Introduction to Robotics - Motivation

Winter 2021/2022

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Machine Vision and Perception Group (I6)

Course details

- Lectures

  during current hygene rules, online under the link

  posted on https://mvp.in.tum.de/courses/robotics

Tutorial (live discussion)

  Mon 14:00-15:00 (starts Nov 8th)

- Office hours

  send e-mail with subject „[robot_class]...“ to burschka@tum.de

Requirements:

  good knowledge in linear algebra, differential calculus

  vector algebra and (Newton-Euler Dynamics)

  mandatory for MSc Robotics

Literature

Slides

https://mvp.in.tum.de/courses/robotics/slides/

Login: robotics

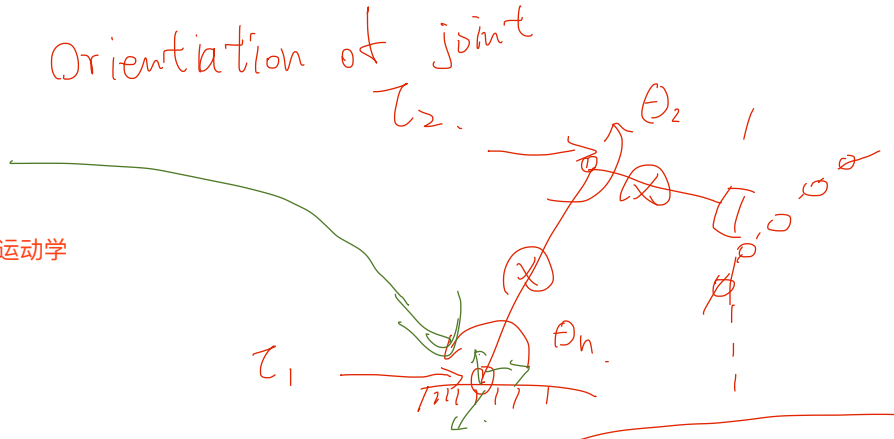
Passwd: slides21 robot_slides_22

- Literature

Introduction to Robotics Mechanics and Control
John J, Craig. Prentice Hall. ISBN 0-13-123629-6

Content

- This Robotics Lecture
  - Application Areas
  - Coordinate Frames
  - Forward Kinematics
  - Inverse Kinematics
  - Trajectory generation
  - Newton-Euler/Lagrange Analysis
  - PID control
  - Force Control



$$\vec{\tau} = \vec{f}(m, v, a \dots)$$

$$\vec{x} = \vec{f}(\vec{\Theta})$$

$$\vec{\Theta} = \vec{f}^{-1}(\vec{x})$$

orientation　　position

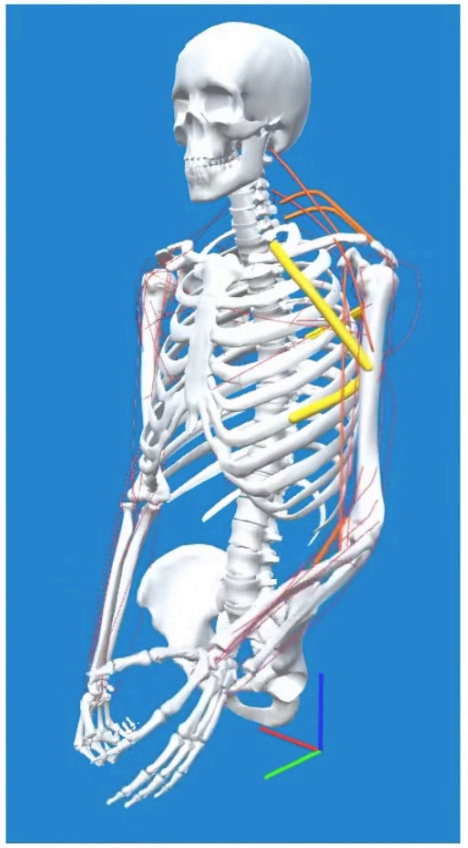
Additional Lecture “Advanced Deep Learning in Robotics“

Lecture in summer term

„Robot Motion Control“　(Trajectory Planning)

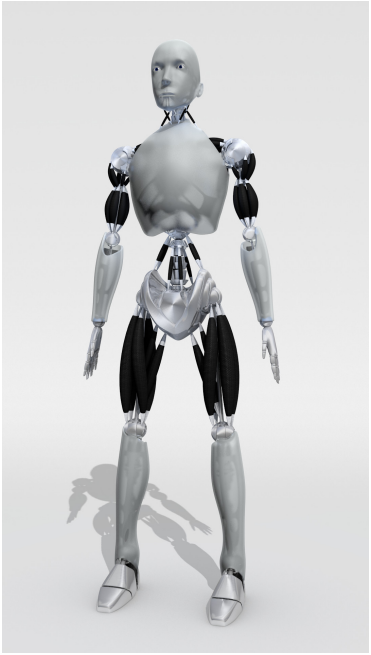
What are we trying to solve?

Passive behaviour test & pain expression recognition



1x

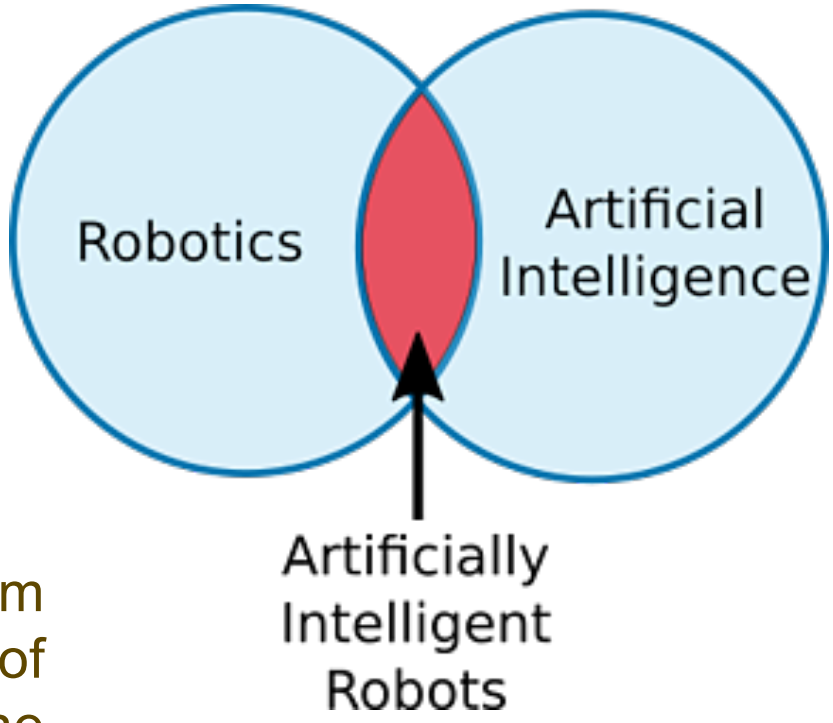
Current Trend to Avoid explicit Programming - Learning Approaches



- Semantics (object recognition) – ImageNet,VGG16
- Action modelling – RNNs

…

A Deep Learning system uses a large number of examples to learn the rules from observation.



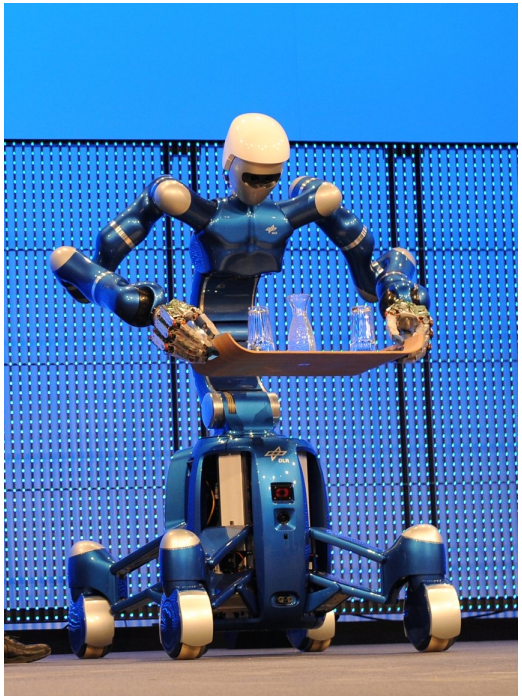
Emergence of Deep Learning – Big Data

Textual or visual query to large database Labeling/Categorization

Categorization of behavioral models for advertising and news

Similarity measures and shopping behavior modelling

What is different in Robotics compared to Big Data Queries?



We need to know not only what is in the area around the robot, but also

机器人很难意识到自己做错了

- How big is the confidence in the correctness of the observation? How much of the object was visible…
- How certain is the system to see a specific object (similarity to other similar ones)?
- Where it is relative to the robot?
- What is the dynamic state of the observed object?
- What is the accuracy of the metric observation?

我们不仅需要知道机器人周围区域的情况，还需要知道

- 对观察的正确性有多大的信心？该物体有多少是可见的...

- 系统看到某个特定物体的把握有多大（与其他类似物体的相似性）？

- 它相对于机器人的位置?

- 被观察物体的动态状态是什么?

- 度量观测的精度是多少?

Basics in this lecture
for model-based robotics

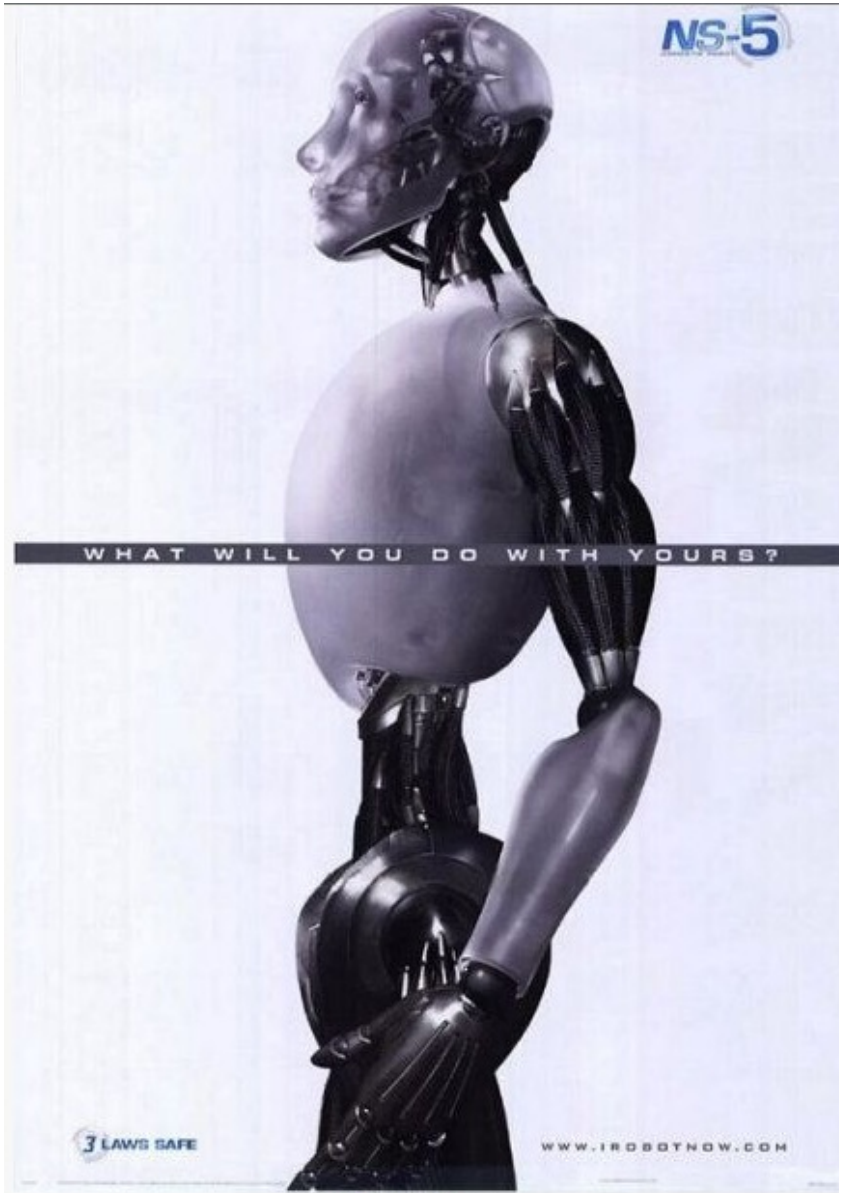
Deep Learning – you teach each possible surface to the robot

Types of robots

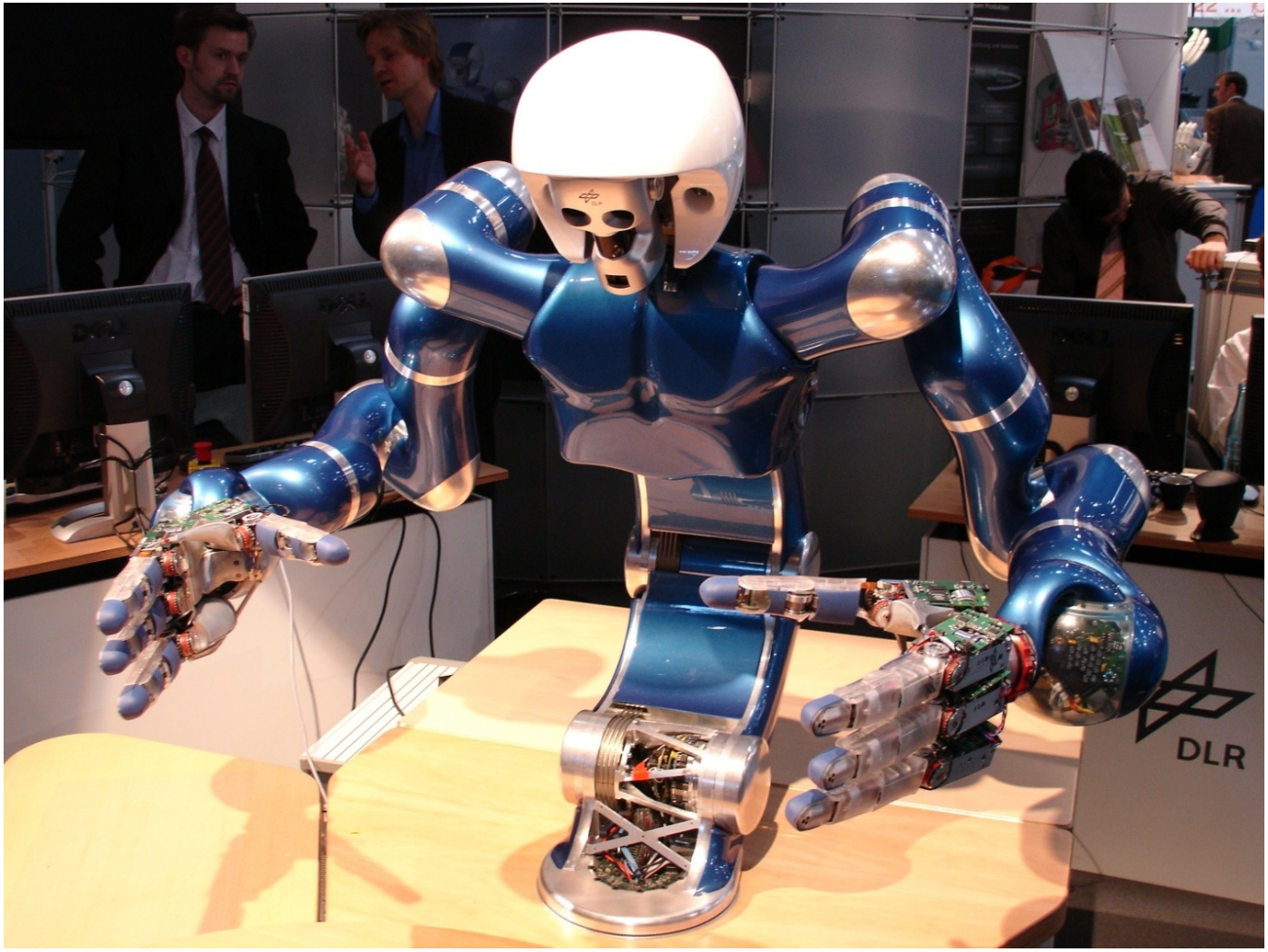
Mobile Robots

Manipulators

What is the lecture (not) about?

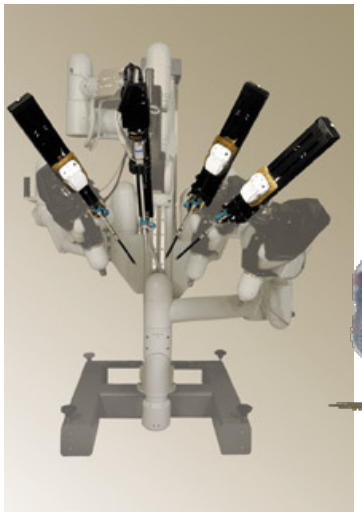


Justin – DLR Oberpfaffenhofen



Where does the term Robot come from?

Touchstones Pictures



- Known mostly from Science Fiction. (*Marvin*, R2D2, ..., *Matrix, ...*)
- Writer Karel Capec coined 1921 the term Robot (in an theater act „Rossums Universalroboter“)
- Word „Robot“ originates from „robota“ (work) but often understood as slave
- Expression „Robot“ commonly used for:

  Human-like machine (android), which can perform human tasks

... some Definitions

Definition des Robot Institute of America (1980)

A robot is a reprogrammable multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of taks

机器人是一种可重复编程的多功能机械手，旨在通过可变的编程运动来移动材料、零件、工具或专用设备，以完成各种任务。

History of Robotics

- Early mechanical components

1738	J. de Vaucanson	mechanical music-playing dolls
1774	P. Jacquet-Droz	simple Androids
1805	J. Jacquard	programmable weaving loom (punch cards)

- Development of industrial robots

1946	G.C. Devol	device to record magnetic signals used to control a device
1951		First telemanipulation devices for radioactive materials
1952	MIT	Prototype einer NC-Machine (1961: programming language APT)
1954	C.W. Kenward	Patent for development of a robot

History of Robotics

1954	G.C. Devol	Programmed transportation of objects
1959	Planet Corp. (Firma)	First mechanical robot controller
1960	Unimation	First industrial robot „Unimate“ with hydraulic actuation control similar to an NC-machine
1961	Ford	First installation of a robot of type Unimation
1968	Stanford (SRI)	Mobile robot „Shakey“ with multiple sensors
		(camera, tactile sensors)
1973	SRI	First programming language for robots „WAVE“
1974 -		Programing language AL
		(WAVE and AL are the base for VAL)
		- electrically actuated robot
1978	Unimation	PUMA (Programmierbare Universalmaschine für Montage-Anwendungen)

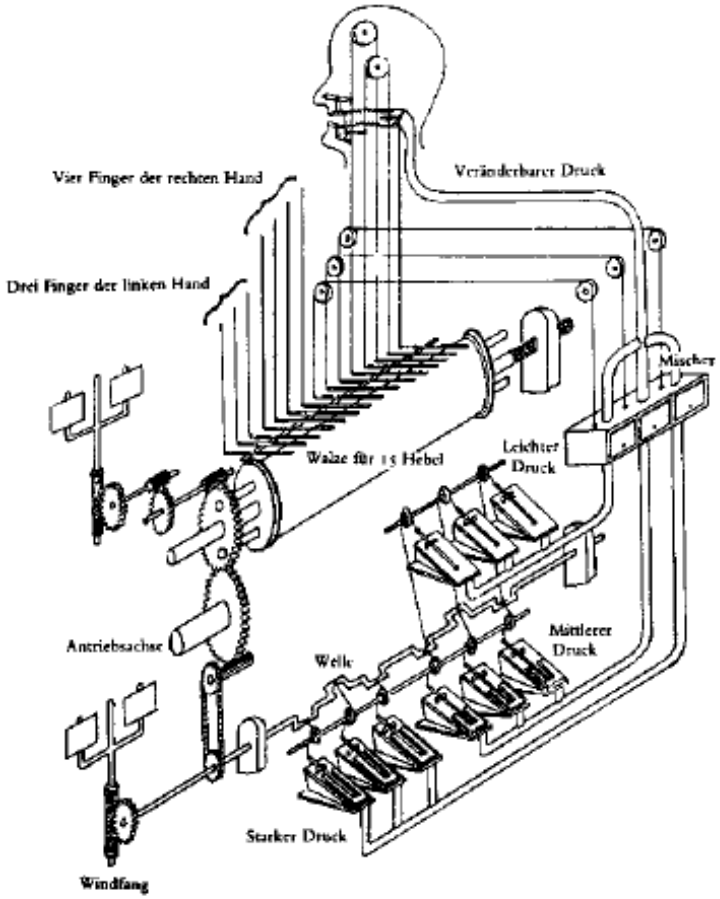
Early Robots

Jumeau, Musizierende Puppen, 1880

Trompeter, Kaufmann (Dresden), 1810

... continued

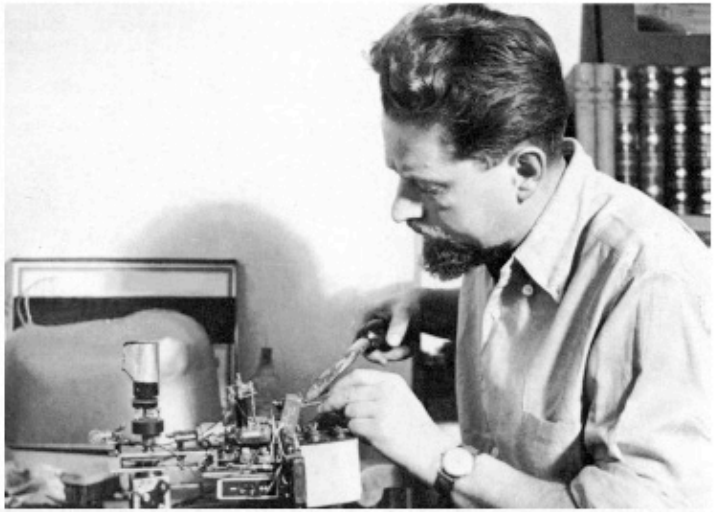
Allesschreibende Wundermaschine,
Knaus, Wien 1760

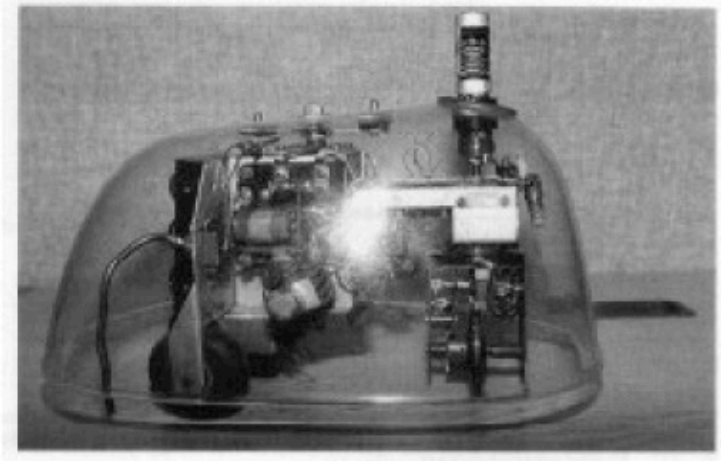


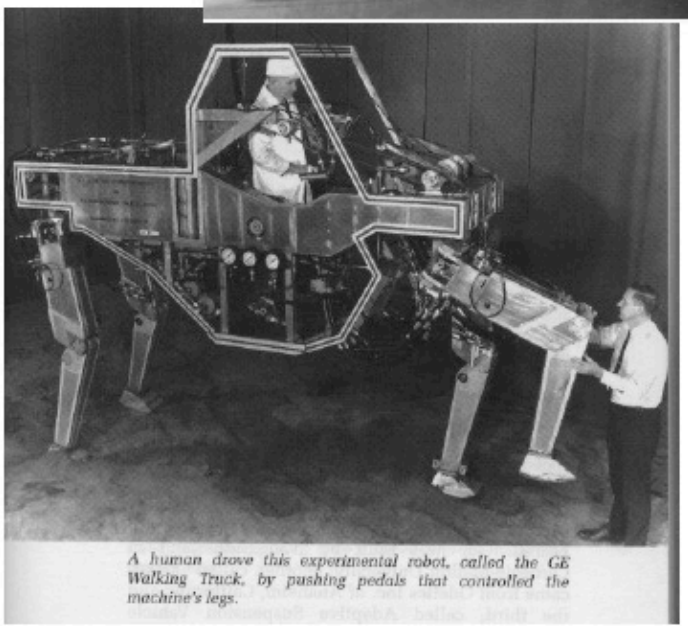
Mechanik eines Flötenspielers, Vaucanson, 1738

History

CNC-Technik und Teleoperatoren: 1946 bis 1955



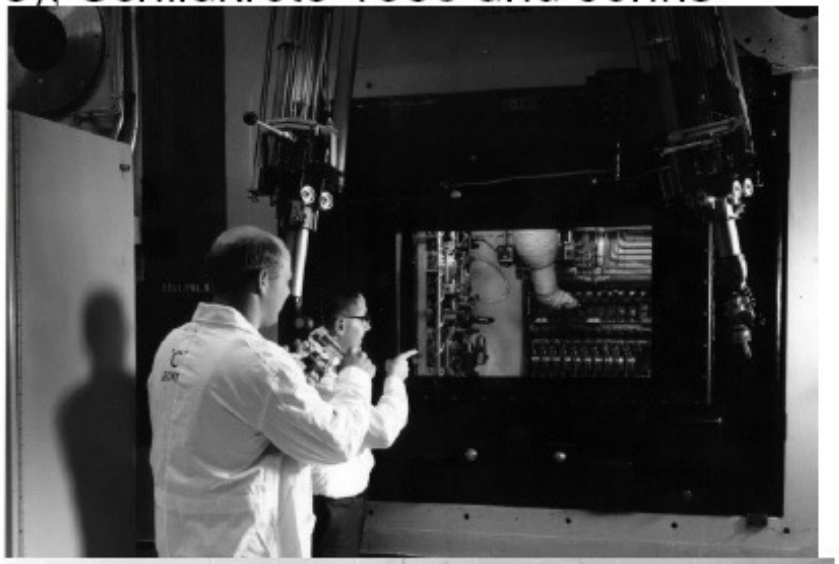


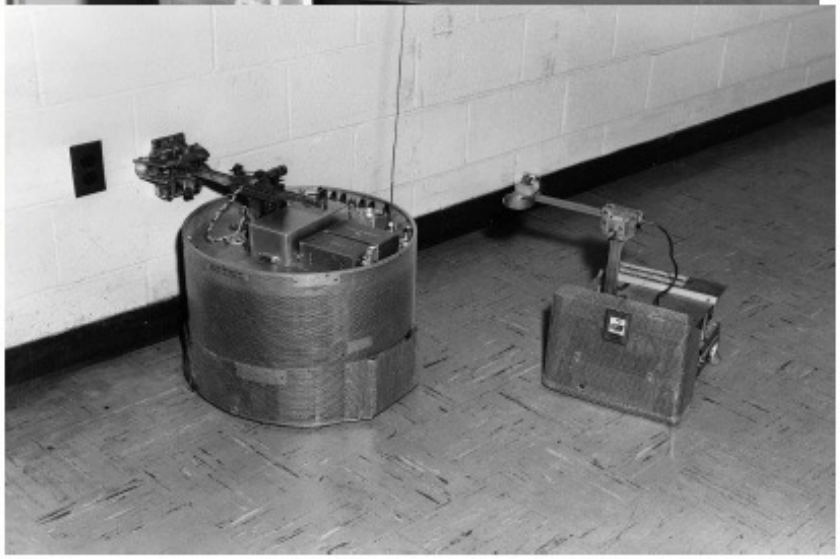


A human drove this experimental robot, called the GE Walking Truck, by pushing pedals that controlled the machine's legs.

History (cont'd)

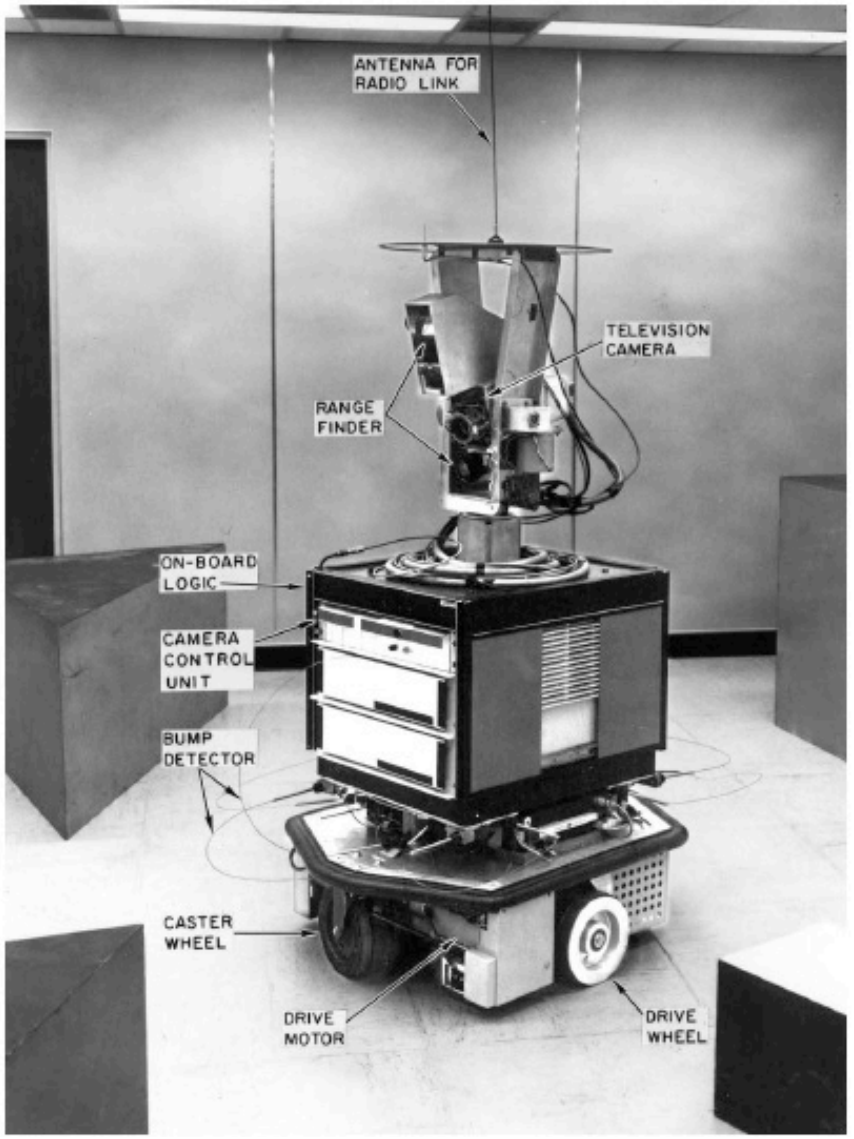
Erste Roboter: Unimate (kommerziell ab 1963), Schildkröte 1950 und Johns Hopkins wall-follower 1964





History

Shakey (Stanford)
1966-72

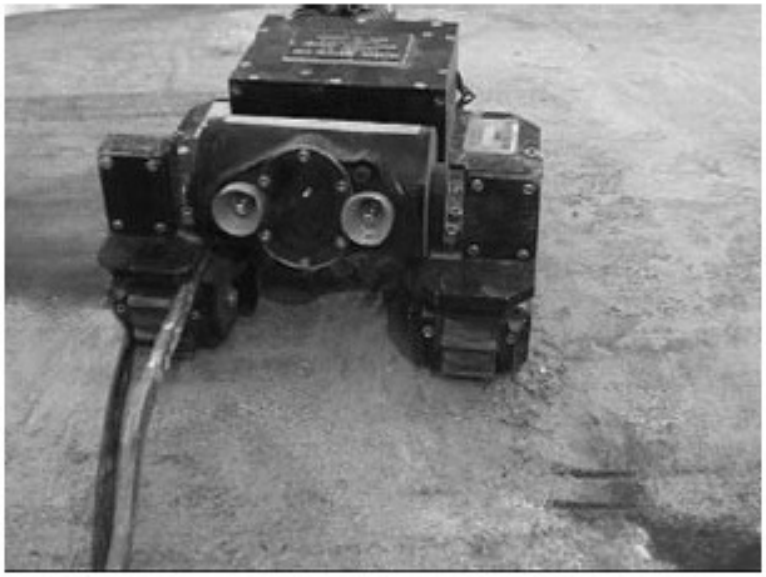


- Guides (museum, tourist attractions, etc.)

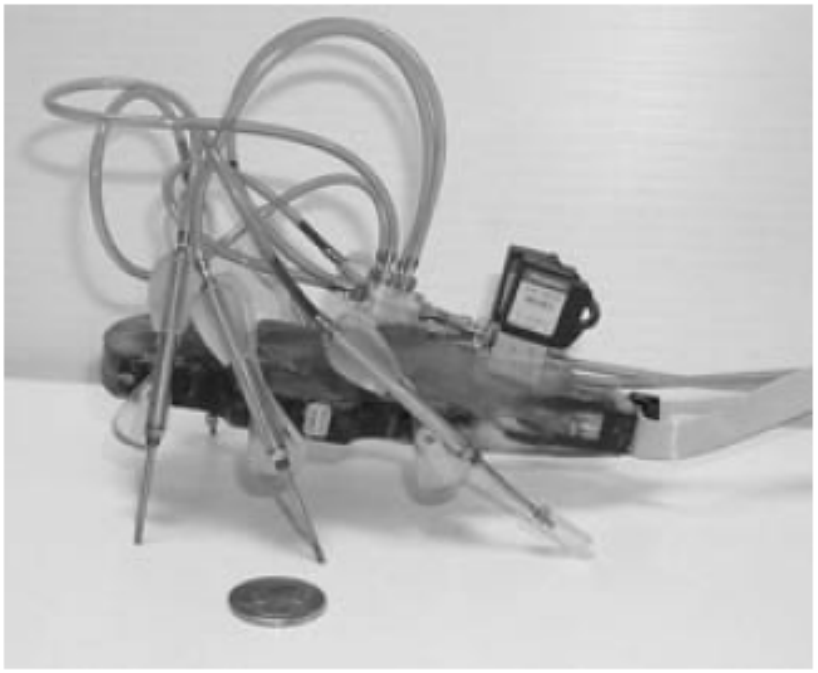
Rhino (CMU/Bonn ICS)

- Search and Rescue
- Remote-controlled
- Robust, Tethered

Center for Robot-Assisted Search and Rescue (University of South Florida)

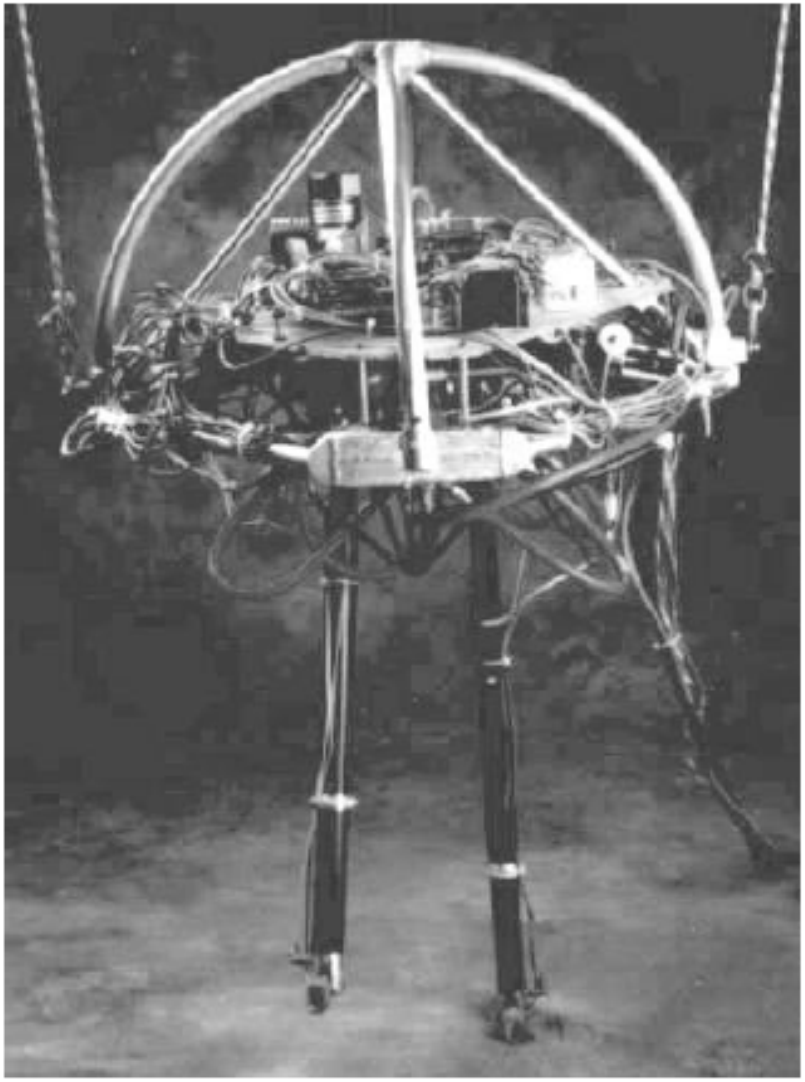


- Walking and running robots (one or more legs)
- Purpose:
  - Handle uneven terrain
  - Help us understand biological locomotion



"Sprawlita" (Stanford)

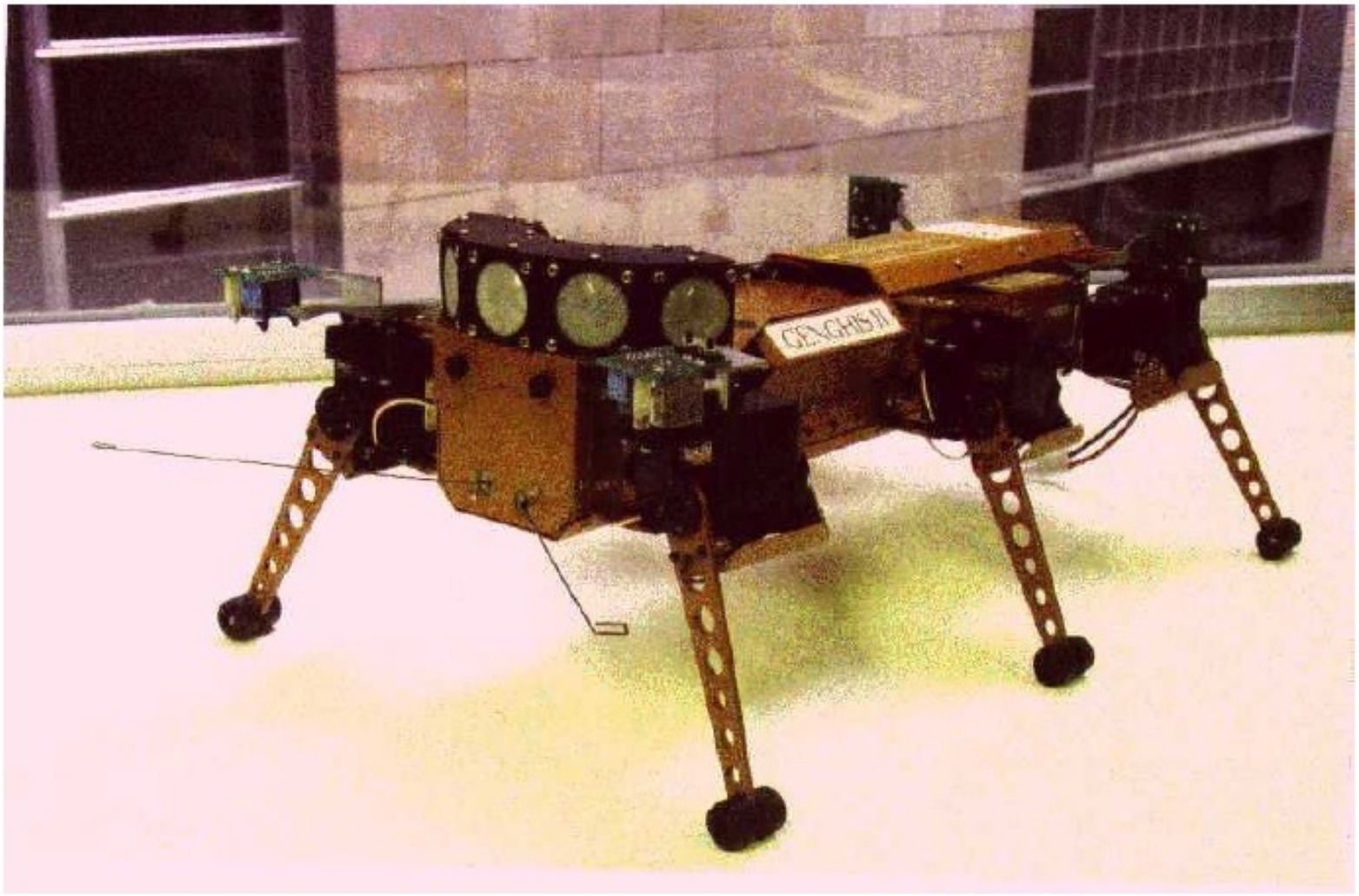
- Hopping robots use accurate dynamic models of the system
- Specialized controllers stabilize the system

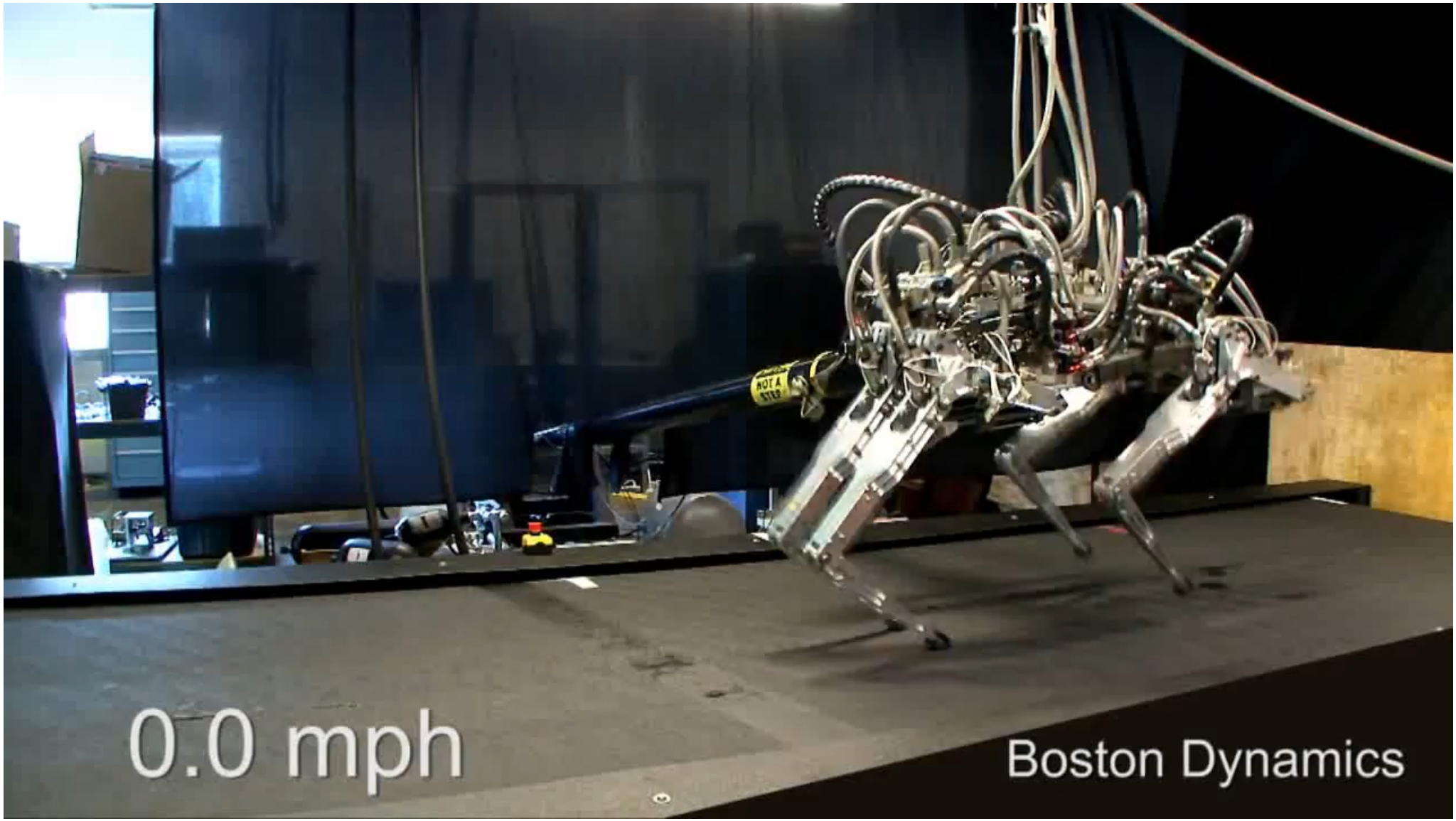


3D Biped (MIT)

History

Legged robots since approx. 1985

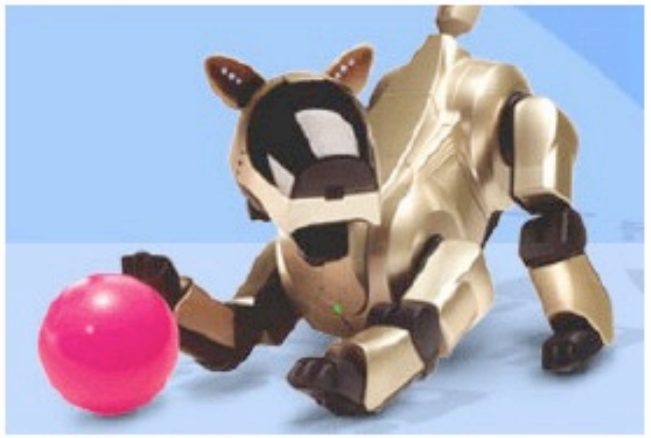



0.0 mph
Boston Dynamics

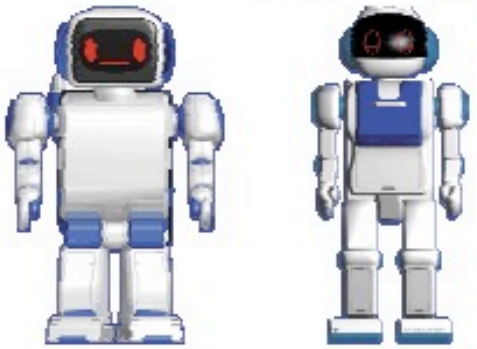

Boston Dynamics

Entertainment Robots

Hasbro: „My real baby“



Sony: „Aibo“

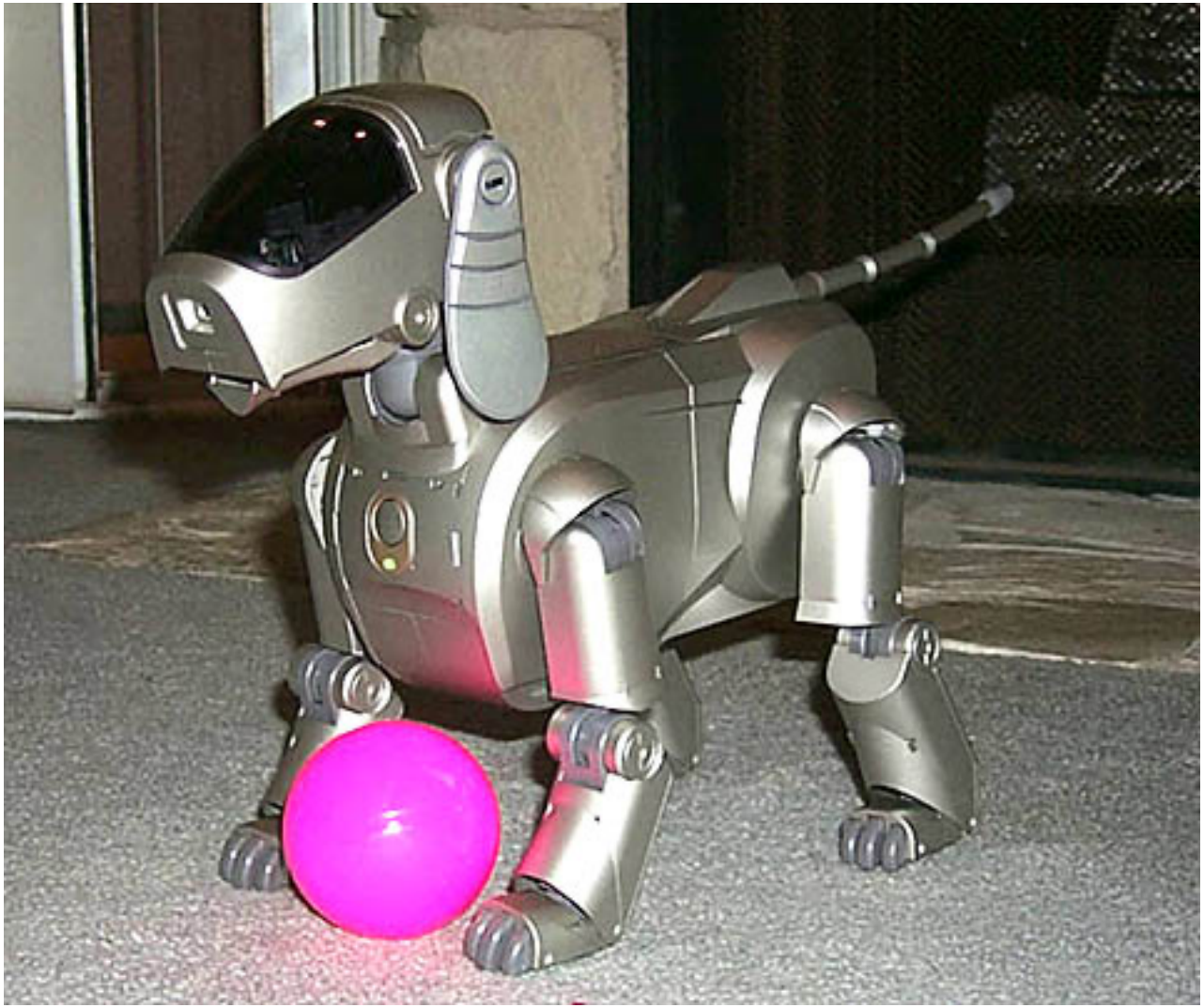


Sega C-Bot and R-Bot:
Einfache Stimmener-kennung und Bewegung

Massenmarkt Heim- und Edutainment-Anwendungen

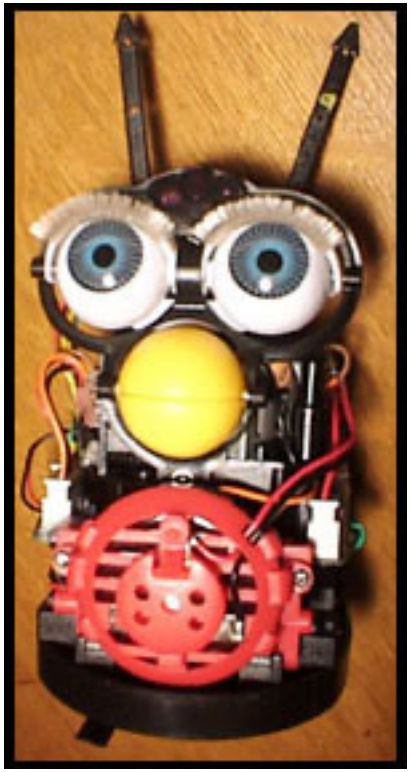
- Aibo: > 120.000 Stück verkauft (à $2.500)
- My Real Baby: > 150.000 (à $100)

AIBO - Sony Entertainment Robot



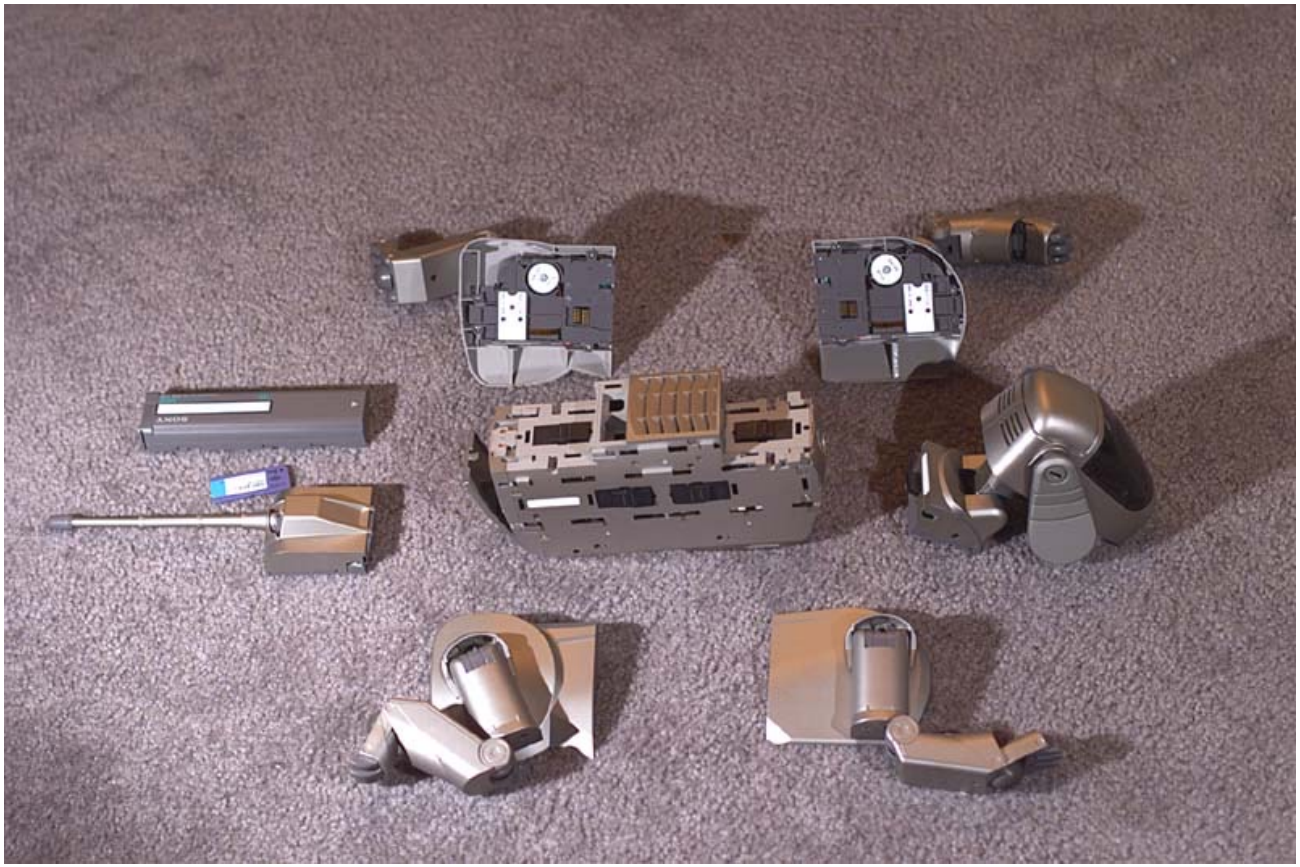
Other systems:

Tamagochi,
Furby

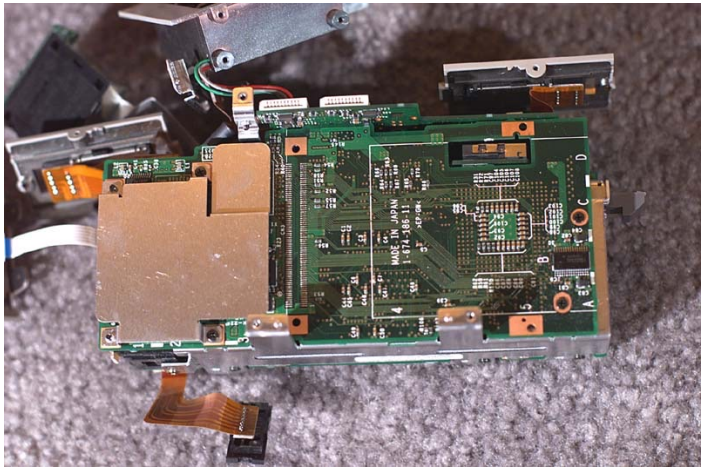


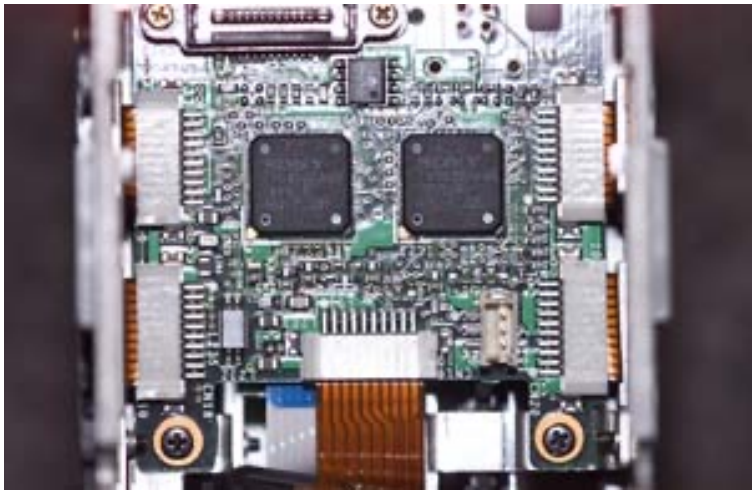
and……

AIBO:



AIBO's specifications:





4-Legged Autonomous Robot (Equipped with 4-legged hardware modules)

CPU : R3000 MIPS 64 Bit RISC Processor

Main Internal Memory : 16 MB DRAM

Operating System : Aperios (Sony's Proprietary Real-Time OS)

Supplemental Memory : PC Card (Type II, 2 slots)

Video Input : CCD Color Video Camera (1/5 inch, 180,000 pixels)

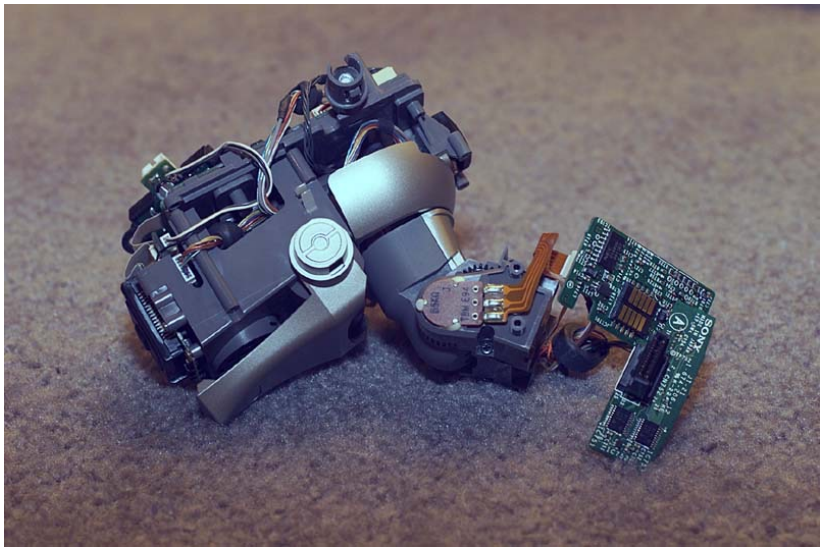
Audio Input : Stereo Microphone

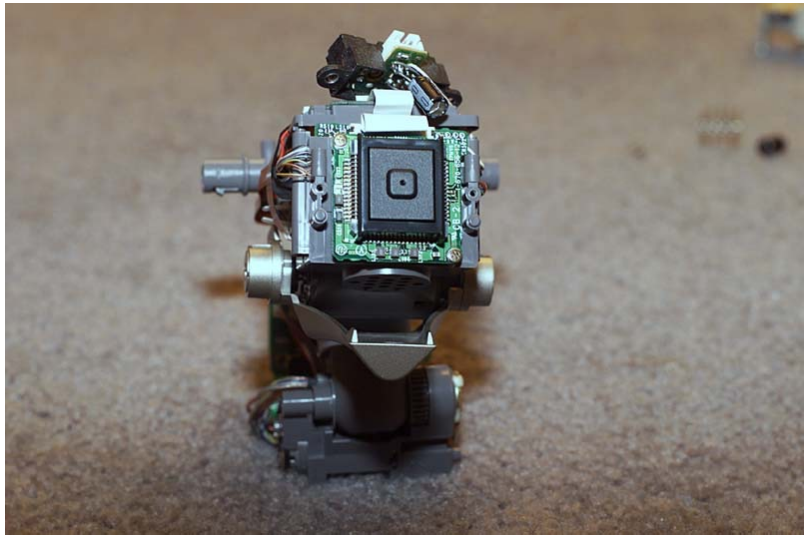
Audio Output : Speaker (Mono)

Walking Speed : About 5m/min.

Weight : 1.25kg (including batteries) -ion Battery

AIBO's modules (head):

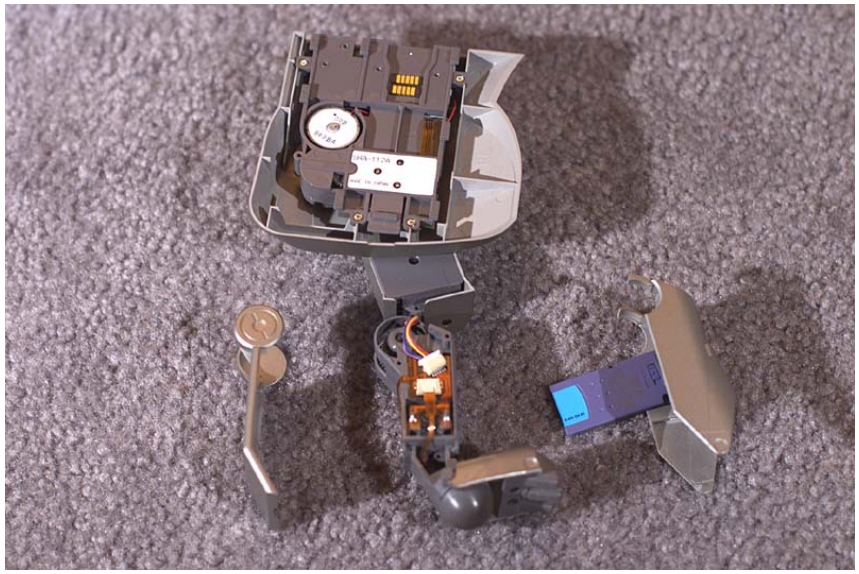




Head: 3 degrees of freedom

contains: infrared sensors, LEDs (green, red) [eyes],
CCD color camera 180.000 pixels,
pressure transducer [can distinguish difference: praising-scolding],
motors for pan and sidewards

AIBO's modules (legs):

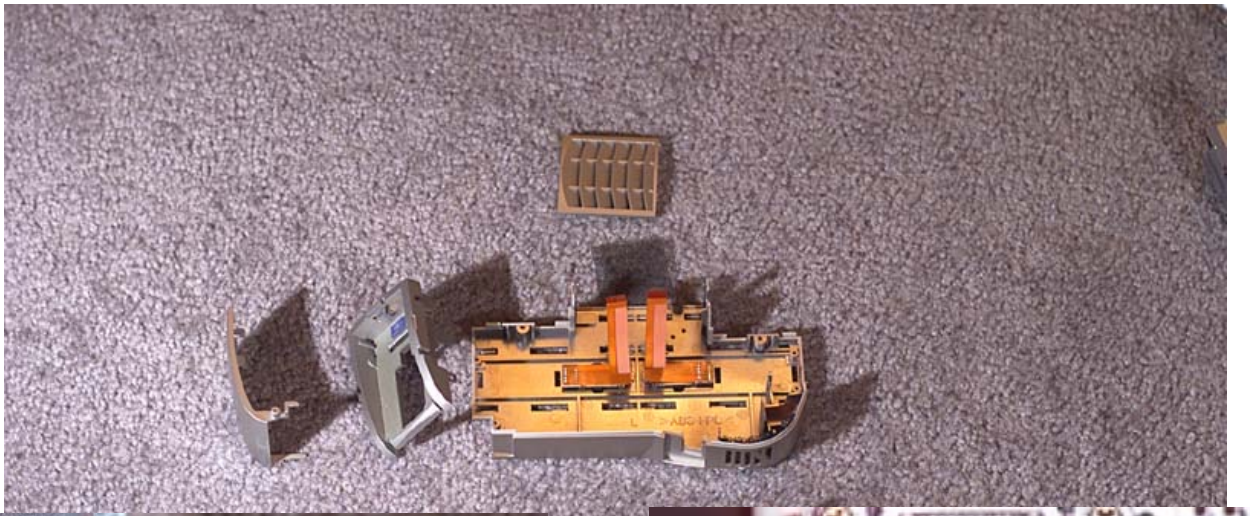


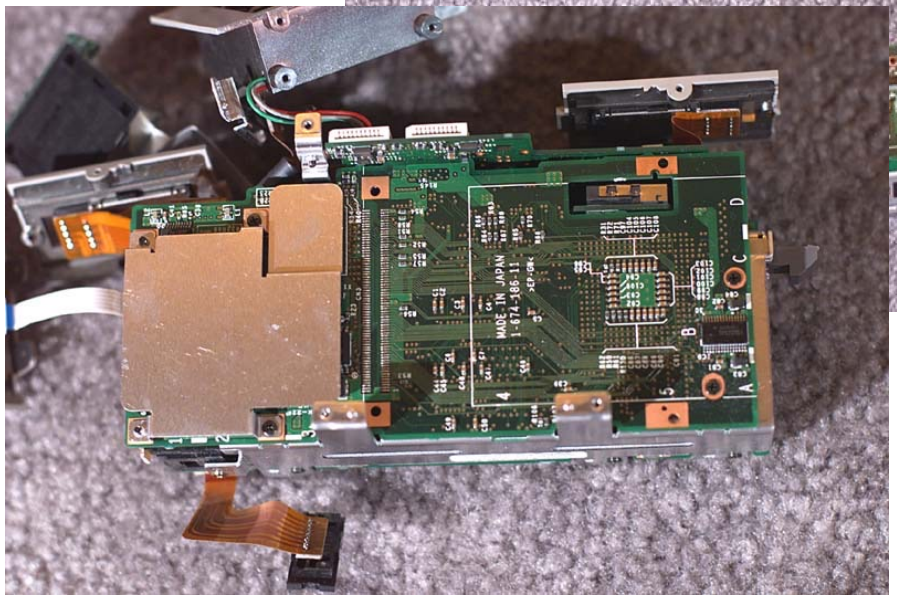
Leg: 3 degrees of freedom

Each of the eight segments has the same cartridge in it. The lower leg controls the elbow / knee and the upper leg controls swinging each leg out from the shoulder / hip. Movement back and forth, is controlled by a motor inside the side plate. The motor cartridges fit into the leg segments.

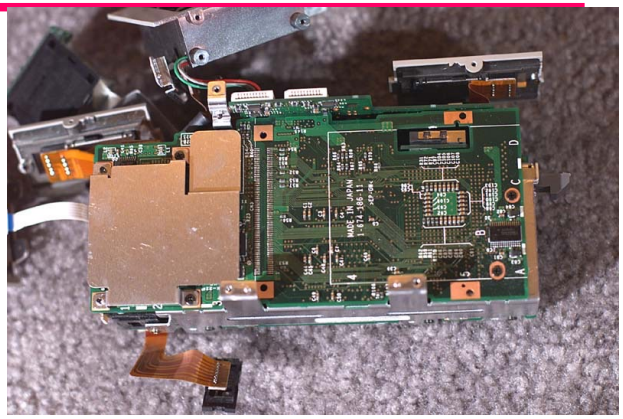
Pressure sensors and buttons in the legs

AIBO's hardware (body):





AIBO's software:



Aperios (formerly Apertos) Reflective OO OS

see: www.csl.sony.co.jp/project/Apertos

[technical papers]

supported platforms: MIPS R3000, i486-Intel

OPEN-R Architecture for Entertainment Robots

http://www.world.sony.com/News/Press/Archive/199806/98-052/index.html

1) Interchangeable Hardware Modules for Various Physical Configurations

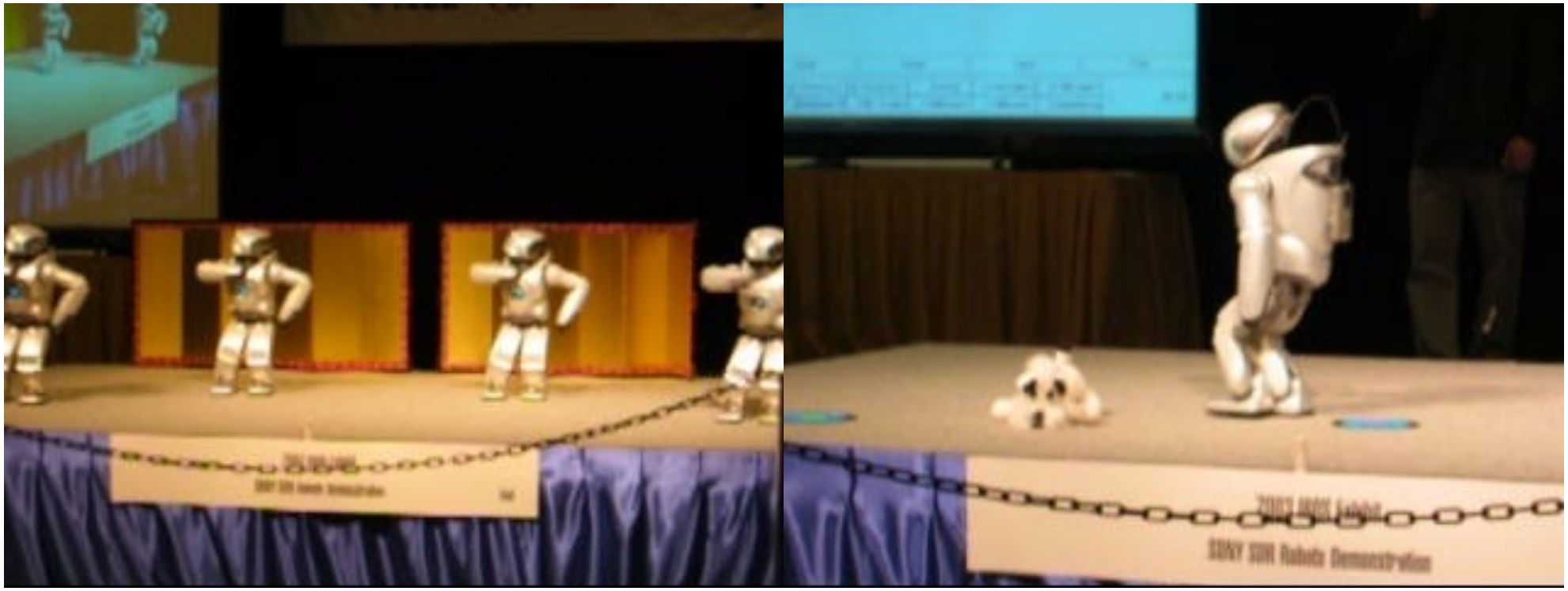
2) Hardware-Related Data Transmission for Plug-and-Play Connectivity

3) Interchangeable Software Modules for New Applications

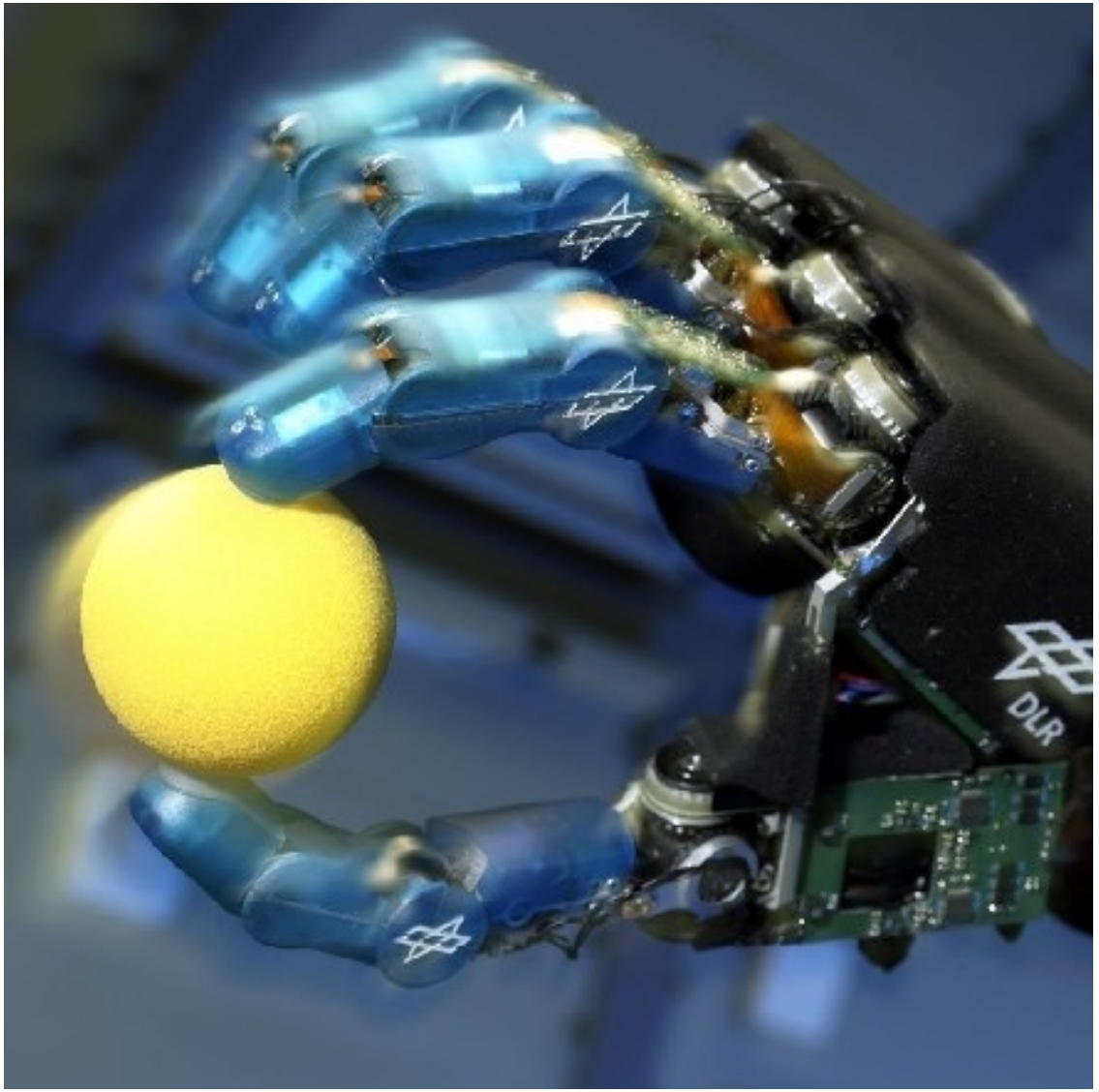
4) Expandability for Accommodation of New Functions

Humanoid Robots (Honda)

Sony's CURIO



Manipulators

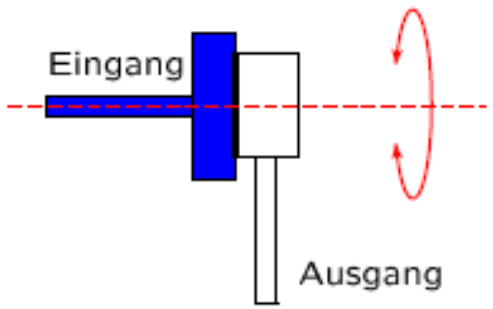


DLR


cleaning up
cluttered objects


Rollin‘ Justin
A platform for
mobile manipulation
Institute of Robotics and Mechatronics
German Aerospace Center (DLR)
Deutsches Zentrum
für Luft- und Raumfahrt

Types of robotic joints



revolving joint

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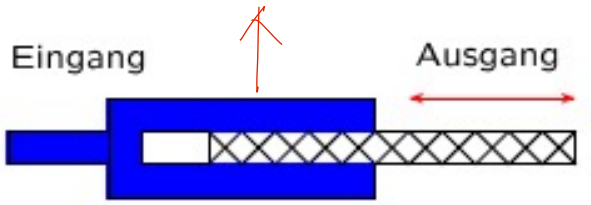
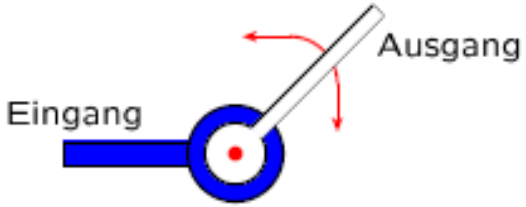


linear joint



rotational joint

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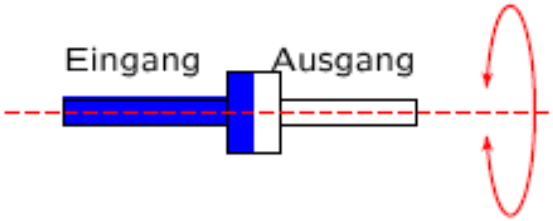
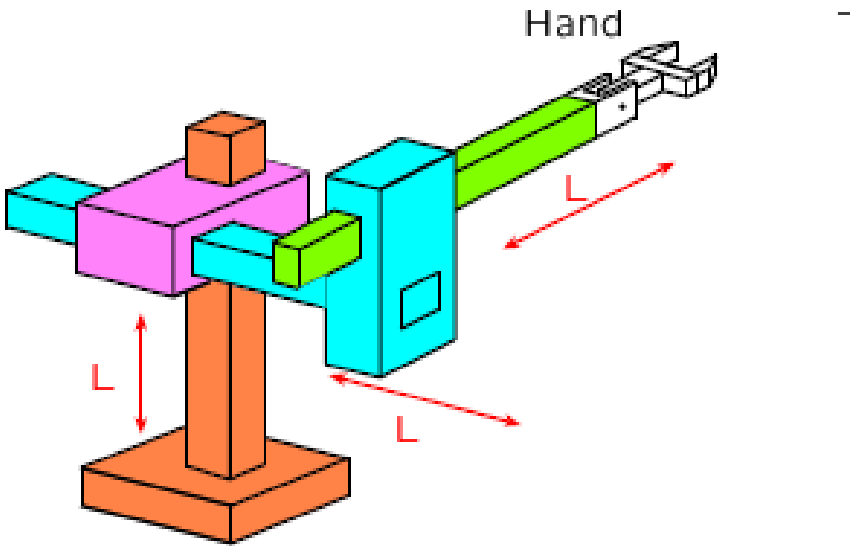


twistingjoint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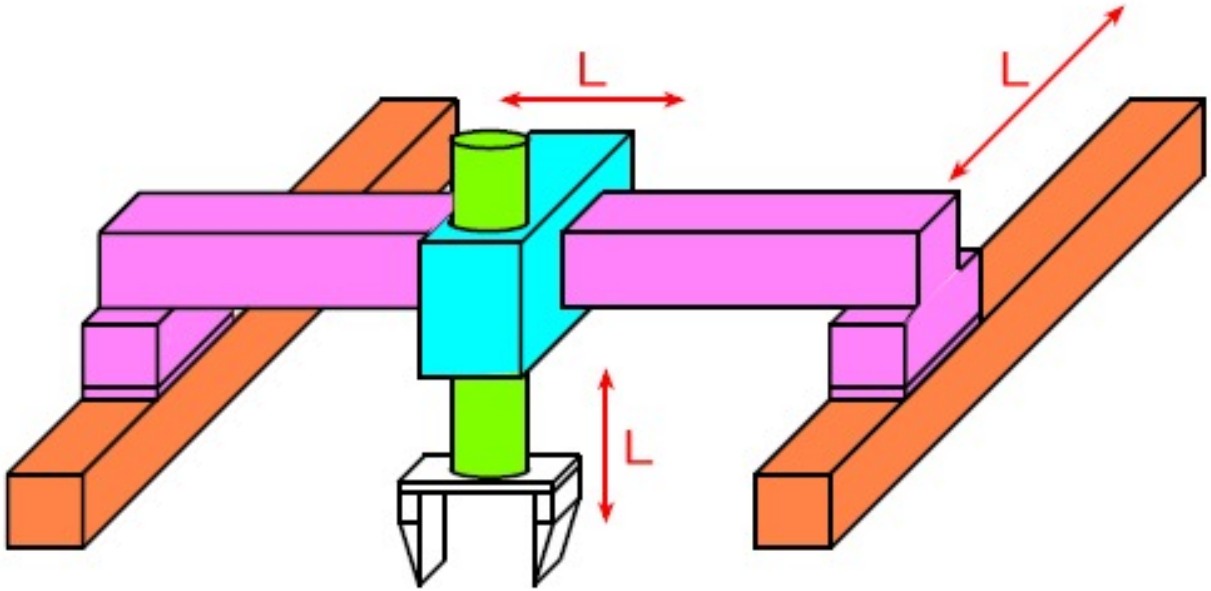
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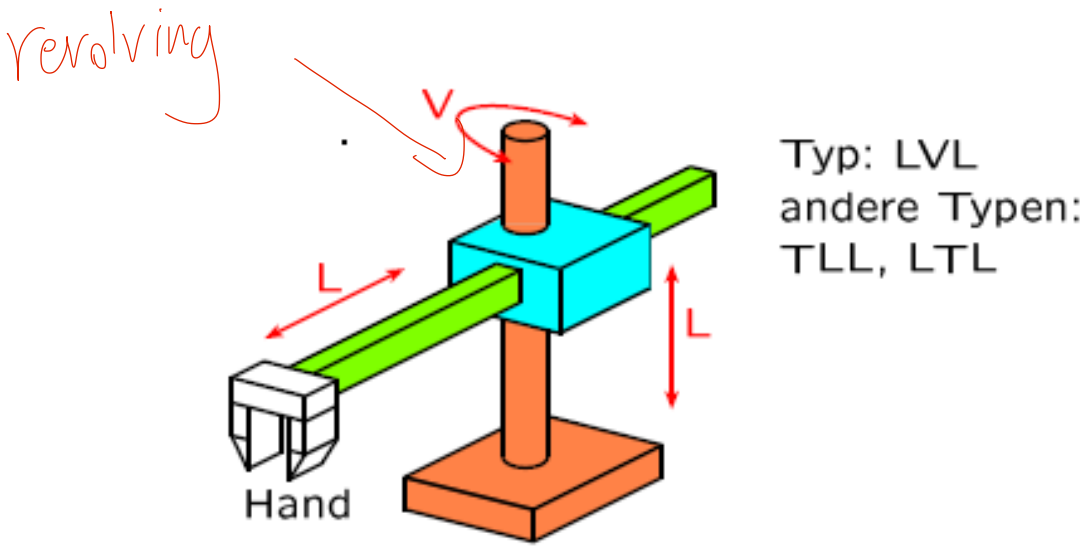
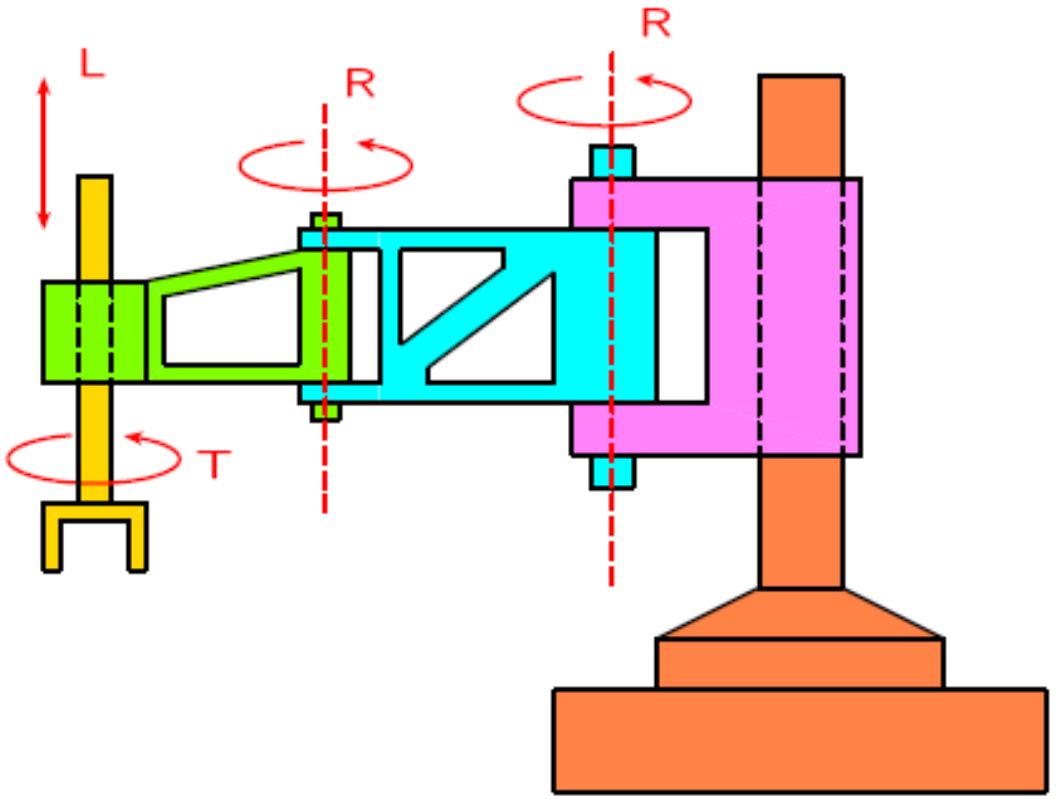
Zylinderkoordinaten

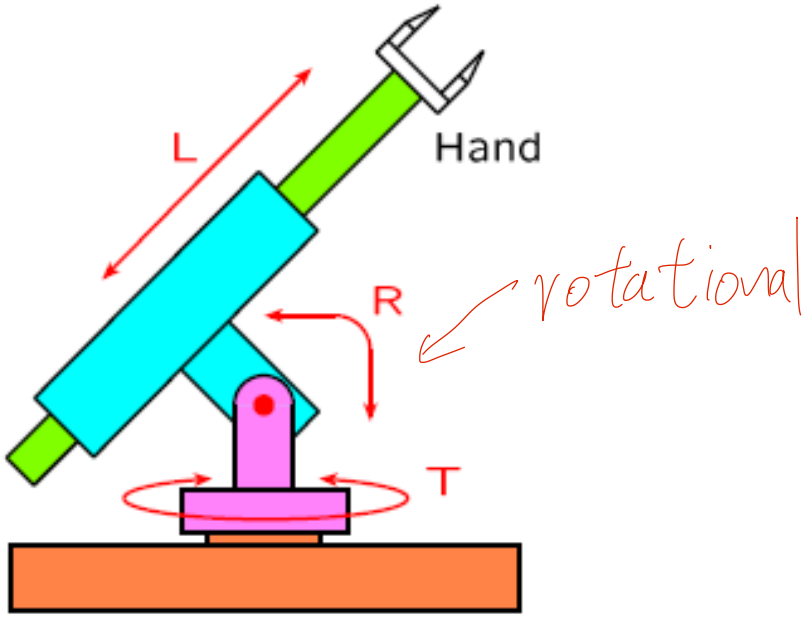


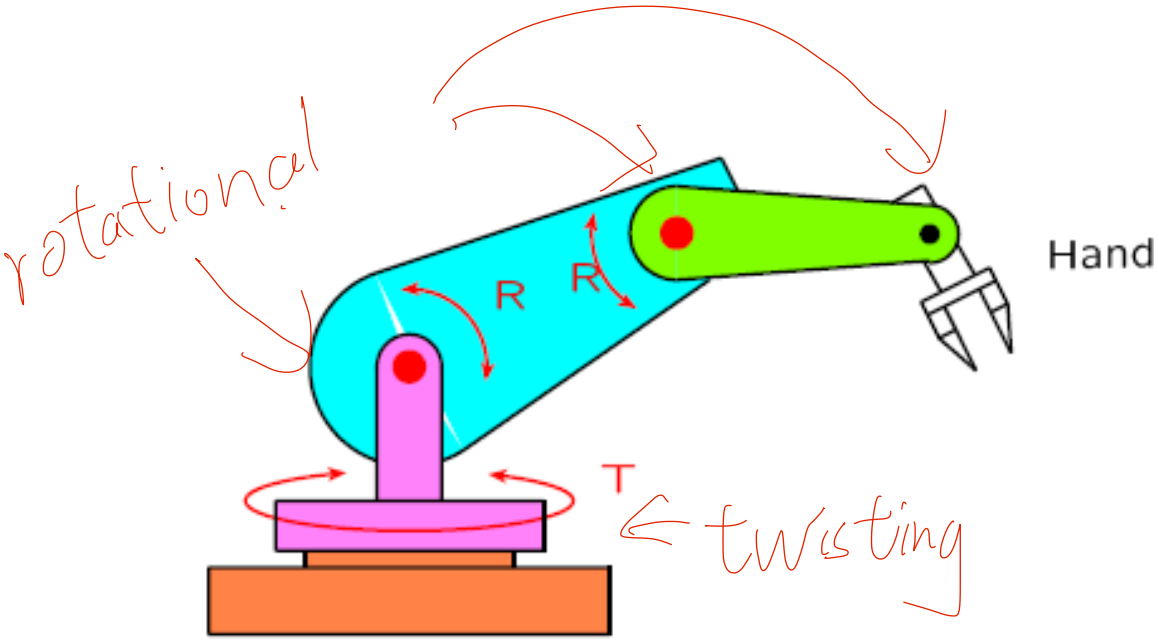
Typ: LVL
andere Typen:
TLL, LTL

Arbeitsraum: Hohlzylinder

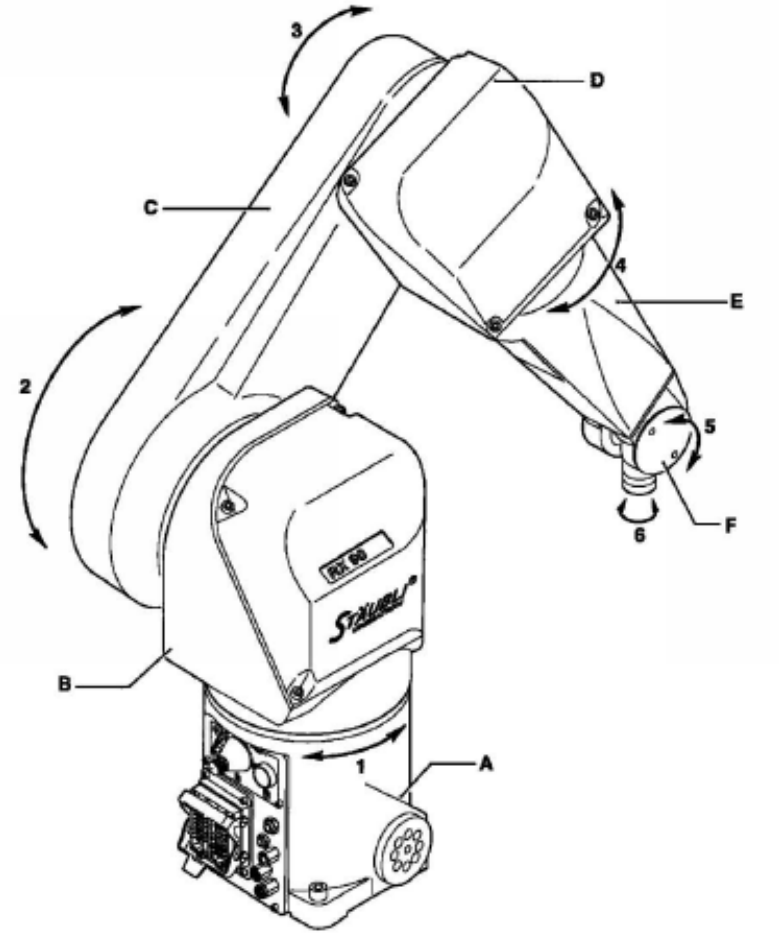


- SCARA = selective compliance assembly robot arm

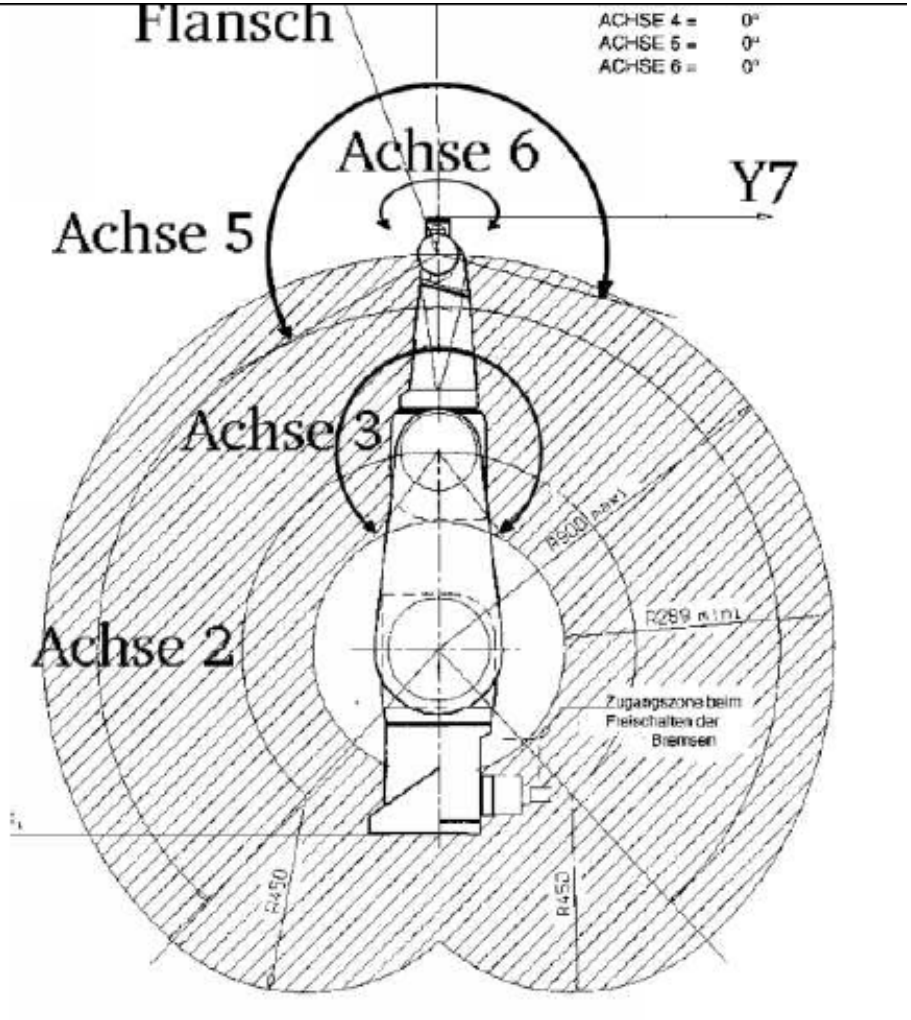

L
Hand
R
rotational
T


rotational
R
R
Hand
T
twisting

Stäubli- RX90



Gelenke und Arme RX-90



vertikaler Schnitt Arbeitsraum des RX-90