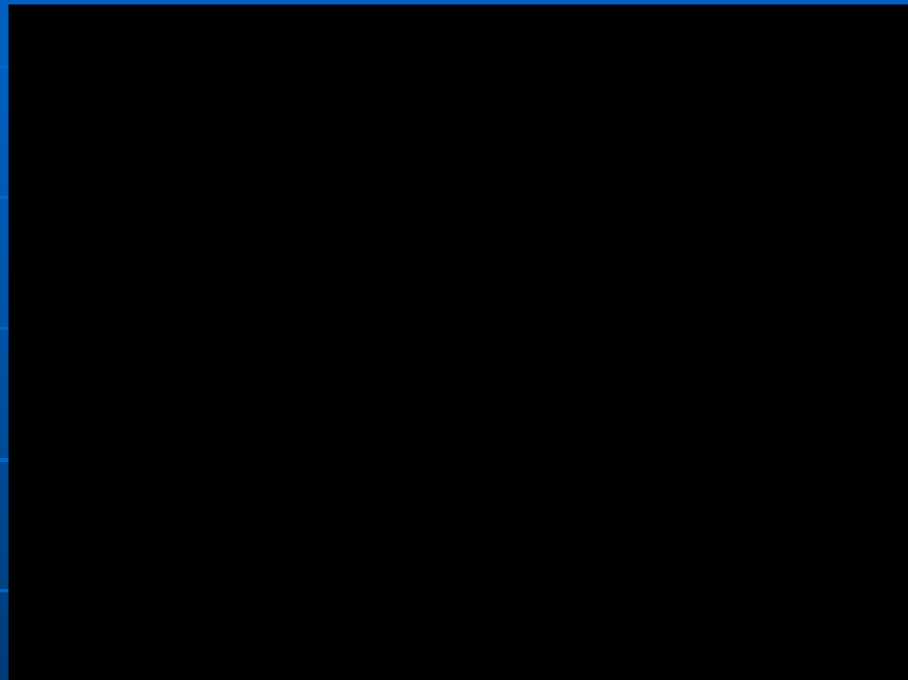
Schematic view of the 2 DoF motor unit; on the right: section of the catheter; the dotted channels are used by the cables.

Future and Emerging Technologies

Neurobotics - The fusion of Neuroscience and Robotics, FP6-IST-001917 (www.neurobotics.info). A project funded by the Future and Emerging Technologies arm of the IST programme

Segmentazione delle immagini endoscopiche

- Risultati:
  - L'algoritmo di segmentazione riesce sempre ad isolare correttamente le regioni lumen le quali non vengono mai sovradimensionate
  - Le vene vengono riconosciute correttamente
  - I nervi vengono isolati correttamente anche se esistono possibili interpretazioni sbagliate di bolle d'aria con riflessi molto luminosi
  - L'impiego del software su filmati di endoscopia su animale hanno evidenziato le capacità dell'algoritmo di essere impiegato in applicazioni in tempo reale

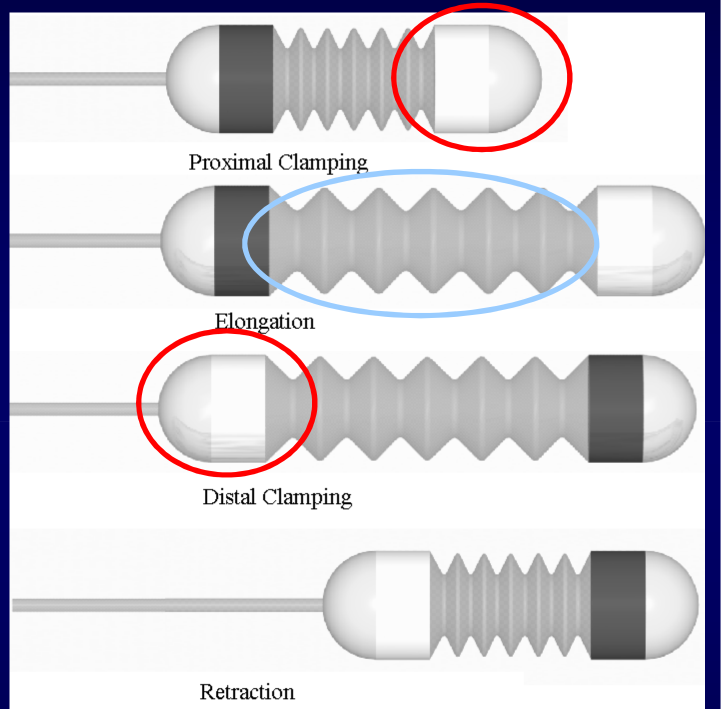


“Inchworm” locomotion

Distal clamper

Central elongator

Proximal clamper



Typical colonoscopy prototype

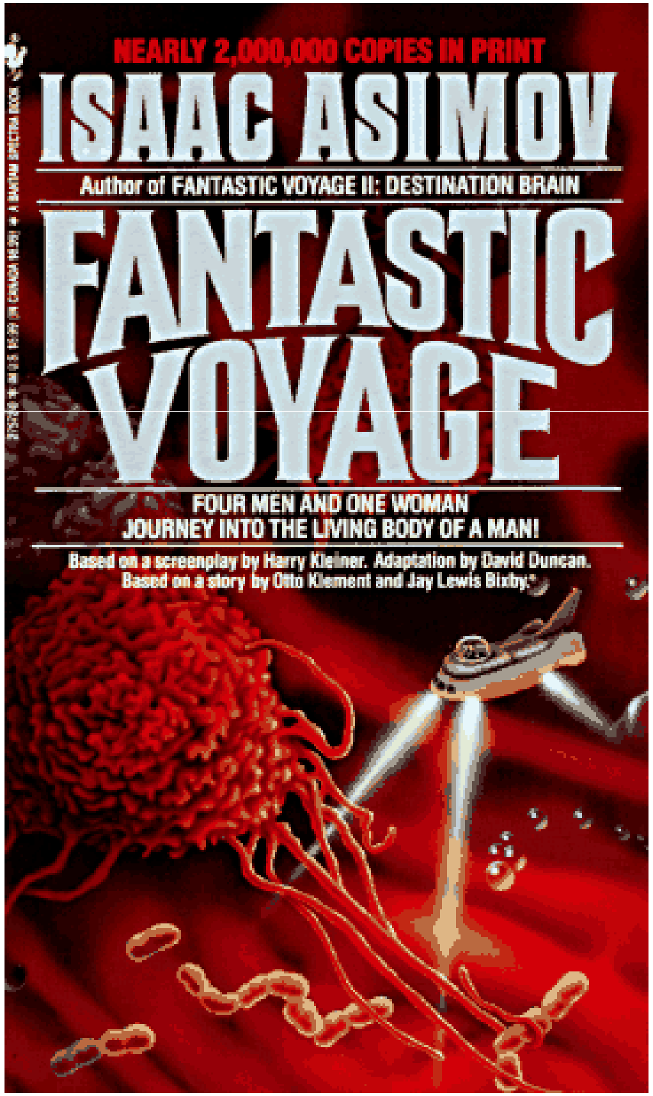
Diameter : 24 mm

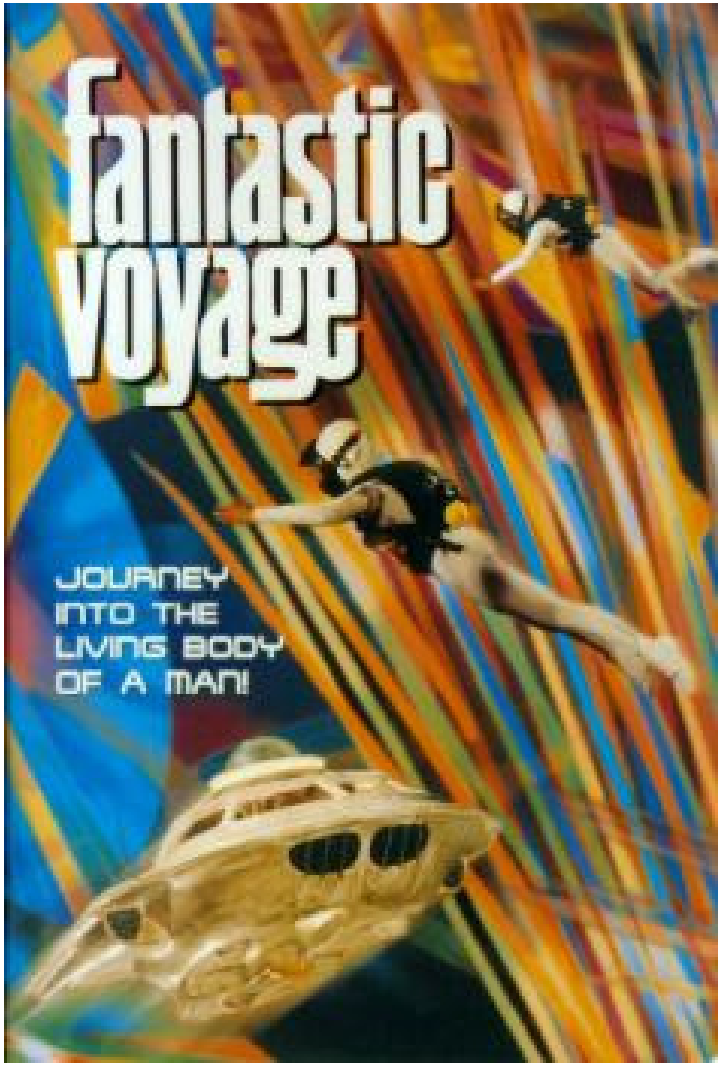
Retracted Length : 115 mm

Elongated Length : 195 mm

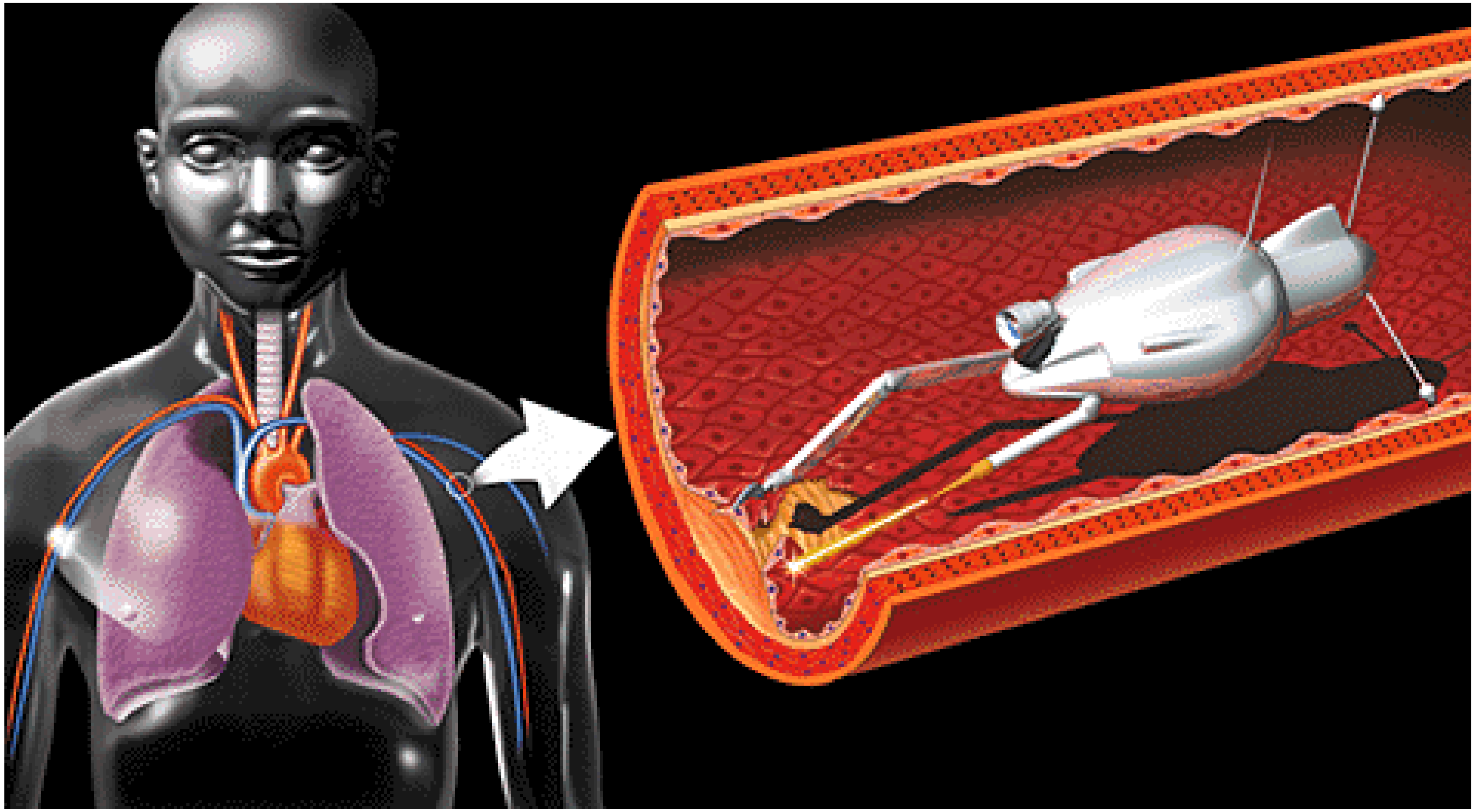
Stroke: 80 mm

Fantascienza...?



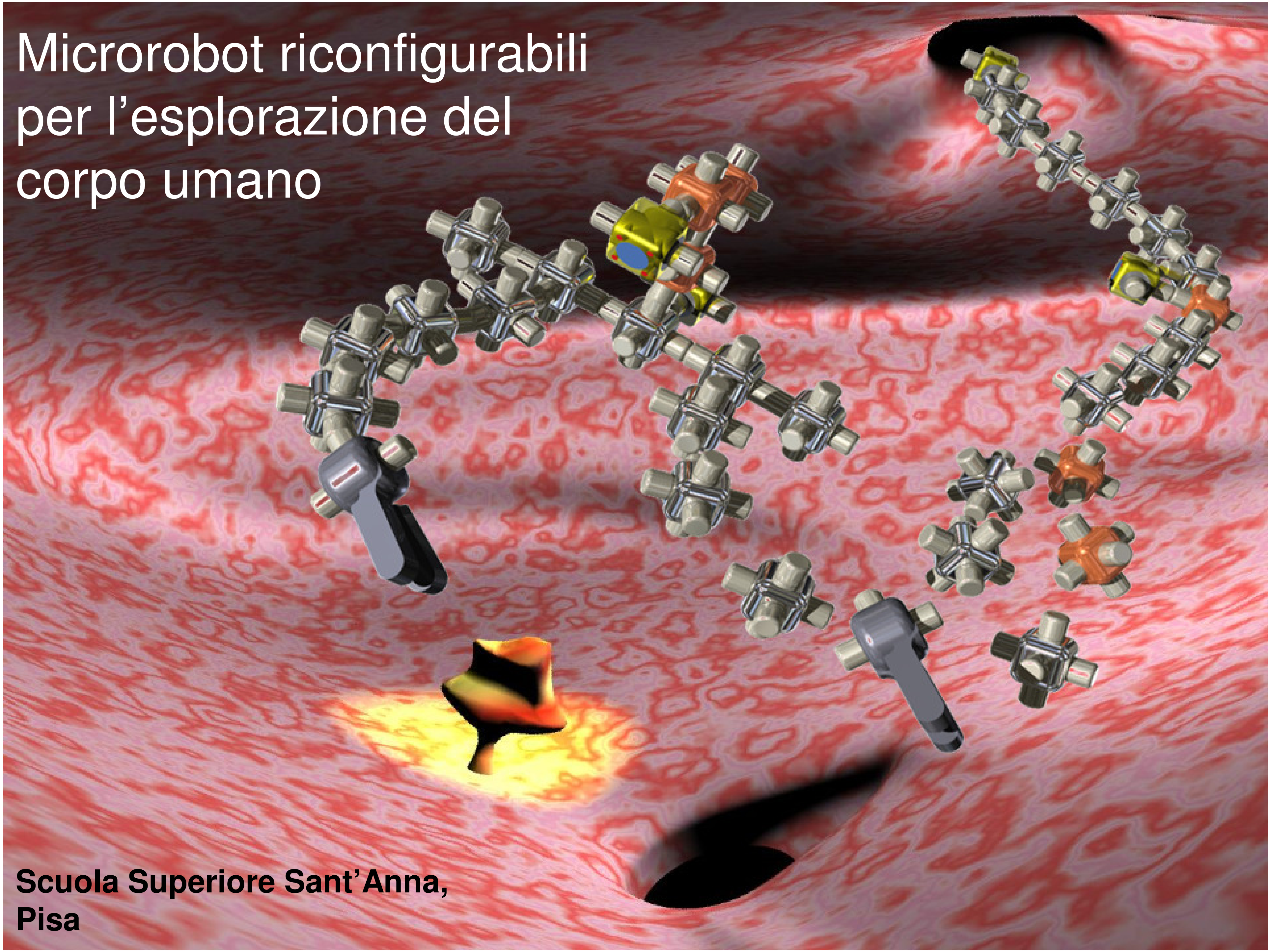


…o sogno ingegneristico?



Una capsula robotica per esplorare il corpo umano

Scuola Superiore Sant’Anna, Pisa

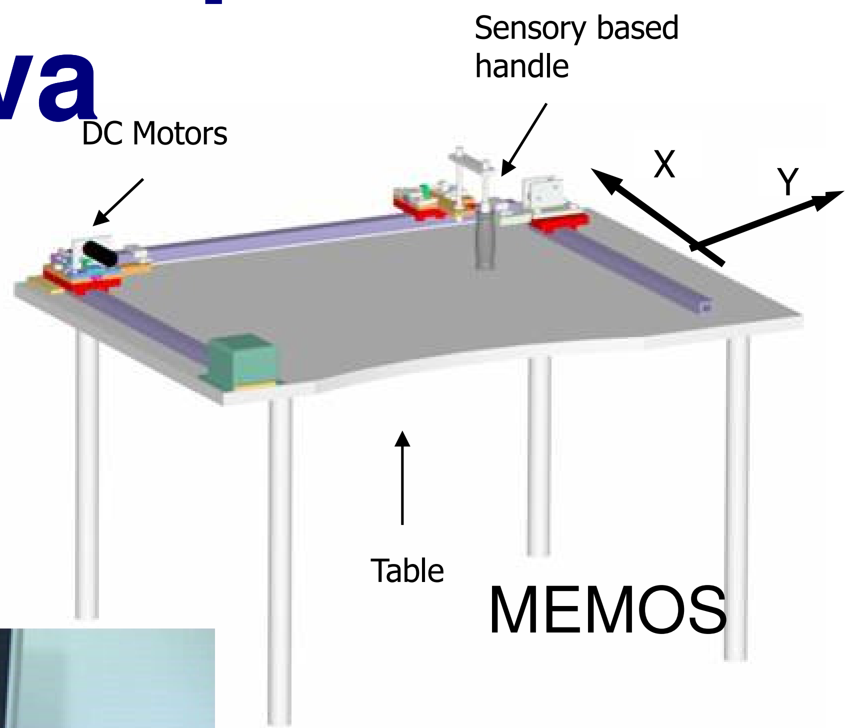

Microrobot riconfigurabili per l'esplorazione del corpo umano
Scuola Superiore Sant'Anna, Pisa

Ingegneria Biorobotica

Robotica in riabilitazione

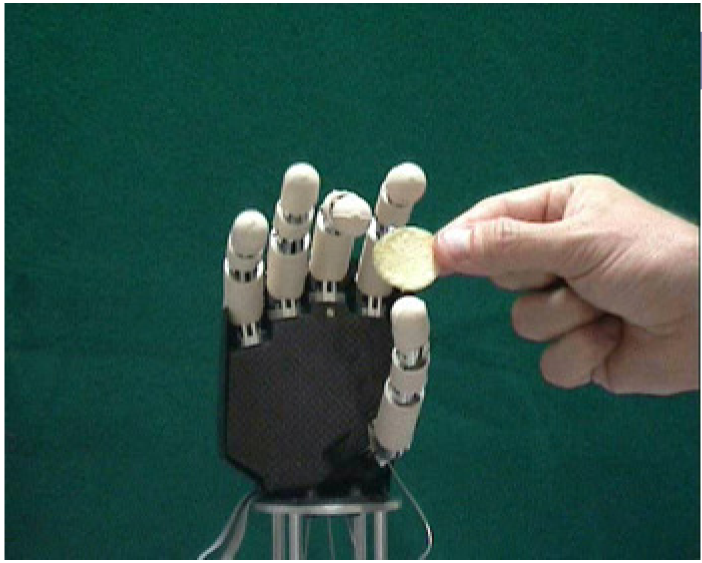
Macchine robotiche per la terapia riabilitativa

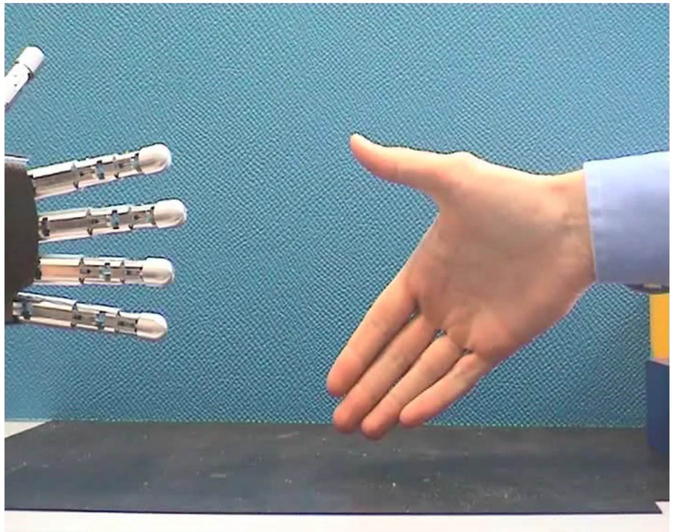
MIT-Manus

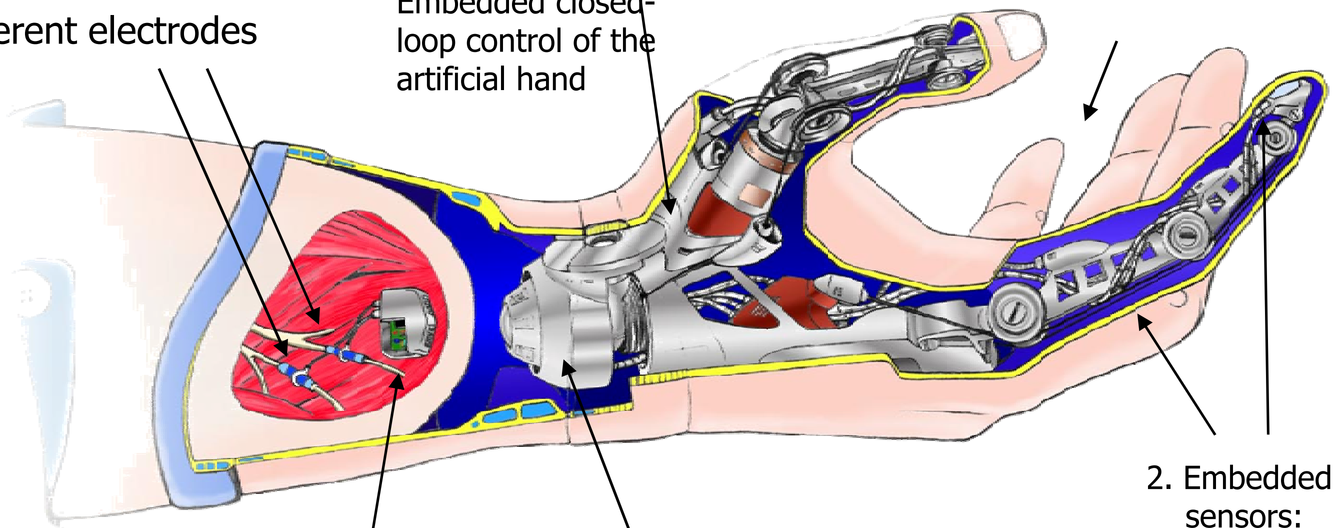


MEMOS

Una mano bionica







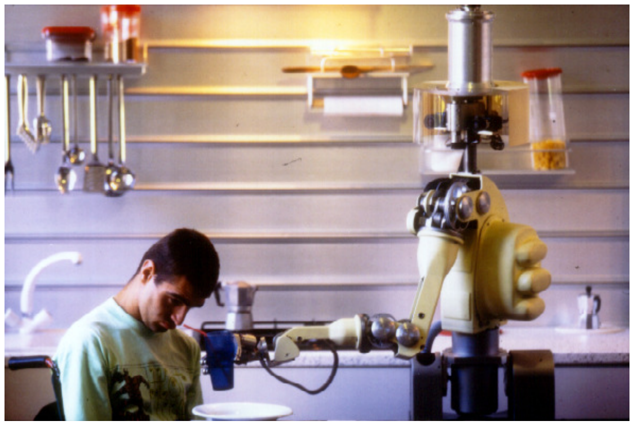
The CYBERHAND Project
IST/FET-2001-35094

ARTS Lab

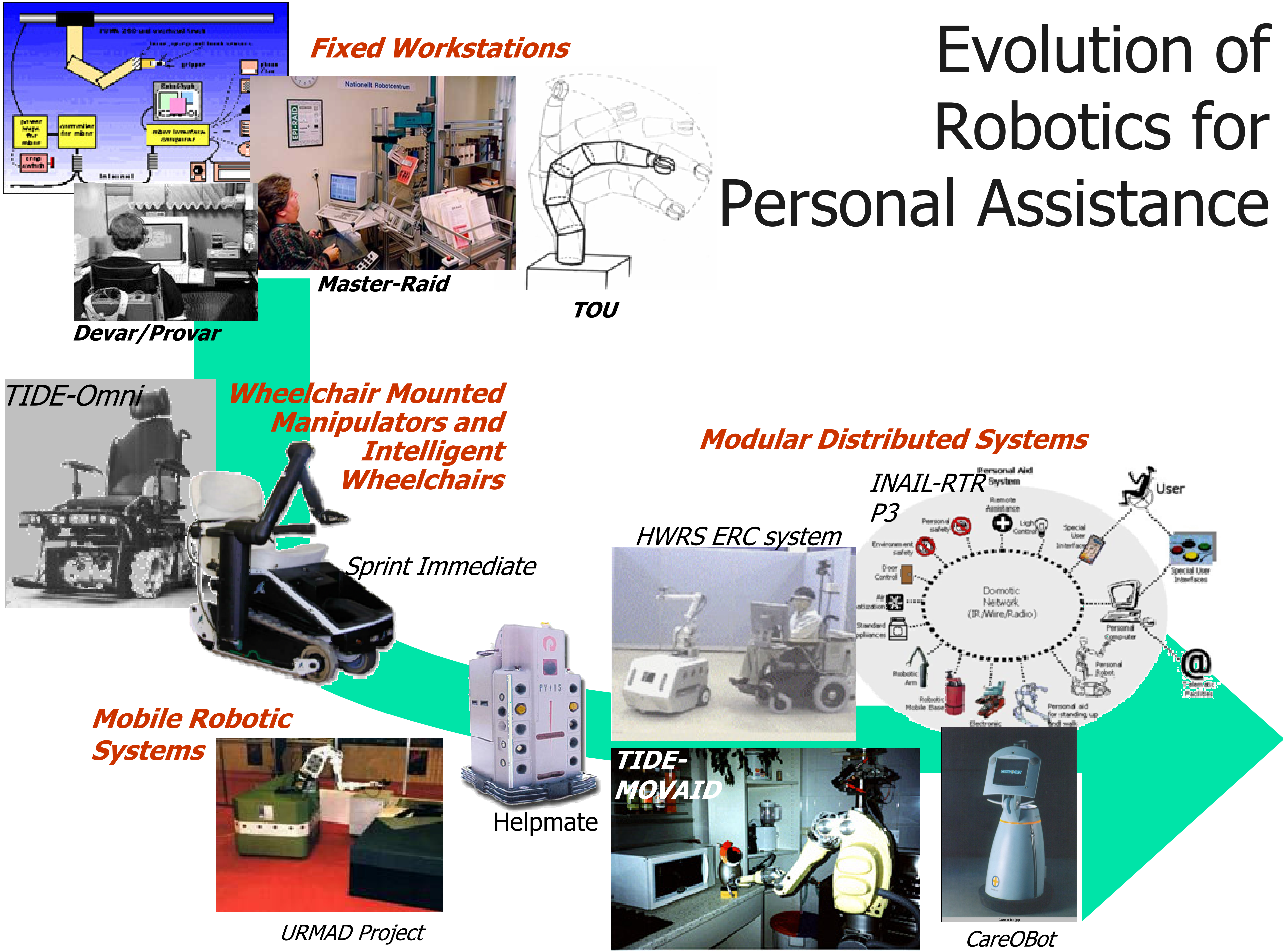
Advanced Robotics Technology and Systems

Robotica per l'assistenza a disabili

- Stazioni robotiche fisse
- Manipolatori su carrozzina
- Carrozzine intelligenti
- Robot mobili
- Sistemi robotici distribuiti ed ambienti intelligenti



Evolution of Robotics for Personal Assistance



Stazioni robotiche fisse

Un manipolatore robotico impiegato presso una stazione di lavoro fissa

DeVar/ProVar

VA R&D Rehabilitation Center, Palo Alto, CA

First prototype: 1982
First evaluation: 1985

Stazioni robotiche fisse per disabili:
EU TIDE Programme, “RAID” Project

First prototype: 1993
First evaluation: 1995

A robotic workstation for persons with physical disabilities in a computerized office environment

Manipolatori su carrozzina

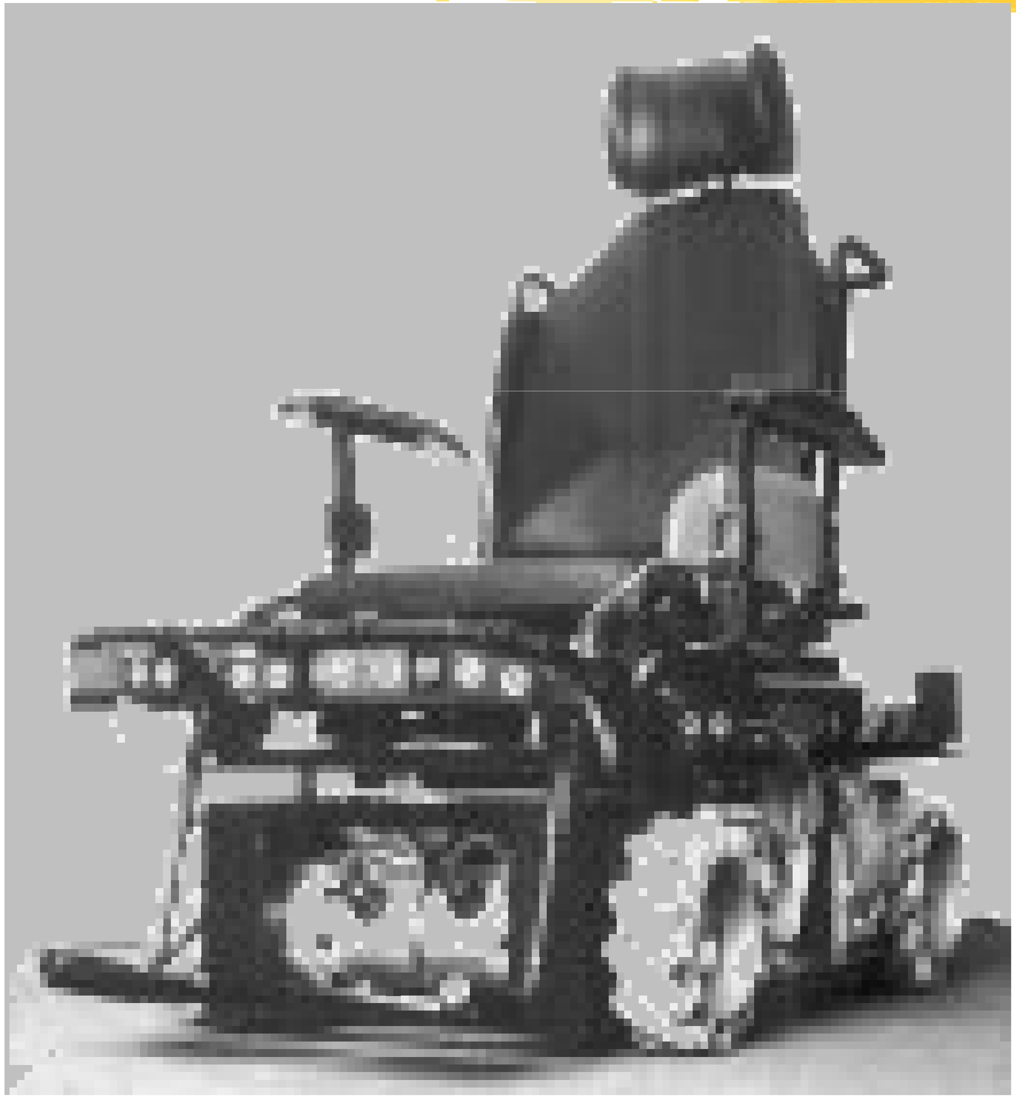
SPRINT-
IMMEDIATE

Manipolatore a bordo di una carrozzina elettrica ad assetto variabile per il superamento delle barriere architettoniche

First prototype: 1994

First evaluation: 1995

Smart wheelchairs: EU TIDE "OMNI" Project



First prototype: 1995
First evaluation: 1996

Omnidirectional wheelchair with 'smart' navigation system based on ultrasound and infrared sensors for obstacle detection